Monograph

Effective Work Functions of the Elements

Database, Most probable value, Previously recommended value, Polycrystalline thermionic contrast, Change at critical temperature, Anisotropic dependence sequence, Particle size dependence

Hiroyuki Kawano[1]

Faculty of Science, Ehime University, Bunkyo 2-5, Matsuyama 790-8577, Japan

As a token of deep gratitude, I would like to dedicate this monograph to my supervisors during my student days at Kyoto University and also to my family as follows:

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ABSTRACT

As a much-enriched supplement to the previous review paper entitled the "Effective work functions for ionic and electronic emissions from mono- and polycrystalline surfaces" [Prog. Surf. Sci. 83 (2008) 1–165], the present monograph summarizes a comprehensive and up-to-date database in Table 1, which includes more than ten thousands of experimental and theoretical data accumulated mainly during the last half century on the work functions (ϕ^+, ϕ^e and ϕ^-) effective for positive-ionic, electronic and negative-ionic emissions from mono- and polycrystalline surfaces of 88 kinds of chemical elements ($_1$H–$_{99}$Es), and also which includes the main experimental condition and method employed for each sample specimen (bulk or film) together with 490 footnotes. From the above database originating from 4461 references published to date in the fields of both physics and chemistry, the most probable values of ϕ^+, ϕ^e and ϕ^- for substantially clean surfaces are statistically estimated for about 600 surface species of mono- and polycrystals. The values recommended for ϕ^e together with ϕ^+ and ϕ^- in Table 2 are much more abundant in both surface species and data amount, and also they may be more

Monocrystallization degree governing work function
Annealing temperature dependent work function value
Methodologically dependent work function study
Gordy–Thomas equation
Hensley's equation
Anisotropy dependent work function sequence
Smoluchowski rule
Anisotropic surface energy correlative work function examination
Anisotropic melting point correlated work function evaluation
Wigner–Seitz radius dependent work function values
Solid–liquid phase transitional work function change
Allotropic transformational work function change
Bulgers orientation relationship
Magnetic transitional work function change
Metastable metal film work function
Metastable film thickness dependent Curie temperature
Superconductive transformational work function change
Particle size dependent work function

reliable and convenient than those in popular handbooks and reviews consulted widely still today by great many workers, because the latter is based on less-plentiful data on ϕ^e published generally before ~1980 and also because it covers no value recommended for ϕ^+ and ϕ^-.

Consequently, Table 1 may be more advantageous as the latest and most abundant database on work functions (especially ϕ^e) for quickly referring to a variety of data obtained under specified conditions. Comparison of the most probable values of ϕ^e recommended for each surface species between this article and other literatures listed in Tables 2 and 3 indicates that consideration of the recent work function data accumulated particularly during the last ~40 years is very important for correct analysis of these surface phenomena or processes concerned with either work function or its changes.

On the basis of our simple model about the work function of polycrystal consisting of a number of patchy faces (1–i) having each a fractional area (F_i) and a local work function (ϕ_i), its values of both ϕ^+ and ϕ^e are theoretically calculated and also critically compared with a plenty of experimental data. In addition, the "polycrystalline thermionic work function contrast" ($\Delta\phi^* \equiv \phi^+ - \phi^e$) well-known as the thermionic peculiarity inherent in every polycrystal is carefully analyzed as a function of the degree of monocrystallization (δ_m) corresponding to the largest (F_m) among F_i's (Tables 4–6 and Fig. 1), thereby yielding the conclusions as follows: (1) $\Delta\phi^* \simeq$ const (>0) holds for the generally called "polycrystalline" surfaces (usually $\delta_m <$ 50%), (2) $\Delta\phi^*$ ranges from ~0.3 eV (Pt) to 0.7 eV (Nb) depending upon the polycrystalline surface species, (3) in the case of the "submonocrystal" (50 < δ_m < 100%) tentatively named here, $\Delta\phi^*$ decreases parabolically down to zero as δ_m increases from ~50% up to 100% (monocrystal), (4) $\Delta\phi^* = 0.0$ eV applies to a clean and smooth monocrystalline surface ($\delta_m \approx$ 100%) alone, (5) regarding negative ion emission, on the other hand, our theoretical prediction of $\Delta\phi^{**} \equiv \phi^- - \phi^e = 0.0$ eV is experimentally verified to hold for any surface species under any surface conditions (Table 7), (6) every polycrystal (usually, $\delta_m <$ 50%) may be concluded in general to have a unique value of ϕ^e characteristic of its species with little dependence upon δ_m, (7) this conclusion affords us first a sound basis for supporting theoretically the experimental fact (Table 2) that every species of polycrystal has a nearly constant value of ϕ^e as well as ϕ^+ (usually within the uncertainty of ±0.1 eV) depending little upon the difference in the surface components (F_i and ϕ_i) among specimens so long as $\delta_m <$ 50%, (8) on the contrary to polycrystal ($\delta_m <$ 50%), any submonocrystal (50 < δ_m < 100%) has such an anomaly that it does not possess the unique value of work function characteristic of the surface species itself, because its ϕ^e as well as ϕ^+ changes considerably depending upon δ_m, (9) consequently, submonocrystal must be taken as another type (category) different from both poly- and monocrystals, (10) in this way, δ_m acts as the *key* factor mainly governing the work functions in the different mode between poly- and submonocrystals with δ_m lower and higher than the "critical point" of 50%, respectively, (11) on the contrary to δ_m, ϕ_m belonging to δ_m has a differential effect on both ϕ^+ and ϕ^e, but their values remain nearly constant so long as $\delta_m <$ 50% and, thus interestingly, (12) the complicate governance of ϕ^+ and ϕ^e by both δ_m and ϕ_m and also the anomaly of submonocrystal (cf. (8) above) observed first by our theoretical analysis may be considered as a new contribution to the work function studies developed to date.

Together with brief comments and experimental conditions, typical data on ϕ^e and/or ϕ^+ are summarized from the various aspects of (1) examination of the work function dependence upon the surface atom density of low-Miller-index monocrystals of typical metals such as Al, Ni, W and Re (Table 8), (2) demonstration of the above dependence usually called the "anisotropic work function dependence sequences" of both $\phi^e(110) > \phi^e(100) > \phi^e(111)$ and $\phi^+(110) > \phi^+(100) > \phi^+(111)$ for various bcc-metals (e.g., Nb, Mo, Ta and W) exactly obeying the Smoluchowski rule (Table 9), (3) substantiation of both $\phi^e(111) > \phi^e(100) > \phi^e(110)$ for a variety of fcc-metals (except Al and Pb) and $\phi^+(111) > \phi^+(100) > \phi^+(110)$ for Ni strictly following the above rule (Table 10), (4) verification of the quantitative relations between work function and surface energy and also melting point of the three low index planes of several metals (typically, Ni), (5) examination of the work function change ($\Delta\phi^e$) due to allotropic transformation from α to β or β to γ phase (Table 11) together with a concise outline of the Burgers orientation relationship, (6) evaluation of $\Delta\phi^e$ due to liquefying (Table 12), (7) estimation of $\Delta\phi^e$ due to transformation from ferro- to paramagnetic state (Table 13) in addition to a brief description of the Curie point dependence upon metastable metal film thickness above one monolayer, (8) estimation of $\Delta\phi^e$ due to transition from normal to superconducting state (Table 14), (9) study of the work function dependence on the Wigner–Seitz radius and also comparison between its theoretical values (by Kohn) and experimental data (Fig. 2), (10) inspection of the annealing effect on work function for layers or films, (11) verification of the coincidence of work function values among different experimental methods, and (12) inquisition of the work function dependence upon the size of fine particles (~20–100 Å in radius) studied by theory and experiment.

Contents

1. Introduction

The work function (ϕ) of a solid surface is the minimum energy necessary for an electron to transfer from the Fermi level to field-free space, and it is one of the important factors governing the electronic and ionic emissions from any surfaces by any means. Typically, positive-ionic, electronic and negative-ionic emissions from a patchy surface by various mechanisms (processes) are strongly dependent upon the effective work functions of ϕ^+, ϕ^e and ϕ^-, respectively, and they are evaluated theoretically from Eqs. (1)–(3) [1351].

$$\phi^+ = kT \ln[\Sigma F_i \exp(\phi_i/kT)], \tag{1}$$

$$\phi^e = -kT \ln[\Sigma F_i \exp(-\phi_i/kT)], \tag{2}$$

$$\phi^- = -kT \ln[\Sigma F_i \exp(-\phi_i/kT)]. \tag{3}$$

Here, F_i is the fractional surface area of the patch site (i) having the local work function (ϕ_i), where the total of ΣF_i is unity. All of the three above are the mean work functions weighted statistically according to the tendencies that positive ions (M^+) are *predominantly* emitted from high work function sites but that negative ions (X^-) and electrons (e^-) are done so from the sites of low ϕ_i. This predominance has a very important role in governing (determining) mainly the effective work functions of a patchy surface having various values of ϕ_i's and F_i's. Namely, ϕ_m belonging to F_m ($\equiv \delta_m$), the latter of which is named here the "degree of monocrystallization" correspondent to the largest among F_i's, has the "differential effect" upon both ϕ^+ and ϕ^e according to the condition whether ϕ_m is relatively higher or lower than the others among ϕ_i's, as will be demonstrated later (Section 4.4).

Such a theoretical prediction as mentioned just above is supported experimentally by a typical example of a Na/W system [85], as clearly shown in Fig. 20 [1351]. Of course, both ϕ^+ and ϕ^e of a patchy surface are generally different from the *simple* average given by

$$\phi^a = \Sigma F_i \phi_i. \tag{4}$$

Needless to say, ϕ^a is not weighted statistically according to the predominance mentioned just above. Consequently, the inequality of $\phi^+ > \phi^a > \phi^e$ always holds for any patchy surfaces, and it is to clean and smooth monocrystalline ones ($\delta_m = 100\%$) alone that the equality of $\phi^+ = \phi^a = \phi^e$ is applicable, as will be demonstrated in Section 4. On the contrary, it is reported for an actual specimen of polycrystalline W (F_i = 46.3%-(310), 18.9%-(110), 15.5%-(112), 14.0%-(100) and 5.4%-(111) oriented) that $\phi^a = 4.59 \approx 4.6$ eV calculated from Eq. (4) is taken as ϕ^e and also that the value ($\phi^a = \phi^e = 5.6$ eV) is considered to agree well with $\phi^e = 4.8 \pm 0.05$ eV determined for the same specimen by field emission [489] (for further information, see W(D) in Table 6 to be given later in Section 4.2). Regarding an imaginary specimen of W consisting of the four (100)–(112) faces with each 25% fractional area, ϕ^+ is theoretically estimated to be 4.51 eV [3843], which is much smaller than $\phi^a = 4.74$ eV to be evaluated from Eq. (4) and also than $\phi^+ = 5.12$ eV done so from Eq. (1) [3844]. Again, this result of $\phi^+ = 4.51$ eV $< \phi^a = 4.74$ eV also is not well consistent with our theoretical prediction (for detail, see Footnote 295 in Table 1).

Eqs. (1)–(3) are theoretically derived according to our simple model of thermal stimulation (thermal ionic and electronic emissions) [281]. However, the work functions to be thus calculated for a given species are generally expected to agree either well or fairly with those determined experimentally by any other methods without depending upon any of the emission mechanisms (processes) such as ion bombardment (secondary ion emission), electron impact (electron-stimulated ion desorption), fast-atom incidence (fast or cold surface ionization), photon irradiation (photoelectron and photoion emissions), very high electric voltage application (field-electron and -ion emissions) and so on [1351]. The progress achieved up to ~1980 for the studies of thermal positive ionic and electronic emissions is outlined or summarized in several books [14–17] and review articles [2,18–22]. Both of the features and data on the emissions studied mainly after ~1980 are summarized together with experimental conditions in Sections 2 and 3 [1351]. For other emissions due to various mechanisms, a brief information may be obtained from several books [13,615,1354,2829].

Since the work function (ϕ^e) is very important in many fields of pure and applied physics and chemistry and also since it is necessary to know the accurate or most probable value of ϕ^e as the universal (or material) constant characteristic of each of the essentially clean mono- and polycrystalline surface species of the chemical elements, many handbooks [10–12,1352–1354,1358,1359,4137,4191,4318] and reviews [13,488,1045,1312,1355–1357] are published to summarize the recommended or selected values of ϕ^e for a variety of surface species. Especially, both Michaelson [1045,1355] and Fomenko [10,12,1354] have made a valuable contribution to compiling critically the work function data on various poly- and monocrystalline surfaces. However, their publications don't include any work function data published after ~1980. In addition, their contents summarized for monocrystals are not sufficiently abundant in both surface species and work function data themselves, compared with those generally expected today in many fields of science and technology. Consequently, many workers may feel inconvenience in finding the accurate or reliable values of work function of various surface species, especially of monocrystalline ones interested in quite many workers. Typically, a theoretical study published in 2003 [4130] states that any experimental data for α-Fe(110) are not available for comparison with the theoretical value of 4.73 eV calculated by the authors themselves [4130], although many experimental data of 4.72–5.32 eV determined for α-Fe(110) by PE, CPD or FE [e.g., 530,1273,2035] were already published in 1971−2000 (see Table 1 to be shown later). For another example published in 2008 [4131], $\phi^e = 4.94$ eV for Cu(111) and 5.03 eV for β-Co(111) are cited from Table 2 in our previous review (in 2008) [1351] and from a theoretical article (in 2007) [2910], respectively, because any data on the latter are not included in any of the reviews and books published in 1949−2008 [1351], in contrast to this article tabulating seven data on β-Co(111) (4.93–5.76 eV [e.g., 229,2068,3192] published in 1992−2008) in Table 1. Similarly in an experimental study reported for

Pr in 1998 [4263], it is stated that ϕ^e has not yet been experimentally determined for Pr. But, several articles [2011,4066,4251,4253] published already in 1974–1982 include ϕ^e = 2.6–2.67 eV for Pr measured by FE or CPD (see Table 1), the data of which are slightly larger than 2.50 eV done by IP of Pr-clusters [4263] (see Result (18) in Section 11.3 about clusters).

The recent or present situation exemplified above suggests that a new and enriched handbook on work function should be widely distributed among all of the workers active in the fields of pure and applied surface sciences so as to be ready for consulting the recent data on work function and also for easily finding the most probable value of any surface species of chemical elements under study. From this point of view, the present author has tried to compile Table 1 covering the up-to-date and abundant work function data on a vast number of surface species of almost all the chemical elements and also to make up Table 2 recommending the most probable value of each species. Both of the tables may be very effective for filling up such a great blank in work function data as found in many handbooks and also for covering a very long absence from compiling new data during the last several tens of years since ~1980.

As will be shown later in Tables 2 and 3 and also discussed concretely in Section 3.2, some of the recommended or selected values [typically, 12,1045,1354,1358] don't seem to be very accurate or reliable enough to be fully acceptable today, mainly because many of them are usually based on the meager or scanty data published entirely before ~1980. Nevertheless, many of the preferable values of work function (ϕ^e) [1045], for example, have long been often and widely cited still to date by total 1935 groups of workers at present (May 2017) [4158] since the progressive review was published by Michaelson [1045] in 1977. In addition, many publications [typically, 1045,1352,1353,1355,1356,1358,1359] don't include any data on ϕ^+ and $\Delta\phi^*$. Consequently, they seem to be scarcely suitable enough in general for analyzing correctly these data on positive ion emission from polycrystals, although such emission or positive surface ionization (PSI) has long been employed widely as a very convenient technique for various purposes such as positive ion beam production, atomic and molecular beam detection, isotopic ratio determination, ionization potential measurement, analysis of surface state and processes, and so on [2,4–7,15,16,18,19,21,22]. Even a recent publication such as CRC Handbook (97th Ed. in 2016−2017) [1358] is entirely based on the data published before ~1980, similarly with those (82nd−96th editions in 2001−2015) [e.g., 11,1359]. Consequently, some of the work function values recommended in the above publications don't seem to be fully accurate or reliable enough to be straight or undoubtedly acceptable today. Typically for Cu(100), ϕ^e = 5.10 eV [358] cited in CRC Handbooks (1997−2017) [typically, 1358,4318] deviates considerably from our value of 4.58 ± 0.06 eV to be recommended in Table 2 and also from 4.59 ± 0.03 eV [953,2006] considered to be most reliable at present. Such a deviation as ranging from ~0.2 to 1.0 eV is found also for many other surface species, as will be demonstrated later in Section 3.2 and Table 3.

Recently (2015) after ~35 years' absence since ~1980, Derry et al. [4088] have published a compact review on clean monocrystalline metal surface work function, where the recommended values are based on these experimental data about 45 species of low-Miller-index surfaces for 15 kinds of very familiar metals without including much data achieved by theory for a variety of surface species of various elements. Consequently, it seems to be still confidently expected to publish such a comprehensive article on both experimental and theoretical work function data as covering not only low- but also high-Miller-index surfaces together with polycrystalline ones for more than several tens of quite many chemical elements interested generally in physics and chemistry.

It must be kept in mind that (1) the generally called "work function (ϕ)" appearing in usual publications [e.g., 1045,1352,1358] means $\phi = \phi^e$ unless otherwise stated, (2) the equality of $\phi^+ = \phi^e = \phi^- = \phi^a = \phi$ holds for clean and smooth monocrystalline surfaces alone, (3) the partial inequality of $\phi^+ > \phi^a > \phi^e = \phi^- = \phi$ conforms to these cases other than the case (2) mentioned just above and, hence, the relation of $\phi^+ - \phi^e \equiv \Delta\phi^* > 0$ applies always to both polycrystalline surfaces ($\delta_m < 50\%$) and non-clean and/or non-smooth monocrystalline ones ($\delta_m = 100\%$) in addition to the tentatively named "submonocrystalline" ones ($50 < \delta_m < 100\%$) to be fully explained later (Sections 4.3–4.5) and (4) $\phi^e = \phi^- = \phi$ is applicable to any surface species under any conditions irrespective of the degrees in both surface contamination and irregularity [1351]. Much data on $\Delta\phi^* > 0$ will be listed in Tables 4 and 5 based on both theory and experiment.

In principle, work function is generally expected to be the universal constant for each of the "clean and smooth" monocrystalline surface species. In practice, however, its data are found to scatter in a wide range (typically, ~4.1–5.2 eV for W(100), see Table 1) among different specimens or workers for the same surface species of actual "monocrystals". In other words, the degree of deviation from ideal surface conditions is different more or less among the actual specimens under study. This difference is usually due to such causes that the degrees of both surface contamination and defects and also of heteroatom density are different among the monocrystalline specimens under study and also that the extents of error in both measurement and data-processing are not identical among the corresponding workers. As one more cause, we can not deny the possibility that some of the specimens under study are somewhat less than 100% in the degree of monocrystallization (δ_m), as will be discussed later in Section 4. Especially in the case of a polycrystalline species consisting of patchy faces having F_i and ϕ_i, on the other hand, δ_m (largest among F_i's) also may be attributable as an additional cause to the difference in ϕ^e among various specimens. Typically for "submonocrystalline" tungsten ($50 < \delta_m < 100\%$), ϕ^e is 4.87 ± 0.06 eV at $\delta_m = 80\%$, while ϕ^e of the usually called "polycrystalline" tungsten ($\delta_m < 50\%$) remains nearly constant at 4.52 ± 0.10 eV with little dependence upon δ_m so long as $\delta_m < 50\%$, as will be demonstrated in Table 6 and Section 4. There, the anomaly of the former quite different from the latter is described thoroughly.

In the case of theoretical calculation, much larger scattering (typically, ~3.7–7.8 eV for W(100), see Table 1) is found for any monocrystalline surface species among different authors. This is probably because some of the theoretical models themselves are not yet fully perfect or reasonable and/or because some of their selections of numerical values of the parameters governing work function are neither adequate nor suitable.

Such a present situation outlined above suggests powerfully that much work function data accumulated to date by using various methods should be collected from not only regular publications in a variety of scientific fields but also special reports, conference proceedings and doctoral theses as many as possible and also that the abundant data coming from such a broad survey should be

examined carefully, in order to estimate accurately the most probable values of ϕ^e as well as ϕ^+ and ϕ^- for a large number of the mono- and polycrystalline surface species which are widely interested in theoretical and/or experimental researches by many workers.

From the above aspect, the present author has already published a comprehensive review paper [1351], where many of the work function data published to ∼2005 are tabulated and also examined carefully to estimate the most reliable value of work function for each of mono- and polycrystalline surfaces of popular elements together with several compounds. Regarding the chemical elements, however, the previous review includes the work function data for only 18 kinds of elements, and it involves the best estimate of the work function value for 74 surface species alone, thereby strongly indicating that a new article about the work function database enriched in both quality and quantity should be published in order to estimate the most probable values of work function for much more surface species of most of the solid and liquid elements in the periodic table.

The above viewpoint has made the present author to prepare this new article, which is intended mainly (1) to summarize comprehensively a larger amount (more than ten thousands) of theoretical and experimental work function data published to date, (2) to estimate accurately the most probable values of work functions (ϕ^e, ϕ^+ and ϕ^-) for both mono- and polycrystalline surfaces of almost all the solid elements and also for some of the liquid ones so long as the work function data are available today, (3) to determine correctly the polycrystalline thermionic contrasts ($\Delta\phi^* \equiv \phi^+ - \phi^e$ and $\Delta\phi^{**} \equiv \phi^- - \phi^e$), (4) to reveal clearly the *key* factor of δ_m governing mainly the work functions of both poly- and submonocrystals, (5) to examine carefully the anisotropic work function dependence upon surface atom density for the three low-Miller-index planes of both bcc- and fcc-monocrystals, (6) to epitomize concisely the work function dependence upon the Wigner–Seitz radius together with a comparison between theory and experiment, (7) to inspect closely the work function changes caused by allotropic, magnetic, superconductive and solid–liquid transitions according to the temperature variation around each critical point, (8) to outline briefly the work function and Curie point of metastable metal films and also (9) to explicate fully the work function dependence upon the size of fine particles.

Together with the specified condition and method employed for each work function measurement, the database on ϕ^e, ϕ^+ and ϕ^- to be summarized later for mono-, submono- and polycrystalline surfaces in Table 1 may be useful for quickly surveying more than ten thousands of sample systems (bulk or film) employed to date for a variety of work function studies by theory and experiment. As will be shown in Table 2 together with the literature values either recommended or selected previously by other authors [12,1045,1354,1358] and also by the present author [1351], many of the most probable values estimated from the above database (Table 1) may be citable or consultable as probably the most accurate and reliable reference data, nowadays at least, on ϕ^e, ϕ^+ and/or ϕ^- for general studies on work function and related subjects, and also many of them thus recommended for monocrystalline surfaces may be useful at present as the most reliable sources of local work function (ϕ_i) to be employable in Eqs. (1)–(3). The general reliability of our most probable values of ϕ^e to be listed in Table 2 is examined objectively by comparison with those recommended by others [12,1045,1354,1358]. In addition, the work function difference between the former and the latter will be discussed considerably in Section 3.2, and also the distribution of the difference ranging from 0.05 to 1.0 eV between the two will be summarized in Table 3.

For better understanding the polycrystalline thermionic contrast ($\Delta\phi^* \equiv \phi^+ - \phi^e$) dependent upon the degree of surface inhomogeneity in work function over the entire surface area, many experimental data are summarized for 32 surface species in Tables 4 and 5, clearly showing that clean and smooth monocrystalline surfaces alone stand upon $\Delta\phi^* = 0.0$ eV and also that polycrystalline ones have $\Delta\phi^* \approx 0.3 - 0.7$ eV, dependent upon the polycrystalline species. These data on $\Delta\phi^*$ may be helpful for analyzing correctly these positive ion emission data obtained for polycrystalline surface systems, where ϕ^e is not available in general for an accurate or reliable analysis of the latter data (see Section 4.1).

In order to clarify the problem how the work function of a patchy surface is governed by both local work function (ϕ_i) and its fractional surface area (F_i), some of the typical examples for calculating both ϕ^+ and ϕ^e from Eqs. (1) and (2) are summarized for W together with $\Delta\phi^*$ in Table 6. In addition, the quantitative relation between the contrast ($\Delta\phi^*$) and the maximum value ($\delta_m \equiv F_m$) among the various areas (F_i's) will be shown in Fig. 1 (see Section 4.3).

To examine closely the theoretical prediction that $\Delta\phi^{**} \equiv \phi^- - \phi^e \approx 0$ always holds without depending upon both surface species and condition, all of the experimental data available today are summarized for several elements in Table 7, which suggests strongly that $\Delta\phi^{**} = 0.0$ eV fitly applies to any mono-, submono- and polycrystals even when their surfaces are neither atomically clean nor flat (smooth), in contrast to $\Delta\phi^* = 0.0$ eV applicable only to those surfaces homogeneous in work function over the entire area.

From the viewpoint of the Smoluchowski rule [1040] concerning the relationship between surface-atom density and work function for monocrystalline surfaces of the three low-Miller-index orientations, the anisotropic sequences of both $\phi^e(110) > \phi^e(100) > \phi^e(111)$ for various bcc-metals and also $\phi^e(111) > \phi^e(100) > \phi^e(110)$ for fcc-ones are examined by using many experimental and theoretical data listed in Tables 8–10, fairly indicating that more than half of the respective data on Al and Pb (both fcc) alone does not satisfy the latter sequence (mentioned just above) in contrast to many other fcc-metals (Table 10). It cannot be emphasized enough that $\phi^+(hkl)$ is first reported here for both bcc-metals (Nb, Mo, Ta and W) and fcc-one (Ni) to follow faithfully the above rule.

To investigate the work function changes ($\Delta\phi^e$) due to allotropic, magnetic, superconductive and solid–liquid transitions, experimental data of many or several surface species are summarized in Tables 11–14, indicating that quite many of the surface species have $|\Delta\phi^e| < 0.1$ eV. In addition, the peculiarity of metastable metal films is outlined together with typical data on work function and Curie point depending upon film thickness. Finally, work function dependence upon the size of fine particles will be summarized together with comparison between theory and experiment in Section 11.

2. Database

The present author believes it very important to estimate the most probable work function values of many mono- and polycrystalline surfaces and also to solve the problem how the work function of an actual surface depends upon the specimen and/or condition employed by each individual group of workers. From this viewpoint, he has tried to do best for obtaining work function data as much as possible since ~2000 and also for inspecting both experimental condition and surface processing employed by each group of workers. In consequence, he has managed to summarize theoretical and experimental work function data based on 4461 references published to date in various fields of not only physics but also chemistry, as shown in Table 1. It contains the data for about 600 surface species of 88 kinds of chemical elements ($_1$H–$_{99}$Es) and also does the main conditions (residual gas pressure and surface temperature) and method together with 490 footnotes in order to provide further information about specimen preparation, surface treatment, data processing, etc. Such description may be very helpful to judging the questions whether the surface under study is substantially clean and/or whether the sample layers are essentially uniform over the entire surface area, in addition to resolving the problem how ϕ^e changes depending upon the degree of monocrystallization (δ_m) correspondent to the largest among the patchy surface areas (F_i's) for the poly- or submonocrystalline specimen having various values of local work function (ϕ_i's).

Table 1 consists of the nine columns to be explained concisely below, where the main points of experimental conditions are entered in Columns 2–5. In addition, several subjects and topics related to the items present in some of the columns will be outlined together with brief discussions.

Table 1
Theoretical and experimental data on the effective work functions (ϕ^+ or ϕ^- and ϕ^e) determined for various surfaces under the conditions specified herein. The value of ϕ^- is given with a superscript of N in the column of ϕ^+. Each of the recommended values herein is compared with that selected or recommended by other workers in Table 2.

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				1. Hydrogen H				
fcc								
H(100)	–	–	–	–	–	3.73	TC	[231]
H(110)	–	–	–	–	–	3.75	TC	[231]
H(111)	–	–	–	–	–	3.80	TC	[231]
H	–	–	–	–	–	3.77	TC	[1924]
H	–	–	–	–	–	3.84	TC	[231]
H	–	–	–	–	–	3.86	TC	[231]
H	–	–	–	–	–	4.0	TC	[944]
H	–	–	–	–	–	4.0	TC	[2648]
H	–	–	–	–	–	4.41	TC	[1924]
H	–	–	–	–	–	4.67	TC	[2648]
H	–	–	–	–	–	5.25	TC	[1955]
Recommended	–	–	–	–	–	**3.89 ± 0.09**	–	–
				3. Lithium Li				
bcc								
Li(100)	–	–	–	–	–	2.310	TC	[2947]
Li(100)	–	–	–	–	–	2.40	TC	[475][3]
Li(100)	–	–	–	–	–	2.61	TC	[1159,1980,3067]
Li(100)	–	–	–	–	–	2.9	TC	[474]
Li(100)	–	–	–	–	–	2.92	TC	[231]
Li(100)	–	–	–	–	–	2.93	TC	[1595]
Li(100)	–	–	–	–	–	2.96	TC	[1595]
Li(100)	–	–	–	–	–	2.96	TC	[4461][490]
Li(100)	–	–	–	–	–	2.986	TC	[4091]
Li(100)	–	–	–	–	–	3.0	TC	[474]
Li(100)	–	–	–	–	–	3.00	TC	[1095]
Li(100)	–	–	–	–	–	3.02	TC	[2427]
Li(100)	–	–	–	–	–	3.03	TC	[553]
Li(100)	–	–	–	–	–	3.03	TC	[637,2418]
Li(100)	–	–	–	–	–	3.037	TC	[2432]
Li(100)	–	–	–	–	–	3.04	TC	[3467]
Li(100)	–	–	–	–	–	3.05	TC	[1595]
Li(100)	–	–	–	–	–	3.06	TC	[637,2418]
Li(100)	–	–	–	–	–	3.09	TC	[1595]
Li(100)	–	–	–	–	–	3.1	TC	[474]
Li(100)	–	–	–	–	–	3.10	TC	[478]

(*continued on next page*)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Li(100)	–	–	–	–	–	3.10	TC	[321]
Li(100)	–	–	–	–	–	3.11	TC	[3478]
Li(100)	–	–	–	–	–	3.11	TC	[1595]
Li(100)	–	–	–	–	–	3.11	TC	[711]
Li(100)	–	–	–	–	–	3.135	TC	[4460][490]
Li(100)	–	–	–	–	–	3.15	TC	[334]
Li(100)	–	–	–	–	–	3.20	TC	[3478]
Li(100)	–	–	–	–	–	3.25	TC	[476]
Li(100)	–	–	–	–	–	3.26	TC	[711]
Li(100)	–	–	–	–	–	3.27	TC	[1237]
Li(100)	–	–	–	–	–	3.28	TC	[1595]
Li(100)	–	–	–	–	–	3.28	TC	[3814]
Li(100)	–	–	–	–	–	3.30	TC	[475]
Li(100)	–	–	–	–	–	3.30	TC	[1030]
Li(100)	–	–	–	–	–	3.32	TC	[555]
Li(100)	–	–	–	–	–	3.32	TC	[556]
Li(100)	–	–	–	–	–	3.36	TC	[637]
Li(100)	–	–	–	–	–	3.39	TC	[476]
Li(100)	–	–	–	–	–	3.4	TC	[1088]
Li(100)	–	–	–	–	–	3.47	TC	[1030]
Li(100)	–	–	–	–	–	3.56	TC	[472]
Li(100)	–	–	–	–	–	3.60	TC	[1557]
Li(100)	–	–	–	–	–	3.70	TC	[1414]
Li(100)	–	–	–	–	–	3.71	TC	[1414]
Recommended	–	–	–	–	–	**3.12 ± 0.03**	–	–
Li(110)	–	–	–	–	–	2.31	TC	[2835]
Li(110)	–	–	–	–	–	2.40	TC	[475]
Li(110)	–	–	–	–	–	2.45	TC	[593]
Li(110)	–	–	–	–	–	2.479	TC	[2947]
Li(110)	–	–	–	–	–	2.75	TC	[3712]
Li(110)	–	–	–	–	–	2.78	TC	[1159,1980,3067]
Li(110)	–	–	–	–	–	2.90	TC	[3713]
Li(110)	–	–	–	–	–	2.96	TC	[3693]
Li(110)	–	–	–	–	–	3.00	TC	[1095]
Li(110)	–	–	–	–	–	3.09	TC	[231]
Li(110)	–	–	–	–	–	3.10	TC	[2835]
Li(110)/W(110)[1]	Li	–	?	~300	–	3.11 ± 0.05	CPD	[3361]
Li(110)/Mo(110)[1]	Li	–	?	~300	–	3.11 ± 0.05	CPD	[3361]
Li(110)	–	–	–	–	–	3.12	TC	[3692]
Li(110)	–	–	–	–	–	3.18	TC	[711]
Li(110)	–	–	–	–	–	3.18	TC	[4461][490]
Li(110)	–	–	–	–	–	3.22 ± 0.01*	TC	[4440]
Li(110)	–	–	–	–	–	3.221	TC	[4091]
Li(110)	–	–	–	–	–	3.25	TC	[1086]
Li(110)	–	–	–	–	–	3.26	TC	[2427]
Li(110)	–	–	–	–	–	3.27	TC	[553]
Li(110)	–	–	–	–	–	3.286	TC	[2432]
Li(110)	–	–	–	–	–	3.31	TC	[476,711]
Li(110)	–	–	–	–	–	3.32	TC	[3467]
Li(110)	–	–	–	–	–	3.33	TC	[334]
Li(110)	–	–	–	–	–	3.35	TC	[1734]
Li(110)	–	–	–	–	–	3.359	TC	[4460][490]
Li(110)	–	–	–	–	–	3.37	TC	[1086]
Li(110)	–	–	–	–	–	3.40	TC	[637]
Li(110)	–	–	–	–	–	3.43	TC	[637,2418]
Li(110)	–	–	–	–	–	3.43	TC	[3814]
Li(110)	–	–	–	–	–	3.44	TC	[476]
Li(110)	–	–	–	–	–	3.45	TC	[1734]
Li(110)	–	–	–	–	–	3.46	TC	[637,2418]
Li(110)	–	–	–	–	–	3.5	TC	[1086,1088]
Li(110)	–	–	–	–	–	3.54	TC	[1237]
Li(110)	–	–	–	–	–	3.55	TC	[475]
Li(110)	–	–	–	–	–	3.55	TC	[555]
Li(110)	–	–	–	–	–	3.55	TC	[556]
Li(110)	–	–	–	–	–	3.58	TC	[1030]
Li(110)	–	–	–	–	–	3.6	TC	[3137]
Li(110)	–	–	–	–	–	3.6	TC	[1086,1088]
Li(110)	–	–	–	–	–	3.61	TC	[321]
Li(110)	–	–	–	–	–	3.61	TC	[2402]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Li(110)	–	–	–	–	–	3.63	TC	[555]
Li(110)	–	–	–	–	–	3.63	TC	[1086]
Li(110)	–	–	–	–	–	3.66	TC	[1086]
Li(110)	–	–	–	–	–	3.75	TC	[1086]
Li(110)	–	–	–	–	–	3.77	TC	[472]
Li(110)	–	–	–	–	–	3.78	TC	[1086]
Li(110)	–	–	–	–	–	3.87	TC	[1030,1089]
Li(110)	–	–	–	–	–	3.91	TC	[1089]
Li(110)	–	–	–	–	–	3.92	TC	[1087]
Li(110)	–	–	–	–	–	3.93	TC	[3713]
Li(110)	–	–	–	–	–	3.99	TC	[3693]
Li(110)	–	–	–	–	–	4.05	TC	[1089]
Li(110)	–	–	–	–	–	4.24	TC	[3692]
Recommended	–	–	–	–	–	**3.37 ± 0.05**	–	–
Li(111)	–	–	–	–	–	2.30	TC	[475]
Li(111)	–	–	–	–	–	2.35	TC	[593]
Li(111)	–	–	–	–	–	2.58	TC	[1159,1980,3067]
Li(111)	–	–	–	–	–	2.6	TC	[4461][490]
Li(111)	–	–	–	–	–	2.746	TC	[4091]
Li(111)	–	–	–	–	–	2.90	TC	[231]
Li(111)	–	–	–	–	–	2.90	TC	[1095]
Li(111)	–	–	–	–	–	2.925	TC	[4460][490]
Li(111)	–	–	–	–	–	2.93	TC	[553]
Li(111)	–	–	–	–	–	2.94	TC	[3467]
Li(111)	–	–	–	–	–	2.96	TC	[711]
Li(111)	–	–	–	–	–	2.97	TC	[321]
Li(111)	–	–	–	–	–	3.09	TC	[637,2418]
Li(111)	–	–	–	–	–	3.12	TC	[476,711]
Li(111)	–	–	–	–	–	3.12	TC	[637,2418]
Li(111)	–	–	–	–	–	3.13	TC	[1237]
Li(111)	–	–	–	–	–	3.13	TC	[556]
Li(111)	–	–	–	–	–	3.15	TC	[3814]
Li(111)	–	–	–	–	–	3.16	TC	[1030]
Li(111)	–	–	–	–	–	3.19	TC	[555]
Li(111)	–	–	–	–	–	3.2	TC	[1088]
Li(111)	–	–	–	–	–	3.20	TC	[1030]
Li(111)	–	–	–	–	–	3.25	TC	[475]
Li(111)	–	–	–	–	–	3.26	TC	[476]
Li(111)	–	–	–	–	–	3.42	TC	[472]
Li(111)	–	–	–	–	–	3.44	TC	[637]
Li(111)	–	–	–	–	–	3.58	TC	[1557]
Recommended	–	–	–	–	–	**3.04 ± 0.08**	–	–
Li(112)	–	–	–	–	–	3.30	TC	[321]
Li/W	Li	–	?	~300	–	1.84	PE	[2206]
Li/Si(100)	Li	–	8×10^{-11}	360	–	2.1*	CPD	[2414]
Li	–	–	–	–	–	2.1	TC	[2845]
Li/Si(100)	Li	–	$<1 \times 10^{-10}$	133, ~300	–	2.1*	PE	[2057]
Li	–	–	–	–	–	2.19	TC	[3725]
Li/Cu(100)	–	–	–	–	–	2.2*	TC	[3205]
Li/Si(100)[n]	Li	–	$<1 \times 10^{-10}$	~300	–	2.22 ± 0.05*	PE	[3935]
Li$_n$(n → ∞)[389]	–	–	–	–	–	2.25	TC	[4262]
Li/?	Li	–	?	?	–	2.28	?	[3785]
Li/Si(100)	Li	–	8×10^{-11}	360	–	2.3*	CPD	[2414]
Li/Ru(001)	Li	–	4×10^{-11}	200	–	2.3 ± 0.1*	CPD	[3606]
Li/glass	Li	–	?	~300	–	2.32 ± 0.03[2]	CPD	[349]
Li/Si(100)	Li	–	$<8 \times 10^{-11}$	~300	–	2.36*	PE	[2278]
Li/Si(100)	Li	–	$<2 \times 10^{-10}$	~300	–	2.36 ± 0.16*	PE	[2412]
Li/Si(100)	Li	–	$<3 \times 10^{-10}$	~300	–	2.38*	CPD	[1929]
Li/Si(100)[n]	Li	–	8×10^{-11}	360–500	–	2.4*	CPD	[1874]
Li/Si(111)[n]	Li	–	8×10^{-10}	~300	–	2.4	CPD	[2736]
Li/Cu(110)	Li	–	5×10^{-11}	140	–	2.4 ± 0.1	PE	[3454]
Li/Pt(111)	–	–	–	–	–	2.400	TC	[3245]
Li/Ni	Li	–	$<10^{-9}$	77	–	2.42	CPD	[2139,3698]
Li/?	Li	–	?	~300	–	2.42	PE	[3027]
Li	–	–	–	–	–	2.45	TC	[1744]
Li/Ni(110)	Li	–	8×10^{-11}	150	–	2.47*	CPD	[3219]
Li/graphene	–	–	–	–	–	2.49	TC	[4079]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Li/Ni	Li	–	$<10^{-9}$	77	–	2.49	CPD	[3128]
Li/glass	Li	–	?	~300	–	2.49 ± 0.02[2]	CPD	[1374]
Li/Si(100)[p]	Li	–	8×10^{-11}	380–525	–	2.5*	CPD	[1874]
Li	–	–	–	–	–	2.5	TC	[3558]
Li/W	Li	–	$(<10^{-10})$	77	–	2.5	FE	[2711]
Li/Na/Cu(100)	Li	–	$\leq 1 \times 10^{-10}$	180	–	2.5	PE	[2678]
Li/Si(100)	–	–	–	–	–	2.5 ± 0.1*	TC	[3647]
Li	–	–	–	–	–	2.50*	TC	[1955]
Li	–	–	–	–	–	2.51	TC	[1571]
Li	–	–	–	–	–	2.52	TC	[1571]
Li/Cu(100)	Li	–	$\sim 10^{-10}$	~300	–	2.52 ± 0.08*	PE	[3297]
Li/Ni(110)	Li	–	8×10^{-11}	~300	–	2.53*	CPD	[3219]
Li/Si(100)[422]	Li	–	2×10^{-10}	~300	–	2.53	CPD	[4016]
Li/steel	Li	–	$\sim 10^{-10}$	~300–400	–	2.54 ± 0.02	PE	[4298,4299]
Li/Si(100)	Li	–	$<3 \times 10^{-10}$	~300	–	2.58*	CPD	[1929]
Li/Si(111)	Li	–	5×10^{-10}	~300	–	2.6	CPD	[2485]
Li/MgO(100)	Li	–	1×10^{-10}	~300	–	2.6	CPD	[1942]
Li/Si(100)	–	–	–	–	–	2.6*	TC	[732,4068]
Li/glass	Li	–	$\leq 10^{-7}$	~300	–	2.6	PE	[3253]
Li/Ru(001)	Li	–	$\leq 2 \times 10^{-10}$	100	–	2.6*	PE	[344]
Li	–	–	–	–	–	2.60	TC	[3477]
Li	–	–	–	–	–	2.63	TC	[3477]
Li	–	–	$\sim 10^{-10}$	~300	–	2.64 ± 0.02	PE	[4298,4315]
Li/Ru(001)	–	–	–	–	–	2.68	TC	[346]
Li/Ru(001)	Li	–	$\leq 2 \times 10^{-10}$	100	–	2.7*	PE	[344]
Li/Mo	Li	–	$\leq 3 \times 10^{-7}$	~300	–	2.7	PE	[1433]
Li/W(111)	Li	–	$(\leq 10^{-11})$	77	–	2.7	FE	[1977]
Li/W(110)	Li	–	?	5 (100)	–	2.7	CPD	[2387]
Li/Si(111)	Li	–	$<2 \times 10^{-11}$	90	–	2.7 ± 0.1*	PE	[3487]
Li/W(110)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.75	FE	[1974]
Li/W(111)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.75	FE	[1974]
Li/W(112)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.75	FE	[1974]
Li/Ru(001)	Li	–	4×10^{-11}	~100–200	–	2.8	CPD	[1875,2285]
Li/Mo(112)	Li	–	$(\leq 10^{-11})$	77	–	2.8	CPD	[2027]
Li/Mo(110)	Li	–	?	77 (100)	–	2.8	CPD	[2387]
Li/Ni(100)	Li	–	$\leq 3 \times 10^{-10}$	~300	–	2.8	CPD	[936]
Li/Ir	Li	–	$\leq 10^{-4}$ (Li)	~700–1200	–	2.80	TE	[169]
Li/W(111)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.80*	FE	[1974]
Li/Ge(100)	Li	–	$<1 \times 10^{-10}$	78	–	2.80*	FE	[4081]
Li/Ru(001)	–	–	–	–	–	2.86	TC	[346]
Li	–	–	–	0	–	2.86	TC	[4419]
Li/Ag(111)	Li	–	1×10^{-10}	~300	–	2.86*	CPD	[2866,2873]
Li/Ni(110)	Li	–	8×10^{-11}	150	–	2.87	CPD	[3219]
Li	–	–	–	–	–	2.87	TC	[3312]
Li/W(110)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.87*	FE	[1974]
Li/Ge(111)	Li	–	$<1 \times 10^{-10}$	78	–	2.87*	FE	[4081]
Li(fp)	–	–	?	453	–	2.88	PE	[4256]
Li/W(112)[39]	Li	–	$(\leq 10^{-11})$	77	–	2.88 ± 0.02	CPD	[380]
Li/Ge(100)	Li	–	$\leq 10^{-10}$	~300	–	2.88 ± 0.08*	FE	[3936]
Li/W(110)	Li	–	$(\leq 10^{-11})$	77	–	2.9	FE	[1977]
Li/W(112)	Li	–	$(\leq 10^{-11})$	77	–	2.9	FE	[1977]
Li/C$_{60}$/Ni(110)	Li	–	8×10^{-11}	~300	–	2.9	CPD	[696]
Li	–	–	–	–	–	2.9	TC	[706]
Li/W(100)	Li	–	$(<10^{-11})$	~300	–	2.9	CPD	[2034,3976]
Li/W(111)	Li	–	$\sim 10^{-11}$	~300	–	2.9	CPD	[2535]
Li/W(112)	Li	–	$(\leq 10^{-11})$	~300	–	2.9	CPD	[259,380]
Li/W(110)	Li	–	$(\leq 10^{-11})$	77	–	2.9	FE	[259]
Li/W(111)	Li	–	$(\leq 10^{-11})$	~300	–	2.9	CPD	[259]
Li/W(110)	Li	–	$(\leq 10^{-11})$	5	–	2.9	CPD	[2387]
Li/Mo(110)	Li	–	$(\leq 10^{-11})$	77	–	2.9	CPD	[2387]
Li/Si(100)	Li	–	$<2 \times 10^{-11}$	~300	–	2.9*	PE	[2283]
Li/Ta(112)	Li	–	$(\leq 10^{-11})$	77, ~300	–	2.9	CPD	[2662]
Li/Si(100)	–	–	–	–	–	2.9 ± 0.1*	TC	[3647]
Li/Ge(111)	Li	–	$\leq 10^{-10}$	~300	–	2.90 ± 0.09*	FE	[3936]
Li/W(112)[39]	Li	–	$(\leq 10^{-11})$	77	–	2.91 ± 0.03	FE	[380]
Li	–	–	–	–	–	2.92	TC	[298]
Li/W(111)	Li	–	$\sim 10^{-9}$	77	–	2.92	FE	[363]
Li/W(112)[39]	Li	–	$(\leq 10^{-11})$	~300	–	2.93	CPD	[380,3341]
Li/W(112)[39]	Li	–	$(\leq 10^{-10})$	77	–	2.93*	FE	[1974]
Li/Ni(110)	Li	–	8×10^{-11}	~300	–	2.93	CPD	[3219]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Li(fp)[42]	–	–	?	?	–	2.93 ± 0.05	PE	[3482]
Li(fp)	–	–	?	77	–	2.94	PE	[4256]
Li/W	Li	–	~10⁻⁹	77	–	2.94	FE	[363]
Li/W(112)	Li	–	(≤10⁻¹¹)	~300	–	2.94	CPD	[380]
Li(cluster)	–	–	–	–	–	2.95	TC	[3479]
Li/Pt(100)	–	–	–	–	–	2.96	TC	[3168]
Li/Au(100)	–	–	–	–	–	2.96	TC	[3168]
Li/Mo(110)	–	–	–	–	–	2.990	TC	[4046]
Li/Ni(110)	Li	–	≤8 × 10⁻¹¹	~300	–	3.0	CPD	[696]
Li/Si(111)	Li	–	?	~300	–	3.0*	?	[1716]
Li/Re	Li	–	~10⁻⁹	77	–	3.05	FE	[363]
Li/sapphire	Li	–	~10⁻⁹	78	–	3.05	PE	[1512]
Li/W(100)	Li	–	~10⁻⁹	77	–	3.06	FE	[363]
Li	–	–	–	–	–	3.07	TC	[231]
Li/Re(2111)	Li	–	~10⁻⁹	77	–	3.09	FE	[363]
Li/W(100)	Li	–	(<10⁻¹¹)	~300	–	3.1	CPD	[259]
Li/W(110)	Li	–	(<10⁻¹¹)	~300	–	3.1	CPD	[259]
Li/W(110)	Li	–	(<10⁻¹¹)	77	–	3.1	CPD	[259]
Li/Pt	Li	–	~10⁻¹⁰	~300	–	3.1	CPD	[437]
Li	–	–	–	–	–	3.10	TC	[1066]
Li	–	–	–	–	–	3.10	TC	[3467]
Li/W(011)	Li	–	(≤10⁻¹¹)	77	–	3.10	CPD	[2500]
Li/W(011)	Li	–	(≤10⁻¹¹)	77 (250)	–	3.10	CPD	[2500]
Li	–	–	–	–	–	3.11	TC	[521]
Li/W(112)	Li	–	~10⁻⁹	77	–	3.12	FE	[363]
Li/Pt(100)	–	–	–	–	–	3.154	TC	[3245]
Li	–	–	–	–	–	3.18	TC	[231]
Li/W(110)	Li	–	~10⁻⁹	77	–	3.19*	FE	[363]
Li/Mo(112)	–	–	–	–	–	3.2	TC	[468]
Li	–	–	–	–	–	3.21	TC	[1924]
Li_n(n → ∞)[389]	–	–	–	–	–	3.21	TC	[4262]
Li/Re(2112)	Li	–	~10⁻⁹	77	–	3.21*	FE	[363]
Li/Al(111)	Li	–	?	~300	–	3.22	CPD	[734]
Li/Re(2110)	Li	–	~10⁻⁹	77	–	3.24	FE	[363]
Li	–	–	–	–	–	3.24	TC	[4101]
Li	–	–	–	–	–	3.24	TC	[2427]
Li/Ru(0001)	Li	–	?	~300	–	3.3	PE	[4020]
Li	–	–	–	–	–	3.3	TC	[3558]
Li/W(110)	–	–	–	–	–	3.30	TC	[531]
Li	–	–	–	–	–	3.31	TC	[2629]
Li	–	–	–	–	–	3.32	TC	[3312]
Li	–	–	–	–	–	3.32	TC	[1613]
Li	–	–	–	–	–	3.33	TC	[1924]
Li	–	–	–	–	–	3.33	TC	[2061]
Li/Re(1011)	Li	–	~10⁻⁹	77	–	3.33*	FE	[363]
Li/W(100)	–	–	–	–	–	3.34	TC	[531]
Li/W(111)	–	–	–	–	–	3.34	TC	[531]
Li	–	–	–	–	–	3.36	TC	[553,2427]
Li	–	–	–	–	–	3.36	TC	[3477]
Li	–	–	–	–	–	3.36	TC	[3168]
Li	–	–	–	–	–	3.37	TC[3]	[475,519,2474]
Li	–	–	–	–	–	3.39	TC	[3220]
Li/W(112)	–	–	–	–	–	3.40	TC	[531]
Li	–	–	–	–	–	3.43	TC	[230]
Li	–	–	–	–	–	3.44	TC	[3467]
Li	–	–	–	–	–	3.45	TC	[738]
Li/Ru(001)	–	–	–	–	–	3.51	TC	[346]
Li	–	–	–	–	–	3.52	TC	[1571]
Li	–	–	–	–	–	3.53	TC	[1582]
Li	–	–	–	–	–	3.56	TC	[1167]
Li	–	–	–	–	–	3.58	TC	[1578,1582]
Li	–	–	–	–	–	3.60	TC	[1167]
Li	–	–	–	–	–	3.61	TC	[1167]
Li	–	–	–	–	–	3.63	TC	[1167]
Li	–	–	–	–	–	3.75	TC	[2382]
Li/Ru(001)	–	–	–	–	–	3.89	TC	[346]
Li/Pt(110)	–	–	–	–	–	4.004	TC	[3245]
Li	–	–	–	–	–	4.08	TC	[2629]
Recommended	–	–	–	–	–	**2.90 ± 0.03**[469]	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				4. Beryllium Be				
hcp ($\alpha, T < 800$ **K**)								
Be(0001)	–	–	–	–	–	4.7	TC	[3150]
Be(0001)	–	–	–	–	–	4.95	TC	[4427]
Be(0001)/mica[4]	Be	–	~10^{-10}	~300	–	4.98 ± 0.10	PE	[2009]
Be(0001)	–	–	?	77	–	5.0	PE	[2998]
Be(0001)	–	–	–	–	–	5.0 ± 0.1	TC	[3514]
Be(0001)	–	–	–	–	–	5.02 ± 0.05	TC	[3242]
Be(0001)/glass[4]	Be	–	?	~300	–	5.08 ± 0.08	CPD	[1782]
Be(0001)	–	–	–	–	–	5.1 ± 0.1	TC	[3514]
Be(0001)	–	–	<5×10^{-11}	~300	–	5.10 ± 0.02	PE	[2025]
Be(0001)	–	–	–	–	–	5.23	TC	[4417]
Be(0001)	–	–	–	–	–	5.25 ± 0.04	TC	[720]
Be(0001)	–	–	–	–	–	5.29	TC	[4004]
Be(0001)	–	–	–	–	–	5.3	TC	[1711]
Be(0001)	–	–	–	–	–	5.32	TC	[4461][490]
Be(0001)	–	–	–	–	–	5.321	TC	[4460][490]
Be(0001)	–	–	–	–	–	5.35	TC	[1734]
Be(0001)	–	–	–	–	–	5.36	TC	[3481]
Be(0001)	–	–	–	–	–	5.4	TC	[1704]
Be(0001)	–	–	–	–	–	5.45	TC	[4004]
Be(0001)	–	–	–	–	–	5.54	TC	[1925,1927,3200]
Be(0001)	–	–	–	–	–	5.556	TC	[4460][490]
Be(0001)	–	–	–	–	–	5.57	TC	[3481]
Be(0001)	–	–	–	–	–	5.61	TC	[4005]
Be(0001)	–	–	–	–	–	5.62	TC	[334]
Be(0001)	–	–	–	–	–	6.83	TC	[321]
Recommended	–	–	–	–	–	**5.27 ± 0.11**	–	–
Be(1010)	–	–	–	–	–	4.48	TC	[4461][490]
Be(1010)/W(110)	Be	–	<1×10^{-10}	~300	–	4.6	CPD	[3122]
Be(1010)	–	–	–	–	–	4.6 ± 0.1*	TC	[4442]
Be(1010)	–	–	–	–	–	4.644	TC	[4461][490]
Be(1010)	–	–	–	–	–	4.71	TC	[4004]
Be(1011)	–	–	–	–	–	5.03	TC	[4004]
Be(1011)	–	–	–	–	–	5.23	TC	[4004]
Be(1012)	–	–	–	–	–	4.81	TC	[4004]
Be(1012)	–	–	–	–	–	5.04	TC	[4004]
Be(1013)	–	–	–	–	–	4.46	TC	[4004]
Be(1013)	–	–	–	–	–	4.73	TC	[4004]
Be(1121)	–	–	–	–	–	4.58	TC	[4004]
Be(1121)	–	–	–	–	–	4.82	TC	[4004]
Be(1122)	–	–	–	–	–	4.81	TC	[4004]
Be(1122)	–	–	–	–	–	4.94	TC	[4004]
Be(1123)	–	–	–	–	–	4.25	TC	[4004]
Be(1123)	–	–	–	–	–	4.42	TC	[4004]
Be(1124)	–	–	–	–	–	5.72	TC	[321]
Be(2130)	–	–	–	–	–	4.17	TC	[4004]
Be(2130)	–	–	–	–	–	4.38	TC	[4004]
Be(3140)	–	–	–	–	–	4.23	TC	[4004]
Be(3140)	–	–	–	–	–	4.55	TC	[4004]
Be/W	Be	–	~10^{-10}	~300 (1070)	–	2.5	FE	[1784]
Be$_{45}$(cluster)	–	–	–	–	–	2.94	TC	[2657]
Be/W	Be	–	~10^{-7}	~300 (1070)	–	3.0	FE	[1784]
Be	–	–	?	~300	–	3.10	CPD	[2297]
Be	–	–	–	–	–	3.11	TC	[2493]
Be$_{45}$(cluster)	–	–	–	–	–	3.16	TC	[2657]
Be	–	–	–	–	–	3.17	TC	[2493]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Be	–	–	?	?	–	3.17	PE	[3027]
Be(wire)	–	–	$<2 \times 10^{-9}$	~1100–1250	–	3.22 ± 0.08	TE	[2241]
Be/W(111)	Be	–	?	?	–	3.27 ± 0.13	FE	[1803]
Be	–	–	?	293	–	3.28	PE	[3028]
Be	–	–	–	–	–	3.50	TC	[1569]
Be	–	–	–	–	–	3.51	TC	[1571]
Be(block)	–	–	? (Cs)	~900–1600	–	367	TE	[3413]
Be(block)	–	–	~10^{-9}	~900–1200	–	3.67 ± 0.03	TE	[179]
Be	–	–	?	~300	–	3.7	PE	[2090]
Be	–	–	–	–	–	3.75	TC	[521]
Be	–	–	–	–	–	3.8	TC	[1955]
Be	–	–	–	–	–	3.80	TC	[2639]
Be/Al$_2$O$_3$/Al^{390}	Be	–	?	~300	–	3.89	CPD	[3057]
Be/Al$_2$O$_3$/Al^{390}	Be	–	?	~300	–	3.905 ± 0.05	CPD	[3057]
Be	–	–	$<8 \times 10^{-10}$	~300	–	3.92	CPD	[2657,2666,3286]
Be/metal	Be	–	?	~300	–	3.92	PE	[2561]
Be	–	–	–	–	–	3.93	TC	[1569]
Be	–	–	5×10^{-11}	~300	–	3.95	CPD	[3289]
Be/W	Be	–	?	~300 (≤850)	–	4.0 ± 0.1	FE	[1798]
Be	–	–	–	–	–	4.04	TC	[1744]
Be/Al$_2$O$_3$/Al^{390}	Be	–	?	~300	–	4.04 ± 0.06*	CPD	[3057]
Be/W	Be	–	?	~300	–	4.1	CPD	[2577]
Be/W(110)	Be	–	~10^{-10}	~300 (~850)	–	4.1	FE	[2837]
Be$_{33}$(cluster)	–	–	–	–	–	4.11	TC	[2657]
Be	–	–	–	–	–	4.21	TC	[738]
Be/GaAs	Be	–	?	?	–	4.26	?	[3054]
Be	–	–	–	0	–	4.30	TC	[4419]
Be	–	–	–	–	–	4.35	TC	[2629]
Be	–	–	–	–	–	4.39	TC	[1976]
Be/W	Be	–	~10^{-10}	~300 (~850)	–	4.4	FE	[2837]
Be$_{33}$(cluster)	–	–	–	–	–	4.41	TC	[2657]
Be$_{45}$(cluster)	–	–	–	–	–	4.43	TC	[2666,3790]
Be$_\infty$(cluster)	–	–	–	–	–	4.5	TC	[2365]
Be/W	Be	–	≤2×10^{-9}	~300	–	4.53	CPD	[3530]
Be	–	–	–	–	–	4.62	TC	[1613]
Be$_{45}$(cluster)	–	–	–	–	–	4.62	TC	[2666,3790]
Be/W(110)	Be	–	2×10^{-10}	300, 600	–	4.75	CPD	[3550]
Be/Mo(112)	Be	–	~10^{-11}	5{~300}	–	4.77*	CPD	[4450]
Be	–	–	–	–	–	4.79	TC	[1571]
Be	–	–	–	–	–	4.8	TC	[944]
Be/W	Be	–	?	?	–	4.8 ± 0.05	FE	[3937]
Be	–	–	–	–	–	4.80	TC	[1569]
Be/Mo(110)	Be	–	~10^{-11}	~300	–	4.82*	CPD	[4450]
Be/W(100)	Be	–	2×10^{-10}	~300	–	4.86 ± 0.03*	CPD	[3550]
Be/W(100)	Be	–	?	~300	–	4.90	CPD	[3981]
Be	–	–	–	–	–	4.91	TC	[298]
Be	–	–	–	–	–	4.97	TC	[1564]
Be/mica^4	Be	–	~10^{-10}	~300	–	4.98 ± 0.10	PE	[2009]
Be/W	Be	–	$<10^{-8}$	~300	–	~5.0	FE	[2308]
Be/W(112)	Be	–	$<5 \times 10^{-11}$	~300	–	5.00*	CPD	[1700]
Be	–	–	–	–	–	5.04	TC	[1564]
Be$_{19}$(cluster)	–	–	–	–	–	5.04	TC	[2657]
Be/glass^4	Be	–	?	~300	–	5.08 ± 0.08	CPD	[1782]
Be	–	–	–	–	–	5.11	TC	[1569]
Be	–	–	–	–	–	5.11 ± 0.06	TC	[3366]
Be	–	–	–	–	–	5.19	TC	[3729]
Be/W(111)	Be	–	~10^{-10}	~300 (~850)	–	5.3	FE	[2837]
Be$_{19}$(cluster)	–	–	–	–	–	5.35	TC	[2657]
Be	–	–	–	–	–	5.35 ± 0.16	TC	[1577]
Be	–	–	–	–	–	5.37	TC	[2629]
Be	–	–	–	–	–	5.39	TC	[1578,3458]
Be/W(112)	Be	–	1×10^{-10}	~300	–	5.6	CPD	[3117]
Be/W(112)	Be	–	~10^{-10}	~300 (~850)	–	6.0	FE	[2837]
Recommended	–	–	–	–	–	**4.28 ± 0.13**	–	–

Hexagonal (β, $T > 800$ K for bulk)

Be	–	–	?	?	–	3.66	TE	[3410]
Be	–	–	≤10^{-9}	~900–1200	–	3.665 ± 0.03	TE	[650]
Be	–	–	? (Cs)	~1200–1600	–	3.67	TE	[3413]
Be	–	–	≤1×10^{-9}	~900–1250	–	3.67 ± 0.03	TE	[179,3413]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Be/W(100)	Be	–	2×10^{-10}	1200	–	4.56 ± 0.03*	CPD	[3550]
Be/W(100)	Be	–	2×10^{-10}	1170	–	4.59 ± 0.03*	CPD	[3550]
Be/W(110)	Be	–	2×10^{-10}	1000	–	4.65	CPD	[3550]
Be/W(110)	Be	–	2×10^{-10}	800	–	4.69	CPD	[3550]
Be/W(100)	Be	–	2×10^{-10}	1000	–	4.87 ± 0.03*	CPD	[3550]
Recommended	–	–	–	–	–	**4.2 ± 0.5**	–	–

5. Boron B

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
B(mono)[391]	–	–	?	?	–	3.8 ± 0.1	TE	[1415]
B(mono)[391]	–	–	?	~300	–	4.3 ± 0.1	PE	[1415]
B(mono)[391]	–	–	$\sim 10^{-9}$	~300	–	4.30 ± 0.05	PE	[3100]
B(mono)	–	–	$\leq 3 \times 10^{-10}$	~1300–2400	–	4.45	TE	[1397]
B(hexagonal)	–	–	–	–	–	3.64	TC	[1571]
B(graphitic)	–	–	–	–	–	3.88	TC	[1571]
B[479]	–	–	–	–	–	4.09	TC	[4359]
B	–	–	–	–	–	4.10	TC	[1744]
B	–	–	–	–	–	4.11	TC	[4358]
B	–	–	–	–	–	4.16	TC	[4358,4439]
B	–	–	$<2 \times 10^{-6}$	1550–1855	–	4.38	TE	[3431]
B	–	–	–	–	–	4.44	TC	[298]
B/W[392]	–	–	–	–	–	4.5	TC	[913,4344]
B/W[392]	B	–	?	?	–	4.5	FE	[3503]
B/Ta	B_2H_6	–	$<3 \times 10^{-8}$	~300 (1000)	–	4.5 ± 0.1	PE	[1371]
B(nanowire)	–	–	–	–	–	4.52	TC	[4411]
B(graphitic)	–	–	–	–	–	4.66	TC	[1571]
B	–	–	–	–	–	4.77	TC	[1901]
B[479]	–	–	–	–	–	4.89	TC	[4359]
B	–	–	–	–	–	4.9	TC	[1955]
B/W	B	–	2×10^{-10}	?	–	5	FE	[2772]
B/W	B	–	2×10^{-10}	1230	–	5.1	FE	[2376]
B/Mo(110)	B	–	2×10^{-10}	~300 (~900)	–	5.3	CPD	[2698]
B[479]	–	–	–	–	–	5.39	TC	[4359]
B/Mo(110)[252]	B	–	2×10^{-10}	~300	–	5.8	CPD	[2698,2700,3655, 3963,4271]
B/La/Mo(110)[252]	B	–	2×10^{-10}	~300	–	5.8	CPD	[2700]
B/Gd/Mo(110)[252]	B	–	2×10^{-10}	~300	–	5.8	CPD	[2700]
Recommended	–	–	–	–	–	**4.50 ± 0.09**	–	–

6. Carbon C

Diamond (Diamond Structure)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(100)[B5]	–	–	$\sim 10^{-8}$	~300	–	2.9	FE	[2751]
C(100)[B5]	–	–	$\sim 10^{-8}$	~300	–	3.6	FE	[2751]
C(100)[B]	–	–	$<2 \times 10^{-10}$	~300	–	3.85 ± 0.2	CPD	[224]
C(100)[N]	–	–	1×10^{-11}	~300	–	4.7	PE	[1830]
C(100)[B]	–	–	$<2 \times 10^{-10}$	~300 (~1000)	–	4.75 ± 0.2	CPD	[224]
C(100)	–	–	–	–	–	5.04	TC	[3485]
C(100)[B6]	–	–	1×10^{-11}	~300	–	5.3	PE	[1830]
C(100)	–	–	–	–	–	5.5	TC	[2884]
C(100)	–	–	–	–	–	5.54	TC	[2758,2759]
C(100)[B6]	–	–	1×10^{-11}	~300	–	5.7	PE	[1830]
C(100)[B]	–	–	$\sim 10^{-10}$	~300	–	6.00	PE	[1829]
Recommended	–	–	–	–	–	**5.0 ± 0.6**	–	–
C(111)/Mo[7]	–	–	5×10^{-8}	~300	–	3.2	PE	[544,4059]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.2	PE	[1205]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.3	PE	[1205]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.4	FE	[1205]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.5	FE	[1205]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.8	FE	[1205]
C(111)/Mo[8]	–	–	5×10^{-8}	~300	–	3.8	PE	[1205]
C(111)/Mo[7]	–	–	5×10^{-8}	~300	–	4.8	PE	[544,4059]
C(111)[B]	–	–	$\sim 10^{-10}$	~300 (1400)	–	4.85	CPD	[3597,3598]
C(111)[B]	–	–	$\sim 10^{-10}$	~300	–	4.97 ± 0.07	CPD	[1733,1736,3598]
C(111)/Mo[7]	–	–	5×10^{-8}	~300	–	5.1	PE	[544,4059]
C(111)	I_2	I_2^-	5×10^{-10}	723	5.4^N	–	NSI	[3771]
C(111)	–	–	$\sim 10^{-10}$	~300	–	5.5 ± 0.05	PE	[2131]
C(111)[B]	–	–	1×10^{-11}	~300	–	5.6	PE	[1830]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(111)	–	–	$\sim 10^{-8}$	~ 300	–	5.96	PE	[3434]
C(111)	–	–	6×10^{-4}	~ 300	–	6.1	PE	[3434]
C(111)	–	–	–	–	–	7 ± 0.7	TC	[2213]
Recommended	–	–	–	–	–	**5.4 ± 0.5**	–	–
C(112)	–	–	–	–	–	5.17	TC	[1627]

Polycrystalline Diamond or Diamond-like-Carbon

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C/Si(100)	CH_4, N_2	–	1×10^{-7}	500	–	1.5–4.5	FE	[3489]
C/Mo/Si	C	–	$< 10^{-5}$	~ 300 (670)	–	1.51	FE	[1726]
C/Si(100)	CH_4, N_2	–	1×10^{-7}	~ 300	–	1.7–5.4	FE	[3489]
C/W	C^+	–	$< 10^{-10}$	~ 300	–	2	FE	[2904]
C/Si(nw)/Si	CH_4, Ar	–	?	~ 300 (673)	–	2.23	FE	[3305]
C^p/Mo[480]	PH_3, CH_4	–	?	$\sim 700\{\sim 1200\}$	–	2.3	TE	[4371]
C/Si(nw)/Si	CH_4, Ar	–	?	~ 300 (673)	–	3.43	FE	[3305]
C/Si[9]	–	–	$\sim 10^{-9}$	~ 300	–	3.7	FE	[3568]
C/Mo[9]	–	–	$\sim 10^{-9}$	~ 300	–	3.7	FE	[3568]
C/Si	CH_4, H_2	–	$\sim 10^{-6}$	?	–	3.9	TE	[4286]
C/W[10]	–	–	$< 10^{-8}$	~ 300	–	4.1	FE	[2230]
C/Si	CH_4, N_2	–	1×10^{-7}	~ 300	–	4.1 ± 0.1	FE	[3489]
C/Mo,Ta	CH_4, H_2	–	?	~ 300 (~ 2300)	–	4.15 ± 0.05	FE	[2682]
C/cnt	CH_4, H_2	–	$\sim 10^{-6}$	~ 1200–1350	–	4.26	TE	[4286,4287]
C^B/W(100)	CH_4, B_2H_6	–	$\sim 10^{-8}$	1362{1100}	–	4.57	TE	[3015]
C/Mo,Ta	CH_4, H_2	–	?	~ 1500–1700	–	4.75 ± 0.05	TE	[2682]
C/Si(100)	?	–	$\leq 10^{-8}$	~ 300	–	4.9	PE	[2060]
C/Si	C^+	–	4×10^{-9}	~ 300	–	4.9 ± 0.1	CPD	[297]
C/Si	CH_4, H_2	–	?	~ 300 (?)	–	4.98	FE	[3742]
C/Si/Si(111)	CH_4, H_2	–	$\leq 10^{-9}$	~ 300 (~ 900)	–	5.0	FE	[2527]
C/Si	–	–	–	–	–	≥ 5.1	TC	[3299]
C/Si(mono)	CH_4, H_2	–	4×10^{-9}	~ 300 (?)	–	5.19 ± 0.1	PE	[699]
C/Mo	CH_4, H_2	–	$< 10^{-9}$	~ 300 (~ 1200)	–	5.2	FE	[3649]
C/Si(100)[29]	CH_4, H_2	–	$\leq 10^{-10}$	~ 300 (≥ 1200)	–	5.2 ± 0.2	FE	[698]
C/Si(100)[29]	CH_4, H_2	–	$\leq 10^{-10}$	~ 300 (≥ 1200)	–	5.6 ± 0.2	FE	[698,3620]
C/Si(100)[p]	CH_4, H_2	–	$\leq 10^{-10}$	~ 300 (≥ 1200)	–	6 ± 0.3	FE	[2066]
C(natural)	–	–	$\sim 10^{-8}$	~ 300	–	6.02 ± 0.1	PE	[3411]
C/Si(100)	CH_4, H_2	–	$\leq 10^{-10}$	~ 300 (≥ 1200)	–	6.3 ± 0.3	FE	[3620]
C/Si[9]	–	–	$\sim 10^{-9}$	~ 300	–	7.1	FE	[3568]
C/Mo[9]	–	–	$\sim 10^{-9}$	~ 300	–	7.1	FE	[3568]
Recommended	–	–	–	–	–	**4.6 ± 0.6**	–	–

Monocrystalline Graphite[488]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(0001)	–	–	–	–	–	3.6	TC	[1573]
C(0001)	–	–	–	–	–	4.1	TC	[1573]
C(0001)	–	–	–	–	–	4.44	TC	[1174]
C(0001)	–	–	4×10^{-11}	~ 300	–	4.5	PE	[4415]
C(0001)	–	–	–	–	–	4.65 ± 0.20[11]	TC	[1174]
C(0001)	–	–	2×10^{-10}	95	–	4.7	CPD	[525]
C(0001)	–	–	$\sim 10^{-10}$	~ 300	–	4.7 ± 0.1	PE	[236]
C(0001)	–	–	–	–	–	5.23	TC	[1174]
C(0001)	–	–	–	–	–	6.36	TC	[1503]
C(0001)	–	–	–	–	–	6.62	TC	[1503]
C(0001)	–	–	–	–	–	10.1	TC	[1503]
Recommended	–	–	–	–	–	**4.6 ± 0.3**	–	–
C(mono)	–	–	?	?	–	3.93[12]	FE	[2581]
C(mono)	–	–	$\leq 1 \times 10^{-10}$	~ 300	–	4.45	CPD	[286,450,537,665,839]
C(mono)	–	–	2×10^{-10}	~ 300	–	4.6	PE	[289,2653]
C(mono)	–	–	?	~ 300	–	4.60	PE	[1094]
C(mono)	–	–	$\sim 10^{-10}$	~ 300	–	4.7	PE	[235]
C(mono)	–	–	$\sim 10^{-10}$	~ 300 (1800)	–	4.7 ± 0.2	PE	[2508]

Highly Oriented Pyrolytic Graphite (HOPG)[488]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(HOPG)	–	–	$< 10^{-10}$	~ 300	–	4.4	PE	[284,1441]
C(HOPG)	–	–	4×10^{-10}	~ 300	–	4.4	PE	[4001]
C(HOPG)/C	?	–	$\sim 10^{-8}$	~ 2000–2400	–	4.4 ± 0.2	TE	[631]
C(HOPG)	–	–	?	~ 300	–	4.45	PE	[4437]
C(HOPG)	–	–	?	~ 300	–	4.475 ± 0.005	CPD	[287]
C(HOPG)	–	–	?	~ 300	–	4.5	FE	[622]
C(HOPG)	–	–	?	~ 300	–	4.5	PE	[4430]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(HOPG)	–	–	6×10^{-11}	~300	–	4.5 ± 0.1	PE	[632]
C(HOPG)	–	–	1×10^{-10}	~300	–	4.50 ± 0.05	PE	[3666]
C(HOPG)[170]	Cs	Cs^+	$\leq 6 \times 10^{-9}$	~1200–1500	4.51 ± 0.15*	(4.58 ± 0.02)	PSI	[1049]
C(HOPG)	–	–	$\leq 6 \times 10^{-9}$	~1200–1500	(4.65 ± 0.10)	4.58 ± 0.02	TE	[112,524,1049]
C(HOPG)	–	–	1×10^{-9}	~300	–	4.6	PE	[289,2653]
C(HOPG)	–	–	?	90	–	4.6	PE	[1620]
C(HOPG)	–	–	?	~300	–	4.6 ± 0.03	CPD	[4422]
C(HOPG)[170]	Cs	Cs^+	$\leq 6 \times 10^{-9}$	~1200–1500	4.60 ± 0.11*	(4.58 ± 0.02)	PSI	[112,524,1049]
C(HOPG)	Cs	Cs^+	$\leq 6 \times 10^{-9}$	~1200–1500	4.62 ± 0.17*	(4.58 ± 0.02)	PSI	[1049]
C(HOPG)	–	–	4×10^{-11}	~300	–	4.65	PE	[292]
C(HOPG)	–	–	2×10^{-11}	~300	–	4.67	CPD	[4279]
C(HOPG)	Cs	Cs^+	$\leq 6 \times 10^{-9}$	~1200–1500	4.69 ± 0.19*	(4.58 ± 0.02)	PSI	[1049]
C(HOPG)	–	–	?	~300	–	4.7	PE	[293]
C(HOPG)	–	–	$<10^{-9}$	~300	–	4.7	PE	[234,294]
C(HOPG)	–	–	1×10^{-9}	~300	–	4.7	PE	[2784]
C(HOPG)[13]	–	–	$<10^{-10}$	~300	–	4.7	CPD	[3215]
C(HOPG)	–	–	$\sim 10^{-10}$	~300	–	4.7 ± 0.1	PE	[526]
C(HOPG)	–	–	?	~300	–	4.79	PE	[4278]
C(HOPG)	–	–	?	~300	–	4.80	PE	[1166,3061]
C(HOPG)	–	–	–	–	–	4.81	TC	[296]
C(HOPG)	Cs	Cs^+	$\leq 6 \times 10^{-9}$	~1200–1500	4.82 ± 0.14*	(4.58 ± 0.02)	PSI	[1049]
C(HOPG)[13]	–	–	$<10^{-10}$	~300	–	5.0	CPD	[3215]
C(HOPG)	–	–	?	~300	–	5.0	CPD	[1600]
Recommended	–	–	–	–	**4.65 ± 0.12**	**4.66 ± 0.05**	–	–

Graphitic Carbon Film (not Carbidic)[443,452]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C/Co(0001)	–	–	–	–	–	3.32	TC	[2423]
C/Mo	C_2H_2	–	$<10^{-10}$	~300 (558)	–	3.5*	FE	[2674]
C/Ni	C_{60}	C_{60}^-	5×10^{-10}	850–950	$3.5–4.0^N$	–	NSI	[3772,3773,3775]
C/Pt(210)	CO	–	$\sim 10^{-11}$	~300 (850)	–	3.6	FE	[453]
C/W	?	–	?	~300 (?)	–	~3.6	CPD	[3767]
C/Ni(111)	–	–	–	–	–	3.60	TC	[2423]
C/Ru(0001)	–	–	–	–	–	3.7	TC	[542]
C/TaC(111)[393]	C_2H_4	–	$<2 \times 10^{-10}$	~300 (1570)	–	3.7 ± 0.1	PE	[290]
C/Pt	C_2H_2	–	$\sim 10^{-9}$	~300 (1270)	–	3.75 ± 0.15	FE	[539,673]
C/Ni	C_{60}	C_{60}^-	5×10^{-10}	850–950	$3.9–4.4^{*N}$	–	NSI	[3772,3773]
C/Si[14]	–	–	?	~300 (770)	–	4.0 ± 0.15	PE	[1611]
C/Re	C_6H_6	–	2×10^{-9}	~300 (2140)	–	4.1	CPD	[407]
C/Ru(0001)	–	–	–	–	–	4.1	TC	[542]
C/Re–C(5%)	–	–	?	~300 (2200)	–	4.1 ± 0.1*	CPD	[2840]
C/Ru(001)	C_2H_4	–	2×10^{-10}	82 (>800)	–	4.2*	CPD	[455]
C/TaC(111)[393]	C_2H_4	–	$<2 \times 10^{-10}$	~300 (1270)	–	4.2 ± 0.1	PE	[290]
C/Ir	Cs	Cs^+	3×10^{-7}	~1200–1300	4.2 ± 0.1	(4.5 ± 0.1)	PSI	[1290]
C/Si[14]	–	–	?	~300	–	4.2 ± 0.15	PE	[1611]
C/Ni(111)	CO	–	$\sim 10^{-10}$	~300 (~560)	–	4.3	PE	[313]
C/Si[14]	–	–	?	~300	–	4.3 ± 0.1	PE	[1611]
C/Ni	CH_4, H_2	–	?	~300 (953)	–	4.3 ± 0.3	CPD	[1211]
C/Re(1010)	C_6H_6	–	$\sim 10^{-10}$	~1350–1750	(4.30 ± 0.05)	4.30 ± 0.05	TE	[4458]
C/Re(1010)	Na	Na^+	$\sim 10^{-10}$	~1150–1750	4.30 ± 0.05	(4.30 ± 0.05)	PSI	[4458]
C/Ir	CH_4	–	? (CH_4)	~1200–1800	(4.6 ± 0.1)	4.4	TE	[107]
C/Pt	C_2H_2	–	1×10^{-6}	1150–1750	(4.4^N)	4.4	TE	[675]
C/Pt	UF_6	UF_6^-	1×10^{-6}	1000	4.4^N	(4.4)	NSI	[675]
C/Pt–W(8%)	UF_6	UF_6^-	1×10^{-6}	1000	4.4^N	–	NSI	[675]
C/V(100)	–	–	–	–	–	4.4	TC	[1617]
C/graphite	?	–	$\sim 10^{-8}$	~1700–2100	–	4.4 ± 0.2	TE	[631]
C/Re[15]	C_6H_6	–	2×10^{-9}	~300 (<1900)	–	4.4 ± 0.3	CPD	[407,408]
C/Pt[338]	Cs	Cs^+	2×10^{-7}	~1400–2000	4.40 ± 0.03*	–	PSI	[50]
C/Pt–W(8%)[16]	K	K^+	?	1290	4.42	–	PSI	[1299]
C/Ir(111)	K	K^+	$<1 \times 10^{-9}$	~800–2000	4.44	–	PSI	[252]
C/Mo(100)	C_6H_6	–	$<10^{-10}$	~300 (1600)	–	4.45	CPD	[324,527]
C/Re(1010)	C_n, C_6H_6	–	1×10^{-10}	~300 (1600)	–	4.45	CPD	[286,537,665,839]
C/Ir(111)	Na	Na^+	$<5 \times 10^{-10}$	1600	4.45	–	PSI	[410]
C/Ir(111)	K	K^+	$<5 \times 10^{-10}$	1600	4.45	–	PSI	[409,411–413]
C/Ir(111)	C_n, C_6H_6	–	$<5 \times 10^{-10}$	~1600	–	4.45	TE	[3277]
C/Pt(111)	C_6H_6	–	$<10^{-10}$	~300 (1200)	–	4.45	CPD	[527,857,889]
C/Pt–W(8%)[170]	K	K^+	?	950–1100	4.46 ± 0.09	–	PSI	[397]
C/Ir	C_6H_6	–	$\leq 5 \times 10^{-6}$	1650–1900	–	4.47*	TE	[3751]
C/Pt[338]	K	K^+	2×10^{-7}	~1300–2000	4.48 ± 0.01*	–	PSI	[50]
C/Pt–W(8%)[341]	K	K^+	?	950–1100	4.48 ± 0.08	–	PSI	[397]
C/Pt–W(8%)	K	K^+	2×10^{-7}	~1200–1700	4.49 ± 0.01	–	PSI	[1285]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C/Pt[338]	Rb	Rb$^+$	2×10^{-7}	~1200–2000	4.49 ± 0.01*	–	PSI	[50]
C/Pt[338]	K	K$^+$	2×10^{-7}	~1300–2000	4.49 ± 0.01	–	PSI	[1285]
C/Ir(111)	C_6H_6	–	≤8×10^{-9}	? (1700)	(4.5)	4.5	TE	[168]
C/Ir(111)	Ba	Ba$^+$	≤8×10^{-9}	?	4.5	(4.5)	PSI	[168]
C/Ir(111)	In	In$^+$	≤8×10^{-9}	?	4.5	(4.5)	PSI	[168]
C/Ru(0001)	C_2H_2	–	~10^{-11}	~300 (870)	–	4.5	PE	[542]
C/W	?	–	<5×10^{-9}	~300 (?)	–	4.5	FE	[288]
C/Ir(111)	In	In$^+$	≤8×10^{-10}	~1200–1600	4.5 ± 0.1	–	PSI	[105,3292,3546, 3547,3551,3783, 3784]
C/Ir	C_2H_4	–	3×10^{-7}	~1100–1200	(4.2 ± 0.1)	4.5 ± 0.1	TE	[1290]
C/Pt–W(8%)	C_4H_{10}	–	2×10^{-6}	1250–1770	(4.50 ± 0.05)	4.50 ± 0.02	TE	[108]
C/Pt–W(8%)	K	K$^+$	2×10^{-6}	~900–1700	4.50 ± 0.05	(4.50 ± 0.02)	PSI	[108]
C/Pt–W(8%)	Rb	Rb$^+$	?	1230	4.50 ± 0.09*	–	PSI	[737]
C/Pt–W(8%)	K	K$^+$	?	1230	4.51 ± 0.05*	–	PSI	[737]
C/Pt–W(8%)	Na	Na$^+$	≤3×10^{-7}	~1100–2150	4.54	–	PSI	[136]
C/Pt–W(8%)	C_4H_{10}	–	5×10^{-7}	~1500 (1750)	(4.58 ± 0.03)	4.54 ± 0.06	TE	[676]
C/Pt	Cs	Cs$^+$	≤6×10^{-9}	~1400–1600	4.55	–	PSI	[98]
C/Ir(111)	In	In$^+$	≤8×10^{-10}	?	4.55	–	PSI	[105]
C/Pt	C	–	?	~1200–1900	–	4.55	TE	[857]
C/Pt–W(8%)	K	K$^+$	2×10^{-6}	~900–1700	4.55 ± 0.07	(4.63 ± 0.06)	PSI	[108]
C/Pt	C_2H_4	–	4×10^{-9}	~1400–1650	–	4.57	TE	[1295]
C/Pt–W(8%)	Na	Na$^+$	5×10^{-7}	~900–1500	4.58 ± 0.03	(4.54 ± 0.06)	PSI	[676]
C/Ir	K	K$^+$	? (CH$_4$)	~1200–2000	4.6 ± 0.1	(4.4)	PSI	[107]
C/?	C	–	?	?	–	4.6 ± 0.2	?	[2640]
C/Pt–W(8%)	C_4H_{10}	–	2×10^{-6}	1250–1770	(4.55 ± 0.07)	4.63 ± 0.06	TE	[108]
C/quartz	C	–	?	~300	–	4.67 ± 0.12*	PE	[762]
C/Fe–Cu	C_2H_2	–	~10^{-8}	1109 (873)	–	4.7	TE	[764]
C/W	C	–	<3×10^{-10}	77 (~1000)	–	4.7 ± 0.05	FE	[663,4015]
C/Re	C_6H_6	–	~10^{-5}	<1800	–	4.7 ± 0.1	TE	[3753]
C/Rh	CsCl	Cs$^+$	<10^{-8}	~1000–1500	4.7 ± 0.1	–	PSI	[647]
C/Mo[17]	–	–	<10^{-9}	1650–1950	–	4.71 ± 0.18	TE	[791]
C/Mo[17]	–	–	<10^{-9}	1650–1950	–	4.73 ± 0.20	TE	[791]
C/Au(110)	C	–	?	~300 {~500}	–	4.74	CPD	[4404]
C/Au(110)	–	–	–	–	–	4.76	TC	[4404]
C/Al–Mg[18]	C	–	?	~300	–	4.79	PE	[2743]
C/Ir(111)	C	–	7×10^{-9}	1615–1785	(4.8)	4.8	TE	[103]
C/Ir(111)	Cs	Cs$^+$	7×10^{-9}	1685	4.8	(4.8)	PSI	[103]
C/Ir(111)	In	In$^+$	7×10^{-9}	1685	4.8	(4.8)	PSI	[103]
C/W	C_4H_{10}	–	?	1470–1810	–	4.8	TE	[237,295]
C/Re[415]	Cs	Cs$^+$	<10^{-8}	~700~1800	4.94*	–	PSI	[3753]
C/Ni	CH$_4$, H$_2$	–	?	~300 (~1300)	–	5	FE	[2802]
C/Si	CH$_4$, H$_2$	–	?	~300 (~1300)	–	5	FE	[2802]
C/Ir(111)	C	–	?	~300	–	5	CPD	[3858]
C/Fe(110)	C_2H_2	–	1×10^{-10}	~300 (550)	–	5.0	PE	[1541]
C/Mo	C	–	~10^{-8}	~300	–	5.0 ± 0.1	CPD	[299,2958]
C/Ag/Mo	C	–	~10^{-8}	~300	–	5.0 ± 0.1	CPD	[299]
C/Si	–	–	~10^{-10}	~300	–	5.0 ± 0.1	PE	[1738]
C/Si(100)[p]	C	–	≤10^{-10}	~300	–	5.0 ± 0.2	PE	[2066]
C/Pt(111)	CH$_4$, H$_2$	–	~10^{-10}	~300 (~600)	–	5.1	CPD	[3650]
C/Si(mono)	?	–	4×10^{-9}	~300 (?)	–	5.19 ± 0.1	PE	[699]
C/Al–Mg[18]	C	–	?	~300	–	5.32	PE	[2743]
C/Pt(111)	C_6H_6, etc.	–	?	~300 (~500)	–	5.4*	CPD	[1425]
C/Ni(100)	CO	–	<5×10^{-10}	~300 (~450)	–	5.7	CPD	[1790]
C/Re	UF$_4$	U$^+$	<1×10^{-8}	~2400–2700	5.84 ± 0.16	–	PSI	[276]
C/Fe(100)[427]	–	–	–	–	–	6.3*	TC	[4026]
Recommended	–	–	–	–	**4.50 ± 0.04**	**4.47 ± 0.05**	–	–
Recommended	–	–	–	–	**4.4 ± 0.1[N]**	–	–	–
Polycrystalline Graphite[488]								
C(filament)	–	–	<10^{-6}	?	–	3.41	TE	[2919]
C	–	–	–	–	–	3.54	TC	[1796]
C(tip)/W	–	–	5×10^{-9}	~300 (3655)	–	3.8	FE	[3607]
C(filament)	–	–	?	?	–	3.94	TE	[2456]
C(filament)	–	–	?	?	–	4.1	TE	[2459]
C(filament)	–	–	<5×10^{-8}	?	–	4.1	TE	[1482]
C	–	–	? (Ba)	~1100–1400	–	4.30	TE	[1773]
C(filament)	–	–	?	~1700–2200	–	4.34	TE	[115]
C(filament)	–	–	<10^{-5}	~1350–2100	–	4.35 ± 0.06	TE	[114]
C	–	–	~10^{-8}	~300	–	4.38 ± 0.01	PE	[760]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(rod)	–	–	?	0^E	–	4.39	TE	[113]
C	–	–	?	~1500 (~2800)	–	4.4	TE	[761]
C	–	–	?	?	–	4.4	TE	[3402]
C	–	–	?	?	–	4.4	TE	[3599]
C(ribbon)	–	–	3×10^{-7}	~1500–2200	(4.45 ± 0.08)	4.40 ± 0.02	TE	[71]
C(vitreous)	–	–	~10^{-10}	~300	–	4.42	CPD	[1516]
C(filament)	–	–	<10^{-6}	≤1610	–	4.44	TE	[285]
C(ribbon)	In	In$^+$	3×10^{-7}	1660–2310	4.44 ± 0.08	(4.40 ± 0.02)	PSI	[71]
C(ribbon)	K	K$^+$	3×10^{-7}	~1500–2000	4.46 ± 0.02	(4.40 ± 0.02)	PSI	[71]
C	–	–	?	?	–	4.5	TE	[2360]
C(filament)	–	–	?	?	–	4.55	TE	[2457]
C(rod)	–	–	?	~1300–2200	–	4.56	TE	[113]
C(filament)	–	–	?	≤2335	–	4.59	TE	[285]
C	–	–	2×10^{-9}	~300	–	4.6	PE	[1165,3225]
C(disk)	–	–	?	~300	–	4.6	CPD	[4175]
C[393]	–	–	<2×10^{-10}	~300	–	4.6 ± 0.1	PE	[290]
C(ribbon)	N$_2^+$	CN$^-$	<1×10^{-10}	1070–1290	4.6 ± 0.2^N	–	NSI	[617]
C(filament)	–	–	?	≤2125	–	4.61	TE	[285]
C(chamber)	–	–	?	0^E	–	4.62	TE	[1460]
C(chamber)	–	–	<10^{-5}	~1500–1650	–	4.62 ± 0.02	TE	[633,2303]
C	–	–	2×10^{-9}	~300	–	4.65 ± 0.05	PE	[291]
C	–	–	–	–	–	4.7	TC	[765]
C	–	–	<10^{-9}	~300	–	4.7	PE	[1894]
C	–	–	?	~300	–	4.72	PE	[2080]
C(vitreous)	–	–	~10^{-6}–10^{-8}	~300	–	4.75	PE	[1894]
C(tip)	–	–	1.8×10^{-7}	~300	–	4.8 ± 0.3	FE	[4445]
C	–	–	<10^{-6}	~300	–	4.81	PE	[2919]
C/SnO$_2$	–	–	?	~300	–	4.81	PE	[4453]
C	–	–	–	–	–	4.81[19]	TC	[296]
C	–	–	?	?	–	4.83	TE	[2569]
C	–	–	?	?	–	4.84	TE	[1462]
C(rod, etc.)	–	–	?	?	–	4.85 ± 0.05	TE, etc.	[238]
C(colloidal)/glass	–	–	<10^{-9}	~300	–	4.85 ± 0.08	CPD	[766]
C	–	–	–	–	–	4.91	TC	[767]
C	–	–	–	–	–	5.0	TC	[298]
C	–	–	?	~300	–	5.0	CPD	[3994]
C	–	–	–	–	–	5.23[19]	TC	[296]
C	–	–	–	~300	–	5.8, 5.85[20]	PE	[1735]
Recommended	–	–	–	–	**4.45 ± 0.05**	**4.63 ± 0.06**	–	–
Recommended	–	–	–	–	**4.6 ± 0.2^N**	–	–	–
Graphene[401,462,468,471,483,489]								
C/Pd(111)	–	–	–	–	–	4.03–4.738	TC	[4308]
C/Ni	C$_2$H$_2$	–	<2×10^{-8}	~300 (1113)	–	4.15 ± 0.05	CPD	[4438]
C/Cu	CH$_4$, H$_2$	–	5×10^{-10}	~300 (~1220)	–	4.25 ± 0.10	PE	[4243,4245]
C	–	–	–	–	–	4.26	TC	[4126]
C/Pd(111)	CH$_4$, Ar	–	?	~300 (~1200)	–	4.3 ± 0.1	CPD	[4282]
C/SiC(0001)	–	–	–	–	–	4.33	TC	[4409]
C	–	–	–	–	–	4.38	TC	[4079]
C/SiO$_2$/Si	–	–	?	~300	–	4.4	PE	[4376]
C/Pd(111)	CH$_4$, Ar	–	<1×10^{-10}	~300 (~1200)	–	4.42–4.49	CPD	[4308]
C	–	–	–	–	–	4.43	TC	[4451]
C(zigzag)	–	–	–	–	–	4.46	TC	[4360]
C[455]	–	–	–	–	–	4.48	TC	[3240]
C	–	–	–	–	–	4.48[468]	TC	[4174,4284]
C	–	–	–	–	–	4.60	CT	[4359]
C[439]	–	–	–	–	–	4.5	TC	[4105]
C/Cu	–	–	?	~300	–	4.5	CPD	[4103]
C	–	–	–	–	–	4.50	TC	[4127]
C	–	–	–	–	–	4.53	TC	[1168]
C/SiC	–	–	?	~300 (?)	–	4.55 ± 0.02	CPD	[4443]
C/SiO$_2$/Si	–	–	?	~300	–	4.56 ± 0.04	PE	[4129]
C/SiO$_2$/Si[442]	–	–	?	~300	–	4.57 ± 0.05	CPD	[4128]
C	–	–	–	–	–	4.58	TC	[4426]
C	–	–	–	–	–	4.60	CT	[4359]
C/HfO$_2$/Si	–	–	5×10^{-10}	~300	–	4.62 ± 0.08	PE	[4285]
C/Cu–Ni[417]	C$_2$H$_2$, etc	–	?	~300{~1500}	–	4.63–4.79	CPD	[3996]
C(sheet)	–	–	–	–	–	4.66	TC	[891]
C/Cu[417]	?	–	?	~300 (?)	–	4.67–4.78	CPD	[3996]
C(sheet)	–	–	–	–	–	4.68	TC	[2557]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C/SiO$_2$/Si[442]	–	–	?	~300	–	4.69 ± 0.05	CPD	[4128]
C/Re(1010)	Na	Na$^+$	~10^{-10}	?	4.7 ± 0.05	–	PSI	[4458]
C	–	–	–	–	–	4.73[21]	TC	[767]
C/?	–	–	?	~1200	–	4.74 ± 0.04	TE	[4283]
C/Cu(111)	–	–	–	–	–	4.77	TC	[4402]
C	–	–	–	–	–	4.80	TC	[1743]
C/SiO$_x$//Si(100)[418]	?	–	?	~300 (?)	–	4.81 ± 0.06	CPD	[3997]
C	–	–	–	–	–	4.84[21]	TC	[767]
C/Cu[418]	CH$_4$	–	?	~300{1308}	–	4.92 ± 0.06	CPD	[3997]
C/Ir(111)	–	–	–	–	–	4.96	TC	[4219]
C(isolated)	–	–	–	–	–	5.11	TC	[4409]
C(ribbon)	–	–	–	–	–	6.30	TC	[3008]
Recommended	–	–	–	–	–	**4.67 ± 0.11**	–	–
Carbon Fullerene[433,454]								
C$_{60}$(111)/GeS(001)[394]	C$_{60}$	–	2 × 10^{-10}	~300{450}	–	4.7	PE	[457]
C$_{60}$(111)/GeS(001)[394]	C$_{60}$	–	2 × 10^{-10}	~300{450}	–	4.74 ± 0.03	PE	[543]
C$_{60}$(111)/GeS(001)[394]	C$_{60}$	–	2 × 10^{-10}	~300{450}	–	4.83 ± 0.05	PE	[543]
C$_{60}$/Ag[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.46	CPD	[2198]
C$_{60}$/Au[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.47	CPD	[2198]
C$_{60}$/Au(111)	C$_{60}$	–	?	~300	–	4.53	CPD	[4449]
C$_{60}$/Cu[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.59	CPD	[2198]
C$_{60}$/Ag[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.60	CPD	[2198]
C$_{60}$/Au[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.62	CPD	[2198]
C$_{60}$/Ag(111)	C$_{60}$	–	1 × 10^{-10}	~300 (520)	–	4.63 ± 0.10	PE	[1195]
C$_{60}$/Au(111)	C$_{60}$	–	1 × 10^{-10}	~300 (570)	–	4.7	PE	[1070]
C$_{60}$/Al	C$_{60}$	–	~10^{-10}	~300	–	4.7 ± 0.1	PE	[1220]
C$_{60}$/Au/Si^n	C$_{60}$	–	?	~300	–	4.70 ± 0.01	CPD	[3228]
C$_{60}$/Cu[395]	C$_{60}$	–	≤1 × 10^{-10}	~300	–	4.72	CPD	[2198]
C$_{60}$/Rh(111)	C$_{60}$	–	1 × 10^{-10}	~300	–	4.80 ± 0.03	PE	[568,2282]
C$_{60}$/Au(110)[396]	C$_{60}$	–	?	?	–	4.82 ± 0.05	?	[3002,3006]
C$_{60}$/Cu(111)[22]	–	–	–	–	–	4.85*	TC	[233]
C$_{60}$/Cu	C$_{60}$	–	?	~300	–	4.85 ± 0.05	PE	[3178]
C$_{60}$/Cu(111)[396]	C$_{60}$	–	<2 × 10^{-10}	~300 (570)	–	4.86	PE	[316]
C$_{60}$/Au(110)	C$_{60}$	–	?	~300 (700)	–	4.9	CPD	[1144]
C$_{60}$/Cu(111)	C$_{60}$	–	4 × 10^{-11}	~300	–	4.9	PE	[4415]
C$_{60}$/Ag(110)	C$_{60}$	–	?	~300 (700)	–	4.92	CPD	[1144]
C$_{60}$/Ni(111)	C$_{60}$	–	<2 × 10^{-10}	~300 (570)	–	4.93	PE	[316]
C$_{60}$/Au(111)[22]	–	–	–	–	–	4.94	TC	[233]
C$_{60}$/Ag(111)[22]	–	–	–	–	–	4.96	TC	[233]
C$_{60}$/Au(111)[22]	–	–	–	–	–	4.96	TC	[233]
C$_{60}$/Ag(111)[22]	–	–	–	–	–	4.99	TC	[233]
C$_{60}$/W	C$_{60}$	–	≤10^{-9}	~300	–	5	FE	[3717]
C$_{60}$/Cr/C(HOPG)	C$_{60}$	–	1 × 10^{-10}	~300	–	5.0	PE	[2794]
C$_{60}$/Rh(111)[23,396]	C$_{60}$	–	6 × 10^{-11}	~300 (≤700)	–	5.05	CPD	[1007]
C$_{60}$/Cu(100)	C$_{60}$	–	?	~300	–	5.06	CPD	[4449]
C$_{60}$/Cu(111)	–	–	–	–	–	5.15	TC	[3486]
C$_{60}$/Al(111)[396]	C$_{60}$	–	~10^{-10}	~300{620}	–	5.15 ± 0.05	PE	[458,2681,2683]
C$_{60}$/Ag(111)	C$_{60}$	–	?	~300	–	5.19	CPD	[4449]
C$_{60}$/Al(110)[396]	C$_{60}$	–	~10^{-10}	~300{620}	–	5.25 ± 0.05	PE	[458,2681,2683]
C$_{60}$/Ta(110)[396]	C$_{60}$	–	?	~300	–	5.4	PE	[460]
C$_{60}$/Ni(110)	C$_{60}$	–	8 × 10^{-11}	~300{650}	–	5.61	CPD	[459,696]
C$_{60}$/Pt(111)[397]	C$_{60}$	–	4 × 10^{-11}	100 (900)	–	5.7	PE	[697]
C$_{60}$	–	–	–	–	–	5.74	TC	[3486]
C$_{60}$ (fine cryst.)	C$_{60}$	–	?	~300	–	6.5	PE	[1166,3061]
C$_{60}$/W	C$_{60}$	–	<1 × 10^{-10}	298, 370	–	11.7 ± 0.5	FE	[2520]
Recommended	–	–	–	–	–	**4.87 ± 0.06**	–	–
Single-Walled Carbon Nanotube[28,402,481]								
C(zigzag)	–	–	–	–	–	3.07–5.25	TC	[1743]
C(chiral)	–	–	–	–	–	3.47–4.92	TC	[1743]
C(armchair)	–	–	–	–	–	3.67–5.01	TC	[1743]
C/Si(100)	CH$_4$,H$_2$	–	≤10^{-10}	~300{1200}	–	3.7 ± 0.3	FE	[1171]
C/Ag/Ti/Cr/Si	–	–	<2 × 10^{-7}	~300 (?)	–	4.21	FE	[2201]
C(quartz)	–	–	?	~300 (~1200)	–	4.31	PE	[2446]
C(open ended)	–	–	–	–	–	4.47	TC	[1740]
C/Ni/W	C$_2$H$_2$	–	<5 × 10^{-8}	~300{870}	–	4.5	FE	[2288]
C(armchair)[455]	–	–	–	–	–	4.5	TC	[3240]
C[24]	–	–	–	–	–	4.5 ± 0.1	TC	[1168]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C(chiral)[455]	–	–	–	–	–	4.5–5.5	TC	[3240]
C(zigzag)[455]	–	–	–	–	–	4.5–5.9	TC	[3240]
C/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.62 ± 0.06	PE	[3246]
C	–	–	–	–	–	4.64	TC	[1877]
C($d \geq 1$ nm)	–	–	–	–	–	4.69 ± 0.01	TC	[1169]
C(flake)	–	–	8×10^{-10}	~300	–	4.7	PE	[3229]
C/SiO$_2$	? (CVD)	–	1×10^{-10}	$\sim300\{1200\}$	–	4.7	PE	[3233]
C($d \rightarrow \infty$)[21]	–	–	–	–	–	4.73	TC	[767]
C/Si	? (CVD)	–	?	$\sim300\{\sim1200\}$	–	4.73	PE	[1172]
C	–	–	–	–	–	4.73	TC	[4446]
C(metallic)	–	–	–	–	–	4.73 ± 0.03	TC	[767]
C/W	–	–	$<3 \times 10^{-9}$	$\sim300\ (\sim1300)$	–	4.76	FE	[546]
C(capped)	–	–	–	–	–	4.78	TC	[1740]
C/ITO	–	–	$<10^{-10}$	~300	–	4.8	PE	[284]
C/GaAs	–	–	2×10^{-9}	~300 (?)	–	4.8	PE	[291,1165]
C/W	–	–	?	~300	–	4.8	FE	[3572]
C/SiO$_2$/Si	? (CVD)	–	1×10^{-7}	~1800–2100	–	4.8 ± 0.1	TE	[2555]
C/glass	–	–	?	~300	–	4.83	PE	[3795]
C($d \rightarrow \infty$)[21]	–	–	–	–	–	4.84	TC	[767]
C(mouth)[27]	–	–	–	–	–	4.86	TC	[3570]
C/ITO	–	–	?	~300	–	4.86	PE	[3795]
C/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.86 ± 0.10	CPD	[3246]
C/W	–	–	$<3 \times 10^{-9}$	$\sim300\ (\sim1300)$	–	4.88	FE	[546]
C	–	–	–	–	–	4.89	TC	[3787]
C/Si(111)[26]	–	–	$\sim10^{-10}$	~300	–	4.94 ± 0.07	CPD	[3246]
C(mouth)[27]	–	–	–	–	–	4.95	TC	[3570]
C/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.97 ± 0.07	CPD	[3246]
C/Si(111)[26]	–	–	$\sim10^{-10}$	~300	–	5.01 ± 0.17	CPD	[3246]
C(bundle)	–	–	–	–	–	5.02 ± 0.05	TC	[767]
C/?	–	–	?	~300	–	5.05	PE	[1166,3061]
C(capped)	–	–	–	–	–	5.05	TC	[2918,3682]
C (5,5)[28]	–	–	–	–	–	5.08	TC	[3570]
C(rope)/Pt	–	–	5×10^{-9}	~300	–	5.1	FE	[547]
C/?	–	–	?	~300	–	5.10	PE	[3061]
C/ITO	–	–	? (air)	~300	–	5.19	PE	[3795]
C(bundle)	–	–	–	–	–	5.2–5.4	TC	[3239]
C(neighbor)[27]	–	–	–	–	–	5.20	TC	[3570]
C/glass	–	–	? (air)	~300	–	5.24	PE	[3795]
C(neighbor)[27]	–	–	–	–	–	5.25	TC	[3570]
C(bundle)	–	–	–	–	–	5.3	TC	[3239]
C(armchair)	–	–	–	–	–	5.46 ± 0.02	TC	[548]
C(zigzag)	–	–	–	–	–	5.60 ± 0.03	TC	[548]
Recommended	–	–	–	–	–	**4.78 ± 0.06**	–	–
Multi-Walled Carbon Nanotube[402,481]								
C(yarn)[470]	–	–	?	~2000–2100	–	3.9	TE	[4307]
C(yarn)[470]	–	–	?	~2100–2200	–	4.1	TE	[4307]
C/glass	–	–	?	~300	–	4.18 ± 0.09	PE	[4003]
C/?	?	–	$\sim10^{-6}$	~300	–	4.2	FE	[1724]
C(pentagon)/Ta[30]	–	–	5×10^{-10}	~300	–	4.2–4.3	FE	[3942]
C/ITO	–	–	$<10^{-10}$	$\sim300\ (\sim470)$	–	4.3	PE	[284,1441]
C/W	? (CVD)	–	1×10^{-9}	$\sim300\{?\}$	–	4.3 ± 0.1	FE	[2546]
C/Si[31]	? (CVD)	–	8×10^{-10}	$\sim300\{\sim570\}$	–	4.4	PE	[3223,3225]
C	–	–	–	–	–	4.51–5.23	TC	[3240]
C(armchair)	–	–	–	–	–	4.53–4.54	TC	[3240]
C(zigzag)	–	–	–	–	–	4.53–4.99	TC	[3240]
C/Si[31]	? (CVD)	–	8×10^{-10}	$\sim300\ (\sim570)$	–	4.6	PE	[3223]
C/W	? (CVD)	–	1×10^{-9}	~600–1400	–	4.6 ± 0.7	TE	[2546]
C(yarn)	–	–	4×10^{-8}	1500–2200	–	4.60 ± 0.04	TE	[1092,4306]
C(powder)	–	–	?	~300	–	4.61 ± 0.03	PE	[4003]
C/W	? (CVD)	–	$\sim10^{-7}$	~300	–	4.61 ± 0.09	CPD	[1208]
C($r > 1$ nm)	–	–	–	–	–	4.63 ± 0.02	TC	[1169]
C/?[32]	?	–	?	~300	–	4.7 ± 0.1	FE	[545]
C/W	? (CVD)	–	1×10^{-9}	~300–720	–	4.7 ± 0.4	FE	[2546]
C/SiO$_2$/Si	? (CVD)	–	1×10^{-7}	~1800–2100	–	4.85 ± 0.03	TE	[2555]
C/Si(100)	CH$_4$, H$_2$	–	$\leq10^{-10}$	$\sim300\ (\sim1200)$	–	4.85 ± 0.2	PE	[1171]
C/Si(100)^p	CH$_4$, H$_2$	–	$\leq10^{-10}$	$\sim300\ (\geq1220)$	–	4.9	FE	[2066]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
C/?	–	–	?	~300	–	4.95	PE	[1166,3061]
C/Si(100)[403]	CH$_4$, H$_2$	–	<10^{-9}	~300{~1200}	–	~5	FE	[3649]
C/Si(100)	CH$_4$, H$_2$	–	≤10^{-10}	~300{~1200}	–	5 ± 0.3	FE	[1171]
C/W	?	–	2 × 10^{-10}	770 (970)	–	5.0	FE	[1840]
C/SiO$_2$	? (CVD)	–	2 × 10^{-10}	~300{1000}	–	5.1 ± 0.2	FE	[1837,3601]
C/Si(100)[403]	CH$_4$, H$_2$	–	~10^{-8}	~300{~1200}	–	5.3 ± 0.2	FE	[698,2425,3943]
C/epoxy	–	–	~10^{-6}	~300	–	5.4	FE	[1728]
C/SiO$_2$	? (CVD)	–	~10^{-10}	~300 (?)	–	5.4	FE	[3601]
C/?[32]	?	–	?	~300 (?)	–	5.6	FE	[545]
C/?[33]	?	–	?	~300	–	5.7	PE	[1735]
C/?[33]	?	–	?	~300	–	5.75	PE	[1735]
C/W[34]	–	–	≤2 × 10^{-11}	~300 (1000)	–	7.3 ± 0.7	FE	[1170]
Recommended	–	–	–	–	–	**4.63 ± 0.04**	–	–
Conical Carbon Nanotube[467]								
C/graphite	CH$_4$, H$_2$	–	~10^{-7}	~1300–1400	–	4.1–4.7	TE	[4280,4286]
C/Pt	CH$_4$, H$_2$	–	~10^{-7}	~1400–1500	–	4.2	TE	[4280,4286]
C/Pt	CH$_4$, H$_2$	–	~10^{-8}	~300 (?)	–	4.5	PE	[4280,4286]

11. Sodium Na

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na(100)	–	–	–	–	–	2.355	TC	[2947]
Na(100)	–	–	–	–	–	2.38	TC	[1254]
Na(100)	–	–	–	–	–	2.40	TC	[1159,3067]
Na(100)	–	–	–	–	–	2.45	TC	[1556]
Na(100)	–	–	–	–	–	2.58	TC	[231]
Na(100)	–	–	–	–	–	2.60	TC	[3467]
Na(100)	–	–	–	–	–	2.638	TC	[4091]
Na(100)	–	–	–	–	–	2.65	TC	[2427]
Na(100)	–	–	–	–	–	2.66	TC	[553]
Na(100)	–	–	–	–	–	2.66	TC	[3477]
Na(100)	–	–	–	–	–	2.69	TC	[4222]
Na(100)	–	–	–	–	–	2.7	TC	[2851]
Na(100)	–	–	–	–	–	2.7	TC	[763]
Na(100)	–	–	–	–	–	2.71	TC	[1408]
Na(100)	–	–	–	–	–	2.75	TC	[475]
Na(100)	–	–	–	–	–	2.76	TC	[334]
Na(100)	–	–	–	–	–	2.77	TC	[711]
Na(100)	–	–	–	–	–	2.80	TC	[1557]
Na(100)	–	–	–	–	–	2.80	TC	[721]
Na(100)	–	–	–	–	–	2.83	TC	[3477]
Na(100)	–	–	–	–	–	2.83	TC	[1553]
Na(100)	–	–	–	–	–	2.84	TC	[556]
Na(100)	–	–	–	–	–	2.86	TC	[473]
Na(100)	–	–	–	–	–	2.88	TC	[555]
Na(100)	–	–	–	–	–	2.88	TC	[1030]
Na(100)	–	–	–	–	–	2.89	TC	[3814]
Na(100)	–	–	–	–	–	2.9	TC	[1088]
Na(100)[43]	–	–	–	–	–	2.9	TC	[2222]
Na(100)	–	–	–	–	–	2.93	TC	[476]
Na(100)	–	–	–	–	–	2.94	TC	[711]
Na(100)	–	–	–	–	–	2.95	TC	[321]
Na(100)	–	–	–	–	–	3.0	TC	[1088]
Na(100)	–	–	–	–	–	3.03	TC	[554]
Na(100)	–	–	–	–	–	3.04	TC	[476]
Na(100)	–	–	–	–	–	3.07	TC	[1030]
Na(100)	–	–	–	–	–	3.08	TC	[472]
Na(100)	–	–	–	–	–	3.27	TC	[1095]
Recommended	–	–	–	–	–	**2.80 ± 0.04**	–	–
Na(110)	–	–	–	–	–	2.01	TC	[3379]
Na(110)	–	–	–	–	–	2.18	TC	[3379]
Na(110)	–	–	–	–	–	2.25	TC	[3379]
Na(110)	–	–	–	–	–	2.464	TC	[2947]
Na(110)	–	–	–	–	–	2.52	TC	[1159,3067]
Na(110)	–	–	–	–	–	2.59	TC	[2685]
Na(110)	–	–	–	–	–	2.7	TC	[1556]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na(110)	–	–	–	–	–	2.75	TC	[231]
Na(110)	–	–	–	–	–	2.76	TC	[3467]
Na(110)	–	–	–	–	–	2.839	TC	[4069]
Na(110)	–	–	–	–	–	2.839	TC	[4091]
Na(110)	–	–	–	–	–	2.85	TC	[2427]
Na(110)	–	–	–	–	–	2.86	TC	[4222]
Na(110)	–	–	–	–	–	2.87	TC	[3477]
Na(110)	–	–	–	–	–	2.87	TC	[2835]
Na(110)	–	–	–	–	–	2.88	TC	[553]
Na(110)	–	–	–	–	–	2.9	TC	[3137]
Na(110)	–	–	–	–	–	2.9	TC	[2851]
Na(110)	–	–	–	–	–	2.9	TC	[1086]
Na(110)/Ni(100)[35]	Na	–	$\sim 10^{-11}$	173	–	2.90 ± 0.10	CPD	[1417]
Na(110)	–	–	–	–	–	2.91	TC	[711]
Na(110)	–	–	–	–	–	2.93	TC	[1086]
Na(110)	–	–	–	–	–	2.93	TC	[2835]
Na(110)	–	–	–	–	–	2.94	TC	[334]
Na(110)	–	–	–	–	–	2.94	TC	[1921]
Na(110)	–	–	–	–	–	3.0	TC	[1734]
Na(110)	–	–	–	–	–	3.00	TC	[473]
Na(110)	–	–	–	–	–	3.00	TC	[3477]
Na(110)	–	–	–	–	–	3.00	TC	[721]
Na(110)	–	–	–	–	–	3.04	TC	[3814]
Na(110)	–	–	–	–	–	3.06	TC	[476,711]
Na(110)	–	–	–	–	–	3.06	TC	[1086]
Na(110)	–	–	–	–	–	3.08	TC	[1030]
Na(110)	–	–	–	–	–	3.1	TC	[763]
Na(110)	–	–	–	–	–	3.1	TC	[1088]
Na(110)	–	–	–	–	–	3.1	TC	[2395]
Na(110)	–	–	–	–	–	3.10	TC	[475]
Na(110)	–	–	–	–	–	3.11	TC	[555]
Na(110)	–	–	–	–	–	3.11	TC	[2402]
Na(110)	–	–	–	–	–	3.13	TC	[556]
Na(110)	–	–	–	–	–	3.15	TC	[593]
Na(110)	–	–	–	–	–	3.16	TC	[476]
Na(110)	–	–	–	–	–	3.22	TC	[3379]
Na(110)	–	–	–	–	–	3.22	TC	[3712]
Na(110)	–	–	–	–	–	3.22	TC	[472,554]
Na(110)	–	–	–	–	–	3.3	TC	[1088]
Na(110)	–	–	–	–	–	3.3	TC	[1086]
Na(110)	–	–	–	–	–	3.32	TC	[1086]
Na(110)	–	–	–	–	–	3.33	TC	[1030,1089]
Na(110)	–	–	–	–	–	3.36	TC	[1087]
Na(110)	–	–	–	–	–	3.39	TC	[1086]
Na(110)	–	–	–	–	–	3.40	TC	[1089]
Na(110)	–	–	–	–	–	3.43	TC	[3713]
Na(110)	–	–	–	–	–	3.44	TC	[3713]
Na(110)	–	–	–	–	–	3.44	TC	[321]
Na(110)	–	–	–	–	–	3.44	TC	[3693]
Na(110)	–	–	–	–	–	3.46	TC	[3693]
Na(110)	–	–	–	–	–	3.49	TC	[1089]
Na(110)	–	–	–	–	–	3.61	TC	[3692]
Na(110)	–	–	–	–	–	3.62	TC	[1095]
Na(110)	–	–	–	–	–	3.64	TC	[3692]
Na(110)	–	–	–	–	–	5.93	TC	[3622]
Recommended	–	–	–	–	–	**$\underline{3.05 \pm 0.04}$**	–	–
Na(111)	–	–	–	–	–	2.26	TC	[3477]
Na(111)	–	–	–	–	–	2.39	TC	[1159,3067]
Na(111)	–	–	–	–	–	2.48	TC	[3477]
Na(111)	–	–	–	–	–	2.54	TC	[231]
Na(111)	–	–	–	–	–	2.56	TC	[711]
Na(111)	–	–	–	–	–	2.57	TC	[3467]
Na(111)	–	–	–	–	–	2.585	TC	[4091]
Na(111)	–	–	–	–	–	2.59	TC	[553]
Na(111)	–	–	–	–	–	2.6	TC	[2851]
Na(111)	–	–	–	–	–	2.60	TC	[1557]
Na(111)	–	–	–	–	–	2.63	TC	[4222]
Na(111)	–	–	–	–	–	2.65	TC	[475]
Na(111)	–	–	–	–	–	2.7	TC	[1088]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na(111)	–	–	–	–	–	2.70	TC	[593]
Na(111)	–	–	–	–	–	2.71	TC	[473]
Na(111)	–	–	–	–	–	2.72	TC	[3814]
Na(111)	–	–	–	–	–	2.73	TC	[476,711]
Na(111)	–	–	–	–	–	2.75	TC	[1553]
Na(111)	–	–	–	–	–	2.75	TC	[1030]
Na(111)	–	–	–	–	–	2.76	TC	[555]
Na(111)	–	–	–	–	–	2.76	TC	[556]
Na(111)	–	–	–	–	–	2.79	TC	[721]
Na(111)	–	–	–	–	–	2.79	TC	[1030]
Na(111)	–	–	–	–	–	2.8	TC	[1088]
Na(111)	–	–	–	–	–	2.82	TC	[472,554]
Na(111)	–	–	–	–	–	2.83	TC	[321]
Na(111)	–	–	–	–	–	2.85	TC	[476]
Na(111)	–	–	–	–	–	3.17	TC	[1095]
Recommended	–	–	–	–	–	**2.68 ± 0.06**	–	–
Na(112)	–	–	–	–	–	3.14	TC	[321]
Na	–	–	–	–	–	1.55	TC	[2704]
Na	–	–	?	~300	–	1.60	CPD	[2297]
Na/Si(100)	Na	–	1×10^{-10}	~300	–	1.7*	CPD	[3294]
Na/Si(100)	Na	–	2×10^{-10}	~300	–	1.7*	PE	[1727]
Na/Si(100)	Na	–	$\sim 10^{-11}$	~300	–	1.7*	PE	[2277]
Na/Si(100)	Na	–	$< 6 \times 10^{-11}$	~300	–	1.7*	CPD	[2433]
Na	–	–	–	~300	–	1.8	TC	[3737]
Na	–	–	–	–	–	1.82	TC	[2456]
Na/Rh(111)	–	–	–	–	–	1.869	TC	[4008]
Na/Si(100)	Na	–	1×10^{-10}	~300	–	1.9*	CPD	[3294]
Na/Si(100)	–	–	–	–	–	1.9*	TC	[2413]
Na/?	Na	–	?	~300	–	1.9 ± 0.1	PE	[3258]
Na/?	Na	–	?	~300	–	1.95 ± 0.02	PE	[3258]
Na/?	Na	–	?	~300	–	1.97 ± 0.03	PE	[3260]
Na/Rh(111)	–	–	–	–	–	1.987	TC	[4008]
Na/TiO$_2$(110)	Na	–	5×10^{-11}	~300	–	2.0	PE	[2787]
NaTiO$_2$/(110)	–	–	–	–	–	2.0*	TC	[3833]
Na/Cs	–	–	–	–	–	2.0*	TC	[3984]
Na/Si(100)	–	–	–	–	–	2.0*	TC	[2406]
Na/W(100)	Na	–	?	~300	–	2.0	PE	[1697]
Na/?	Na	–	?	~300	–	2.01 ± 0.03	PE	[3260]
Na/W	Na	–	?	~300	–	2.04*	CPD	[1459]
Na	–	–	–	–	–	2.05	TC	[1150]
Na/Si(100)	Na	–	1×10^{-10}	~300 (450)	–	2.06*	CPD	[3294]
Na/Ge(100)	Na	–	$< 1 \times 10^{-10}$	~300	–	2.1*	CPD	[2753]
Na/Si(111)	–	–	–	–	–	2.1	TC	[2731]
Na/Pt	Na	–	?	~300	–	2.1	PE	[2206]
Na	–	–	–	–	–	2.11	TC	[1951]
Na/W	Na	–	?	380	–	2.11 ± 0.05	FE	[3062]
Na/W	Na	–	?	80	–	2.14*	CPD	[3746]
Na	–	–	–	–	–	2.15	TC	[3725]
Na/Ge(001)	–	–	–	–	–	2.168	TC	[3499]
Na/Ag(100)	Na	–	1×10^{-10}	150	–	2.2	PE	[2038]
Na/Si(100)	Na	–	1×10^{-10}	293	–	2.2*	PE	[2184]
Na/W	Na	–	?	~300	–	2.2	FE	[3062]
Na/Ru(0001)	Na	–	6×10^{-11}	50	–	2.2*	CPD	[2188]
Na/TiO$_2$(110)	Na	–	8×10^{-11}	~300	–	2.2	PE	[3188]
Na/Ge(111)	Na	–	$\sim 10^{-10}$	~300	–	2.2	CPD	[2948]
Na/W	Na	–	$\sim 10^{-6}$	~300	–	2.25	PE	[3934]
Na/?	Na	–	?	~300	–	2.26	CPD	[2808]
Na/Si(100)	Na	–	1×10^{-10}	~300 (450)	–	2.26	CPD	[3294]
Na/W(111)	Na	–	(<10^{-10})	77	–	2.26	FE	[2323]
Na/metal	Na	–	$\leq 10^{-7}$	~300	–	2.27	PE	[1765]
Na/glass	Na	–	$\leq 3 \times 10^{-11}$	195	–	2.27 ± 0.01	PE	[2615]
Na/glass	Na	–	$\sim 2 \times 10^{-8}$	~300	–	2.28	PE	[2564]
Na/Ni	Na	–	$< 10^{-9}$	77	–	2.28	CPD	[2139,3128,3698]
Na/Ge(111)	Na$^+$	–	1×10^{-10}	~300	–	2.28	CPD	[3423]
Na	–	–	–	–	–	2.28	TC	[3637]
Na/quartz	Na	–	$\sim 10^{-10}$	~300	–	2.28 ± 0.08	PE	[1999]
Na/Si(111)	Na$^+$	–	1×10^{-10}	~300	–	2.29	CPD	[3423]
Na/glass	Na	–	?	~300	–	2.29	PE	[2561]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na/Ru(0001)	Na	–	3×10^{-10}	~300	–	2.29	CPD	[1824]
Na/Ge(111)	Na	–	?	~300	–	2.3	CPD	[2812,2813]
Na/Ge(111)	Na	–	2×10^{-10}	~300	–	2.3*	PE	[3648]
Na/W(112)	Na	–	$(<10^{-10})$	77	–	2.3	FE	[2323]
Na/quartz	Na	–	$\sim10^{-10}$	90	–	2.3	PE	[2605]
Na/Si(111)	–	–	–	–	–	2.3*	TC	[3962]
Na/Si(100)	Na	–	?	295	–	2.3	PE	[2174]
Na/Rh(100)	Na	–	?	~300	–	2.3	PE	[2158]
Na/Si(111)	Na	–	$<1 \times 10^{-11}$	~300	–	2.3*	CPD	[3484]
Na/Y	Na	–	2×10^{-10}	~300	–	2.3 ± 0.1	PE	[1813]
Na/Sc	Na	–	2×10^{-10}	~300	–	2.3 ± 0.1	PE	[1813]
Na/?	Na	–	?	~300	–	2.3 ± 0.1	PE	[3258]
Na/Cu, Ag	Na	–	5×10^{-9}	~300	–	2.3 ± 0.1	PE	[3081]
$Na_n(n \to \infty)$	–	–	?	~300	–	2.30	IP	[4200]
Na	–	–	–	–	–	2.30	TC	[3728]
Na	–	–	–	–	–	2.30	TC	[1744]
Na/glass	Na	–	$\leq10^{-7}$	~300	–	2.30	PE	[1765]
Na/W(100)	Na	–	$(<10^{-10})$	77	–	2.32	FE	[2323]
Na/?	Na	–	?	77	–	2.33 ± 0.05	PE	[2945]
Na/glass	Na	–	$\leq3 \times 10^{-11}$	195	–	2.34 ± 0.01	PE	[2615]
Na	–	–	–	–	–	2.35	TC	[1458]
Na/Ge(001)	–	–	–	–	–	2.353	TC	[3499,3500]
Na	–	–	–	–	–	2.36	TC	[3352]
Na/Re(1122)	Na	–	$<2 \times 10^{-9}$	~300	–	2.36	FE	[811]
Na/Mo	Na	–	$\sim10^{-10}$	293	–	2.36 ± 0.02	PE[36]	[3336,3337]
Na/quartz	Na	–	?	~300	–	2.36 ± 0.02	PE	[1988]
Na/glass	Na	–	$\leq3 \times 10^{-11}$	77	–	2.37 ± 0.01	PE	[2615]
Na	–	–	$\sim10^{-9}$	298	–	2.38 ± 0.02	PE	[2612,2613,4208]
Na	–	–	$\sim10^{-9}$	370	–	2.39 ± 0.02	PE	[4241,4314]
Na/Ni(110)	Na	–	?	>360	–	2.4*	PE	[2665]
Na/Si(111)	Na	–	$<4 \times 10^{-11}$	~300	–	2.4*	CPD	[2894]
Na/W(110)	Na	–	$\sim10^{-10}$	~300	–	2.4	PE	[2775,3768,3769]
Na/Si(111)	Na	–	4×10^{-11}	~300	–	2.4*	CPD	[3471]
Na	–	–	–	–	–	2.4*	TC	[1955]
Na/Mg(0001)	–	–	–	–	–	2.4*	TC	[2438]
Na/Cu(110)	Na	–	5×10^{-11}	140	–	2.4 ± 0.1	PE	[3454]
Na/Al/glass	Na	–	$<10^{-8}$	~300	–	2.40	PE	[1457]
Na/Mo	Na	–	4×10^{-10}	80	–	2.40 ± 0.03	PE[37]	[3336]
Na	–	–	$\sim10^{-9}$	183	–	2.41	PE	[2612,2613]
Na/Mo	Na	–	$\sim10^{-10}$	80 (293)	–	2.41	PE	[3337]
Na/graphene	–	–	–	–	–	2.42	TC	[4079]
Na/Re	Na	–	$<2 \times 10^{-9}$	~300	–	2.45	FE	[811]
Na/W(110)	Na	–	$(<10^{-12})$	~300	–	2.45	CPD	[1084]
Na/Cu(100)	Na	–	$\leq1 \times 10^{-10}$	180	–	2.45	PE	[2678]
Na/Si(111)	Na	–	$<6 \times 10^{-11}$	~300	–	2.45*	CPD	[2433]
Na/Mo	Na	–	4×10^{-10}	80 (293)	–	2.45 ± 0.04	PE[36]	[3336]
Na/Mo	Na	–	4×10^{-10}	80	–	2.45 ± 0.05	PE[37]	[3336]
Na/Si(111)	Na	–	$<5 \times 10^{-10}$	~300	–	2.46	PE	[2795]
Na/quartz	Na	–	?	~300	–	2.46	PE	[4300]
Na/Ta(110)	Na+	–	$\sim10^{-10}$	~300	–	2.46	CPD	[506]
Na/Ge(100)	Na	–	$<1 \times 10^{-10}$	77–120	–	2.46*	FE	[1550,3170]
Na/Ge(100)	–	–	–	–	–	2.46*	TC	[4042]
Na/?	Na	–	?	?	–	2.46	?	[3785]
Na/Al(100)	–	–	–	–	–	2.46 ± 0.10	TC	[1036]
Na/Ge(001)	–	–	–	–	–	2.475	TC	[3499]
Na/Al(111)	–	–	–	–	–	2.48	TC	[1594]
Na/Ge(111)	Na	–	$<1 \times 10^{-10}$	77–120	–	2.48*	FE	[1550,3170]
Na(fp, $r \to \infty$)[460]	–	–	?	~300	–	2.48*	IP	[4198]
Na(fp, $r \to \infty$)[460]	–	–	?	~300	–	2.49*	IP	[4198]
Na/TiO₂(441)	Na	–	5×10^{-11}	~300	–	2.5	PE	[2787]
Na/Ge(111)	Na	–	$<2 \times 10^{-10}$	100	–	2.5*	PE	[2421]
Na/Si(111)	Na	–	$<1 \times 10^{-10}$	130	–	2.5	PE	[1839]
Na/Si(100)	Na	–	1×10^{-10}	100	–	2.5*	PE	[2184]
Na/Si(100)	–	–	–	–	–	2.5*	TC	[2406]
Na/W(112)	Na	–	$<5 \times 10^{-11}$	~300	–	2.5	CPD	[1666]
Na	–	–	–	–	–	2.5	TC	[2845]
Na/W(112)	Na	–	$(\leq10^{-11})$	77	–	2.5	CPD	[2611]
Na/W(100)	–	–	–	–	–	2.5	TC	[1443]
Na/Li/Cu(100)	Na	–	$\leq1 \times 10^{-10}$	180	–	2.5	PE	[2678]
Na/Al(100)	–	–	–	–	–	2.51 ± 0.10	TC	[1576]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na(fp, $r \to \infty$)	–	–	?	~300	–	2.52 ± 0.04	IP	[2383,4148]
Na/Si(mono)	Na	–	5×10^{-10}	~300	–	2.53*	AI[38]	[1103]
Na/Re(1112)	Na	–	$<2 \times 10^{-9}$	~300	–	2.54	FE	[811]
Na/Ru(0001)	Na	–	?	~300	–	2.54	PE	[4020]
Na	–	–	–	–	–	2.55	TC	[1066]
Na/Al(111)	Na	–	?	~100 (150)	–	2.55	CPD	[2654]
Na/W(111)	Na	–	$<2 \times 10^{-9}$	~300	–	2.55	FE	[811]
Na(nanowire)[453]	–	–	–	–	–	2.55 ± 0.05*	TC	[4178]
Na$_n$($n \to \infty$)[40]	–	–	–	–	–	2.56	TC	[2171]
Na/W(110)	Na	–	$(<10^{-10})$	77	–	2.57	FE	[2323]
Na/Cu(111)	Na	–	5×10^{-11}	~300	–	2.57	PE	[969]
Na/W(110)	Na	–	$(<10^{-12})$	77	–	2.58	CPD	[1084]
Na/W(110)	Na	–	$(<10^{-12})$	77{300}	–	2.58	CPD	[1084]
Na	–	–	–	–	–	2.58	TC	[478]
Na/Cu(110)	Na	–	$<5 \times 10^{-10}$	~300	–	2.58	PE	[3182]
Na/Co(0001)	Na	–	5×10^{-11}	~300	–	2.58 ± 0.03	PE	[1926]
Na	–	–	–	–	–	2.59	TC	[3312]
Na/Mo	Na	–	5×10^{-10}	~300	–	2.59	AI	[4027]
Na	–	–	–	–	–	2.59	TC	[4031]
Na/Si(111)	Na	–	?	~300	–	2.6*	CPD	[1585]
Na/Ru(001)	Na$^+$	–	?	~300	–	2.6*	CPD	[2391]
Na/Ni(110)	Na	–	?	~100	–	2.6*	PE	[2665]
Na/Al(111)	Na	–	$~10^{-10}$	~300	–	2.6	CPD	[2833]
Na/Al(111)	–	–	–	–	–	2.6	TC	[2223]
Na/Ni(111)	Na	–	$<5 \times 10^{-10}$	~300	–	2.6	PE	[2183]
Na/Cu(110)	Na	–	$<5 \times 10^{-10}$	~300	–	2.6	PE	[2183]
Na/Cu(111)	Na	–	$<5 \times 10^{-10}$	~300	–	2.6	PE	[2183]
Na/W(112)	Na	–	$(\leq 10^{-11})$	300, 400	–	2.6	CPD	[2611]
Na/W	Na	–	$<2 \times 10^{-9}$	~300	–	2.6	FE	[811]
Na/Ni(100)	Na	–	8×10^{-11}	~300	–	2.6*	CPD	[3807]
Na/W(112)	Na	–	$<2 \times 10^{-9}$	~300	–	2.6	FE	[811]
Na/Cu(110)	Na	–	$<3 \times 10^{-10}$	~300 (370)	–	2.6*	PE	[2529]
Na	–	–	–	–	–	2.60	TC	[3312]
Na	–	–	–	–	–	2.61	TC	[298]
Na/Al	Na	–	5×10^{-10}	~300	–	2.61*	AI[38]	[1103]
Na	–	–	–	–	–	2.62	TC	[3467]
Na	–	–	–	–	–	2.62	TC	[4150]
Na/Cs/Pt[38]	Na	–	4×10^{-10}	20	–	2.62	AI[38]	[3496]
Na	–	–	–	–	–	2.63	TC	[2382]
Na	–	–	–	–	–	2.63	TC	[4031]
Na/Ni(111)	Na	–	$~10^{-11}$	~300	–	2.64*	PE	[3185]
Na/Cu(111)	Na	–	$~10^{-11}$	~300	–	2.64*	PE	[3185]
Na/Pt	Na	–	5×10^{-10}	~300	–	2.65	AI	[4027]
Na$_n$(fp)	–	–	?	423	–	2.65	PE	[4256]
Na/Cu(111)	Na	–	$~10^{-11}$	~300	–	2.66*	PE	[3183]
Na/Mg	Na	–	5×10^{-10}	~300	–	2.67*	AI[38]	[1103]
Na/graphite	–	–	–	–	–	2.67*	TC	[1843]
Na/W(110)	Na	–	$<2 \times 10^{-9}$	~300	–	2.68	FE	[811]
Na$_n$($n \to \infty$)[40]	–	–	?	110 ± 20	–	2.68	PE	[2171]
Na/Fe(110)	Na	–	5×10^{-11}	~300	–	2.69 ± 0.03	PE	[1926]
Na	–	–	–	–	–	2.7	TC	[2439]
Na/W	Na	–	~430 (Na)	~1900	–	2.7	TE	[1443]
Na/C(HOPG)	Na	–	?	40	–	2.7*	PE	[1618]
Na/Cu(111)[227]	Na	–	1×10^{-10}	~300	–	2.7*	CPD	[2495,2496]
Na/Ni(100)	Na	–	1×10^{-11}	~300	–	2.7*	CPD	[1413]
Na/Ni(100)	Na	–	$~10^{-10}$	~300	–	2.7*	CPD	[1992]
Na/Ni(110)	Na	–	$~10^{-10}$	~300	–	2.7*	CPD	[1992]
Na/Ni(100)	–	–	–	–	–	2.7	TC	[509]
Na/Al(100)	Na	–	$~10^{-10}$	~300	–	2.7*	CPD	[2833]
Na/Si(100)	Na	–	?	100	–	2.7	PE	[2174]
Na/Cu(100)	Na	–	?	~300	–	2.7	PE	[3451]
Na/Ru(001)	Na	–	?	~300	–	2.7*	CPD	[2984]
Na/Ni(111)	Na	–	$<3 \times 10^{-10}$	~300	–	2.7*	PE	[2177]
Na/Cu(111)	Na	–	$<3 \times 10^{-10}$	~300	–	2.7*	PE	[2177]
Na/Si(100)	Na	–	?	70	–	2.7	PE	[2178]
Na/Cu(110)	Na	–	?	?	–	2.7*	?	[3702]
Na/W(110)	Na	–	$<2 \times 10^{-11}$	~300	–	2.7	CPD	[2658]
Na/Al[38]	Na	–	?	~300	–	2.70*	AI	[3789]
Na$_n$($n \to \infty$)	–	–	?	~300	–	2.71	IP, TC	[4197]
Na/Cu(111)	–	–	–	–	–	2.73	TC	[1246]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na$_n$(n → ∞)	–	–	–	–	–	2.75	TC	[4193]
Na(r → ∞)[41]	–	–	–	–	–	2.75	TC	[2860]
Na/quartz	Na	–	~10^{-11}	77	–	2.75	PE	[3424]
Na	–	–	–	–	–	2.75	TC	[477]
Na/C(0001)	Na	–	2×10^{-10}	95	–	2.75	CPD	[525]
Na/Re(1120)	Na	–	<2×10^{-9}	~300	–	2.75	FE	[811]
Na(fp)[42]	–	–	?	?	–	2.75 ± 0.05	PE	[3482]
Na/Y	Na	–	?	~300	–	2.75 ± 0.1	PE	[1691]
Na/W(100)	Na	–	<2×10^{-9}	~300	–	2.76	FE	[811]
Na/Mo(112)	Na	–	(≤10^{-11})	77	–	2.76	CPD	[2030]
Na/graphite	–	–	–	–	–	2.77*	TC	[1843]
Na	–	–	–	–	–	2.77	TC	[3208]
Na/Cu(111)	Na	–	~5×10^{-11}	~300	–	2.77 ± 0.03	PE	[1922,1926]
Na	–	–	–	–	–	2.78	TC	[3477]
Na(cluster)	–	–	–	–	–	2.78	TC	[3479]
Na	–	–	–	–	–	2.78	TC	[1901]
Na/Cr[38]	Na	–	5×10^{-10}	~300	–	2.79	AI[38]	[1103,4027]
Na/Al(100)	Na	–	1×10^{-10}	100	–	2.8	CPD	[2875]
Na/Al(111)[43]	–	–	–	–	–	2.8	TC	[2222]
Na/Si(100)	–	–	–	–	–	2.8*	TC	[2406]
Na/Al(111)	Na	–	~10^{-11}	100 (240)	–	2.8*	CPD	[3296]
Na	–	–	–	–	–	2.8	TC	[706]
Na/Ti	Na	–	?	~300	–	2.8 ± 0.1	PE	[1691]
Na/Al[38]	Na	–	?	~300	–	2.80*	AI	[3789]
Na$_n$(n → ∞)[44]	–	–	~10^{-6}	~300	–	2.81	IP	[2053]
Na	–	–	–	–	–	2.81	TC	[231]
Na/Cu	Na	–	5×10^{-10}	~300	–	2.81	AI	[4027]
Na	–	–	–	–	–	2.83	TC	[231]
Na	–	–	–	–	–	2.84	TC	[2493]
Na	–	–	–	–	–	2.84	TC	[3467]
Na/Al(111)	Na	–	?	140, ~300	–	2.85	CPD	[734]
Na	–	–	–	–	–	2.85	TC	[738]
Na/Au(100)	Na	–	~10^{-11}	130, ~300	–	2.87	CPD	[2746]
Na	–	–	–	–	–	2.88	TC	[477]
Na/Pt(100)	–	–	–	–	–	2.88	TC	[3168]
Na/Au(100)	–	–	–	–	–	2.88	TC	[3168]
Na$_n$(n → ∞)	–	–	–	–	–	2.89	TC	[4254]
Na/Ni(111)	–	–	–	–	–	2.9*	TC	[2177]
Na/NbC(111)	Na	–	~1×10^{-10}	~300	–	2.9	PE	[2799]
Na/Al(100)	–	–	–	–	–	2.9	TC	[3149]
Na/Al(111)	Na	–	~5×10^{-10}	~300	–	2.9*	CPD	[2748]
Na/Ni(111)	Na	–	~10^{-10}	~300	–	2.9*	CPD	[1992]
Na/Al(001)	–	–	–	–	–	2.9	TC	[1711]
Na/metal	–	–	–	–	–	2.9	TC	[2195]
Na/Cu(111)	Na	–	<1×10^{-10}	~300	–	2.9*	CPD	[3295]
Na	–	–	–	–	–	2.90	TC	[477]
Na$_n$(n → ∞)	–	–	?	~300	–	2.90	TC	[4197]
Na	–	–	–	–	–	2.91	TC	[2061]
Na	–	–	–	–	–	2.91	TC	[1924,4035,4036]
Na	–	–	–	–	–	2.91	TC	[477]
Na	–	–	–	–	–	2.92	TC	[477]
Na	–	–	–	–	–	2.92	TC	[2427]
Na	–	–	–	–	–	2.92	TC	[1924,3208,4035]
Na	–	–	–	–	–	2.93	TC	[1613]
Na	–	–	–	–	–	2.93	TC	[4101]
Na/Re(1011)	Na	–	<2×10^{-9}	~300	–	2.93	FE	[811]
Na	–	–	–	–	–	2.93	TC	[521]
Na	–	–	–	–	–	2.93	TC	[3628]
Na	–	–	–	–	–	2.93	TC	[4431]
Na	–	–	–	–	–	2.94	TC	[3477]
Na	–	–	–	–	–	2.94	TC	[553,2427]
Na	–	–	–	186	–	2.949	TC	[2419]
Na	–	–	–	–	–	2.97	TC	[2493]
Na	–	–	–	–	–	2.98	TC	[2629]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na	–	–	–	0	–	2.983	TC	[2419]
Na/Al(111)	–	–	–	–	–	3.02	TC	[1594]
Na	–	–	–	–	–	3.06	TC[3]	[475,519,2474]
Na	–	–	–	–	–	3.06	TC	[3168]
Na/C(100)	–	–	–	–	–	3.1*	TC	[2759]
Na/Si(111)	Na	–	<4 × 10⁻¹¹	~300	–	3.1*	CPD	[3947]
Na	–	–	–	–	–	3.1	TC	[944]
Na/Al(111)	–	–	–	–	–	3.11	TC	[3158]
Na	–	–	–	–	–	3.16	TC	[1578]
Na	–	–	–	–	–	3.17	TC	[230]
Na/C(HOPG)	Na	–	?	90	–	3.2	PE	[1618]
Na/ZrC(100)	Na	–	?	~300	–	3.4	PE	[2798]
Na/quartz	Na	–	?	~300	–	3.45 ± 0.04	PE	[1988]
Na/Ta(110)	–	–	–	–	–	3.51	TC	[2538]
Recommended	–	–	–	–	–	**2.54 ± 0.03**	–	–

Liquid (*T* > 371 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Na	–	–	~10⁻⁸	371	–	2.38	PE	[4208]
Na	–	–	~10⁻⁹	372	–	2.39	PE	[4241]
Na	–	–	–	371	–	2.924	TC	[2419]

12. Magnesium Mg

hcp

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mg(0001)	–	–	–	–	–	3.0	TC	[3137]
Mg(0001)	–	–	–	–	–	3.2	TC	[1215]
Mg(0001)	–	–	–	–	–	3.3	TC	[1215]
Mg(0001)	–	–	–	–	–	3.4	TC	[1215]
Mg(0001)	–	–	–	–	–	3.44	TC	[231]
Mg(0001)	–	–	–	–	–	3.58	TC	[3467]
Mg(0001)[45]	–	–	5 × 10⁻¹¹	100–150	–	3.65	CPD	[3174]
Mg(0001)	–	–	–	–	–	3.65	TC	[1179]
Mg(0001)	–	–	–	–	–	3.66	TC	[3004]
Mg(0001)	–	–	–	–	–	3.69	TC	[2427]
Mg(0001)	–	–	–	–	–	3.69	TC	[1699]
Mg(0001)	–	–	–	–	–	3.69	TC	[1028]
Mg(0001)	–	–	–	–	–	3.7	TC	[1704,1711]
Mg(0001)	–	–	–	–	–	3.705	TC	[4460][490]
Mg(0001)	–	–	–	–	–	3.71	TC	[4417]
Mg(0001)	–	–	–	–	–	3.71	TC	[553]
Mg(0001)	–	–	–	–	–	3.718 ± 0.009	TC	[2556]
Mg(0001)	–	–	–	–	–	3.72	TC	[3234]
Mg(0001)	–	–	–	–	–	3.72	TC	[343]
Mg(0001)	–	–	–	–	–	3.72	TC	[4326]
Mg(0001)	–	–	–	–	–	3.74	TC	[4215]
Mg(0001)[46]	–	–	–	–	–	3.75 ± 0.05*	TC	[2552]
Mg(0001)	–	–	–	–	–	3.76	TC	[3481]
Mg(0001)	–	–	–	–	–	3.76	TC	[4004]
Mg(0001)	–	–	–	–	–	3.80	TC	[1179]
Mg(0001)	–	–	–	–	–	3.83	TC	[1028,1179]
Mg(0001)	–	–	1 × 10⁻¹⁰	~300	–	3.84 ± 0.02	PE	[2135]
Mg(0001)	–	–	–	–	–	3.86	TC	[334]
Mg(0001)	–	–	–	–	–	3.87	TC	[4005]
Mg(0001)	–	–	–	–	–	3.88	TC	[3481]
Mg(0001)	–	–	–	–	–	3.88	TC	[1030,1089]
Mg(0001)	–	–	–	–	–	3.89	TC	[4004]
Mg(0001)	–	–	–	–	–	3.9	TC	[2851]
Mg(0001)	–	–	–	–	–	4.0	TC	[2851]
Mg(0001)	–	–	–	–	–	4.0	TC	[2400]
Mg(0001)	–	–	–	–	–	4.00	TC	[1089]
Mg(0001)	–	–	–	–	–	4.01	TC	[1030]
Mg(0001)	–	–	–	–	–	4.05	TC	[475]
Mg(0001)	–	–	–	–	–	4.06	TC	[3004]
Mg(0001)	–	–	–	–	–	4.10	TC	[593]
Mg(0001)	–	–	–	–	–	4.18	TC	[556]
Mg(0001)	–	–	–	–	–	4.2	TC	[1088]
Mg(0001)	–	–	–	–	–	4.20	TC	[1089]
Mg(0001)	–	–	–	–	–	4.38	TC	[1087]
Recommended	–	–	–	–	–	**3.79 ± 0.07**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mg(1010)	–	–	–	–	–	3.39	TC	[4461][490]
Mg(1010)	–	–	–	–	–	3.64	TC	[4004]
Mg(1010)	–	–	–	–	–	3.652	TC	[4460][490]
Mg(1010)	–	–	–	–	–	3.76	TC	[4004]
Mg(1010)	–	–	–	–	–	3.79	TC	[4005]
Mg(0111)	–	–	–	–	–	3.70	TC	[4004]
Mg(0111)	–	–	–	–	–	3.88	TC	[4004]
Mg(0112)	–	–	–	–	–	3.63	TC	[4004]
Mg(0112)	–	–	–	–	–	3.74	TC	[4004]
Mg(0113)	–	–	–	–	–	3.58	TC	[4004]
Mg(0113)	–	–	–	–	–	3.66	TC	[4004]
Mg(1121)	–	–	–	–	–	3.56	TC	[4004]
Mg(1121)	–	–	–	–	–	3.68	TC	[4004]
Mg(1122)	–	–	–	–	–	3.67	TC	[4004]
Mg(1122)	–	–	–	–	–	3.80	TC	[4004]
Mg(1123)	–	–	–	–	–	3.53	TC	[4004]
Mg(1123)	–	–	–	–	–	3.68	TC	[4004]
Mg(2130)	–	–	–	–	–	3.49	TC	[4004]
Mg(2130)	–	–	–	–	–	3.72	TC	[4004]
Mg(3140)	–	–	–	–	–	3.48	TC	[4004]
Mg(3140)	–	–	–	–	–	3.68	TC	[4004]
Mg/glass	–	–	?	~300	–	>2.4	PE	[4010]
Mg	–	–	–	–	–	2.7	TC	[2456]
Mg	–	–	?	~300	–	<3.0	PE	[2295]
Mg	–	–	–	–	–	3.1	TC	[1955]
Mg/ins/Al[47]	Mg	–	?	~300	–	3.10 ± 0.09	CPD	[2028]
Mg	–	–	–	–	–	3.15	TC	[1744]
Mg/SiO₂/Si	Mg	–	?	~300 (570)	–	3.19	PE	[2355]
Mg	–	–	~7 × 10⁻⁹	~300	–	3.25	PE	[2001]
Mg	–	–	–	–	–	3.33	TC	[521]
Mg	–	–	–	–	–	3.34	TC	[231]
Mg	–	–	–	0	–	3.34	TC	[4419]
Mg/SiO₂/Si(100)	Mg	–	?	~300	–	3.45[48]	PE	[1442]
Mg	–	–	–	–	–	3.46	TC	[1924]
Mg	–	–	–	–	–	3.48	TC	[3467]
Mg	–	–	–	–	–	3.5	TC	[944]
Mg	–	–	1 × 10⁻⁵	~300	–	3.53	CPD	[1883]
Mg	–	–	–	–	–	3.54	TC	[231]
Mg	–	–	–	–	–	3.54	TC	[2427]
Mg	–	–	?	~300	–	3.55	CPD	[1883]
Mg[240]	–	–	?	~300	–	3.58*	CPD	[1367]
Mg	–	–	?	~300	–	3.58	CPD	[2297]
Mg	–	–	–	–	–	3.58	TC	[3467]
Mg/Al₂O₃/Si(100)	Mg	–	?	~300	–	3.6[48]	PE	[1442]
Mg/Mo(112)	Mg	–	?	?	–	3.6	CPD	[2404,2407]
Mg	–	–	?	~300	–	3.60*	CPD	[3621]
Mg/Mo	Mg	–	?	~300	–	3.60 ± 0.02	PE	[1635]
Mg/Ta	Mg	–	?	~300	–	3.60 ± 0.02	PE	[1635]
Mg/glass	Mg	–	?	~300	–	3.60 ± 0.02	PE	[1635]
Mg/glass[49]	Mg	–	?	~300	–	3.61 ± 0.03	CPD	[1368]
Mg/?	Mg	–	?	~300	–	3.63	PE	[1639]
Mg	–	–	–	–	–	3.65	TC	[2704]
Mg/glass[50]	Mg	–	?	~300	–	3.65 ± 0.05	CPD	[1368]
Mg	–	–	–	–	–	3.66	TC[3]	[475,2474]
Mg/quartz[51]	Mg	–	1 × 10⁻⁶	~300	–	3.66	PE	[1968,1973]
Mg	–	–	–	–	–	3.66	TC	[2629]
Mg	–	–	–	–	–	3.66	TC	[4418]
Mg/TiO₂(100)	Mg	–	?	~300	–	3.66	PE	[1612]
Mg/glass	Mg	–	?	~300	–	3.67 ± 0.02	PE	[1640]
Mg/glass	Mg	–	?	~300	–	3.68	PE	[2561]
Mg	–	–	<3 × 10⁻¹¹	~300	–	3.68 ± 0.15	AI	[4055]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mg/glass[88]	Mg	–	$<10^{-9}$	~300{77}	–	3.7	CPD	[1526]
Mg/Mo(112)	Mg	–	?	~300	–	3.7	CPD	[2409]
Mg	–	–	–	–	–	3.7	TC	[1993]
Mg	–	–	–	–	–	3.70	TC	[1066]
Mg	–	–	–	–	–	3.70	TC	[738]
Mg	–	–	5×10^{-10}	~300	–	3.72	PE	[594]
Mg/Cr	Mg	–	5×10^{-10}	~300	–	3.72	AI[38]	[1103]
Mg	–	–	–	–	–	3.75	TC	[3729]
Mg	–	–	–	–	–	3.75	TC	[1613]
Mg/W[244]	Mg	–	$\leq 2 \times 10^{-9}$	~300, ~900	–	3.76	CPD	[3530]
Mg	–	–	–	–	–	3.77	TC	[298]
Mg	–	–	–	–	–	3.77	TC	[1924]
Mg/glass[49,50]	Mg	–	?	~300	–	3.78	CPD	[1368]
Mg/W	Mg	–	$\leq 2 \times 10^{-9}$	~300	–	3.78	CPD	[3530]
Mg/Ni	Mg	–	?	~300	–	3.79	PE	[1640]
Mg	–	–	–	–	–	3.8	TC	[706]
Mg/W(112)	Mg	–	$(\leq 10^{-11})$	77	–	3.8	CPD	[2635]
Mg[38]	–	–	?	~300	–	3.80*	AI	[3789]
Mg	–	–	–	–	–	3.82	TC	[553,2427]
Mg	–	–	–	–	–	3.82	TC	[3477]
Mg	–	–	–	–	–	3.84	TC	[3477]
Mg/Au(100)	–	–	–	–	–	3.87	TC	[4326]
Mg	–	–	–	–	–	3.99	TC	[1578]
Mg/Si	–	–	–	–	–	4.08	TC	[1653]
Mg/Si	–	–	–	–	–	4.11	TC	[1653]
Mg/Re(1010)	Mg	–	$(<10^{-11})$	77 (~300)	–	4.11	CPD	[4275]
Mg/GaP	–	–	–	–	–	4.14	TC	[1653]
Mg/ZrO$_2$/Si(100)	Mg	–	?	~300	–	4.15[48]	PE	[1442]
Mg	–	–	–	–	–	4.18	TC	[1976]
Mg/GaP	–	–	–	–	–	4.25	TC	[1653]
Mg(foil)	–	–	$<1 \times 10^{-10}$	~300	–	4.3 ± 0.2	PE	[3584]
Recommended	–	–	–	–	–	**3.65 ± 0.05**	–	–

13. Aluminium Al

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(100)	–	–	–	–	–	3.22	TC	[2697]
Al(100)	–	–	–	–	–	3.36	TC	[3638]
Al(100)	–	–	?	~300	–	3.38 ± 0.07	PE	[239]
Al(100)	–	–	–	–	–	3.62	TC	[231]
Al(100)	–	–	–	–	–	3.63	TC	[3467]
Al(100)	–	–	–	–	–	3.71	TC	[473]
Al(100)	–	–	–	–	–	3.77	TC	[553]
Al(100)	–	–	–	–	–	3.780	TC	[560,2432]
Al(100)	–	–	–	–	–	3.782	TC	[1626]
Al(100)	–	–	–	–	–	3.8	TC	[2982]
Al(100)	–	–	–	–	–	3.805	TC	[1626]
Al(100)	–	–	–	–	–	3.806	TC	[2914]
Al(100)	–	–	–	–	–	3.83	TC	[476]
Al(100)	–	–	–	–	–	3.831	TC	[1626]
Al(100)	–	–	–	–	–	3.87	TC	[3004]
Al(100)	–	–	?	–	–	3.9	TC	[1088]
Al(100)	–	–	–	–	–	3.92	TC	[1159,3067]
Al(100)/Ge(100)[52]	–	–	–	–	–	3.94	TC	[3949]
Al(100)	–	–	–	–	–	4.00	TC	[321]
Al(100)	–	–	–	–	–	4.06	TC	[476]
Al(100)	–	–	–	–	–	4.1	TC	[2851]
Al(100)	–	–	–	–	–	4.1 ± 0.3	TC	[1568]
Al(100)	–	–	–	–	–	4.16	TC	[1030]
Al(100)	–	–	–	–	–	4.175 ± 0.052	TC	[2352]
Al(100)	–	–	–	–	–	4.20	TC	[475]
Al(100)/Al(100)[53]	Al	–	$\sim 10^{-10}$	~300 (~520)	–	4.20 ± 0.03	PE	[612]
Al(100)/KCl(100)	Al	–	$\sim 10^{-10}$	~300 (~520)	–	4.20 ± 0.03*	PE	[612]
Al(100)	–	–	–	–	–	4.21	TC	[2548]
Al(100)	–	–	–	–	–	4.22	TC	[1921]
Al(100)	–	–	–	–	–	4.227	TC	[2523]
Al(100)	–	–	–	–	–	4.24	TC	[1175]
Al(100)	–	–	–	–	–	4.25	TC	[593]
Al(100)	–	–	–	–	–	4.25	TC	[556]
Al(100)	–	–	–	–	–	4.255	TC	[4460][490]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(100)	–	–	–	–	–	4.259	TC	[1175]
Al(100)	–	–	–	–	–	4.27	TC	[555,715]
Al(100)	–	–	–	–	–	4.27	TC	[3004]
Al(100)	–	–	–	–	–	4.27	TC	[4233]
Al(100)	–	–	–	–	–	4.27	TC	[4401]
Al(100)	–	–	–	–	–	4.27 ± 0.01	TC	[3241]
Al(100)	–	–	–	–	–	4.28	TC	[3241]
Al(100)	–	–	–	–	–	4.29	TC	[4233]
Al(100)	–	–	–	–	–	4.29	TC	[4357]
Al(100)	–	–	1×10^{-10}	~300	–	4.29	PE	[1572]
Al(100)	–	–	–	–	–	4.30	TC	[1030]
Al(100)	–	–	–	–	–	4.30	TC	[4087,4410]
Al(100)	–	–	–	–	–	4.30	TC	[1435]
Al(100)	–	–	–	–	–	4.32	TC	[4434]
Al(100)	–	–	–	–	–	4.35	TC	[1936]
Al(100)	–	–	–	–	–	4.36	TC	[1943]
Al(100)	–	–	–	–	–	4.38	TC	[1943]
Al(100)	–	–	–	–	–	4.38	TC	[561,721,1936, 4398]
Al(100)	–	–	–	–	–	4.39	TC	[3595]
Al(100)	–	–	–	–	–	4.39	TC	[2065,3485]
Al(100)	–	–	–	–	–	4.39	TC	[1936]
Al(100)	–	–	–	–	–	4.4	TC	[2905]
Al(100)	–	–	–	–	–	4.40	TC	[1936]
Al(100)	–	–	–	–	–	4.40	TC	[2065,2067]
Al(100)	–	–	–	–	–	4.41	TC	[557]
Al(100)	–	–	$<10^{-10}$	~300	–	4.41 ± 0.03	PE	[241]
Al(100)	–	–	–	–	–	4.42	TC	[482,721,4398]
Al(100)	–	–	–	–	–	4.42 ± 0.04	TC	[719]
Al(100)	–	–	–	–	–	4.43	TC	[4117]
Al(100)	–	–	–	–	–	4.432 ± 0.004	TC	[720]
Al(100)	–	–	–	–	–	4.45	TC	[1557]
Al(100)	–	–	–	–	–	4.46	TC	[716]
Al(100)	–	–	–	–	–	4.46	TC	[1943]
Al(100)	–	–	–	–	–	4.46	TC	[716]
Al(100)	–	–	–	–	–	4.46 ± 0.03	TC	[1935]
Al(100)	–	–	–	–	–	4.49	TC	[244]
Al(100)	–	–	–	–	–	4.50	TC	[3203]
Al(100)	–	–	–	–	–	4.50	TC	[714,984]
Al(100)	–	–	–	–	–	4.505	TC	[481]
Al(100)	–	–	–	–	–	4.51	TC	[1821]
Al(100)	–	–	–	–	–	4.51 ± 0.03	TC	[717,718]
Al(100)	–	–	–	–	–	4.53	TC	[1002]
Al(100)	–	–	–	–	–	4.54	TC	[240,2221]
Al(100)	–	–	–	–	–	4.56	TC	[1943]
Al(100)	–	–	–	–	–	4.59	TC	[1259]
Al(100)	–	–	–	–	–	4.63	TC	[240,714,984]
Al(100)	–	–	–	–	–	4.67	TC	[245,3149]
Al(100)	–	–	–	–	–	4.69	TC	[1563]
Al(100)	–	–	–	–	–	4.69	TC	[2697]
Al(100)	–	–	–	–	–	4.7	TC	[1088]
Al(100)	–	–	–	–	–	4.7	TC	[1711,1734]
Al(100)	–	–	–	–	–	4.7	TC	[3149,3156]
Al(100)	–	–	–	–	–	4.7 ± 0.1	TC	[713]
Al(100)	–	–	–	–	–	4.82	TC	[3339]
Al(100)	–	–	–	–	–	4.82	TC	[1871]
Al(100)	–	–	–	–	–	4.85	TC	[3477]
Al(100)	–	–	–	–	–	4.86	TC	[2697]
Al(100)	–	–	–	–	–	4.90	TC	[1095]
Al(100)	–	–	–	–	–	5.07 ± 0.10	TC	[1576]
Al(100)	–	–	–	–	–	5.24	TC	[3477]
Al(100)	–	–	–	–	–	5.45 ± 0.1	TC	[1036]
Recommended	–	–	–	–	–	**4.28 ± 0.05**	–	–
Al(110)	–	–	–	–	–	2.83	TC	[2697]
Al(110)	–	–	–	–	–	3.59	TC	[553]
Al(110)	–	–	–	–	–	3.60	TC	[473]
Al(110)	–	–	–	–	–	3.642	TC	[1626]
Al(110)	–	–	–	–	–	3.643	TC	[1626,2914]
Al(110)	–	–	–	–	–	3.65	TC	[475]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(110)	–	–	–	–	–	3.7	TC	[2851]
Al(110)	–	–	–	–	–	3.7	TC	[2982]
Al(110)	–	–	–	–	–	3.70	TC	[593]
Al(110)	–	–	–	–	–	3.73	TC	[1159,3067]
Al(110)	–	–	–	–	–	3.76	TC	[321]
Al(110)	–	–	–	–	–	3.8	TC	[1088]
Al(110)	–	–	?	~300	–	3.80	PE	[239]
Al(110)	–	–	–	–	–	3.81	TC	[231]
Al(110)	–	–	–	–	–	3.82	TC	[3467]
Al(110)	–	–	–	–	–	3.85	TC	[1435]
Al(110)	–	–	–	–	–	3.87	TC	[3004]
Al(110)	–	–	–	–	–	3.88	TC	[555]
Al(110)	–	–	–	–	–	3.88	TC	[3004]
Al(110)	–	–	–	–	–	3.89	TC	[715]
Al(110)	–	–	–	–	–	3.89	TC	[1030]
Al(110)	–	–	–	–	–	3.92	TC	[4401]
Al(110)	–	–	–	–	–	3.95	TC	[1030]
Al(110)	–	–	–	–	–	3.97	TC	[474]
Al(110)	–	–	–	–	–	3.97	TC	[1563]
Al(110)	–	–	–	–	–	4.02	TC	[556]
Al(110)	–	–	–	–	–	4.06	TC	[4233]
Al(110)/Al(110)[53]	Al	–	~10^{-10}	~300 (~520)	–	4.06 ± 0.03	PE	[612]
Al(110)	–	–	–	–	–	4.07	TC	[474]
Al(110)	–	–	–	–	–	4.07	TC	[1175]
Al(110)	–	–	–	–	–	4.09	TC	[4087,4410]
Al(110)	–	–	–	–	–	4.10	TC	[476]
Al(110)	–	–	–	–	–	4.11	TC	[4233]
Al(110)	–	–	–	–	–	4.12	TC	[559]
Al(110)	–	–	–	–	–	4.14	TC	[559]
Al(110)	–	–	–	–	–	4.15	TC	[474]
Al(110)	–	–	–	–	–	4.19	TC	[1943]
Al(110)	–	–	–	–	–	4.2	TC	[2905]
Al(110)	–	–	–	–	–	4.20	TC	[557]
Al(110)	–	–	–	–	–	4.20	TC	[1212]
Al(110)	–	–	–	–	–	4.20	TC	[1943]
Al(110)	–	–	–	–	–	4.21	TC	[2548]
Al(110)	–	–	–	–	–	4.21 ± 0.04	TC	[719]
Al(110)	–	–	–	–	–	4.22	TC	[557]
Al(110)	–	–	–	–	–	4.22	TC	[1213]
Al(110)	–	–	–	–	–	4.25	TC	[3203]
Al(110)	–	–	–	–	–	4.26	TC	[1943]
Al(110)	–	–	–	–	–	4.28	TC	[476]
Al(110)	–	–	–	–	–	4.28	TC	[4117]
Al(110)	–	–	<10^{-10}	~300	–	4.28 ± 0.02	PE	[241,242]
Al(110)	–	–	–	–	–	4.29	TC	[721,4398]
Al(110)	–	–	–	–	–	4.30	TC	[561,721,4398]
Al(110)	–	–	–	–	–	4.30	TC	[2697]
Al(110)	–	–	–	–	–	4.32 ± 0.03	TC	[247,718]
Al(110)	–	–	–	–	–	4.35	TC	[1095]
Al(110)	–	–	~10^{-10}	~300	–	4.35 ± 0.05	PE	[458,2681]
Al(110)	–	–	–	–	–	4.36	TC	[1943]
Al(110)	–	–	–	–	–	4.44	TC	[3477]
Al(110)	–	–	–	–	–	4.47	TC	[2697]
Al(110)	–	–	–	–	–	4.5	TC	[1088]
Al(110)	–	–	–	–	–	4.5	TC	[1214]
Al(110)	–	–	–	–	–	4.83	TC	[248]
Al(110)	–	–	–	–	–	4.91	TC	[3477]
Recommended	–	–	–	–	–	**4.05 ± 0.06**	–	–
Al(111)	–	–	?	~300	–	3.11 ± 0.10	PE	[239]
Al(111)	–	–	–	–	–	3.13	TC	[2697]
Al(111)	–	–	–	–	–	3.47	TC	[1030,1089]
Al(111)	–	–	–	–	–	3.48	TC	[476]
Al(111)	–	–	–	–	–	3.53	TC	[1089]
Al(111)	–	–	–	–	–	3.6	TC	[3137]
Al(111)	–	–	–	–	–	3.6	TC	[1086]
Al(111)	–	–	–	–	–	3.7	TC	[1176,1216]
Al(111)	–	–	–	–	–	3.7	TC	[1011,1215]
Al(111)	–	–	–	–	–	3.72	TC	[231]
Al(111)	–	–	–	–	–	3.73	TC	[476]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(111)	–	–	–	–	–	3.73	TC	[3467]
Al(111)	–	–	–	–	–	3.77	TC	[473]
Al(111)	–	–	–	–	–	3.78	TC	[3491]
Al(111)	–	–	–	–	–	3.79	TC	[1086]
Al(111)	–	–	–	–	–	3.8	TC	[1011,1215]
Al(111)	–	–	–	–	–	3.8	TC	[2222,2223]
Al(111)	–	–	–	–	–	3.83	TC	[1089]
Al(111)[54]	–	–	–	–	–	3.83–4.59	TC	[1101]
Al(111)	–	–	–	–	–	3.86	TC	[3004]
Al(111)	–	–	–	–	–	3.87	TC	[1042]
Al(111)	–	–	–	–	–	3.87	TC	[1086]
Al(111)	–	–	–	–	–	3.87	TC	[3158]
Al(111)	–	–	–	–	–	3.9	TC	[2982]
Al(111)	–	–	–	–	–	3.92	TC	[1030]
Al(111)	–	–	–	–	–	4.0	TC	[1086,1088]
Al(111)	–	–	–	–	–	4.0	TC	[1011,1215]
Al(111)	–	–	–	–	–	4.02	TC	[4087,4410]
Al(111)	–	–	–	–	–	4.04	TC	[1028,1179]
Al(111)	–	–	–	–	–	4.05	TC	[475]
Al(111)	–	–	–	–	–	4.05	TC	[4233]
Al(111)	–	–	–	–	–	4.059	TC	[1626]
Al(111)	–	–	–	–	–	4.06	TC	[1175]
Al(111)	–	–	–	–	–	4.07	TC	[3220]
Al(111)	–	–	–	–	–	4.08	TC	[4233]
Al(111)	–	–	–	–	–	4.08	TC	[2427]
Al(111)	–	–	–	–	–	4.08	TC	[4215]
Al(111)	–	–	–	–	–	4.085	TC	[735]
Al(111)	–	–	–	–	–	4.09	TC	[343]
Al(111)	–	–	–	–	–	4.09	TC	[553,1177]
Al(111)	–	–	–	–	–	4.092	TC	[735]
Al(111)	–	–	–	–	–	4.094	TC	[735]
Al(111)	–	–	–	–	–	4.096	TC	[560,2432]
Al(111)	–	–	–	–	–	4.1	TC	[1011,1215]
Al(111)	–	–	–	–	–	4.1	TC	[1088,2851]
Al(111)	–	–	–	–	–	4.10	TC	[1011]
Al(111)	–	–	–	–	–	4.117	TC	[1626,2914]
Al(111)	–	–	–	–	–	4.12	TC	[1159,3067]
Al(111)	–	–	–	–	–	4.12	TC	[1176]
Al(111)	–	–	–	–	–	4.12	TC	[1086,2844]
Al(111)	–	–	–	–	–	4.12	TC	[4029,4255]
Al(111)	–	–	–	–	–	4.13	TC	[2444]
Al(111)	–	–	–	–	–	4.15	TC	[2844]
Al(111)	–	–	–	–	–	4.16	TC	[2444]
Al(111)	–	–	–	–	–	4.17	TC	[1943]
Al(111)	–	–	–	–	–	4.17	TC	[3004]
Al(111)	–	–	–	–	–	4.17	TC	[1178]
Al(111)	–	–	–	–	–	4.18	TC	[555,715]
Al(111)	–	–	–	–	–	4.18	TC	[2402]
Al(111)	–	–	–	–	–	4.18	TC	[1921]
Al(111)	–	–	–	–	–	4.18	TC	[1943]
Al(111)/Ru(0001)[57]	Al	–	8×10^{-11}	~300	–	4.18 ± 0.06*	CPD	[301]
Al(111)	–	–	–	–	–	4.181	TC	[1626]
Al(111)	–	–	–	–	–	4.19	TC	[557]
Al(111)	–	–	–	–	–	4.19	TC	[1179]
Al(111)	–	–	–	–	–	4.19	TC	[1435]
Al(111)	–	–	–	–	–	4.2	TC	[2400]
Al(111)	–	–	–	–	–	4.2	TC	[2851]
Al(111)	–	–	–	–	–	4.2	TC	[734]
Al(111)	–	–	–	–	–	4.2	TC	[1011,1215]
Al(111)	–	–	–	–	–	4.20	TC	[3491]
Al(111)	–	–	5×10^{-11}	~300	–	4.20 ± 0.05	PE	[1915]
Al(111)	–	–	–	–	–	4.21	TC	[3491]
Al(111)	–	–	–	–	–	4.21	TC	[2548]
Al(111)	–	–	–	–	–	4.21	TC	[1028,1179]
Al(111)	–	–	–	–	–	4.22	TC	[1086]
Al(111)	–	–	–	–	–	4.22	TC	[1943]
Al(111)	–	–	–	–	–	4.22	TC	[4174,4284]
Al(111)	–	–	–	–	–	4.23	TC	[482,721,4398]
Al(111)	–	–	–	–	–	4.238	TC	[2523]
Al(111)	–	–	–	–	–	4.24	TC	[3175]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(111)	–	–	$<10^{-10}$	~300	–	4.24 ± 0.02	PE	[241,242]
Al(111)	–	–	–	–	–	4.24 ± 0.04	TC	[1101]
Al(111)	–	–	–	–	–	4.25	TC	[561,721,4398]
Al(111)	–	–	–	–	–	4.25	TC	[3203]
Al(111)	–	–	?	100	–	4.25	CPD	[2654]
Al(111)	–	–	–	–	–	4.25	TC	[2685]
Al(111)/Ru(0001)[57]	Al	–	8×10^{-11}	~300	–	4.25*	CPD	[301,2417]
Al(111)	–	–	~10^{-10}	~300	–	4.25 ± 0.05	PE	[458,2681]
Al(111)	–	–	–	–	–	4.26	TC	[248]
Al(111)	–	–	–	–	–	4.26	TC	[1086]
Al(111)	–	–	–	~20–300	–	4.26	TC	[4310]
Al(111)/Al(111)[53]	Al	–	~10^{-10}	~300 (~520)	–	4.26 ± 0.03	PE	[612]
Al(111)	–	–	–	–	–	4.26 ± <0.1	TC	[1559]
Al(111)	–	–	–	–	–	4.27	TC	[556]
Al(111)	–	–	–	–	–	4.275	TC	[1096,2377]
Al(111)	–	–	–	–	–	4.28	TC	[2636]
Al(111)/quartz	Al	–	~10^{-10}	~300 (~520)	–	4.28 ± 0.01	PE	[612]
Al(111)	–	–	1×10^{-10}	~300	–	4.29	PE	[1572]
Al(111)/quartz[55]	Al	–	~10^{-9}	~300 (623)	–	4.29	PE	[3313]
Al(111)	–	–	~10^{-11}	~300	–	4.29 ± 0.02	PE	[1217,1598]
Al(111)	–	–	$<10^{-10}$	~300	–	4.3	PE	[249]
Al(111)	–	–	–	–	–	4.3	TC	[1011]
Al(111)	–	–	–	–	–	4.3	TC	[1176,1216]
Al(111)	–	–	–	–	–	4.3	TC	[2905]
Al(111)	–	–	?	20, 40	–	4.3	PE	[1688,2642]
Al(111)	–	–	?	?	–	4.30	?	[1218]
Al(111)	–	–	–	–	–	4.31	TC	[1011]
Al(111)	–	–	–	–	–	4.31	TC	[4401]
Al(111)/quartz[55]	Al	–	~10^{-9}	~300	–	4.31	PE	[3313]
Al(111)	–	–	–	–	–	4.31 ± 0.03	TC	[718]
Al(111)	–	–	–	–	–	4.32	TC	[321]
Al(111)	–	–	–	–	–	4.32	TC	[1943]
Al(111)	–	–	–	–	–	4.32	TC	[1594]
Al(111)	–	–	–	–	–	4.33	TC	[4117]
Al(111)	–	–	–	–	–	4.34	TC	[1011]
Al(111)	–	–	8×10^{-11}	90	–	4.36	PE	[250]
Al(111)	–	–	–	–	–	4.36	TC	[1557]
Al(111)	–	–	–	–	–	4.37	TC	[474]
Al(111)	–	–	–	–	–	4.38	TC	[1086]
Al(111)	–	–	1×10^{-10}	90, 300	–	4.38 ± 0.02	PE	[566]
Al(111)	–	–	–	–	–	4.39	TC	[1592,1594]
Al(111)/Ag(111)[56]	Al	–	$\leq 5 \times 10^{-10}$	150, 300	–	4.4	CPD	[2888]
Al(111)	–	–	–	–	–	4.4	TC	[1011]
Al(111)	–	–	–	–	–	4.4	TC	[1097]
Al(111)	–	–	–	–	–	4.40	TC	[1734]
Al(111)/Ru(0001)[57]	Al	–	8×10^{-11}	~300	–	4.41*	CPD	[301,2417]
Al(111)	–	–	–	–	–	4.43	TC	[1011]
Al(111)	–	–	?	?	–	4.48	?	[3661]
Al(111)	–	–	–	–	–	4.48 ± 0.08*	TC	[474]
Al(111)	–	–	–	–	–	4.49	TC	[1098]
Al(111)	–	–	–	–	–	4.491	TC	[481]
Al(111)	–	–	–	–	–	4.5	TC	[1011]
Al(111)	–	–	–	–	–	4.52	TC	[474]
Al(111)	–	–	~10^{-11}	40	–	4.53	PE	[1219]
Al(111)	–	–	–	–	–	4.53	TC	[1011]
Al(111)	–	–	–	–	–	4.54	TC	[334]
Al(111)	–	–	–	–	–	4.545	TC	[1096]
Al(111)	–	–	–	–	–	4.55	TC	[2636]
Al(111)	–	–	–	–	–	4.55 ± 0.05	TC	[558]
Al(111)	–	–	–	–	–	4.56	TC	[1594]
Al(111)	–	–	–	–	–	4.56	TC	[474]
Al(111)	–	–	–	–	–	4.60	TC	[2697]
Al(111)	–	–	–	–	–	4.62	TC	[1099]
Al(111)	–	–	–	–	–	4.7	TC	[1011]
Al(111)	–	–	–	–	–	4.7	TC	[1001,1097,3441]
Al(111)	–	–	–	–	–	4.74	TC	[1011]
Al(111)	–	–	–	–	–	4.75	TC	[1095]
Al(111)	–	–	–	–	–	4.77	TC	[2697]
Al(111)	–	–	–	–	–	4.81	TC	[1563]
Al(111)	–	–	–	–	–	4.82	TC	[1259]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al(111)	–	–	–	–	–	4.90	TC	[1087]
Al(111)	–	–	–	–	–	4.99	TC	[3477]
Al(111)	–	–	–	–	–	5.2	TC	[1100]
Al(111)	–	–	–	–	–	5.35	TC	[3477]
Al(111)	–	–	–	–	–	5.4	TC	[3441]
Recommended	–	–	–	–	–	**4.24 ± 0.04**	–	–
Al	–	–	–	–	–	2.62	TC	[3080]
Al	–	–	–	–	–	2.87	TC	[1436]
Al	–	–	?	~300	–	2.98	PE	[2460]
Al	–	–	–	–	–	3.0	TC	[2456]
Al	–	–	–	–	–	3.08	TC	[1436]
Al/?	Al	–	?	~300	–	3.15	CPD	[2708]
Al[130]	–	–	–	–	–	3.194	TC	[2887]
Al/Si(110)	Al	–	~10^{-11}	~300	–	3.2 ± 0.2	FE	[2394]
Al	–	–	?	~300	–	3.23	CPD	[2539]
Al(fp)[130]	–	–	–	–	–	3.233	TC	[2887]
Al	–	–	~10^{-8}	~300	–	3.26	PE	[3315]
Al(fp)[130]	–	–	–	–	–	3.269	TC	[2887]
Al	–	–	?	~300	–	3.38	CPD	[2297]
Al	–	–	?	~300	–	3.41*	CPD	[3621]
Al	–	–	6×10^{-3}	~300	–	3.43 ± 0.10	PE	[2079,2080]
Al	–	–	–	–	–	3.44	TC	[738]
Al/quartz[51]	Al	–	~10^{-5}	~300	–	3.47	PE	[1973]
Al/Si(111)	–	–	–	–	–	3.5	TC	[1679]
Al	–	–	?	~300	–	3.58	PE	[4278]
Al	–	–	–	–	–	3.62	TC	[231]
Al	–	–	–	–	–	3.64	TC	[521]
Al	–	–	–	–	–	3.65	TC	[477]
Al	–	–	–	–	–	3.66	TC	[1066]
Al	–	–	?	~300	–	3.70	PE	[239]
Al	–	–	–	–	–	3.73	TC	[3467]
Al	–	–	–	–	–	3.74	TC	[477,1924,4035, 4036]
Al	–	–	–	–	–	3.77	TC	[2427]
Al/quartz	–	–	~10^{-5}	~300	–	3.78	PE	[1973]
Al	–	–	–	–	–	3.79	TC	[1436]
Al	–	–	–	–	–	3.8*	TC	[1955]
Al	–	–	–	–	–	3.80	TC	[2949]
Al	–	–	–	–	–	3.815	TC	[2523]
Al	–	–	–	–	–	3.83	TC	[231]
Al	–	–	–	–	–	3.83	TC	[3467]
Al	–	–	–	–	–	3.87	TC[3]	[475]
Al	–	–	–	–	–	3.88	TC	[2474]
Al	–	–	1×10^{-5}	~300	–	3.88	CPD	[1883]
Al/Al$_2$O$_3$/Si(100)	Al	–	?	~300	–	3.9[48]	PE	[1442]
Al	–	–	–	–	–	3.93	TC	[230]
Al	–	–	–	–	–	3.99	TC	[4419]
Al/glass	Al	–	~10^{-6}–10^{-8}	~300	–	4.0	PE	[1894]
Al	–	–	~10^{-10}	~300	–	4.0 ± 0.1	PE	[1220]
Al	–	–	–	–	–	4.00	TC	[1901]
Al/Ag(110)	Al	–	<4×10^{-11}	~300	–	4.04*	PE	[3466]
Al/Si$_3$N$_4$	Al	–	?	?	–	4.06	?	[3519,3520]
Al/glass	Al	–	<10^{-8}	~300	–	4.08	PE	[1457]
Al/Pd/Ta(110)[398]	Al	–	8×10^{-11}	~300	–	4.1	PE	[2271]
Al	–	–	?	~300	–	4.1	PE	[1412]
Al/quartz[102]	Al	–	≤10^{-8}	4.2	–	4.1 ± 0.2	CPD	[1686]
Al	–	–	~10^{-7}	~300	–	4.12	CPD	[3513]
Al	–	–	–	–	–	4.12	TC	[477]
Al/SiO$_2$/Si	Al	–	?	~300 (570)	–	4.13	PE	[2355]
Al/SiO$_2$	Al	–	?	?	–	4.14	?	[3519,3520]
Al	–	–	–	–	–	4.14	TC	[2629]
Al	–	–	5×10^{-10}	~300	–	4.15	PE	[594]
Al/GaP	–	–	–	–	–	4.15	TC	[1653]
Al/Si(100)	–	–	–	–	–	4.15	TC	[3485]
Al/Pd(001)	Al	–	5×10^{-11}	325	–	4.15	CPD	[3206,3209]
Al/glass	Al	–	<1×10^{-9}	~300	–	4.15 ± 0.05	CPD	[655]
Al(nanowire)[453]	–	–	–	–	–	4.15 ± 0.05*	TC	[4178]
Al	–	–	–	–	–	4.16	TC	[2005]
Al	–	–	~10^{-9}	~300	–	4.16	PE	[3212]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al	–	–	–	–	–	4.17	TC	[477]
Al/Si(111)	Al	–	5×10^{-11}	~300	–	4.17 ± 0.05	CPD	[613,636]
Al/glass[59]	Al	–	5×10^{-11}	~300	–	4.17 ± 0.07	CPD	[1071,2100]
Al	–	–	–	–	–	4.18	TC	[3637]
Al	–	–	–	–	–	4.19	TC	[3264,3265,3267]
Al/W(111)	Al	–	$<1 \times 10^{-10}$	~300	–	4.19*	FE	[2616]
Al/glass	Al	–	$\leq 10^{-8}$	~300	–	4.19 ± 0.03	CPD	[349]
Al	–	–	–	–	–	4.2	TC	[706]
Al	–	–	–	–	–	4.2	TC	[4031]
Al	–	–	–	–	–	4.2	TC	[944]
Al/quartz	–	–	?	~300	–	4.2	PE	[4281]
Al/quartz	Al	–	$\leq 10^{-8}$	293	–	4.2 ± 0.2	CPD	[1686]
Al/quartz	Al	–	$\leq 10^{-8}$	135	–	4.2 ± 0.2	CPD	[1686]
Al[102]	–	–	$\leq 10^{-8}$	5	–	4.20	FE	[1686]
Al	–	–	$\leq 10^{-8}$	77	–	4.20	FE	[1686]
Al/glass	Al	–	?	90	–	4.20 ± 0.02	PE	[3031]
Al/glass	Al	–	?	~300	–	4.20 ± 0.02	PE	[3031]
Al/W	Al	–	$\sim 10^{-10}$	~300 (≤800)	–	4.20 ± 0.05	FE	[2715]
Al/glass	Al	–	$\sim 10^{-8}$	~300	–	4.20 ± 0.05	CPD	[133]
Al/glass	Al	–	5×10^{-11}	~300	–	4.20 ± 0.07	CPD	[1071]
Al/SiO$_2$	Al	–	?	~300	–	4.208	CPD	[1221]
Al/W	Al	–	$<1 \times 10^{-10}$	~300	–	4.21 ± 0.04	FE	[2616]
Al	–	–	–	–	–	4.22	TC	[1399]
Al	–	–	?	~300	–	4.22 ± 0.04*	CPD	[3867]
Al/glass	Al	–	5×10^{-11}	~300	–	4.22 ± 0.06	CPD	[1071]
Al	–	–	–	–	–	4.24	TC	[477,1924,4035]
Al$_n$(n → ∞)[459]	–	–	?	~300	–	4.25	TC	[4194,4197]
Al	–	–	?	?	–	4.25	?	[1535]
Al/ZrO$_2$/Si(100)	Al	–	?	~300	–	4.25[48]	PE	[1442]
Al	–	–	–	–	–	4.25	TC	[2439]
Al	–	–	–	–	–	4.25	TC	[4031]
Al	–	–	?	~300	–	4.25	PE	[3249]
Al/W	Al	–	$\leq 5 \times 10^{-8}$	~300	–	4.25 ± 0.05	CPD	[690]
Al/quartz	Al	–	$<1 \times 10^{-9}$	~300	–	4.25 ± 0.10	CPD	[655]
Al	–	–	$<3 \times 10^{-11}$	~300	–	4.25 ± 0.15	AI	[4055]
Al	–	–	–	466.5	–	4.259	TC	[2419]
Al/GaP	–	–	–	–	–	4.26	TC	[1653]
Al/quartz	Al	–	$<5 \times 10^{-10}$	293	–	4.26	PE	[1102]
Al/Mo(011)	Al	–	$\leq 2 \times 10^{-10}$	~300	–	4.26	CPD	[2655]
Al/Al$_2$O$_3$/Mo(011)	Al	–	$\leq 2 \times 10^{-10}$	~300	–	4.26	CPD	[2655]
Al/MgO/Mo(011)	Al	–	$\leq 2 \times 10^{-10}$	~300	–	4.26	CPD	[2655]
Al/quartz	Al	–	$\leq 5 \times 10^{-10}$	78	–	4.26 ± 0.01	PE	[435]
Al/Si	Al	–	$<6 \times 10^{-9}$	~300	–	4.26 ± 0.02	FE	[1540]
Al/Ta(110)[398]	Al	–	8×10^{-11}	~300	–	4.27	PE	[2271]
Al	–	–	–	–	–	4.27	TC	[553,2427]
Al	–	–	–	–	–	4.27	TC	[3477]
Al/quartz	Al	–	$<2 \times 10^{-9}$	~300	–	4.27 ± 0.02	PE	[725,1498]
Al	–	–	–	0	–	4.276	TC	[2419]
Al	–	–	–	–	–	4.28	TC	[3220]
Al$_n$(n → ∞)	–	–	–	–	–	4.28	TC	[4193]
Al$_{2000}$(z → 0)[60]	–	–	?	~300	–	4.28 ± 0.03	IP	[2199]
Al$_{32000}$(z → 0)[60]	–	–	?	~300	–	4.28 ± 0.03	IP	[2199]
Al/quartz[55]	Al	–	$\sim 10^{-9}$	~300 (623)	–	4.29	PE	[3313]
Al/quartz	Al	–	$<5 \times 10^{-10}$	293 (618)	–	4.29	PE	[1102]
Al/quartz	Al	–	$<5 \times 10^{-10}$	78 (293)	–	4.29 ± 0.01	PE	[435]
Al/quartz	Al	–	$<5 \times 10^{-10}$	78 (550)	–	4.29 ± 0.01	PE	[435]
Al/glass	Al	–	5×10^{-11}	~300	–	4.29 ± 0.09*	CPD	[1071]
Al	–	–	–	–	–	4.292	TC	[2649]
Al	–	–	–	–	–	4.3	TC	[1173]
Al/?	Al	–	$\sim 10^{-5}$	~300	–	4.3	CPD	[1376]
Al[58]	–	–	?	~300	–	4.3	CPD	[2550]
Al/Mo	Al	–	7×10^{-11}	~300	–	4.3	PE	[2226]
Al	–	–	–	–	–	4.3	TC	[1993]
Al	–	–	–	–	–	4.30	TC	[2914]
Al	–	–	$<3 \times 10^{-9}$	~300	–	4.30	CPD	[1180]
Al/quartz	Al	–	$\leq 5 \times 10^{-10}$	293 (~550)	–	4.30	PE	[435]
Al	–	–	–	–	–	4.30	TC	[1626,4431]
Al/quartz[55]	Al	–	$\sim 10^{-9}$	~300	–	4.31	PE	[3313]
Al/Si(001)	–	–	–	–	–	4.317	TC	[1941]
Al/Si(111)	Al	–	2×10^{-10}	~300	–	4.32 ± 0.1	PE	[2623]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
$Al_{32-95}(\infty)$	–	–	?	230	–	4.338	IP	[4192]
Al/W(001)	Al	–	$<1 \times 10^{-10}$	~300	–	4.34*	FE	[2616]
Al/Al	Al	–	?	~300	–	4.34	PE	[3250]
Al	–	–	–	–	–	4.34	TC	[298]
$Al_{32-95}(\infty)$	–	–	?	65	–	4.349	IP	[4192]
Al	–	–	–	–	–	4.35	TC	[1976]
Al/SiO_2	Al	–	?	~300	–	4.353	CPD	[1221]
Al/glass	Al	–	?	~300	–	4.36	PE	[1948]
Al/W(111)	Al	–	$<1 \times 10^{-10}$	~300	–	4.36	FE	[2616]
Al_{32000}[449]	–	–	–	–	–	4.36 ± 0.03*	TC	[2199]
Al	–	–	–	–	–	4.37	TC	[1613]
Al/Si	–	–	–	–	–	4.39	TC	[1653]
Al/Ag(110)	Al	–	$<4 \times 10^{-11}$	~300	–	4.40	PE	[3466]
Al/Si	–	–	–	–	–	4.42	TC	[1653]
Al/Si(111)	Al	–	$<5 \times 10^{-10}$	~300	–	4.45	PE	[1694]
Al/Mo(110)	Al	–	$<3 \times 10^{-10}$	~300	–	4.50	CPD	[2403]
Al_{2000}[449]	–	–	–	–	–	4.51 ± 0.03*	TC	[2199]
Al/W(001)	Al	–	$<1 \times 10^{-10}$	~300	–	4.65	FE	[2616]
Al/Si(111)	–	–	–	–	–	4.70 ± 0.1	TC	[3549,3740]
Al[61]	–	–	?	~300–600	–	4.75 ± 0.22	PE	[1222]
Al/Si(111)	Cs, Li	Cs^+	?	~300	4.8*	–	CPD	[1342]
Al[61]	–	–	?	~300–600	–	4.90 ± 0.06	PE	[1222]
Al	Cs	Cs^+	?	~300	4.96*	–	CPD	[611]
Recommended	–	–	–	–	**4.9 ± 0.1**	**4.26 ± 0.03**	–	–

Liquid ($T \geq 933$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Al	–	–	–	–	–	4.241	TC	[2419]

14. Silicon Si

Diamond Structure

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si(100)	–	–	–	–	–	4.33	TC	[2521,2525]
Si(100)	–	–	–	–	–	4.36	TC	[2521]
Si(100)p	–	–	$\leq 10^{-9}$	300E	–	4.41*[62]	TE	[1225]
Si(100)[65]	–	–	–	~300	–	4.47*	TC	[2097]
Si(100)n	–	–	?	~300 (?)	–	4.5	PE	[2242]
Si(100)n	–	–	7×10^{-9}	~1200–1500	(4.54–4.84)	4.53 ± 0.1	TE	[74]
Si(100)n[64]	K	K^+	7×10^{-9}	~900–1550	4.54 ± 0.2	(4.53 ± 0.1)	PSI	[74]
Si(100)n	–	–	?	~300	–	4.6	PE	[2059]
Si(100)p	–	–	3×10^{-11}	~300	–	4.6	PE	[1872]
Si(100)n[64]	Li	Li^+	7×10^{-9}	~1050–1550	4.60 ± 0.03	(4.53 ± 0.1)	PSI	[74]
Si(100)	–	–	–	–	–	4.604	TC	[1941]
Si(100)n	–	–	?	~300 (1170)	–	4.7	PE	[768]
Si(100)n[64]	Na	Na^+	7×10^{-9}	~1000–1550	4.70 ± 0.02	(4.53 ± 0.1)	PSI	[74]
Si(100)	–	–	–	–	–	4.712	TC	[4460][490]
Si(100)n	–	–	4×10^{-11}	200	–	4.72 ± 0.05	CPD	[880]
Si(100)n[63]	Li	Li^+	7×10^{-9}	~1050–1550	4.74 ± 0.05	(4.53 ± 0.1)	PSI	[74]
Si(100)	–	–	–	–	–	4.79	TC	[4461][490]
Si(100)p	–	–	5×10^{-11}	~300	–	4.8	PE	[1868,1869,3605]
Si(100)p	–	–	$<10^{-9}$	~300 (773)	–	4.81	CPD	[116]
Si(100)n[63]	Tl	Tl^+	7×10^{-9}	~950–1550	4.81 ± 0.03	(4.53 ± 0.1)	PSI	[74]
Si(100)n[64]	Tl	Tl^+	7×10^{-9}	~950–1550	4.81 ± 0.07	(4.53 ± 0.1)	PSI	[74]
Si(100)p	–	–	$<10^{-9}$	~300 (773)	–	4.82	CPD	[116,1771]
Si(100)/W(110)	Si	–	?	~300	–	4.83	PE	[3448]
Si(100)p	–	–	$\leq 10^{-9}$	1330–1500	–	4.83 ± 0.03	TE	[1225]
Si(100)n[63]	Na	Na^+	7×10^{-9}	~1000–1550	4.84 ± 0.03	(4.53 ± 0.1)	PSI	[74]
Si(100)n[63]	K	K^+	7×10^{-9}	~900–1550	≥4.84	(4.53 ± 0.1)	PSI	[74]
Si(100)	–	–	1×10^{-10}	~300	–	4.85	PE	[2972]
Si(100)p	–	–	?	~300	–	4.85	TCS	[4050,4177]
Si(100)	–	–	2×10^{-10}	~300	–	4.85	FE	[275,440]
Si(100)	–	–	$\sim 10^{-10}$	200	–	4.85	CPD	[302]
Si(100)n	–	–	$\sim 10^{-11}$	~300	–	4.85 ± 0.1	PE	[2130]
Si(100)	–	–	–	–	–	4.859	TC	[3498,3501]
Si(100)[65]	–	–	–	1000	–	4.86*	TC	[2097]
Si(100)n	–	–	5×10^{-11}	~300	–	4.87	PE	[2150]
Si(100)p	–	–	–	–	–	4.876	TC	[4179]
Si(100)	–	–	–	–	–	4.9	TC	[1223]
Si(100)	–	–	5×10^{-11}	~300	–	4.9	PE	[1224]
Si(100)p	–	–	$<1 \times 10^{-10}$	~300	–	4.9	PE	[3177,3187,3189, 3191]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si(100)[n]	–	–	?	70 (1200)	–	4.9*	PE	[2178]
Si(100)	–	–	3×10^{-11}	~300	–	4.9 ± 0.1	PE	[2951]
Si(100)	–	–	–	–	–	4.9 ± 0.1	TC	[2680]
Si(100)[p]	–	–	2×10^{-10}	~300	–	4.91	FE	[1387]
Si(100)[p]	–	–	$\leq 10^{-9}$	~300 (1550)	–	4.91 ± 0.05	CPD	[1225]
Si(100)[n]	–	–	$\sim 10^{-10}$	~300 (~1200)	–	4.92	PE	[4125]
Si(100)[p]	–	–	$<10^{-9}$	~300	–	4.92 ± 0.02	CPD	[116,1771]
Si(100)[p]	–	–	$<10^{-9}$	~300 (1350)	–	4.96	CPD	[116]
Si(100)[n]	–	–	4×10^{-11}	~300	–	4.96	CPD	[1861]
Si(100)[p]	–	–	$\sim 10^{-10}$	~300	–	5.05 ± 0.05	PE	[1851]
Si(100)	–	–	–	–	–	5.1	TC	[3362]
Si(100)	–	–	$<1 \times 10^{-10}$	~300 (1120)	–	5.11 ± 0.03	PE	[1491,3950]
Si(100)[65]	–	–	–	1500	–	5.14*	TC	[2097]
Si(100)	–	–	–	–	–	5.12	TC	[2067,3485]
Recommended	**–**	**–**	**–**	**–**	**4.72 ± 0.10**	**4.82 ± 0.05**	**–**	**–**
Si(110)[p70]	–	–	?	1250–1400	–	3.17 ± 0.05	TE	[1500]
Si(110)[p434]	Na	Na$^+$	$\leq 5 \times 10^{-7}$	1000	3.32	(3.40)	PSI	[1472]
Si(110)[p434]	K	K$^+$	$\leq 5 \times 10^{-7}$	1000	3.32	(3.40)	PSI	[1472]
Si(110)[p434]	–	–	$\leq 5 \times 10^{-7}$	1000	(3.32)	3.40	TE	[1472]
Si(110)[n70]	–	–	?	1250–1400	–	3.76 ± 0.05	TE	[1500]
Si(110)[p70]	–	–	?	1400–1625	–	4.12 ± 0.05	TE	[1500]
Si(110)[p]	–	–	$\sim 10^{-9}$	1265–1500	–	4.12 ± 0.05	TE	[635]
Si(110)[p434]	Na	Na$^+$	$<5 \times 10^{-7}$	1600	4.14	(4.70)	PSI	[1472]
Si(110)[p434]	K	K$^+$	$<5 \times 10^{-7}$	1600	4.14	(4.70)	PSI	[1472]
Si(110)[n70]	–	–	?	1400–1625	–	4.14 ± 0.05	TE	[1500]
Si(110)[p434]	–	–	$\leq 5 \times 10^{-7}$	1300	(4.31)	4.31	TE	[1472]
Si(110)[p434]	Na	Na$^+$	$\leq 5 \times 10^{-7}$	1300	4.31	(4.31)	PSI	[1472]
Si(110)[p434]	K	K$^+$	$\leq 5 \times 10^{-7}$	1300	4.31	(4.31)	PSI	[1472]
Si(110)[p434]	Na	Na$^+$	$\leq 5 \times 10^{-7}$	1600	4.38	(4.70)	PSI	[1472]
Si(110)[p434]	K	K$^+$	$\leq 5 \times 10^{-7}$	1600	4.38	(4.70)	PSI	[1472]
Si(110)[p434]	Na	Na$^+$	$\leq 5 \times 10^{-7}$	1500–1600	4.38 ± 0.01	(4.69 ± 0.01)	PSI	[1472]
Si(110)[p434]	K	K$^+$	$\leq 5 \times 10^{-7}$	1500–1600	4.38 ± 0.01	(4.69 ± 0.01)	PSI	[1472]
Si(110)[p]	–	–	$\leq 10^{-9}$	~300	–	4.41*	TE	[1225]
Si(110)[65]	–	–	–	300	–	4.47*	TC	[2097]
Si(110)[p434]	–	–	$\leq 5 \times 10^{-7}$	1500–1600	(4.38 ± 0.01)	4.69 ± 0.01	TE	[1472]
Si(110)[p434]	–	–	$\leq 5 \times 10^{-7}$	1600	(4.38)	4.70	TE	[1472]
Si(110)[p]	–	–	$<10^{-9}$	~300 (773)	–	4.70	CPD	[116,1771]
Si(110)	–	–	$<1 \times 10^{-10}$	~300 (1120)	–	4.73 ± 0.03	PE	[1491,3950]
Si(110)[n]	–	–	$\leq 2 \times 10^{-10}$	~300	–	4.75 ± 0.01	PE	[3184]
Si(110)[p]	–	–	$<10^{-9}$	~300 (1350)	–	4.85	CPD	[116]
Si(110)[65]	–	–	–	1000	–	4.86*	TC	[2097]
Si(110)[p]	–	–	$\leq 10^{-9}$	1300–1600	–	4.87 ± 0.06	TE	[1225]
Si(110)[p]	–	–	$<10^{-9}$	~300	–	4.89 ± 0.02	CPD	[116,1771]
Si(110)[p]	–	–	$<10^{-9}$	~300 (1350)	–	4.91	CPD	[116]
Si(110)[65]	–	–	–	1500	–	5.14*	TC	[2097]
Recommended	**–**	**–**	**–**	**–**	**4.36 ± 0.03**	**4.44 ± 0.24**	**–**	**–**
Si(111)[p432]	–	–	?	~1100–1150	–	3.2	TE	[3540]
Si(111)	–	–	–	–	–	4.0	TC	[1679,2219]
Si(111)[n66]	–	–	$\leq 1 \times 10^{-7}$	1340–1600	(4.86–4.90)	4.04 ± 0.05	TE	[72]
Si(111)[p66]	–	–	$\sim 10^{-9}$	1265–1500	–	4.05 ± 0.04	TE	[635]
Si(111)[p66]	–	–	1×10^{-7}	~1300–1600	(4.84, 4.86)	4.07 ± 0.05	TE	[73]
Si(111)	–	–	?	1080–1600	–	4.1 ± 0.1	TE	[1662]
Si(111)[n]	–	–	?	~300	–	4.15	CPD	[4368]
Si(111)[p432]	–	–	?	~1150–1450	–	4.2	TE	[3540]
Si(111)	–	–	?	>1300	–	4.20	TE	[1510]
Si(111)	–	–	4×10^{-10}	~300	–	4.40 ± 0.05	PE	[1181,1227]
Si(111)	–	–	–	–	–	4.44	TC	[2688]
Si(111)[n64]	K	K$^+$	7×10^{-9}	850–1550	4.44 ± 0.1	(4.55 ± 0.1)	PSI	[74]
Si(111)[n67]	–	–	$<5 \times 10^{-11}$	60	–	4.5	PE	[2893]
Si(111)	–	–	–	–	–	4.5	TC	[300]
Si(111)	–	–	5×10^{-11}	~300	–	4.50	PE	[2865,3461]
Si(111)	–	–	$<5 \times 10^{-11}$	~300	–	4.50 ± 0.02	PE	[3109]
Si(111)	–	–	2×10^{-10}	?	(5.00, 5.23)	4.51 ± 0.05	TE	[75]
Si(111)[p]	–	–	?	~300	–	4.52	PE	[1229]
Si(111)	–	–	4×10^{-10}	~300	–	4.52 ± 0.03	PE	[1552]
Si(111)	–	–	$<4 \times 10^{-10}$	400	–	4.53	PE	[3708]
Si(111)	–	–	$\leq 4 \times 10^{-11}$	~300	–	4.53	PE	[1429,1430,2733]
Si(111)[p]	–	–	1×10^{-10}	~300 (1000)	–	4.55 ± 0.1	PE	[118]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si(111)	–	–	2×10^{-10}	?	(4.81 ± 0.05)	4.55 ± 0.05	TE	[75]
Si(111)	–	–	1×10^{-10}	~300 (?)	–	4.55 ± 0.1	PE	[118]
Si(111)[n]	–	–	7×10^{-9}	~1200–1500	(4.44–4.99)	4.55 ± 0.1	TE	[74]
Si(111)[n68]	–	–	$<3 \times 10^{-11}$	~300 (550)	–	4.56 ± 0.02	PE	[1228]
Si(111)[p]	–	–	2×10^{-10}	?	(4.76 ± 0.05)	4.58 ± 0.05	TE	[75]
Si(111)[n]	–	–	2×10^{-10}	?	(4.78 ± 0.05)	4.59 ± 0.05	TE	[75]
Si(111)	–	–	2×10^{-11}	~300	–	4.595	PE	[3196]
Si(111)[n]	–	–	3×10^{-10}	~300	–	4.6	CPD	[1959]
Si(111)	–	–	$<5 \times 10^{-10}$	~300	–	4.6	PE	[2795]
Si(111)	–	–	1×10^{-10}	298	–	4.6	PE	[1900,1906]
Si(111)	–	–	$\sim10^{-10}$	~300	–	4.60	PE	[2972]
Si(111)	–	–	$<1 \times 10^{-10}$	~300 (1100)	–	4.60 ± 0.03	PE	[1491,3950]
Si(111)[p]	–	–	$<4 \times 10^{-10}$	~300	–	4.60	PE	[3282]
Si(111)[p69]	–	–	1×10^{-10}	~300 (1000)	–	4.60 ± 0.13	CPD	[118]
Si(111)[p69]	–	–	1×10^{-10}	~300 (?)	–	4.60 ± 0.13	CPD	[118]
Si(111)[p,n]	–	–	$<10^{-9}$	1335	–	4.62	CPD	[119]
Si(111)[n]	–	–	5×10^{-11}	~300	–	4.63	PE	[2150]
Si(111)[n]	Na	Na$^+$	2×10^{-10}	?	4.63 ± 0.05	(4.59 ± 0.05)	PSI	[75]
Si(111)	–	–	–	–	–	4.64	TC	[4461][490]
Si(111)[n67]	–	–	3×10^{-11}	60	–	4.65	PE	[2660]
Si(111)[n]	–	–	$<4 \times 10^{-10}$	~300	–	4.65	PE	[3282]
Si(111)[p]	–	–	$<10^{-9}$	~300 (773)	–	4.66	CPD	[116]
Si(111)[n]	–	–	?	~300	–	4.66 ± 0.05	PE	[2776]
Si(111)	–	–	–	–	–	4.667	TC	[4460][490]
Si(111)[p]	–	–	$<10^{-9}$	~300 (773)	–	4.67	CPD	[116,1771]
Si(111)[n63]	K	K$^+$	7×10^{-9}	~850–1550	4.69 ± 0.1	(4.55 ± 0.1)	PSI	[74]
Si(111)[p]	–	–	3×10^{-10}	~300	–	4.7	CPD	[1959]
Si(111)[p,n]	–	–	5×10^{-11}	~300	–	4.7	PE	[2623,2625]
Si(111)	–	–	3×10^{-11}	~300	–	4.7 ± 0.1	PE	[2951]
Si(111)	–	–	–	–	–	4.71	TC	[2444]
Si(111)[p,n]	–	–	$<10^{-9}$	1638	–	4.72	CPD	[119]
Si(111)[p]	–	–	$\sim10^{-10}$	~300 (1550)	–	4.72	PE	[902]
Si(111)	–	–	$\sim10^{-10}$	~300	–	4.72	CPD	[3696]
Si(111)[n425]	–	–	$<10^{-10}$	~300	–	4.73 ± 0.07	CPD	[117,118]
Si(111)[n425]	–	–	$<10^{-10}$	~300	–	4.73 ± 0.07	PE	[117,118]
Si(111)[n68]	–	–	$<3 \times 10^{-11}$	~300 (800)	–	4.74 ± 0.02	PE	[1228]
Si(111)[p]	–	–	$\sim10^{-10}$	~300	–	4.74 ± 0.03	PE	[1851]
Si(111)[p]	–	–	$\leq10^{-9}$	~300 (1550)	–	4.74 ± 0.05	CPD	[1225,1387]
Si(111)[n63]	Li	Li$^+$	7×10^{-9}	~1000–1550	4.75 ± 0.03	(4.55 ± 0.1)	PSI	[74]
Si(111)[p]	–	–	$<10^{-9}$	~300	–	4.76	CPD	[116]
Si(111)[n]	–	–	$\sim10^{-10}$	~300	–	4.76	PE	[1388]
Si(111)[n]	–	–	5×10^{-10}	~300	–	4.76 ± 0.03	CPD	[3043]
Si(111)[p]	Na	Na$^+$	2×10^{-10}	?	4.76 ± 0.05	(4.58 ± 0.05)	PSI	[75]
Si(111)[p]	–	–	$<10^{-9}$	~300	–	4.77 ± 0.02	CPD	[116,1771]
Si(111)[p]	–	–	$\sim10^{-10}$	~300 (1600)	–	4.77 ± 0.05	PE	[1384]
Si(111)[n]	Na	Na$^+$	2×10^{-10}	?	4.78 ± 0.05	(4.59 ± 0.05)	PSI	[75]
Si(111)[n426]	–	–	$\sim10^{-10}$	~300	–	$4.79 \pm 0.02^*$	PE	[1889]
Si(111)[n64]	Tl	Tl$^+$	7×10^{-9}	~900–1550	4.79 ± 0.03	(4.55 ± 0.1)	PSI	[74]
Si(111)	–	–	3×10^{-11}	~300	–	4.8 ± 0.1	PE	[2951]
Si(111)	–	–	–	–	–	4.8	TC	[2731]
Si(111)	–	–	$\sim10^{-10}$	130	–	4.8	PE	[1817]
Si(111)[p]	K	K$^+$	?	1280	4.80	(4.1 ± 0.1)	PSI	[272]
Si(111)[n]	–	–	$<10^{-10}$	~300	–	4.80 ± 0.03	CPD	[117]
Si(111)[n66]	–	–	$\leq1 \times 10^{-7}$	1340–1600	(4.86–4.90)	$4.80 \pm 0.04^*$	TE	[72]
Si(111)[n64]	Na	Na$^+$	7×10^{-9}	~850–1550	4.80 ± 0.04	(4.55 ± 0.1)	PSI	[74]
Si(111)[n63]	Na	Na$^+$	7×10^{-9}	~850–1550	4.81 ± 0.02	(4.55 ± 0.1)	PSI	[74]
Si(111)	Na	Na$^+$	2×10^{-10}	?	4.81 ± 0.05	(4.55 ± 0.05)	PSI	[75]
Si(111)	–	–	–	–	–	4.811	TC	[4460][490]
Si(111)	–	–	1×10^{-10}	~300	–	4.82	PE	[1226]
Si(111)[n−p425]	–	–	$<10^{-10}$	~300	–	4.83	CPD	[117]
Si(111)	–	–	$\sim10^{-10}$	~300	–	4.83	PE	[3696]
Si(111)[p]	–	–	$<8 \times 10^{-11}$	~300 (1030)	–	4.83	CPD	[301]
Si(111)[p]	–	–	$\leq8 \times 10^{-11}$	~300	–	4.83	PE	[1904]
Si(111)[n68]	–	–	$<3 \times 10^{-11}$	~300	–	4.83 ± 0.02	PE	[1228]
Si(111)[p410]	–	–	$\leq1 \times 10^{-7}$	~1300–1600	(4.85–4.88)	$4.83 \pm 0.04^*$	TE	[73]
Si(111)[p]	–	–	$\sim10^{-10}$	~300	–	4.83 ± 0.05	CPD	[1396,1971]
Si(111)[p]	–	–	1×10^{-10}	~300	–	4.83 ± 0.07	CPD	[117]
Si(111)[n64]	Li	Li$^+$	7×10^{-9}	~1000–1550	4.84 ± 0.03	(4.55 ± 0.1)	PSI	[74]
Si(111)[n]	Na	Na$^+$	2×10^{-10}	?	4.84 ± 0.05	–	PSI	[75]
Si(111)[p66]	–	–	1×10^{-7}	1490–1510	(4.88 ± 0.10)	4.84 ± 0.14	CPD	[73]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si(111)[p]	–	–	?	~300	–	4.85	PE	[1229,3719]
Si(111)[p]	–	–	$<5 \times 10^{-11}$	~300	–	4.85 ± 0.02	PE	[2019,3109,3699]
Si(111)[p]	–	–	$<10^{-10}$	~300	–	4.85 ± 0.03	CPD	[117]
Si(111)	–	–	$\sim10^{-10}$	~300	–	4.85 ± 0.04	PE	[2151]
Si(111)[n]	–	–	5×10^{-11}	~300	–	4.85 ± 0.05	CPD	[613,636,3270]
Si(111)[p66]	Cs	Cs^{+}	1×10^{-7}	~1100–1600	4.85 ± 0.08	(4.86 ± 0.11)	PSI	[73]
Si(111)[p]	–	–	8×10^{-11}	~300 (1080)	–	4.850 ± 0.030	CPD	[301]
Si(111)	–	–	1×10^{-10}	~300	–	4.86	PE	[1551,3281]
Si(111)[n]	Li	Li^{+}	$\leq1 \times 10^{-7}$	1150–1620	4.86 ± 0.07	(4.04 ± 0.05)	PSI	[72]
Si(111)[p66]	–	–	1×10^{-7}	1490–1510	(4.85 ± 0.08)	4.86 ± 0.11	CPD	[73]
Si(111)	–	–	$<4 \times 10^{-10}$	~300	–	4.87	PE	[1566,3279]
Si(111)[n–p]	–	–	5×10^{-11}	~300	–	4.87 ± 0.02	PE	[1230,3589,3819]
Si(111)[n]	Na	Na^{+}	$\leq1 \times 10^{-7}$	1150–1620	4.87 ± 0.03	(4.04 ± 0.05)	PSI	[72]
Si(111)	–	–	$<5 \times 10^{-10}$	~300	–	4.88	PE	[1694]
Si(111)[p66]	Cs	Cs^{+}	1×10^{-7}	~1100–1600	4.88 ± 0.10	(4.84 ± 0.14)	PSI	[73]
Si(111)	–	–	–	–	–	4.889	TC	[4425]
Si(111)[n]	–	–	?	~300	–	4.89	PE	[2752]
Si(111)[p424]	–	–	1×10^{-10}	~300	–	4.9	PE	[1226]
Si(111)[n]	Cs	Cs^{+}	2×10^{-10}	~300	4.9 ± 0.1*	–	CPD	[609]
Si(111)[p]	–	–	$\sim10^{-10}$	~300	–	4.90	PE	[1388]
Si(111)[n]	In	In[+]	$\leq1 \times 10^{-7}$	1290–1620	4.90 ± 0.10	(4.04 ± 0.05)	PSI	[72]
Si(111)	–	–	–	–	–	4.902	TC	[4424]
Si(111)[p]	–	–	$<10^{-10}$	~300	–	4.92 ± 0.07	CPD	[117]
Si(111)[p]	–	–	$<10^{-10}$	~300	–	4.92 ± 0.07	PE	[117]
Si(111)[p426]	–	–	$\sim10^{-10}$	~300	–	4.97 ± 0.02*	PE	[1889]
Si(111)[n63]	Tl	Tl[+]	7×10^{-9}	~900–1550	4.99 ± 0.05	(4.55 ± 0.1)	PSI	[74]
Si(111)[n424]	–	–	1×10^{-10}	~300	–	5.0	PE	[1226]
Si(111)/W(100)	Si	–	$<5 \times 10^{-10}$	298 (613)	–	5.0	CPD	[355]
Si(111)	Na	Na^{+}	2×10^{-10}	?	5.00 ± 0.05	(4.51)	PSI	[75]
Si(111)[p67]	–	–	3×10^{-11}	~300	–	5.05	PE	[2660]
Si(111)[n67]	–	–	3×10^{-11}	~300	–	5.05	PE	[2660]
Si(111)[p]	Na	Na^{+}	?	1280	5.05	(4.1 ± 0.1)	PSI	[272]
Si(111)	–	–	–	–	–	5.05 ± 0.1	TC	[3549,3740]
Si(111)[p]	Na	Na^{+}	?	1380	5.06	(4.1 ± 0.1)	PSI	[272]
Si(111)[p]	–	–	2×10^{-10}	~300	–	5.10	PE	[1971]
Si(111)[p]	–	–	$<10^{-10}$	~300	–	5.15 ± 0.08	PE	[117]
Si(111)	–	–	$<5 \times 10^{-9}$	~300	–	5.18	PE	[3714]
Si(111)[p424]	–	–	1×10^{-10}	~300	–	5.2	PE	[1226]
Si(111)	Li	Li^{+}	2×10^{-10}	?	5.23 ± 0.05	(4.51 ± 0.05)	PSI	[75]
Si(111)[p67]	–	–	$<5 \times 10^{-11}$	60	–	5.4	PE	[2893]
Si(111)[p,n]	–	–	$<10^{-10}$	~300	–	5.4	PE	[3333]
Si(111)[p67]	–	–	3×10^{-11}	60	–	5.56	PE	[2660]
Si(111)	–	–	–	–	–	5.92	TC	[3151]
Si(111)	–	–	–	–	–	6.45	TC	[3151]
Recommended	–	–	–	–	**4.83 ± 0.07**	**4.86 ± 0.09**	–	–
Si(112)[p70]	–	–	?	~1250–1400	–	3.86 ± 0.05	TE	[1500]
Si(112)[n70]	–	–	?	~1250–1400	–	3.92 ± 0.05	TE	[1500]
Si(112)[p70]	–	–	?	~1400–1625	–	4.10 ± 0.05	TE	[1500]
Si(112)[p]	–	–	$\sim10^{-9}$	1265–1500	–	4.22 ± 0.05	TE	[635]
Si(112)[n70]	–	–	?	~1400–1625	–	4.4 ± 0.1	TE	[1500]
Si(112)	–	–	–	–	–	5.11	TC	[1627]
Recommended	–	–	–	–	–	**4.1 ± 0.2**	–	–
Si(541)[p70]	–	–	?	~1250–1400	–	3.67 ± 0.05	TE	[1500]
Si(541)[n70]	–	–	?	~1250–1400	–	3.74 ± 0.05	TE	[1500]
Si(541)[p70]	–	–	?	~1400–1625	–	4.17 ± 0.05	TE	[1500]
Si(541)[n70]	–	–	?	~1400–1625	–	4.3 ± 0.1	TE	[1500]
Recommended	–	–	–	–	–	**4.0 ± 0.3**	–	–
Si(???)	–	–	? (Cs)	~1300	–	3.9	TE	[1468]
Si(???)	–	–	$\leq3 \times 10^{-10}$	~1300–1700	–	3.96	TE	[1397]
Si(???)	–	–	?	~1200–1300	–	4.0	TE	[1468]
Si(???)	–	–	5×10^{-10}	~300	–	4.88	AI[38]	[1103]
Si/Mo(100)	Si	–	$<1 \times 10^{-10}$	295	–	3.2	FE	[1675]
Si/Mo(112)	Si	–	$<1 \times 10^{-10}$	295	–	3.4	FE	[1675]
Si	–	–	?	~1250–1700	–	3.59 ± 0.1	TE	[113]
Si	–	–	?	?	–	3.6	TE	[3402]
Si/Mo	Si	–	6×10^{-11}	~300 (1000)	–	3.81	FE	[3343]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si/W(100)	Si	–	$<3 \times 10^{-10}$	295	–	3.91	FE	[1671]
Si/W(111)	Si	–	$<3 \times 10^{-10}$	295	–	3.98	FE	[1671]
Si	–	–	$\sim10^{-10}$	?	–	4.0–4.3	TE	[1478]
Si	–	–	?	$\sim$1373–1623	–	4.02 ± 0.02	TE	[1308]
Si(nanowire)[71]	–	–	?	$\sim$300	–	4.13	PE	[2200]
Si[p]	–	–	?	$\sim$300	–	4.13 ± 0.05	CPD	[1309]
Si/Ba/W(110)[72]	Si	–	$<5 \times 10^{-10}$	$\sim$300	–	4.2–4.6	FE	[2013]
Si/W(112)	Si	–	$<3 \times 10^{-10}$	295	–	4.21	FE	[1671]
Si/Mo	Si	–	$<1 \times 10^{-10}$	295	–	4.23	FE	[1675]
Si/W(100)	Si	–	$<1 \times 10^{-10}$	295	–	4.26	FE	[1671]
Si	–	–	$\sim10^{-9}$	1265–1500	–	4.30 ± 0.03	TE	[635]
Si	–	–	–	–	–	4.35	TC	[298]
Si	–	–	?	$\sim$300	–	4.37–4.67	PE	[3609]
Si	–	–	–	–	–	4.4	TC	[1955]
Si/Si(111)[73]	Si	–	$\sim10^{-11}$	77	–	4.4 ± 0.1	PE	[2822]
Si[n][441]	–	–	–	–	–	4.42–4.63	TC	[4119]
Si[p]	–	–	$<2 \times 10^{-6}$	523	–	4.5	CPD	[1310]
Si[n]	–	–	$<2 \times 10^{-6}$	523	–	4.5	CPD	[1310]
Si[n]	–	–	?	$\sim$300	–	4.5 ± 0.1	CPD	[1600]
Si	–	–	–	–	–	4.56	TC	[1901]
Si[p]	–	–	$<2 \times 10^{-6}$	1023	–	4.6	CPD	[1310]
Si[n]	–	–	$<2 \times 10^{-6}$	1023	–	4.6	CPD	[1310]
Si	–	–	$<10^{-10}$	?	–	4.6	TE	[1492]
Si/W[76]	Si	–	2×10^{-10}	77 ($\leq$640)	–	4.6	FE	[2248]
Si/W(111)	Si	–	$<1 \times 10^{-10}$	295	–	4.66	FE	[1671]
Si/Mo	Si	–	$<1 \times 10^{-10}$	295	–	4.7	FE	[1675]
Si/W(110)	Si	–	$\leq5 \times 10^{-10}$	$\sim$300	–	4.7	FE	[2013]
Si/Ta(100)	Si	–	$<5 \times 10^{-11}$	$\sim$300	–	4.7	CPD	[3776]
Si/W[74]	–	–	–	–	–	4.7	TC	[913,4344]
Si/CoSi$_2$(111)	Si	–	?	$\sim$300	–	4.70 ± 0.05	PE	[2169]
Si/Co/CoSi$_2$(111)[75]	Si	–	?	$\sim$300	–	4.70 ± 0.05	PE	[2169]
Si/W[74]	Si	–	$<1 \times 10^{-10}$	295	–	4.72 ± 0.05	FE	[1231]
Si/W	Si	–	5×10^{-11}	$\sim$300 ($\leq$950)	–	4.77	FE	[3094]
Si/W[76]	Si	–	2×10^{-10}	77 ($\leq$525)	–	4.78 ± 0.06*	FE	[2248]
Si(amorphized)	–	–	$<3 \times 10^{-11}$	$\sim$300	–	478 ± 0.15	AI	[4055]
Si/W	Si	–	$<5 \times 10^{-10}$	298	–	4.8	CPD	[355]
Si	–	–	–	–	–	4.8	TC	[1993]
Si/W(110)	Si	–	$<1 \times 10^{-9}$	293	–	4.80	CPD	[1520]
Si[p](porous)	–	–	$<5 \times 10^{-9}$	$\sim$300	–	4.80–5.70	CPD	[1602]
Si/Si/W	Si	–	5×10^{-11}	$\sim$300 ($\leq$950)	–	4.82	FE	[3094]
Si/W(100)	Si	–	$\leq5 \times 10^{-10}$	298	–	4.82	CPD	[355]
Si/W(110)	Si	–	?	$\sim$300	–	4.83	PE	[3448]
Si[n][465]	–	–	5×10^{-11}	$\sim$300	–	4.85	CPD	[613]
Si	–	–	5×10^{-10}	$\sim$300	–	4.88	AI[38]	[1103]
Si/W(111)	Si	–	$\sim10^{-10}$	$\sim$300	–	4.9	FE	[818]
Si/W(100)	Si	–	?	$\sim$300	–	4.9	FE	[1438]
Si/W(111)	Si	–	$<1 \times 10^{-10}$	295	–	4.94	FE	[1671,2350]
Si	–	–	–	–	–	5.0	TC	[706]
Si/W(111)	Si	–	$\sim10^{-10}$	$\sim$300	–	5.0 ± 0.1	FE	[2713]
Si/W(116)	Si	–	$\sim10^{-10}$	$\sim$300	–	5.0 ± 0.1	FE	[2713]
Si/W(012)	Si	–	$\sim10^{-10}$	$\sim$300	–	5.0 ± 0.1	FE	[2713]
Si/W(013)	Si	–	$\sim10^{-10}$	$\sim$300	–	5.0 ± 0.1	FE	[2713]
Si/W	Si	–	$<3 \times 10^{-10}$	77	–	5.0 ± 0.1	FE	[4015]
Si/W(100)	Si	–	$<1 \times 10^{-10}$	295	–	5.01	FE	[1671,2350]
Si/W(100)	Si	–	$\sim10^{-10}$	613	–	5.02	CPD	[355]
Si[p][441]	–	–	–	–	–	5.03–5.10	TC	[4119]
Si/W(110)	Si	–	$<1 \times 10^{-10}$	295	–	5.06	FE	[1671]
Si	–	–	–	–	–	5.08	TC	[1744]
Si/W	Si	–	$\leq10^{-10}$	$\sim$300	–	5.1 ± 0.1	FE	[2712]
Si	Cs	Cs$^+$	?	$\sim$300	5.14*	–	CPD	[611]
Si/W(116)	Si	–	$<1 \times 10^{-10}$	295	–	5.15	FE	[1671,2350]
Si/Mo(112)	Si	–	$<1 \times 10^{-10}$	295	–	5.17	FE	[1675]
Si	–	–	–	–	–	5.17	TC	[4285]
Si/W(112)	Si	–	$<1 \times 10^{-10}$	295	–	5.30	FE	[1671,2350]
Si/Mo(100)	Si	–	$<1 \times 10^{-10}$	295	–	5.37	FE	[1675]
Si/W(112)	Si	–	$<1 \times 10^{-10}$	295	–	5.40	FE	[1671]
Si(tip)	–	–	$\sim10^{-10}$	$\sim$300	–	5.46	FE	[3072]
Si/W(113)	Si	–	$<1 \times 10^{-10}$	295	–	5.82	FE	[1671,2350]
Si/W(110)	Si	–	$<1 \times 10^{-10}$	295	–	5.82	FE	[1671,2350]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Si/W(110)	Si	–	$<1 \times 10^{-10}$	295	–	5.90	FE	[1671]
Recommended	–	–	–	–	–	**4.65 ± 0.09**	–	–

15. Phosphorus P

P(111)	–	–	$\sim3 \times 10^{-10}$	~300	–	<1.34	CPD	[1681]
P(111)	–	–	$\sim3 \times 10^{-10}$	~300	–	1.41	CPD	[1681]
P	–	–	–	0	–	3.4–4.1	TC	[3034]
P	–	–	–	–	–	4.9	TC	[1905]
P	–	–	–	–	–	5.04	TC	[1901]
P	–	–	–	–	–	5.1	TC	[1955]
P/Fe(100)[427]	–	–	–	–	–	5.1*	TC	[4026]
Recommended	–	–	–	–	–	**5.0 ± 0.1**	–	–

16. Sulfur S

Film or Bulk (*α*, Rhombic, *T* < 370 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
S	–	–	–	0	–	3.9–4.5	TC	[3034]
S/Fe(110)	–	–	–	–	–	4.44	TC	[3236]
S/Fe(110)	–	–	–	–	–	4.66	TC	[3946,4337]
S/Fe(100)	–	–	–	–	–	4.71	TC	[4009]
S/Fe(110)[77]	–	–	–	–	–	4.98	TC	[4313]
S/Fe(110)[77]	–	–	–	–	–	4.999	TC	[4313]
S/Fe(100)[423]	–	–	–	–	–	5.0*	TC	[4019]
S/Ni	S_2	–	$\leq1 \times 10^{-10}$	77	–	5.0	FE	[1560]
S/Ni	S_2	–	$\leq1 \times 10^{-10}$	77 (530)	–	5.0	FE	[1560]
S/Si(100)	S_2	–	$<10^{-10}$	~300	–	5.0 ± 0.2*	CPD	[2890–2892]
S/Cu(111)	S_2	–	?	~470–870	–	5.067 ± 0.010	CPD	[948]
S/Cu(110)	S_2	–	?	~470–870	–	5.070 ± 0.010	CPD	[948]
S/Cu(210)	S_2	–	?	~470–870	–	5.075 ± 0.010	CPD	[948]
S/Cu(113)	S_2	–	?	~470–870	–	5.078 ± 0.010	CPD	[948]
S/Fe(110)[77]	–	–	–	–	–	5.08	TC	[4313]
S/Cu(112)	S_2	–	?	~470–870	–	5.083 ± 0.010	CPD	[948]
S/Ag(111)	S_2	–	?	~300	–	5.1*	CPD	[3118]
S/W	S_2	–	$<5 \times 10^{-10}$	~300 (≤770)	–	5.1	FE	[1524]
S/Ni	S_2	–	$<10^{-11}$	77	–	5.1	FE	[4017]
S/W(100)	S_2	–	$<2 \times 10^{-10}$	~300	–	5.1	CPD	[2854]
S/W(100)	S_2	–	$<2 \times 10^{-10}$	~300 (900)	–	5.1	CPD	[2854]
S/W(100)	H_2S	–	$<1 \times 10^{-10}$	~300 (900)	–	5.1	PE	[2669]
S/Ru(0001)	–	–	–	–	–	5.16	TC	[2554]
S/Cu(100)	S_2	–	?	~470–870	–	5.161 ± 0.010	CPD	[948]
S/Fe(110)	S_2	–	$\sim1 \times 10^{-10}$	~300 (1070)	–	5.2	PE	[1541]
S/W(310)	S_2	–	$\sim1 \times 10^{-10}$	~300 (570)	–	5.2	FE	[3438]
S/Fe(100)	–	–	–	–	–	5.2	TC	[1104]
S/Si(100)	–	–	–	–	–	5.2*	TC	[2062]
S/Mo(100)	H_2S	–	?	~300 (970)	–	5.2*	CPD	[3660]
S/Ru(001)	H_2S	–	$<2 \times 10^{-10}$	350	–	5.2 ± 0.2	PE	[2374]
S/Pd(111)[79]	S_2	–	?	550	–	5.20*	CPD	[2877]
S/Fe(100)[78]	–	–	2×10^{-9}	315 (970)	–	5.21 ± 0.03	PE	[565,3311]
S/Pd(111)[79]	S_2	–	?	~300	–	5.25*	CPD	[2877]
S/Fe(100)[78]	–	–	2×10^{-9}	315 (970)	–	5.26	PE	[565,3311]
S/Ni(110)	H_2S	–	$<1 \times 10^{-10}$	~300 (≥1070)	–	5.29	CPD	[1110]
S/W	S_2	–	0.1 (S_2)	~2200	–	5.3	TE	[394]
S/Fe(100)	–	–	–	–	–	5.3	TC	[1104]
S/Si(100)[n]	S_2	–	$\sim10^{-10}$	~300	–	5.30	PE	[4125]
S/Fe(100)	–	–	–	–	–	5.31	TC	[1708,1710]
S/Pd(111)[79]	S_2	–	?	100	–	5.31*	CPD	[2877]
S/Fe(100)	S_2	–	$<8 \times 10^{-11}$	673	–	5.33 ± 0.05*	CPD	[4324]
S/W(100)	S_2	–	$\sim1 \times 10^{-10}$	~300 (570)	–	5.4	FE	[3438]
S/W(111)	S_2	–	$\sim1 \times 10^{-10}$	~300 (570)	–	5.4	FE	[3438]
S/Ni(111)	H_2S	–	$<5 \times 10^{-10}$	~300 (~450)	–	5.4*	CPD	[1790]
S/Rh(100)	–	–	–	–	–	5.4 ± <0.2	TC	[1909]
S/Fe(100)	S_2	–	$<8 \times 10^{-11}$	~300	–	5.40 ± 0.05	CPD	[4324]
S/Ni(100)	H_2S	–	$<5 \times 10^{-10}$	~300 (~450)	–	5.45 ± 0.10*	CPD	[1790]
S/Fe(100)	–	–	–	–	–	5.47 ± 0.05*	TC	[4009]
S/W	S_2	–	$<5 \times 10^{-10}$	~300	–	5.5	FE	[1524]
S/W(110)	S_2	–	$<2 \times 10^{-10}$	~300	–	5.5	CPD	[2856]
S/W(110)	S_2	–	$<2 \times 10^{-10}$	~900	–	5.5	CPD	[2856]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
S/W	S_2	–	~10^{-5} (S_2)	~1700	–	5.5	TE	[394]
S/Fe(100)[427]	–	–	–	–	–	5.5	TC	[1104,4026]
S/Ni(100)	S_2	–	<10^{-10}	~300	–	5.5*	CPD	[2889]
S/Ni(100)	?	–	?	?	–	5.5 ± 0.1*	?	[3355]
S/Mo(100)	H_2S	–	≤10^{-5} (H_2S)	1450	–	5.5 ± 0.1	TE	[784]
S/Cu(111)	–	–	–	–	–	5.53*	TC	[2699]
S/Mo(100)	–	–	–	–	–	5.6	TC	[3457]
S/Ni(100)	?	–	?	?	–	5.6 ± 0.1*	?	[3355]
S/Ni(100)	–	–	–	–	–	5.65	TC	[1918]
S/Ni(111)	H_2S	–	<1×10^{-10}	~300 (≥1070)	–	5.65	CPD	[1110]
S/Ta(112)	–	–	<2×10^{-9}	~1300–1500	–	5.7	TE	[802]
S/Ni(100)	–	–	–	–	–	5.7 ± 0.1*	TC	[2976]
S	–	–	–	–	–	5.7 ± 0.1	TC	[1905]
S/Ni(100)	H_2S	–	<1×10^{-10}	~300 (≥1070)	–	5.73	CPD	[1110]
S	–	–	–	–	–	5.74	TC	[1901]
S/Fe(100)[423]	–	–	–	–	–	5.8*	TC	[4019]
S/Rh(111)	S_2	–	~10^{-10}	~300	–	6.0*	CPD	[1910]
S	–	–	–	–	–	6.0	TC	[1955]
S	–	–	–	–	–	6.02	TC	[3512]
S/W(110)	S_2	–	~1×10^{-10}	~300 (570)	–	6.2	FE	[3438]
S/Ag(111)	–	–	–	–	–	6.25*	TC	[2699]
S/Fe(100)[423]	–	–	–	–	–	6.5*	TC	[4019]
Recommended	–	–	–	–	–	**5.31 ± 0.08**	–	–

19. Potassium K

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K(100)	–	–	–	–	–	2.03	TC	[1254]
K(100)	–	–	–	–	–	2.21	TC	[231]
K(100)	–	–	–	–	–	2.214	TC	[2947]
K(100)	–	–	–	–	–	2.224	TC	[4091]
K(100)	–	–	–	–	–	2.25	TC	[2427]
K(100)	–	–	–	–	–	2.25	TC	[1159,3067]
K(100)	–	–	–	–	–	2.26	TC	[3467]
K(100)	–	–	–	–	–	2.27	TC	[553]
K(100)/KF(100)[80]	K	–	<5×10^{-10}	0^E	–	2.33 ± 0.05	PE	[2946]
K(100)	–	–	–	–	–	2.34	TC	[334]
K(100)	–	–	–	–	–	2.39	TC	[1547]
K(100)	–	–	–	–	–	2.40	TC	[475]
K(100)	–	–	–	–	–	2.43	TC	[711]
K(100)	–	–	–	–	–	2.49	TC	[321]
K(100)	–	–	–	–	–	2.50	TC	[1557]
K(100)	–	–	–	–	–	2.51	TC	[1030]
K(100)	–	–	–	–	–	2.55	TC	[3814]
K(100)	–	–	–	–	–	2.59	TC	[472]
K(100)	–	–	–	–	–	2.60	TC	[711]
K(100)	–	–	–	–	–	2.60	TC	[476]
K(100)	–	–	–	–	–	2.68	TC	[476]
K(100)	–	–	–	–	–	2.7	TC	[1088]
K(100)	–	–	–	–	–	2.71	TC	[1030]
K(100)	–	–	–	–	–	2.8	TC	[763]
K(100)	–	–	–	–	–	2.80	TC	[1095]
Recommended	–	–	–	–	–	**2.47 ± 0.04**	–	–
K(110)	–	–	–	–	–	2.13	TC	[2685]
K(110)	–	–	–	–	–	2.278	TC	[2947]
K(110)	–	–	–	–	–	2.35	TC	[1159,3067]
K(110)	–	–	–	–	–	2.37	TC	[231]
K(110)	–	–	–	–	–	2.372	TC	[4091]
K(110)	–	–	–	–	–	2.38	TC	[334,3179]
K(110)/glass	K	–	<5×10^{-9}	286–330	–	2.39 ± 0.01	PE	[2476]
K(110)/NaCl(100)[80]	K	–	<5×10^{-10}	0^E	–	2.41 ± 0.05	PE	[2946]
K(110)	–	–	–	–	–	2.42	TC	[2427]
K(110)	–	–	–	–	–	2.43	TC	[3467]
K(110)	–	–	–	–	–	2.44	TC	[553]
K(110)	–	–	–	–	–	2.57	TC	[1086]
K(110)	–	–	–	–	–	2.58	TC	[711]
K(110)	–	–	–	–	–	2.64	TC	[2835]
K(110)	–	–	–	–	–	2.7	TC	[1088]
K(110)	–	–	–	–	–	2.7	TC	[3137]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K(110)	–	–	–	–	–	2.7	TC	[1086]
K(110)	–	–	–	–	–	2.72	TC	[1030]
K(110)	–	–	–	–	–	2.74	TC	[1086]
K(110)	–	–	–	–	–	2.74	TC	[2402]
K(110)	–	–	–	–	–	2.75	TC	[476,711]
K(110)	–	–	–	–	–	2.75	TC	[475]
K(110)	–	–	–	–	–	2.75	TC	[2835]
K(110)	–	–	–	–	–	2.76	TC	[472]
K(110)	–	–	–	–	–	2.790	TC	[4069]
K(110)	–	–	–	–	–	2.80	TC	[593]
K(110)	–	–	–	–	–	2.82	TC	[476]
K(110)	–	–	–	–	–	2.83	TC	[1087]
K(110)	–	–	–	–	–	2.84	TC	[3693]
K(110)	–	–	–	–	–	2.86	TC	[3713]
K(110)	–	–	–	–	–	2.9	TC	[1088]
K(110)	–	–	–	–	–	2.9	TC	[1086]
K(110)	–	–	–	–	–	2.90	TC	[321]
K(110)	–	–	–	–	–	2.94	TC	[1086]
K(110)	–	–	–	–	–	2.95	TC	[1086]
K(110)	–	–	–	–	–	2.96	TC	[3814]
K(110)	–	–	–	–	–	2.97	TC	[3692]
K(110)	–	–	–	–	–	3.01	TC	[1030,1089]
K(110)	–	–	–	–	–	3.02	TC	[3693]
K(110)	–	–	–	–	–	3.03	TC	[3712]
K(110)	–	–	–	–	–	3.03	TC	[3713]
K(110)	–	–	–	–	–	3.06	TC	[1089]
K(110)	–	–	–	–	–	3.07	TC	[1086]
K(110)	–	–	–	–	–	3.09	TC	[1086]
K(110)	–	–	–	–	–	3.10	TC	[1089]
K(110)	–	–	–	–	–	3.15	TC	[1095]
K(110)	–	–	–	–	–	3.15	TC	[3692]
K(110)	–	–	–	–	–	3.2	TC	[763]
K(110)	–	–	–	–	–	5.14	TC	[3622]
Recommended	–	–	–	–	–	**2.74 ± 0.04**	–	–
K(111)/Au/Si(111)[419]	K	–	~10^{-10}	~300	–	2.0	PE	[3999]
K(111)	–	–	–	–	–	2.17	TC	[231]
K(111)	–	–	–	–	–	2.18	TC	[4091]
K(111)	–	–	–	–	–	2.19	TC	[553]
K(111)	–	–	–	–	–	2.21	TC	[3467]
K(111)	–	–	–	–	–	2.21	TC	[711]
K(111)	–	–	–	–	–	2.24	TC	[1159,3067]
K(111)	–	–	–	–	–	2.35	TC	[475]
K(111)	–	–	–	–	–	2.38	TC	[476,711]
K(111)	–	–	–	–	–	2.39	TC	[1030]
K(111)	–	–	–	–	–	2.39	TC	[321]
K(111)	–	–	–	–	–	2.40	TC	[593]
K(111)	–	–	–	–	–	2.40	TC	[3814]
K(111)	–	–	–	–	–	2.42	TC	[472]
K(111)	–	–	–	–	–	2.45	TC	[1030]
K(111)	–	–	–	–	–	2.47	TC	[1557]
K(111)	–	–	–	–	–	2.48	TC	[476]
K(111)	–	–	–	–	–	2.5	TC	[1088]
K(111)/C$_{12}$/Au/ Si(111)[419]	K	–	~10^{-10}	~300	–	2.66	PE	[3999]
K(111)	–	–	–	–	–	2.75	TC	[1095]
Recommended	–	–	–	–	–	**2.39 ± 0.02**	–	–
K(112)	–	–	–	–	–	2.65	TC	[321]
K	–	–	–	–	–	1.05	TC	[2704]
K/NiO(100)	K	–	<1×10^{-10}	~300	–	1.3 ± 0.2	CPD	[2401]
K/Si(100)	–	–	–	–	–	1.4*	TC	[2406]
K/Si(100)	K	–	<4×10^{-11}	~300	–	1.4*	PE	[3709]
K/Si(100)	–	–	–	–	–	1.5*	TC	[3665]
K/Ge(100)	K$^+$	–	1×10^{-10}	~300	–	1.5	CPD	[3423]
K/Si(100)	K	–	~10^{-11}	295	–	1.5*	PE	[2274,2276]
K/Si(100)	K	–	<3×10^{-10}	~300	–	1.50*	CPD	[1929]
K/Si(100)	K	–	<6×10^{-11}	~300	–	1.57*	CPD	[2433]
K/Si(111)[221]	K	–	~10^{-9}	~300	–	1.6*	PE	[1823]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K/Pt	K	–	?	~300	–	1.6	PE	[2206]
K/Si(100)	K	–	?	~300	–	1.6*	PE	[2994]
K/Si(111)	K	–	~10^{-11}	~300	–	1.6*	PE	[3685]
K	–	–	–	~300	–	1.6	TC	[3737]
K/Cu(100)	–	–	–	–	–	1.6*	TC	[3810]
K/Si(100)	K	–	5×10^{-11}	~300	–	1.6	PE	[1868,1869]
K/Si(100)	K	–	3×10^{-11}	~300	–	1.6	PE	[1872]
K	–	–	?	~300	–	1.60	CPD	[2297]
K/Pt	K	–	1×10^{-8}	273	–	1.61	CPD	[2083]
K/W	K	–	?	~300	–	1.66*	CPD	[1459]
K/Si(100)	K	–	$\leq 1 \times 10^{-10}$	~300	–	1.7	PE	[3191]
K/TiO$_2$(110)	K	–	4×10^{-11}	~300	–	1.70	PE	[2192]
K/Si(100)	K	–	$<3 \times 10^{-10}$	~300	–	1.70*	CPD	[1929]
K/Si(100)	–	–	–	–	–	1.75*	TC	[2399]
K/Si(100)	K	–	$<10^{-10}$	~300	–	1.75*	CPD	[2885]
K/Pt(111)	K	–	?	95	–	1.8	PE	[859]
K/Si(100)	K	–	?	~300	–	1.8*	PE	[2741]
K/Pt(111)	K	–	8×10^{-11}	~300	–	1.8	PE	[427,1584,2863]
K/W(100)	K	–	?	~300	–	1.8	PE	[1697]
K/TiO$_2$(110)	K	–	8×10^{-11}	~300	–	1.8	PE	[3188]
K/W(110)	K	–	$\leq 1 \times 10^{-10}$	~300	–	1.8	PE	[3191]
K/Si(111)	K	–	2×10^{-11}	~300	–	1.8	PE	[3196]
K/Si(111)	K	–	3×10^{-11}	~300	–	1.8*	CPD	[3470]
K/Si(111)	K	–	$<8 \times 10^{-11}$	~300	–	1.8*	PE	[2991]
K/Si(111)	K	–	4×10^{-10}	~300	–	1.8*	CPD	[2781]
K/Si(100)	K	–	5×10^{-11}	273	–	1.8*	PE	[2882]
K/Si(111)	K	–	?	~300	–	1.8*	CPD	[1587]
K/Si(100)	–	–	–	–	–	1.8*	TC	[2339]
K/Si(111)	K$^+$	–	1×10^{-10}	~300	–	1.80	CPD	[3423]
K/Ge(111)	K$^+$	–	1×10^{-10}	~300	–	1.82	CPD	[3422,3423]
K/Pt(111)	K	–	1×10^{-10}	~300	–	1.9	PE	[3989]
K/Si(100)	K	–	2×10^{-10}	~300	–	1.9*	CPD	[2785]
K/Si(100)	K	–	$<8 \times 10^{-11}$	250 (~300)	–	1.9*	PE	[2677]
K/Pt(111)	K	–	~10^{-10}	~300	–	1.9	PE	[1565]
K/Pt(111)	K	–	$\leq 1 \times 10^{-10}$	~300	–	1.9	PE	[3191]
K/W(110)	K	–	?	78 (400)	–	1.9	FE	[267,3818]
K/Si(111)	K	–	5×10^{-11}	~300	–	1.9*	PE	[3464,3465]
K/Rh(111)	–	–	–	–	–	1.925	TC	[4008]
K/W	K	–	?	375	–	1.95	FE	[3859]
K/Si(111)	K	–	$<6 \times 10^{-11}$	~300	–	1.96*	CPD	[2433]
K/TiO$_2$(110)	K	–	4×10^{-11}	~300	–	1.97	PE	[2192]
K/Au/Si(111)[419]	K	–	~10^{-10}	~300	–	2.0	PE	[3999]
K/Ni	K	–	~1×10^{-10}	78 (242)	–	2.0	FE	[1570]
K/Pd(111)	K	–	$<10^{-10}$	100 (450)	–	2.0	PE	[3817]
K/W(110)[81]	–	–	–	–	–	2.0	TC	[267,3818]
K/Si(100)	K	–	?	~300	–	2.0*	PE	[2741]
K/Co	K	–	?	320	–	2.0*	PE	[3373]
K/Pt(111)	K	–	2×10^{-10}	~300	–	2.0	PE	[3455]
K/ZrC(111)	K	–	$<4 \times 10^{-10}$	~300	–	2.0	PE	[2800]
K/Si(100)	–	–	–	–	–	2.0*	TC	[2224]
K/?	K	–	?	?	–	2.0	PE	[2231]
K/W(100)	K$^+$	–	~10^{-10}	~300	–	2.01	CPD	[506]
K	–	–	–	–	–	2.03	TC	[1254]
K/Pt	K	–	1×10^{-8}	195	–	2.03	CPD	[2083]
K/Ag(111)	K	–	4×10^{-10}	100	–	2.04	PE	[1579,2988]
K	–	–	–	–	–	2.05	TC	[1150]
K/W(110)[82]	K	–	$<1 \times 10^{-11}$	78	–	2.05*	FE	[373]
K	–	–	–	–	–	2.07	TC	[4031]
K/W(111)	K	–	~3×10^{-9}	~300	–	2.08	FE	[2766]
K	–	–	–	–	–	2.09	TC	[1951]
K	–	–	–	0	–	2.09	TC	[4419]
K/W(111)	K	–	?	78 (400)	–	2.1	FE	[267]
K/W(112)	K	–	?	78 (400)	–	2.1	FE	[267]
K/W	K	–	?	78 (400)	–	2.1	FE	[267]
K/NbC(100)	K	–	$<5 \times 10^{-10}$	~300	–	2.1	PE	[2796,2797]
K/W(111)	–	–	–	–	–	2.1	TC	[509]
K/Fe(110)	–	–	–	–	–	2.1*	TC	[3663]
K/Cu(110)	K	–	?	~300	–	2.1	PE	[1242]
K/Si(100)	K	–	4×10^{-10}	~300	–	2.1*	CPD	[2781]
K/Ag(100)	K	–	?	~300	–	2.10	PE	[2740]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K/Ag(111)	K	–	1×10^{-10}	~300	–	2.10	CPD	[2867]
K	–	–	–	–	–	2.11	TC	[1066]
K/Cu(100)	K	–	1×10^{-11}	123	–	2.11 ± 0.02	PE	[3900]
K/W(100)	K	–	3×10^{-9}	~300	–	2.12	FE	[2766]
K/Ag	K	–	?	20, 80	–	2.12	PE	[3028]
K/Ag/glass[83]	K	–	$<10^{-8}$	~300	–	2.12	CPD	[1456]
K/Cu(119)	K	–	1×10^{-11}	123	–	2.12 ± 0.02*	PE	[3900]
K	–	–	–	–	–	2.13	TC	[4031]
K/quartz	K	–	?	82	–	2.137 ± 0.003	PE	[1961]
K/W(112)	–	–	–	–	–	2.14*	TC	[2978]
K/Mo	K	–	$<1 \times 10^{-11}$	78	–	2.14	FE	[648]
K/Ge(100)	K	–	$<1 \times 10^{-10}$	78	–	2.14	FE	[1550,3164]
K/Rh(111)	–	–	–	–	–	2.149	TC	[4008]
K/W	K	–	$<10^{-11}$	78	–	2.15	FE	[267]
K/W(111)	K	–	$<1 \times 10^{-11}$	78	–	2.15 ± 0.05	FE	[373]
K/W	K	–	?	~300	–	2.15 ± 0.05	PE	[3797]
K/Ag/glass[83]	K	–	$<10^{-8}$	~300	–	2.16	CPD	[1456]
K/Ge(111)	K	–	$<1 \times 10^{-10}$	78	–	2.16	FE	[1550,3164]
K/GaAs(110)	K	–	$<1 \times 10^{-10}$	~300	–	2.16	CPD	[2793]
K/Ag(100)	K	–	8×10^{-11}	125–150	–	2.17	CPD	[2790]
K/Ag/glass[83]	K	–	$<10^{-8}$	~300	–	2.17 ± 0.05*	CPD	[1456]
K/quartz	K	–	?	206	–	2.177 ± 0.004	PE	[1960,1961]
K/W	K	–	3×10^{-9}	~300	–	2.18	FE	[2766]
K(fp)	–	–	?	279	–	2.18	PE	[4256]
K/Re	K	–	$<10^{-10}$	~300	–	2.18 ± 0.05	FE	[1800]
K	–	–	–	–	–	2.2	TC	[1955]
K/Si(100)	K	–	?	200	–	2.2	CPD	[2783]
K/W	K	–	?	295	–	2.2	FE	[3859]
K/Si(100)[422]	K	–	2×10^{-10}	~300	–	2.2	CPD	[4016]
K/Mg(0001)	–	–	–	–	–	2.2	TC	[2438]
K/Al(100)	K	–	1×10^{-10}	100	–	2.2	CPD	[2875]
K/W	K	–	$(<10^{-10})$	77	–	2.2	FE	[2709]
K/Ru(001)	K	–	?	~300	–	2.2*	CPD	[2984]
K/quartz	K	–	$\sim 10^{-10}$	90	–	2.2	PE	[2605]
K/C/Fe–Cu	K	–	$\sim 10^{-8}$	873–973	–	2.2	TE	[764]
K/Rh(111)	K	–	1×10^{-10}	~300	–	2.2	PE	[568,2282]
K/Fe(110)	K	–	1×10^{-10}	~300	–	2.2	PE	[1232]
K/TiO$_2$(100)	K	–	4×10^{-11}	~300	–	2.2 ± 0.1	PE	[1717]
K/Cu(100)	K	–	$<5 \times 10^{-11}$	120	–	2.2 ± 0.1*	CPD	[1819]
K/C(100)	K	–	$<2 \times 10^{-10}$	90, 300	–	2.2 ± 0.2*	CPD	[2197]
K/Ta(111)	K	–	$<1 \times 10^{-11}$	78	–	2.20	FE	[648]
K/Mo(100)	K	–	$<1 \times 10^{-11}$	78	–	2.20	FE	[648]
K/W	K	–	$<1 \times 10^{-11}$	78	–	2.20	FE	[373]
K/Ru(0001)	K	–	3×10^{-10}	295	–	2.20	CPD	[1822]
K	–	–	–	–	–	2.20	TC	[3725]
K/Ni	K	–	$\leq 4 \times 10^{-7}$	~300	–	2.20	PE	[1765]
K	–	–	–	–	–	2.21	TC	[3728]
K/W(112)	K	–	$\sim 3 \times 10^{-9}$	~300	–	2.21	FE	[2766]
K/W(100)	K	–	?	78	–	2.21	CPD	[3981]
K/quartz	K	–	?	~300	–	2.216 ± 0.004	PE	[1960,1961]
K/Ni	K	–	$<10^{-9}$	77	–	2.24	CPD	[2139,3128,3698]
K/W	K	–	$<5 \times 10^{-8}$	77 (400)	–	2.24	FE	[267,269]
K/Ag/glass	K	–	$\sim 10^{-8}$	~80	–	2.24	PE	[1452]
K/Ag/glass[83]	K	–	$<10^{-8}$	~300	–	2.24	CPD	[1456]
K/?	K	–	?	?	–	2.24	?	[3785]
K/W(112)	–	–	–	–	–	2.25	TC	[267]
K/Ru(001)	K	–	1×10^{-10}	100	–	2.25	PE	[529]
K/Pd(100)	K	–	?	80	–	2.25	PE	[3176]
K/Ru(1010)	K	–	3×10^{-10}	430	–	2.25	CPD	[2161]
K/Mo(112)	K	–	$<1 \times 10^{-11}$	78	–	2.25	FE	[648]
K/glass	K	–	$\sim 10^{-9}$	82	–	2.25	PE	[2576]
K/Ta	K	–	$<1 \times 10^{-11}$	78	–	2.26	FE	[648]
K/Si(100)	K	–	1×10^{-10}	70	–	2.26	PE	[2190]
K	–	–	?	~300	–	2.26	PE	[2614]
K/Re(001)	K	–	2×10^{-10}	100	–	2.26	CPD	[513,3378]
K/Si(100)	K	–	5×10^{-11}	60, 273	–	2.26	PE	[1715]
K/Ta(110)	K$^+$	–	$\sim 10^{-10}$	~300	–	2.26	CPD	[506]
K	–	–	10^{-9}	298	–	2.26	PE	[2612–2614]
K/Pt	K	–	2×10^{-6}	~300	–	2.26 ± 0.02	PE	[2562]
K/Cu(111)	K	–	5×10^{-11}	~300	–	2.26 ± 0.03	PE	[1926]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K	–	–	$\sim 10^{-9}$	335	–	2.27	PE	[4241]
K/metal	K	–	$\leq 4 \times 10^{-7}$	~300	–	2.27 ± 0.03	PE	[1765]
K/W(112)	K	–	$<1 \times 10^{-11}$	78	–	2.27 ± 0.05	FE	[373]
K	–	–	–	–	–	2.28	TC	[3477]
K	–	–	–	–	–	2.28	TC	[3352]
K(cluster)	–	–	–	–	–	2.28	TC	[3479]
K	–	–	–	–	–	2.28	TC	[4150]
$K_n (n \to \infty)$	–	–	?	~300	–	2.28	IP	[4161]
K(fp)[42]	–	–	?	?	–	2.28 ± 0.05	PE	[3482]
K/Pt(111)	K	–	$<3 \times 10^{-10}$	~300	–	2.29	PE	[2529]
K	–	–	$\sim 10^{-9}$	183	–	2.29	PE	[2612,2613]
K	–	–	–	–	–	2.29	TC	[3312]
$K_n (n \to \infty)$	–	–	–	–	–	2.29	TC	[4244]
K/graphite[464]	–	–	–	–	–	2.29*	TC	[4211]
$K_n (n \to \infty)$	–	–	?	195–395	–	2.29	PE	[4227]
K[156]	–	–	$<10^{-8}$	298	–	2.29 ± 0.03	PE	[2470,4208]
K/glass	K	–	$\leq 5 \times 10^{-9}$	298	–	2.29 ± 0.015	PE	[2476]
K/W	K	–	?	4.2, 21	–	2.3	FE	[3065]
K/Ni(111)	K	–	5×10^{-11}	120	–	2.3*	CPD	[3806]
K/Mo(112)	–	–	–	–	–	2.3	TC	[509]
K	–	–	–	–	–	2.3	TC	[706]
K/?	K	–	$<8 \times 10^{-11}$	77	–	2.3	PE	[3675]
K/Ni(100)	K	–	2×10^{-10}	120	–	2.3	PE	[2505]
K/Si(100)[422]	K	–	2×10^{-10}	~300	–	2.3*	CPD	[4016]
K/Al(111)	–	–	–	–	–	2.3	TC	[2223]
K/Fe(111)	K	–	$<10^{-10}$	~300	–	2.3*	CPD	[1865,2497]
K/Au(100)	K	–	$\sim 10^{-10}$	130, 300	–	2.3	CPD	[3202]
K/Ru(001)	K	–	5×10^{-11}	80	–	2.3	CPD	[1815]
K/Re(1010)	K	–	$\leq 10^{-11}$	77	–	2.3	CPD	[2503]
K	–	–	–	–	–	2.3	TC	[1993]
K/Rh(100)	K	–	$<1 \times 10^{-10}$	100	–	2.3	CPD	[3456]
K/Cu(110)	K	–	5×10^{-11}	140	–	2.3 ± 0.1	PE	[3454]
K/Cu, Ag	K	–	2×10^{-8}	~300	–	2.3 ± 0.1	PE	[3081]
K/C(0001)	K	–	3×10^{-10}	83–160	–	2.3 ± 0.1	CPD	[2801][488]
K/Ta(100)	K	–	$<1 \times 10^{-11}$	78	–	2.30	FE	[648]
K/Ta(112)	K	–	$<1 \times 10^{-11}$	78	–	2.30	FE	[648]
K	–	–	–	–	–	2.30	TC	[3467]
$K_n (n \to \infty)$	–	–	?	~300	–	2.30	IP,TC	[4197]
$K_n (n \to \infty)$	–	–	–	–	–	2.30	TC	[4244]
K/Pt	K	–	1×10^{-8}	85	–	2.30	CPD	[2083]
K/Mo	K	–	$\sim 10^{-10}$	~300	–	2.30 ± 0.02	PE	[3337]
K/Fe(110)	K	–	5×10^{-11}	~300	–	2.32 ± 0.03	PE	[1926]
K	–	–	–	–	–	2.33	TC	[298]
K/W(100)	K	–	$<1 \times 10^{-11}$	78	–	2.34	FE	[373]
K/graphite	–	–	–	–	–	2.35*	TC	[1843]
K/NbC(111)	K	–	$\leq 1 \times 10^{-10}$	~300	–	2.35	PE	[2797]
K/graphite[464]	–	–	–	–	–	2.36	TC	[4211]
K/Au(100)	K	–	$\sim 10^{-11}$	130, 300	–	2.37	CPD	[2746]
K/Mo	K	–	$\sim 10^{-10}$	80 (293)	–	2.38	PE	[3337]
K	–	–	–	–	–	2.38	TC	[3312]
K	–	–	–	–	–	2.38	TC	[4031]
K/Mo(112)	K	–	$(\leq 10^{-11})$	77	–	2.38	CPD	[2031]
K/glass	K	–	$\leq 3 \times 10^{-11}$	77	–	2.38 ± 0.01	PE	[2615]
K/glass	K	–	$\sim 10^{-10}$	77	–	2.39 ± 0.01	PE	[1481,1489]
K/Si(111)	K	–	3×10^{-10}	90	–	2.4*	PE	[2801]
K/Cu(111)	K	–	3×10^{-10}	90	–	2.4*	PE	[2801]
K/Au(111)	K	–	?	~300	–	2.4	PE	[1297]
K/cnt/Al_2O_3	K	–	5×10^{-8}	~300 (340)	–	2.4	PE	[4373]
K/Ni	K	–	$\sim 1 \times 10^{-10}$	78 (242)	–	2.4*	FE	[1570]
K/Re(1010)	K	–	$(\leq 1 \times 10^{-10})$	~300	–	2.4	CPD	[2490]
K/Ni(100)	K	–	?	20	–	2.4*	PE	[3662]
K/Ni(100)	K	–	?	20 (150)	–	2.4*	PE	[3662]
K/Ag(111)	K	–	1×10^{-10}	≤ 300	–	2.4	CPD	[1907]
K/Cu(100)	K	–	?	110	–	2.4*	PE	[3155]
K/Ta(100)	–	–	–	–	–	2.4	TC	[509]
K/Al(111)	K	–	?	100	–	2.4*	PE	[3629]
K/Si(100)ⁿ	K	–	8×10^{-11}	55, 273	–	2.4	PE	[2668]
K/Ru(001)	K	–	$<2 \times 10^{-10}$	85	–	2.4	CPD	[2176]
K/Cu(111)	K	–	$\sim 10^{-11}$	~300	–	2.4*	PE	[1825]
K/Ru(001)	K	–	$\sim 1 \times 10^{-10}$	85	–	2.4	CPD	[1818]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K/Rh(111)	K	–	$\leq 5 \times 10^{-10}$	45	–	2.4	PE	[1128]
K/Pd(100)	K	–	$<2 \times 10^{-10}$	250	–	2.4*	CPD	[1574]
K/Ru(001)	K	–	4×10^{-11}	120	–	2.4*	PE	[2886]
K/Ru(001)[84]	K	–	$<8 \times 10^{-11}$	130	–	2.4	PE	[528]
K/Rh(111)	K	–	1×10^{-10}	50 (845)	–	2.4	PE	[1204]
K/W	K	–	$<1 \times 10^{-11}$	78	–	2.4 ± 0.05	FE	[373]
K/Ni(100)	K	–	$\sim 10^{-10}$	~ 300	–	2.4 ± 0.1*	CPD	[1411]
K/Si(100)	–	–	–	–	–	2.4 ± 0.2*	TC	[1702]
K/Cu(111)	K	–	$<5 \times 10^{-10}$	~ 300	–	2.40	CPD	[2517,3459]
K/W(100)	K	–	?	78	–	2.40	FE	[373]
K/Mo(111)	K	–	$<1 \times 10^{-11}$	78	–	2.40	FE	[648]
K(fp, $r \to \infty$)[460]	–	–	?	~ 300	–	2.40*	IP	[4198]
K/glass	K	–	$\leq 3 \times 10^{-11}$	195	–	2.40 ± 0.01	PE	[2615]
K	–	–	–	–	–	2.42	TC	[4441]
K/glass	K	–	$\leq 3 \times 10^{-11}$	195	–	2.43 ± 0.01	PE	[2615]
K/Cu(111)	K	–	$<8 \times 10^{-11}$	90–100	–	2.44	CPD	[2191]
K	–	–	–	–	–	2.45	TC	[231]
K/C(0001)[85]	K	–	$<2 \times 10^{-10}$	83	–	2.45 ± 0.15	PE	[2193]
K/W(112)	K	–	?	78	–	2.48	CPD	[658]
K	–	–	–	–	–	2.48	TC	[2061]
K	–	–	–	–	–	2.49	TC	[1924]
K/Ta(110)	–	–	–	–	–	2.5*	TC	[3663]
K/C(0001)[85]	K	–	$\sim 10^{-10}$	83	–	2.5*	PE	[1725]
K/Si(111)	K	–	5×10^{-11}	77	–	2.5*	PE	[3465]
K/Au(100)	K	–	$\sim 10^{-10}$	100	–	2.5	CPD	[3173]
K/Au(100)	K	–	$\sim 8 \times 10^{-10}$	~ 300	–	2.5*	CPD	[2792]
K/Ni(100)	K	–	$\sim 1 \times 10^{-11}$	~ 300	–	2.5*	CPD	[1413]
K/Cu(111)	K	–	3×10^{-10}	85, 160	–	2.5*	PE	[2801]
K/Re(1010)	K	–	$(\leq 1 \times 10^{-10})$	245	–	2.5	CPD	[2490]
K/W(112)	K	–	$(<10^{-11})$	245	–	2.5	CPD	[658]
K	–	–	–	–	–	2.50	TC	[553,2427]
K	–	–	–	–	–	2.50	TC	[3477]
K(fp, $r \to \infty$)[460]	–	–	?	~ 300	–	2.50*	IP	[4198]
K/Mo(110)	K	–	$<1 \times 10^{-11}$	78	–	2.50	FE	[648]
K	–	–	–	–	–	2.51	TC	[231]
$K_n(n \to \infty)$	–	–	?	?	–	2.52	IP	[4227]
K	–	–	–	–	–	2.53	TC	[1924]
K/W(110)	K	–	$\sim 3 \times 10^{-9}$	~ 300	–	2.54	FE	[2766]
K/Fe(100)	K	–	?	~ 300	–	2.55	PE	[1709]
K	–	–	–	–	–	2.55	TC	[738]
K/W(110)[82]	K	–	$<1 \times 10^{-11}$	78	–	2.55 ± 0.05	FE	[373]
K	–	–	–	–	–	2.56	TC	[3467]
K	–	–	–	–	–	2.56	TC	[2427]
K	–	–	–	–	–	2.58	TC	[1901]
K	–	–	–	–	–	2.58	TC	[4101]
K/Si(111)	K	–	5×10^{-11}	77	–	2.6*	PE	[3465]
K/Ag(111)	K	–	$<1 \times 10^{-10}$	~ 300	–	2.6	CPD	[1426]
K/Si(100)	K	–	8×10^{-10}	~ 300	–	2.6*	CPD	[3278]
K/Ag(111)	K	–	?	100	–	2.6*	CPD	[3569]
K	–	–	–	–	–	2.6	TC	[2845]
K/Co(0001)	K	–	$\sim 10^{-10}$	200	–	2.6 ± 0.3	PE	[3381]
K/Ta(110)	K	–	$<1 \times 10^{-11}$	78	–	2.60	FE	[648]
K/Al(111)	K	–	?	140	–	2.61	CPD	[734]
K/Al(111)	K	–	?	~ 300	–	2.61	CPD	[734]
K	–	–	–	–	–	2.62	TC	[1613]
K	–	–	–	–	–	2.62	TC	[2382]
K/graphite	–	–	–	–	–	2.63*	TC	[1843]
K/W	K	–	? (K)	~ 750–950	–	2.65	TE	[2292]
K/Cu(332)	K	–	$<2 \times 10^{-10}$	95	–	2.65*	PE	[1604]
K/C_{12}/Au/Si(111)[419]	K	–	$\sim 10^{-10}$	~ 300	–	2.66	PE	[3999]
K/Cu(100)	K	–	$<5 \times 10^{-10}$	~ 300	–	2.67*	CPD	[1431]
K	–	–	–	–	–	2.67	TC	[1578]
K	–	–	–	–	–	2.68	TC	[2629]
K	–	–	–	–	–	2.69	TC	[767]
K/Au(001)	K	–	$\sim 8 \times 10^{-10}$	~ 100	–	2.7*	CPD	[2792]
K/Pt(111)	K	–	1×10^{-11}	~ 300 (>500)	–	2.7	FE	[3227]
K	–	–	–	–	–	2.74	TC[3]	[475,519,2474]
K	–	–	–	–	–	2.74	TC	[230]
K	–	–	–	–	–	2.76	TC	[521]
K	–	–	–	–	–	2.76	TC	[3628]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
K	–	–	–	–	–	2.8	TC	[944]
K/Ni(100)	K	–	?	40	–	2.8 ± 0.1*	?	[2047]
K/graphite	K	–	4×10^{-10}	90	–	<2.9 ± 0.2	CPD	[2185]
K/Si(111)	–	–	–	–	–	2.9	TC	[300]
K/cnt[86]	K	–	8×10^{-10}	~300	–	3.3	PE	[3229]
K	–	–	–	–	–	3.30	TC	[2629]
K/C(100)	–	–	–	–	–	3.62*	TC	[2759]
K	–	–	–	–	–	3.71	TC	[3080]
K/cnt	K	–	$<2 \times 10^{-7}$	?	–	3.99	FE	[2201]
Recommended	–	–	–	–	–	**2.29 ± 0.02**	–	–
Liquid ($T > 337$ K)								
K	–	–	$\sim 10^{-9}$	338	–	2.27	PE	[4241]
K	–	–	$\leq 5 \times 10^{-9}$	338	–	2.30 ± 0.015	PE	[2476]
K[156]	–	–	$<10^{-8}$	338	–	2.30 ± 0.03	PE	[2470]

20. Calcium Ca

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
fcc (α, $T < 523$ K)								
Ca(100)	–	–	–	–	–	2.55	TC	[1254]
Ca(100)	–	–	–	–	–	2.758	TC	[4091]
Ca(100)	–	–	–	–	–	2.87	TC	[4222]
Ca(100)	–	–	–	–	–	2.9	TC	[3653]
Ca(100)	–	–	–	–	–	2.9	TC	[1711]
Ca(100)	–	–	–	–	–	2.94	TC	[231]
Ca(100)	–	–	–	–	–	2.97	TC	[3467]
Ca(100)	–	–	–	–	–	3.38	TC	[476]
Ca(100)	–	–	–	–	–	3.52	TC	[476]
Ca(100)	–	–	–	–	–	3.57	TC	[1030]
Ca(100)	–	–	–	–	–	3.96	TC	[1030]
Ca(100)	–	–	–	–	–	4.09	TC	[321]
Recommended	–	–	–	–	–	**3.4 ± 0.4**	–	–
Ca(110)	–	–	–	–	–	2.813	TC	[4091]
Ca(110)	–	–	–	–	–	2.83	TC	[4222]
Ca(110)	–	–	–	–	–	2.92	TC	[231]
Ca(110)	–	–	–	–	–	2.92	TC	[3467]
Ca(110)	–	–	–	–	–	3.20	TC	[1030]
Ca(110)	–	–	–	–	–	3.29	TC	[476]
Ca(110)	–	–	–	–	–	3.41	TC	[476]
Ca(110)	–	–	–	–	–	3.43	TC	[1030]
Ca(110)	–	–	–	–	–	3.84	TC	[321]
Recommended	–	–	–	–	–	**3.3 ± 0.3**	–	–
Ca(111)	–	–	–	–	–	2.86	TC	[334,3179]
Ca(111)	–	–	–	–	–	2.936	TC	[4091]
Ca(111)	–	–	–	–	–	2.98	TC	[4215]
Ca(111)	–	–	–	–	–	2.98	TC	[4222]
Ca(111)	–	–	–	–	–	3.10	TC	[231]
Ca(111)	–	–	–	–	–	3.14	TC	[3467]
Ca(111)	–	–	–	–	–	3.26	TC	[2427]
Ca(111)	–	–	–	–	–	3.35	TC	[476]
Ca(111)	–	–	–	–	–	3.4	TC	[1711]
Ca(111)	–	–	–	–	–	3.4	TC	[3653]
Ca(111)	–	–	–	–	–	3.49	TC	[476]
Ca(111)	–	–	–	–	–	3.68	TC	[1030,1089]
Ca(111)	–	–	–	–	–	3.70	TC	[1030]
Ca(111)	–	–	–	–	–	3.76	TC	[1089]
Ca(111)	–	–	–	–	–	3.91	TC	[1089]
Ca(111)	–	–	–	–	–	4.40	TC	[321]
Recommended	–	–	–	–	–	**3.5 ± 0.2**	–	–
bcc (γ, $T > 723$ K)								
Ca(100)	–	–	–	–	–	3.52	TC	[321]
Ca(110)	–	–	–	–	–	2.84	TC	[334]
Ca(110)	–	–	–	–	–	4.09	TC	[321]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ca(111)	–	–	–	–	–	3.37	TC	[321]
Ca(112)	–	–	–	–	–	3.75	TC	[321]
fcc (α, T < 523 K for bulk)								
Ca	–	–	–	–	–	2.1	TC	[2845]
Ca/silica[87]	Ca	–	~10^{-11}	~300	–	2.2	PE	[1418]
Ca/?	Ca	–	<10^{-6}	?	–	2.24	TE	[2919]
Ca[174]	–	–	–	0^E	–	2.24	TC	[1747]
Ca	–	–	–	–	–	2.35	TC	[1744]
Ca/W	Ca	–	≤1 × 10^{-9}	~300 (670)	–	2.4	FE	[2587]
Ca/?	Ca	–	?	~300	–	2.42	PE	[3027]
Ca	–	–	–	–	–	2.50	TC	[2704]
Ca	–	–	–	–	–	2.53	TC	[3476]
Ca	–	–	–	–	–	2.55	TC	[1254]
Ca/silica[87]	Ca	–	~10^{-11}	~300	–	2.55	PE	[1418]
Ca	–	–	–	–	–	2.6	TC	[1955]
Ca	–	–	–	–	–	2.64	TC	[3476]
Ca/glass	Ca	–	?	~300	–	2.66	PE	[2924]
Ca	–	–	?	298	–	2.66 ± 0.07	PE	[3394]
Ca/Ir	Ca	–	≤1 × 10^{-9}	~300 (770)	–	2.7 ± 0.1	FE	[2587]
Ca	–	–	–	–	–	2.70	TC	[1066]
Ca/glass	Ca	–	?	298	–	2.706 ± 0.004	PE	[2232]
Ca	–	–	–	–	–	2.75	TC	[3318]
Ca/W	Ca	–	<2 × 10^{-9}	~300	–	2.75 ± 0.05	FE	[1687]
Ca	–	–	~10^{-6}	298	–	2.76	PE	[3389,3394]
Ca	–	–	–	–	–	2.78	TC	[298]
Ca	–	–	–	–	–	2.80	TC	[2949]
Ca/W[244]	Ca	–	≤2 × 10^{-9}	~900	–	2.84	CPD	[3530]
Ca	–	–	–	–	–	2.87	TC	[4418]
Ca/quartz	Ca	–	<5 × 10^{-10}	~300	–	2.87 ± 0.06	PE	[1997,1998,2024]
Ca/graphite	Ca	–	~10^{-9}	~300	–	2.89	CPD	[2957]
Ca/Mo	Ca	–	~10^{-9}	~300	–	2.89	CPD	[2957]
Ca	–	–	–	–	–	2.9	TC	[1993]
Ca/Cu(100)	Ca	–	~1 × 10^{-11}	110, 300	–	2.9	CPD	[2997]
Ca/Cu	Ca	–	<2 × 10^{-9}	~300	–	2.9	PE	[2332]
Ca/?	Ca	–	<8 × 10^{-11}	~300	–	2.9 ± 0.1	CPD	[3868]
Ca/W[244]	Ca	–	≤2 × 10^{-9}	~300	–	2.90	CPD	[3530]
Ca	–	–	–	–	–	2.91	TC	[3476]
Ca/Re	Ca	–	<8 × 10^{-11}	~300	–	2.92	CPD	[342]
Ca/graphite	Ca	–	~10^{-9}	~300	–	2.95	CPD	[2957]
Ca/silica[87]	Ca	–	~10^{-11}	~300	–	2.98 ± 0.05	PE	[1418]
Ca/glass[88]	Ca	–	<10^{-9}	~300{77}	–	3.0	CPD	[1526]
Ca/Ir	Ca	–	≤1 × 10^{-9}	~300 (770)	–	3.0 ± 0.1	FE	[2587]
Ca	–	–	–	–	–	3.00	TC	[3931]
Ca	–	–	–	–	–	3.01	TC	[3467]
Ca/quartz	Ca	–	~10^{-9}	~300	–	3.06	CPD	[2957]
Ca/graphite	Ca	–	~10^{-9}	~300	–	3.06	CPD	[2957]
Ca	–	–	?	~300	–	3.08	PE	[2080]
Ca	–	–	–	–	–	3.08	TC	[231]
Ca/W	Ca	–	~2 × 10^{-9}	~300	–	3.1	CPD	[3259]
Ca/Pt	Ca	–	?	~1200	–	3.1	TE	[4266]
Ca	–	–	–	–	–	3.1	TC	[706]
Ca	–	–	–	–	–	3.11	TC	[521]
Ca	–	–	–	–	–	3.13	TC	[3729]
Ca/Mo[89]	Ca$^+$	–	<1 × 10^{-9}	~300	–	3.13	PE	[2211]
Ca	–	–	–	–	–	3.15	TC	[1578]
Ca	–	–	–	–	–	3.19	TC	[231]
Ca	–	–	–	–	–	3.2	TC	[3030]
Ca/Ni	Ca	–	?	~300	–	3.20	PE	[2922]
Ca/Ta	Ca	–	~10^{-7}	~300	–	3.21	PE	[2463]
Ca	–	–	–	–	–	3.24	TC	[3467]
Ca/Mo[89]	Ca$^+$	–	<1 × 10^{-9}	~300	–	3.26	PE	[2211]
Ca	–	–	–	–	–	3.28	TC	[1613]
Ca	–	–	–	–	–	3.30	TC	[2629]
Ca	–	–	?	~300	–	3.33	CPD	[2297]
Ca	–	–	–	–	–	3.39	TC	[2474]
Ca/quartz	Ca	–	5 × 10^{-10}	~300	–	3.7 ± 0.3	PE	[2003,2008]
Recommended	–	–	–	–	–	**2.91 ± 0.03**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				21. Scandium Sc[399]				
hcp (α, $T < 1660$ K)								
Sc(0001)	–	–	–	–	–	2.1	TC	[1090]
Sc(0001)	–	–	–	–	–	3.39	TC	[4461][490]
Sc(0001)	–	–	–	–	–	3.556	TC	[4460][490]
Sc(0001)	–	–	–	–	–	3.74	TC	[229,334,3179]
Sc(0001)/W(110)[90]	Sc	–	$\leq 1 \times 10^{-9}$	~300	–	3.8	CPD	[1982]
Sc(0001)	–	–	–	–	–	3.81	TC	[4005]
Sc(0001)	–	–	–	–	–	4.81	TC	[321]
Sc(1010)	–	–	–	–	–	3.10	TC	[4005]
Sc(1010)	–	–	–	–	–	3.35	TC	[4461][490]
Sc(1010)	–	–	–	–	–	3.563	TC	[4460][490]
Sc(1010)	–	–	–	–	–	3.772	TC	[4460][490]
Sc(1010)	–	–	–	–	–	4.60	TC	[321]
Sc(1124)	–	–	–	–	–	4.03	TC	[321]
fcc (β, $T > 1660$ K)								
Sc(100)	–	–	–	–	–	4.39	TC	[321]
Sc(110)	–	–	–	–	–	4.13	TC	[321]
Sc(111)	–	–	–	–	–	3.84	TC	[229,334]
Sc(111)	–	–	–	–	–	4.73	TC	[321]
hcp (α, $T < 1660$ K for bulk)								
Sc/W[91]	Sc	–	1×10^{-10}	~300 (≤ 1300)	–	2.8	FE	[1811]
Sc/W[91]	Sc	–	1×10^{-10}	~300 (≤ 1300)	–	2.9	FE	[1811]
Sc	–	–	–	–	–	2.9	TC	[1744]
Sc/W(100)	–	–	–	–	–	3.0	TC	[4258]
Sc/W	Sc	–	$\leq 7 \times 10^{-8}$	~300	–	3.0	FE	[1804]
Sc/Mo	Sc	–	$\leq 7 \times 10^{-8}$	~300	–	3.1	FE	[1804]
Sc/W(111)	Sc	–	($<10^{-10}$)	77	–	3.1 ± 0.1	FE	[3323]
Sc	–	–	–	–	–	3.15	TC	[3318]
Sc/W(111)	Sc	–	$\leq 10^{-8}$	~1100–1150	–	3.17 ± 0.03	TE	[2337]
Sc/W(111)	Sc	–	$\sim 10^{-9}$	~300	–	3.2	FE	[2011]
Sc[379]	–	–	–	–	–	3.2	TC	[1955]
Sc/W(100)	Sc	–	1×10^{-9}	~300	–	3.2	CPD	[1985]
Sc	–	–	–	–	–	3.23	TC	[1956]
Sc(foil)[255]	–	–	$<10^{-7}$	1300	–	3.23	TE	[3071]
Sc/W(112)	Sc	–	?	~300	–	3.26	CPD	[4011]
Sc	–	–	? (N_2)	~300	–	3.28 ± 0.02	CPD	[4066]
Sc	–	–	–	–	–	3.29	TC	[3476]
Sc[160]	–	–	–	–	–	3.3	TC	[1355]
Sc/W	Sc	–	1×10^{-9}	~300	–	3.3	CPD	[3617,4447]
Sc/Nb	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/Ta	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/Ru	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/Os	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/Ir	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/Nb(110)	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Sc/W(100)	Sc	–	($<10^{-10}$)	77	–	3.3 ± 0.1	FE	[3323]
Sc	–	–	–	–	–	3.30*	TC	[1955]
Sc/Re	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.32 ± 0.03	TE	[2359]
Sc	–	–	–	–	–	3.33	TC	[1066]
Sc/Mo	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.34 ± 0.03	TE	[2359]
Sc/W	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.34 ± 0.03	TE	[2359]
Sc/W(100)	Sc	–	$\sim 10^{-10}$	~300 (≤ 1070)	–	3.36	CPD	[2528]
Sc	–	–	–	–	–	3.39	TC	[3476]
Sc	–	–	–	–	–	3.4	TC	[3318]
Sc/Re–Sc(9%)[92]	–	–	?	1200	–	3.4	TE	[1979]
Sc/Nb(100)	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.4 ± 0.03	TE	[2359]
Sc	–	–	2×10^{-10}	~300	–	3.4 ± 0.1	PE	[1813]
Sc	–	–	?	1200	–	3.45	TE	[1979]
Sc	–	–	–	–	–	3.5	TC	[706]
Sc/W(121)	Sc	–	($<10^{-10}$)	77	–	3.5 ± 0.1	FE	[3323]
Sc/quartz	Sc	–	$\sim 10^{-10}$	~300	–	3.5 ± 0.15	PE	[304]
Sc	–	–	–	–	–	3.53	TC	[298]
Sc/W(100)	Sc	–	$\leq 10^{-8}$	~1000–1150	–	3.56 ± 0.03	TE	[2337,2359]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Sc	–	–	–	–	–	3.6	TC	[1993]
Sc	–	–	~10^{-9}	<1660	–	3.62	TE	[4356]
Sc/W(112)	Sc	–	?	~300 (~600)	–	3.60	CPD	[4011]
Sc/W(110)	Sc	–	≤10^{-8}	~1000–1150	–	3.62 ± 0.03	TE	[2337,2359]
Sc/W(110)	Sc	–	(<10^{-10})	~300	–	3.66*	CPD	[3329]
Sc	–	–	–	–	–	3.71	TC	[3476]
Sc	–	–	–	–	–	3.9	TC	[944]
Sc	–	–	?	~300	–	4.2	CPD	[2202]
Recommended	–	–	–	–	–	**3.33 ± 0.04**	–	–

fcc (β, $T > 1660$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Sc	–	–	–	–	–	3.44	TC	[1066]
Sc	–	–	~10^{-9}	>1660	–	3.46	TE	[4356]

22. Titanium Ti

hcp (α, $T < 1155$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti(0001)	–	–	–	–	–	3.8	TC	[1090,1899]
Ti(0001)/W(110)[93]	Ti	–	<10^{-11}	~300 (~650)	–	4.10	FE	[2196]
Ti(0001)	–	–	–	–	–	4.25	TC	[4417]
Ti(0001)	–	–	–	–	–	4.29	TC	[1980]
Ti(0001)	–	–	–	–	–	4.38	TC	[4087,4410]
Ti(0001)	–	–	–	–	–	4.38	TC	[1179]
Ti(0001)	–	–	–	–	–	4.40	TC	[1028,1179]
Ti(0001)	–	–	–	–	–	4.42	TC	[894]
Ti(0001)	–	–	–	–	–	4.45	TC	[2553]
Ti(0001)	–	–	–	–	–	4.51	TC	[4032,4086]
Ti(0001)	–	–	–	–	–	4.54	TC	[1179]
Ti(0001)	–	–	–	–	–	4.56	TC	[4284]
Ti(0001)	–	–	<10^{-10}	~300	–	4.58 ± 0.05	FE	[2258]
Ti(0001)	–	–	–	–	–	4.59	TC	[229,334]
Ti(0001)	–	–	?	~300	–	4.6 ± 0.2	PE	[3627]
Ti(0001)	–	–	4 × 10^{-11}	~300	–	4.60 ± 0.1	PE	[1902]
Ti(0001)	–	–	–	–	–	4.63	TC	[4032]
Ti(0001)	–	–	–	–	–	4.64	TC	[892]
Ti(0001)	–	–	–	–	–	4.66	TC	[1028,1179]
Ti(0001)/W(110)	Ti	–	(<5 × 10^{-11})	~300 (~900)	–	4.7 ± 0.1	CPD	[4234]
Ti(0001)	–	–	–	–	–	4.72	TC	[4005]
Ti(0001)	–	–	–	–	–	4.75	TC	[893]
Ti(0001)/glass[94]	Ti	–	?	~300	–	5.0	CPD	[2378]
Ti(0001)	–	–	–	–	–	5.00	TC	[321]
Recommended	–	–	–	–	–	**4.53 ± 0.10**	–	–
Ti(1010)	–	–	–	–	–	3.63	TC	[4005]
Ti(1010)	–	–	–	–	–	4.13	TC	[1980]
Ti(1010)/O=Ti[95]	Ti	–	?	~300	–	4.15	CPD	[2378]
Ti(1010)	–	–	–	–	–	4.78	TC	[321]
Ti(1011)/O=Ti[95]	Ti	–	?	~300	–	4.75	CPD	[2378]
Ti(1124)	–	–	–	–	–	4.18	TC	[321]

bcc (β, $T > 1155$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti(100)	–	–	–	–	–	3.94	TC	[321]
Ti(110)	–	–	–	–	–	4.57	TC	[321]
Ti(111)	–	–	–	–	–	3.76	TC	[321]
Ti(112)	–	–	–	–	–	4.18	TC	[321]

hcp (α, $T < 1155$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti	–	–	–	–	–	2.4	TC	[2456]
Ti/Ag	Ti	–	1 × 10^{-7}	~300	–	2.7–3.9	CPD	[1785]
Ti/Au	Ti	–	1 × 10^{-6}	~300	–	3.0–4.2	CPD	[1785]
Ti/W(016)[96]	Ti	–	<8 × 10^{-11}	~300	–	3.03	FE	[3222]
Ti	–	–	<10^{-3}	~300	–	3.10 ± 0.07	PE	[2571]
Ti/W	Ti	–	<8 × 10^{-11}	~300	–	3.18	FE	[3222]
Ti/W(116)	Ti	–	~10^{-10}	~300	–	3.47	FE	[4237]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti/W(012)	Ti	–	$\leq 10^{-10}$	~300	–	3.5	FE	[3327]
Ti/W	Ti	–	$<8 \times 10^{-10}$	78 (≤1100)	–	3.50	FE	[1731]
Ti/W(111)[96]	Ti	–	$<8 \times 10^{-11}$	~300	–	3.50	FE	[3222]
Ti	–	–	–	–	–	3.51	TC	[3476]
Ti/W(011)[96]	Ti	–	$<8 \times 10^{-11}$	~300	–	3.52	FE	[3222]
Ti/glass	Ti	–	$<10^{-9}$	77–90	–	3.52	PE	[2096,3052,3053]
Ti/Ni	Ti	–	?	~300	–	3.55 ± 0.05	PE	[2617]
Ti/glass	Ti	–	$<10^{-9}$	293 (383)	–	3.57	PE	[3052]
Ti/Ge(111)	Ti	–	$\leq 10^{-9}$	~300	–	3.6	FE	[1496]
Ti/W	Ti	–	$\leq 10^{-10}$	~300	–	3.6	FE	[3327,3334]
Ti/W(110)	–	–	–	–	–	3.6*	TC	[2975]
Ti	–	–	–	–	–	3.61	TC	[3476]
Ti/W(023)	Ti	–	$\sim 10^{-10}$	~300	–	3.65	FE	[4237]
Ti/W	Ti	–	$\leq 10^{-10}$	~300	–	3.65 ± 0.06	FE	[3545]
Ti/W(112)	Ti	–	$\sim 10^{-10}$	~300	–	3.66	FE	[4237]
Ti/W(111)	Ti	–	$\leq 10^{-10}$	~300	–	3.7	FE	[3327]
Ti/W(100)	Ti	–	?	<1600	–	3.7	FE	[1438]
Ti/Au	Ti	–	2×10^{-9}	~300	–	3.7–4.7	CPD	[1785]
Ti/W(100)	Ti	–	$<10^{-10}$	800–1100	–	3.70 ± 0.05	FE	[4014]
Ti	–	–	10–12 (Ar)	~300	–	3.72	PE	[1652,4236]
Ti	–	–	–	0	–	3.72	TC	[339]
Ti	Cs	Cs⁺	? (Cs)	~1000	3.74*	(3.75)	PSI	[650]
Ti	–	–	? (Cs)	~1000–1100	(3.74*)	3.75	TE	[650]
Ti/W(001)[96]	Ti	–	$<8 \times 10^{-11}$	~300	–	3.75	FE	[3222]
Ti	–	–	$\leq 1 \times 10^{-9}$	1115	–	3.76	TE	[179]
Ti	–	–	$\leq 10^{-7}$	900–1170	–	3.77–5.5	TE	[2810]
Ti	–	–	–	–	–	3.78	TC	[3318]
Ti/SiO₂	Ti	–	?	~300	–	3.8	PE	[2899]
Ti/W(111)	Ti	–	$\leq 1 \times 10^{-10}$	77	–	3.8	FE	[2372]
Ti/glass	Ti	–	6×10^{-10}	293 (383)	–	3.81	PE	[3053]
Ti	–	–	–	–	–	3.81	TC	[1066]
Ti	–	–	3×10^{-11}	77	–	3.81	FE	[2424]
Ti	–	–	?	~300	–	3.82 ± 0.02	CPD	[2544]
Ti/W(100)	Ti	–	?	<1600	–	3.82 ± 0.05*	FE	[1438]
Ti	–	–	–	–	–	3.83	TC	[3318]
Ti/W(110)	Ti	–	$<5 \times 10^{-10}$	~300	–	3.85 ± 0.03	CPD	[1863]
Ti/W(100)	Ti	–	2×10^{-9}	~1550–1800	–	3.85 ± 0.04	TE	[2461]
Ti/glass	Ti	–	$<10^{-9}$	90 (383)	–	3.87	PE	[2096]
Ti	–	–	–	–	–	3.87	TC	[1901]
Ti	–	–	–	–	–	3.88	TC	[2005]
Ti/W(001)[97]	Ti	–	$\sim 10^{-10}$	293	–	3.88 ± 0.09	FE	[1404]
Ti/W(110)	Ti	–	$\leq 1 \times 10^{-10}$	77	–	3.9	FE	[2372]
Ti/W(112)	Ti	–	$\leq 1 \times 10^{-10}$	77	–	3.9	FE	[2372]
Ti/W	Ti	–	$\leq 7 \times 10^{-8}$	~300	–	3.9	FE	[1804]
Ti/Mo(110)	Ti	–	$\sim 10^{-10}$	~300	–	3.9	CPD	[3679]
Ti/W	Ti	–	$\sim 10^{-9}$	293 (900)	–	3.9	FE	[3738]
Ti	–	–	–	–	–	3.9	TC	[1993]
Ti	–	–	?	?	–	3.9	TE	[3402]
Ti/SiO₂	Ti	–	?	~300 (670)	–	3.9 ± 0.1	PE	[2899]
Ti/glass	Ti	–	?	~300	–	3.95	PE	[3027]
Ti/W(111)[98]	Ti	–	$\sim 10^{-11}$	~300 (600)	–	3.95	PE	[2194]
Ti/W(112)[96]	Ti	–	$<8 \times 10^{-11}$	~300	–	3.95	FE	[3222]
Ti	–	–	$\sim 10^{-6}$	~300	–	3.95	PE	[3027]
Ti/W[99]	Ti	–	5×10^{-11}	~300	–	3.95	FE	[1522]
Ti	–	–	–	–	–	3.95	TC	[2949]
Ti	–	–	$<2 \times 10^{-10}$	~300	–	3.96 ± 0.04	CPD	[1898]
Ti	–	–	–	–	–	3.98	TC	[3476]
Ti	–	–	–	–	–	4.0	TC	[2583]
Ti	–	–	–	–	–	4.0	TC	[1955]
Ti/Ag	Ti	–	1×10^{-7}	~300	–	4.0–4.6	CPD	[1785]
Ti	–	–	–	–	–	4.00	TC	[3637]
Ti/Re(1010)[97]	Ti	–	$\sim 10^{-10}$	293	–	4.00 ± 0.05	FE	[1404]
Ti	–	–	?	~300	–	4.07	PE	[4278]
Ti	–	–	–	–	–	4.09	TC	[1744]
Ti	–	–	3×10^{-11}	77	–	4.1	FE	[2424]
Ti	–	–	–	–	–	4.1	TC	[706]
Ti	–	–	–	–	–	4.10	TC	[3264,3265,3267]
Ti	–	–	$\sim 10^{-8}$	~1400–1700	–	4.10	TE	[4221]
Ti	–	–	1×10^{-9}	~300	–	4.13	CPD	[1252]
Ti	–	–	?	~300	–	4.14	CPD	[2297]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti/TiI$_4$/W	–	–	?	~300 (?)	–	4.17	PE	[2927]
Ti/Au	Ti	–	2×10^{-9}	~300	–	4.2–5.6	CPD	[1785]
Ti	–	–	–	0	–	4.22	TC	[4419]
Ti	–	–	?	~300	–	4.23	CPD	[3338]
Ti/W(110)	Ti	–	($<5 \times 10^{-11}$)	~300	–	4.25	CPD	[4234]
Ti	–	–	$\leq 1 \times 10^{-9}$	1113	–	4.26	TE	[179]
Ti	–	–	2×10^{-10}	~300	–	4.33	PE	[1814]
Ti/quartz	Ti	–	~10^{-10}	~300	–	4.33 ± 0.1	PE	[304]
Ti/Si$_3$N$_4$	–	–	–	–	–	4.36	TC	[3517]
Ti	–	–	–	–	–	4.36	TC	[298]
Ti	–	–	$\leq 1 \times 10^{-9}$	1156	–	4.36	TE	[179]
Ti	–	–	$<10^{-3}$	~300	–	4.36 ± 0.04	PE	[2571]
Ti/W(110)	Ti	–	$\leq 10^{-10}$	~300	–	4.4	FE	[2372]
Ti	–	–	–	–	–	4.4	TC	[944]
Ti	–	–	$<10^{-3}$	~300	–	4.45 ± 0.05	PE	[2571]
Ti/O=Ti[95]	Ti	–	?	~300	–	4.60	CPD	[2378]
Ti/glass[94]	Ti	–	?	~300	–	4.76	CPD	[2378]
Recommended	–	–	–	–	–	**3.87 ± 0.05**	–	–

bcc (β, $T > 1155$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ti	–	–	$\leq 10^{-9}$	~1100–1600	–	3.5–4.4	TE	[124]
Ti	–	–	$\leq 10^{-9}$	~1100–1600	–	3.55–4.25	TE	[650]
Ti/W(111)[98]	Ti	–	~10^{-11}	~300 (1100)	–	3.6	PE	[2194]
Ti/W[99]	Ti	–	5×10^{-11}	~300 (1100)	–	3.65	FE	[1522]
Ti/W(001)[97]	Ti	–	~10^{-10}	293 (1300)	–	3.65 ± 0.05	FE	[1404,1405]
Ti	–	–	? (Cs)	~1100–1400	–	3.7	TE	[650,3413]
Ti	–	–	~10^{-9}	1115–1537	–	3.76 ± 0.03	TE	[179]
Ti/graphite	Ti	–	$<10^{-5}$	1370–1510	–	3.95 ± 0.02	TE	[769,2304]
Ti	–	–	~10^{-8}	~1200–1600	–	4.00 ± 0.05	TE	[1775,1776]
Ti	–	–	3×10^{-9}	~1000–1430	–	4.1	TE	[159]
Ti	–	–	~10^{-9}	~1000–1450	–	4.10	TE	[1773]
Ti	–	–	$\leq 1 \times 10^{-9}$	1253–1585	–	4.23 ± 0.06*	TE	[179]
Ti	–	–	$\leq 1 \times 10^{-9}$	1156–1585	–	4.32 ± 0.08*	TE	[179]
Recommended	–	–	–	–	–	**3.93 ± 0.16**	–	–

23. Vanadium V

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
V(100)	–	–	–	–	–	3.66	TC	[4412]
V(100)	–	–	–	–	–	3.7	TC	[1617]
V(100)	–	–	–	–	–	3.88	TC	[321]
V(100)	–	–	–	–	–	3.93	TC	[2437]
V(100)	–	–	~10^{-10}	~300	–	3.95	CPD	[3641]
V(100)	–	–	–	–	–	4.068	TC	[4460][490]
V(100)	–	–	~10^{-11}	~300	–	4.1 ± 0.1	PE	[2428,3371]
V(100)	–	–	$<8 \times 10^{-11}$	~300	–	4.10 ± 0.05	PE	[3380]
V(100)[100]	–	–	–	–	–	4.19 ± 0.02	TC	[3671]
V(100)	–	–	–	–	–	4.2	TC	[3615]
V(100)	–	–	–	–	–	4.28	TC	[1980,3067]
V(100)	–	–	–	–	–	4.29	TC	[2548]
V(100)	–	–	–	–	–	4.3	TC	[3615]
V(100)	–	–	~10^{-11}	~300	–	4.3 ± 0.1	PE	[3371,3372,3374, 3375]
V(100)	–	–	2×10^{-11}	250	–	4.3 ± 0.15	PE	[3368,3374]
V(100)	–	–	?	?	–	4.46	TE	[3695]
V(100)[195]	–	–	–	–	–	4.56	TC	[1876]
V(100)	–	–	–	–	–	4.57	TC	[229]
Recommended	–	–	–	–	–	**4.27 ± 0.05**	–	–
V(110)	–	–	–	–	–	4.52	TC	[321]
V(110)	–	–	$<8 \times 10^{-11}$	~300	–	4.65 ± 0.08	PE	[2428]
V(110)	–	–	–	–	–	4.96	TC	[2548]
V(110)	–	–	–	–	–	4.97	TC	[1980,3067]
V(110)	–	–	?	?	–	5.00	TE	[3695]
V(110)	–	–	–	–	–	5.017	TC	[4460][490]
V(110)	–	–	–	–	–	5.12	TC	[229,334]
V(110)	–	–	–	–	–	5.13	TC	[3179]
Recommended	–	–	–	–	–	**5.04 ± 0.07**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
V(111)	–	–	–	–	–	3.72	TC	[321]
V(111)	–	–	–	–	–	4.10	TC	[2548]
V(111)	–	–	–	–	–	4.11	TC	[1980,3067]
V(111)	–	–	?	?	–	4.19	TE	[3695]
V(112)	–	–	–	–	–	4.13	TC	[321]
V(112)	–	–	–	–	–	4.50	TC	[1980,3067]
V(116)	–	–	?	?	–	3.95	TE	[3695]
V(116)	–	–	–	–	–	4.11	TC	[1980,3067]
V/quartz[101]	V	–	$\leq 10^{-8}$	15	–	2.9 ± 0.2	CPD	[1686]
V/quartz	V	–	$\leq 10^{-8}$	293	–	3.0 ± 0.2	CPD	[1686]
V/quartz[101]	V	–	$\leq 10^{-8}$	4.2	–	3.1 ± 0.2	CPD	[1686]
$V_n(n \to \infty)$	–	–	–	–	–	3.68 ± 0.10	TC	[4261]
V	–	–	–	–	–	3.7	TC	[1744]
V[101]	–	–	$\leq 10^{-8}$	4.2–15	–	3.77	FE	[1686]
V	–	–	?	0^E	–	3.77	PE	[3027]
V/W(110)	V	–	$\sim 10^{-11}$	~300	–	3.8	CPD	[2430]
V/W(012)	V	–	$< 1 \times 10^{-10}$	~300	–	$3.81 \pm \leq 0.06$	FE	[1529]
V/Mo(110)	V	–	$\leq 2 \times 10^{-10}$	77	–	3.85	CPD	[328]
V/W(023)	V	–	$< 1 \times 10^{-10}$	~300	–	$3.86 \pm \leq 0.06$	FE	[1529]
V/W(111)	V	–	$< 1 \times 10^{-10}$	~300	–	$3.88 \pm \leq 0.06$	FE	[1529]
V	–	–	–	–	–	3.89	TC	[3476]
V	–	–	–	–	–	3.9	TC	[706]
V/TiO$_2$(110)	–	–	–	–	–	3.9*	TC	[4074]
V	–	–	–	–	–	3.94	TC	[3476]
V	–	–	–	–	–	4.0	TC	[3928]
V/W(112)	V	–	$< 1 \times 10^{-10}$	~300	–	$4.01 \pm \leq 0.06$	FE	[1529]
V/W	V	–	1×10^{-10}	77, 300 (~1300)	–	4.02	FE	[4018]
V	–	–	–	–	–	4.03	TC	[1901]
V	–	–	?	~300	–	4.08 ± 0.02	CPD	[2544]
V/W	V	–	1×10^{-10}	77, 300 (~1300)	–	4.08 ± 0.03*	FE	[4018]
V/TiO$_2$(110)	V	–	1×10^{-10}	~300	–	4.1	PE	[3564]
V	–	–	–	–	–	4.10	TC	[3318]
V/graphite	V	–	$< 10^{-5}$	1410–1540	–	4.12 ± 0.02	TE	[769,2304]
V	–	–	–	–	–	4.15	TC	[1066]
V	–	–	$< 2 \times 10^{-10}$	~300	–	4.17 ± 0.04	CPD	[1898]
V	–	–	–	–	–	4.18	TC	[3318]
V/W(110)	V	–	$< 1 \times 10^{-10}$	~300	–	4.19*	FE	[1529]
V	–	–	–	–	–	4.2	TC	[1993]
V	–	–	1×10^{-10}	~300	–	4.2	PE	[3564]
V/Ag(001)	V	–	2×10^{-10}	30	–	4.25 ± 0.05	PE	[3154,4377]
V/quartz	V	–	$\sim 10^{-10}$	~300	–	4.3 ± 0.1	PE	[304]
V	–	–	1×10^{-9}	~300	–	4.30	CPD	[1252]
V	–	–	–	–	–	4.32	TC	[298]
V	–	–	–	–	–	4.33	TC	[2949]
V	–	–	–	–	–	4.37	TC	[3476]
V/W(110)	–	–	$< 1 \times 10^{-10}$	~300	–	$4.42 \pm \leq 0.06$	FE	[1529]
V	–	–	?	~300	–	4.44	CPD	[2297]
V	–	–	–	–	–	4.44	TC	[3264,3265,3267]
V/Mo(110)	V	–	$\leq 2 \times 10^{-10}$	~300	–	4.54	CPD	[328]
V/Mo(110)	V	–	$\leq 2 \times 10^{-10}$	700	–	4.71	CPD	[328]
V	–	–	–	–	–	5.1	TC	[944]
Recommended	–	–	–	–	–	**4.10 ± 0.05**	–	–

24. Chromium Cr

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cr(100)	–	–	–	–	–	3.710 ± 0.005	TC	[2805]
Cr(100)	–	–	–	–	–	3.88	TC	[2818]
Cr(100)	–	–	–	–	–	3.90	TC	[321]
Cr(100)[103]	–	–	5×10^{-10}	~300	–	3.90 ± 0.1	PE	[2870,3951]
Cr(100)/W(100)	Cr	–	5×10^{-10}	~300 (1700)	–	4.0 ± 0.1	CPD	[1488]
Cr(100)	–	–	–	–	–	4.05	TC	[1911,1912]
Cr(100)/Au(100)[103]	Cr	–	5×10^{-10}	~300	–	4.05 ± 0.1	PE	[3951]
Cr(100)	–	–	–	–	–	4.06	TC	[2805]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cr(100)	–	–	?	~300	–	4.10 ± 0.05	PE	[2638]
Cr(100)	–	–	–	–	–	4.25	TC	[1911]
Cr(100)	–	–	–	–	–	4.27	TC	[4034]
Cr(100)	–	–	–	–	–	4.40	TC	[1912]
Cr(100)	–	–	–	–	–	4.46	TC	[1011]
Cr(100)	–	–	~10^{-10}	~300	–	4.46 ± 0.06	CPD	[3445,3446]
Cr(100)	–	–	–	–	–	4.48	TC	[1011]
Cr(100)	–	–	–	–	–	4.50	TC	[2701]
Cr(100)	–	–	–	–	–	4.51	TC	[1011]
Cr(100)	–	–	–	–	–	4.57	TC	[1159]
Cr(100)	–	–	–	–	–	4.57	TC	[2701]
Cr(100)	–	–	–	–	–	4.58	TC	[229]
Cr(100)	–	–	–	–	–	4.60	TC	[1011]
Cr(100)	–	–	–	–	–	4.93	TC	[1011]
Cr(100)	–	–	–	–	–	4.94	TC	[229]
Recommended	–	–	–	–	–	**4.43 ± 0.14**	–	–
Cr(110)	–	–	–	–	–	4.44	TC	[4034]
Cr(110)	–	–	–	–	–	4.44	TC	[2685]
Cr(110)	–	–	–	–	–	4.53	TC	[321]
Cr(110)	–	–	–	–	–	4.70	TC	[2818]
Cr(110)	–	–	–	–	–	4.81	TC	[4421]
Cr(110)	–	–	(≤10^{-11})	~300	–	4.85	CPD	[2380]
Cr(110)/W(110)	Cr	–	~10^{-11}	~300 (~700)	–	4.9	CPD	[4260]
Cr(110)/Au(111)	Cr	–	≤5 × 10^{-10}	~300 (>670)	–	5.0	CPD	[3266]
Cr(110)/Ir(111)	Cr	–	≤5 × 10^{-10}	~300 (>670)	–	5.00 ± 0.04	CPD	[3266]
Cr(110)	–	–	–	–	–	5.08	TC	[1159]
Cr(110)/Nb(110)	Cr	–	~10^{-11}	~300 (~700)	–	5.2	CPD	[4260]
Cr(110)	–	–	–	–	–	5.30	TC	[229]
Cr(110)	–	–	–	–	–	5.45	TC	[229,334]
Recommended	–	–	–	–	–	**4.99 ± 0.19**	–	–
Cr(111)	–	–	–	–	–	3.72	TC	[321]
Cr(111)	–	–	–	–	–	3.78	TC	[4034]
Cr(111)	–	–	–	–	–	3.88	TC	[2818]
Cr(112)	–	–	–	–	–	4.05	TC	[2818]
Cr(112)	–	–	–	–	–	4.15	TC	[321]
Cr(116)	–	–	–	–	–	3.75	TC	[2818]
Cr(210)	–	–	–	–	–	4.15	TC	[2805]
Cr	–	–	? (Cs)	~1000–1400	–	3.57	TE	[650,3413]
Cr/ins/Al[47]	Cr	–	?	~300	–	3.71 ± 0.07	CPD	[2028]
Cr/W(100)	Cr	–	≤5 × 10^{-10}	293 (~900)	–	3.8 ± 0.1	FE	[1494,1515]
Cr/W(100)	Cr	–	5 × 10^{-10}	~300 (1200)	–	3.8 ± 0.1	CPD	[1488]
Cr	–	–	?	~300	–	3.88 ± 0.04	CPD	[2544]
Cr	–	–	?	?	–	3.89	TE	[3410]
Cr/W	Cr	–	≤7 × 10^{-8}	~300	–	3.9	FE	[1804]
Cr	–	–	≤1 × 10^{-9}	~1100–1400	–	3.90 ± 0.04	TE	[179,3413]
Cr	–	–	≤10^{-9}	~1050–1450	–	3.90 ± 0.05	TE	[650]
Cr/W	Cr	–	≤7 × 10^{-8}	~300	–	4.0	FE	[1804]
Cr/W(110)	–	–	–	–	–	4.0*	TC	[3001]
Cr/W(100)	Cr	–	5 × 10^{-10}	~300 (1700)	–	4.0 ± 0.1	CPD	[1488]
Cr/W(111)	Cr	–	?	77	–	4.07*	FE	[4250]
Cr$_n$(n → ∞)	–	–	–	–	–	4.07 ± 0.14	TC	[4261]
Cr/W(110)	Cr	–	<1 × 10^{-10}	100	–	4.1*	CPD	[1580]
Cr/W	Cr	–	1 × 10^{-9}	~300	–	4.10 ± 0.08	FE	[2618]
Cr/W(112)	Cr	–	?	77	–	4.10*	FE	[4250]
Cr/SiO$_2$/Si	Cr	–	?	~300 (570)	–	4.18	PE	[2355]
Cr	–	–	–	–	–	4.18	TC	[3476]
Cr/glass	Cr	–	~4 × 10^{-10}	77–90	–	4.19	PE	[2096,3053]
Cr/Ta(111)	Cr	–	~10^{-9}	~300	–	4.2 ± 0.1	FE	[1786,1789]
Cr	–	–	–	–	–	4.22	TC	[3476]
Cr	–	–	–	–	–	4.3	TC	[706]
Cr	–	–	–	–	–	4.3	TC	[3318]
Cr/Mo(110)	Cr	–	~10^{-10}	~300	–	4.3	CPD	[3679]
Cr	–	–	?	~300	–	4.34	PE	[2924]
Cr	–	–	–	–	–	4.38	TC	[1399]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cr	–	–	?	~300	–	4.38	CPD	[2297]
Cr	–	–	–	–	–	4.4	TC	[1993]
Cr/quartz	Cr	–	≤5 × 10⁻⁹	~300	–	4.4	PE	[2309]
Cr	–	–	–	–	–	4.40	TC	[3264,3265,3267]
Cr/glass	Cr	–	2 × 10⁻¹⁰	293 (373)	–	4.40	PE	[3053]
Cr	–	–	–	–	–	4.40	TC	[3637]
Cr	–	–	–	–	–	4.42	TC	[1066]
Cr	–	–	–	–	–	4.44	TC	[4031]
Cr/glass	Cr	–	?	77 (373)	–	4.44	PE	[2096]
Cr/glass	Cr	–	4 × 10⁻¹⁰	293 (378)	–	4.48	PE	[3053]
Cr	–	–	–	–	–	4.49	TC	[3318]
Cr/quartz	Cr	–	~10⁻¹⁰	~300	–	4.5 ± 0.15	PE	[304]
Cr	–	–	–	–	–	4.51	TC	[298]
Cr/ins/Al⁴⁷	Cr	–	?	~300	–	4.51 ± 0.09	CPD	[2028]
Cr	–	–	–	–	–	4.56	TC	[2949]
Cr/W(110)	Cr	–	(≤10⁻¹¹)	~300	–	4.56	CPD	[2380]
Cr	–	–	5 × 10⁻¹⁰	~300	–	4.57	AI³⁸	[4027]
Cr	–	–	–	–	–	4.57	TC	[4031]
Cr/graphite	Cr	–	<10⁻⁵	~1450–1620	–	4.58 ± 0.02	TE	[769,2304]
Cr	–	–	?	?	–	4.6	TE	[3402]
Cr/?	Cr	–	~10⁻⁵	~300	–	4.6	CPD	[1376]
Cr/Au/glass¹⁰⁴	Cr	–	?	~300	–	4.6	CPD	[3207]
Cr/Ni	Cr	–	?	~300	–	4.6 ± 0.1*	CPD	[3592]
Cr	–	–	2 × 10⁻⁸	~1000–1500	–	4.60	TE	[3400]
Cr/W(110)	Cr	–	~10⁻¹¹	~300	–	4.65	CPD	[4260]
Cr	–	–	–	–	–	4.68	TC	[3476]
Cr/Cu	Cr	–	<1 × 10⁻⁹	80	–	4.68	PE	[2472]
Cr	–	–	?	~80	–	4.7	CPD	[2294]
Cr/W(110)	Cr	–	<1 × 10⁻¹⁰	100 (1100)	–	4.8*	CPD	[1580]
Cr/Au/glass¹⁰⁴	Cr	–	?	~300	–	4.8*	CPD	[3207]
Cr	–	–	–	–	–	4.8	TC	[944]
Cr/W(110)	Cr	–	3 × 10⁻⁹	722	–	4.8	FE	[1615]
Cr	–	–	1 × 10⁻¹⁰	100	–	4.80 ± <0.1	PE	[672]
Cr/Au(100)¹⁰⁵	Cr	–	~10⁻¹¹	~300	–	4.87	PE	[3557]
Cr	–	–	–	–	–	4.88	TC	[1744]
Cr/W(110)	Cr	–	3 × 10⁻⁹	?	–	4.9	FE	[1616]
Cr/Au(111)	Cr	–	≤5 × 10⁻¹⁰	~300	–	4.9	CPD	[3266]
Cr/Ir(111)	Cr	–	≤5 × 10⁻¹⁰	~300	–	4.9	CPD	[3266]
Cr/W(110)	Cr	–	3 × 10⁻⁹	~300	–	5.0	FE	[1615]
Cr	–	–	<2 × 10⁻¹⁰	~300	–	5.05 ± 0.04	CPD	[1898]
Cr	–	–	–	–	–	5.2	TC	[3179]
Cr/Fe/Cr(110)	Cr	–	–	–	–	5.45	TC	[3010]
Cr/W	Cr	–	?	~300	–	7.4	FE	[2225]
Recommended	–	–	–	–	–	**4.38 ± 0.04**	–	–

25. Manganese Mn

fcc (γ, T = 1352–1407 K)

Mn(100)	–	–	–	–	–	4.58	TC	[463]
Mn(100)	–	–	–	–	–	4.97	TC	[321]
Mn(100)	–	–	–	–	–	5.37	TC	[229]
Mn(100)	–	–	–	–	–	5.55	TC	[463]
Mn(100)	–	–	–	–	–	5.76	TC	[229]
Mn(110)	–	–	–	–	–	4.67	TC	[321]
Mn(111)	–	–	–	–	–	5.18	TC	[229]
Mn(111)	–	–	–	–	–	5.36	TC	[321]
Mn(111)	–	–	–	–	–	5.45	TC	[229,334]

bcc (δ, T > 1407 K)

Mn(100)	–	–	–	–	–	4.27	TC	[321]
Mn(100)	–	–	–	–	–	4.90	TC	[229]
Mn(100)	–	–	–	–	–	5.31	TC	[229]
Mn(110)	–	–	–	–	–	4.97	TC	[321]
Mn(110)	–	–	–	–	–	5.34	TC	[229]
Mn(110)	–	–	–	–	–	5.69	TC	[229]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mn(111)	–	–	–	–	–	4.09	TC	[321]
Mn(112)	–	–	–	–	–	4.57	TC	[321]
Cubic (α–β, $T < 1079$ K for bulk)								
Mn	–	–	–	–	–	3.0	TC	[1744]
Mn$_n$(n → ∞)	–	–	5×10^{-4}	77	–	3.1	IP	[4264]
Mn/steel	Mn	–	$<2 \times 10^{-10}$	~300 (?)	–	3.54 ± 0.04	CPD	[1898]
Mn/ins/Al[108]	Mn	–	?	~300	–	3.60 ± 0.04	CPD	[2028]
Mn	–	–	?	~300	–	3.70 ± 0.04	CPD	[2544]
Mn$_n$(n → ∞)	–	–	–	–	–	3.74 ± 0.13	TC	[4261]
Mn	–	–	?	~300	–	3.76	PE	[3027]
Mn	–	–	–	–	–	3.76	TC	[3637]
Mn	–	–	–	–	–	3.8	TC	[2583]
Mn/glass	Mn	–	$<10^{-9}$	90	–	3.82	PE	[2096,3052,3053]
Mn/Cu(111)[106]	Mn	–	4×10^{-11}	~300	–	3.9	CPD	[3710]
Mn	–	–	–	–	–	3.90	TC	[3264,3265,3267]
Mn/glass	Mn	–	8×10^{-10}	293 (373)	–	4.06	PE	[3053]
Mn/glass	Mn	–	$<10^{-9}$	90 (373)	–	4.08	PE	[2096,3052]
Mn/glass	Mn	–	6×10^{-10}	293	–	4.1	PE	[3053]
Mn/quartz	Mn	–	$\sim10^{-10}$	~300	–	4.1 ± 0.2	PE	[304]
Mn	–	–	–	–	–	4.10	TC	[4418]
Mn	–	–	?	~300	–	4.14	CPD	[2297]
Mn/Cu(100)[107]	Mn	–	1×10^{-8}	293	–	4.2 ± 0.1	PE	[1554]
Mn/silica	Mn	–	$<2 \times 10^{-10}$	290	–	4.24 ± 0.02	PE	[923,2113]
Mn	–	–	–	–	–	4.27	TC	[3476]
Mn	–	–	–	–	–	4.37	TC	[298]
Mn	–	–	–	–	–	4.4	TC	[706]
Mn/ins/Al[108]	Mn	–	?	~300	–	4.40 ± 0.07*	CPD	[2028]
Mn	–	–	–	–	–	4.44	TC	[3318]
Mn	–	–	–	–	–	4.46	TC	[3476]
Mn	–	–	–	–	–	4.52	TC	[3318]
Mn	–	–	–	–	–	4.7	TC	[3928]
Mn	–	–	–	–	–	4.88	TC	[3476]
Mn	–	–	–	–	–	5.1	TC	[944]
Recommended	–	–	–	–	–	**4.08 ± 0.11**	–	–
fcc (γ, $T = 1352$–1407 K for bulk)								
Mn	–	–	–	–	–	4.28	TC	[3318]
Mn	–	–	–	–	–	4.34	TC	[3318]
bcc (δ, $T > 1407$ K for bulk)								
Mn/graphite	Mn	–	$<10^{-6}$	~1400–1500	–	3.83 ± 0.02	TE	[769,2304]

26. Iron Fe

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc (α, $T < 1042$ K)[407]								
Fe(100)[109]	–	–	–	–	–	3.7	TC	[2901]
Fe(100)	–	–	–	–	–	3.80	TC	[3946]
Fe(100)	–	–	–	–	–	3.85	TC	[4222]
Fe(100)	–	–	–	–	–	3.85	TC	[4374]
Fe(100)	–	–	–	–	–	3.86	TC	[4218]
Fe(100)	–	–	–	–	–	3.87	TC	[1625]
Fe(100)	–	–	–	–	–	3.88	TC	[4009]
Fe(100)[109]	–	–	–	–	–	3.9	TC	[2901]
Fe(100)	–	–	–	–	–	3.90	TC	[1623]
Fe(100)	–	–	–	–	–	3.91	TC	[1619]
Fe(100)	–	–	–	–	–	3.91	TC	[1625]
Fe(100)	–	–	–	–	–	3.94	TC	[4019]
Fe(100)	–	–	–	–	–	4.06	TC	[2911]
Fe(100)[110]	–	–	$<8 \times 10^{-10}$	77	–	4.17 ± 0.03	CPD	[920,3044]
Fe(100)[109]	–	–	?	~300	–	4.24	PE	[2901]
Fe(100)[110]	–	–	$<8 \times 10^{-10}$	77	–	4.24 ± 0.02	CPD	[920]
Fe(100)	–	–	–	–	–	4.29	TC	[549,1105]
Fe(100)	–	–	–	–	–	4.30	TC	[463]
Fe(100)	–	–	–	–	–	4.35	TC	[2777,3614]
Fe(100)	–	–	$<1 \times 10^{-10}$	~300 (1070)	–	4.4	PE	[919]
Fe(100)	–	–	–	–	–	4.4	TC	[2157]
Fe(100)	–	–	–	–	–	4.45	TC	[1708,1710]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe(100)	–	–	–	–	–	4.47	TC	[1105]
Fe(100)	–	–	–	–	–	4.50	TC	[229,317]
Fe(100)	–	–	–	–	–	4.55	TC	[321]
Fe(100)	–	–	–	–	–	4.57	TC	[1105]
Fe(100)	–	–	–	–	–	4.586	TC	[4337]
Fe(100)	–	–	–	–	–	4.6	TC	[2650]
Fe(100)	–	–	5×10^{-10}	~300	–	4.64 ± 0.03	PE	[3310]
Fe(100)	–	–	$\leq 5 \times 10^{-11}$	~300	–	4.65 ± 0.05	PE	[1607]
Fe(100)	–	–	2×10^{-9}	~300 (720)	–	4.66 ± 0.02	PE	[3311]
Fe(100)	–	–	$\sim 10^{-9}$	~300 (720)	–	4.67 ± 0.03	PE	[921]
Fe(100)	–	–	?	~300	–	4.7	PE	[1709]
Fe(100)	–	–	$< 5 \times 10^{-11}$	~300	–	4.70 ± 0.05	PE	[1831]
Fe(100)	–	–	2×10^{-9}	~300 (820)	–	4.75 ± 0.03	PE	[565]
Fe(100)	–	–	–	–	–	4.77	TC	[1106,4386]
Fe(100)	–	–	–	–	–	4.78	TC	[461]
Fe(100)	–	–	1×10^{-9}	~300	–	4.88 ± 0.07	PE	[564,1107]
Fe(100)	–	–	?	98	–	4.9	PE	[3988]
Fe(100)	–	–	1×10^{-10}	~300	–	5.0	PE	[1531]
Fe(100)	–	–	–	–	–	5.01	TC	[1703]
Recommended	–	–	–	–	–	**4.64 ± 0.05**	–	–
Fe(110)	–	–	–	–	–	4.71	TC	[3761]
Fe(110)/Cu(100)	Fe	–	?	100	–	4.72	PE	[1273]
Fe(110)	–	–	–	–	–	4.73	TC	[4121]
Fe(110)	–	–	–	–	–	4.73	TC	[4130]
Fe(110)	–	–	–	–	–	4.75	TC	[1625]
Fe(110)	–	–	–	–	–	4.76	TC	[1625]
Fe(110)	–	–	–	–	–	4.77	TC	[4120]
Fe(110)	–	–	–	–	–	4.80	TC	[1623]
Fe(110)	–	–	–	–	–	4.81	TC	[1619]
Fe(110)	–	–	–	–	–	4.82	TC	[1619]
Fe(110)	–	–	–	–	–	4.84	TC	[3226]
Fe(110)	–	–	–	–	–	4.86	TC	[2911]
Fe(110)	–	–	–	–	–	4.86	TC	[3236]
Fe(110)/W(110)	Fe	–	?	~300	–	4.98	CPD	[2035]
Fe(110)/W(110)	Fe	–	?	100	–	5.02 ± 0.04	PE	[1273]
Fe(110)	–	–	1×10^{-10}	~300	–	5.05	PE	[1182,1232,1541, 2342]
Fe(110)/W(110)	Fe	–	?	~300 (800)	–	5.1	CPD	[4231]
Fe(110)	–	–	5×10^{-9}	~300	–	5.12	PE	[1107]
Fe(110)	–	–	–	–	–	5.12	TC	[4222]
Fe(110)	–	–	5×10^{-11}	~300	–	5.12 ± 0.06	PE	[922,969]
Fe(110)	–	–	–	–	–	5.16	TC	[334]
Fe(110)	–	–	–	–	–	5.21	TC	[229,317]
Fe(110)	–	–	–	–	–	5.30	TC	[321]
Fe(110)	–	–	–	–	–	5.30	TC	[2745]
Fe(110)/W(110)	Fe	–	3×10^{-10}	~300 (≤1100)	–	5.32 ± 0.02	FE	[530]
Fe(110)	–	–	–	–	–	5.45	TC	[3179]
Recommended	–	–	–	–	–	**4.99 ± 0.04**	–	–
Fe(111)	–	–	–	–	–	3.81	TC	[4222]
Fe(111)	–	–	–	–	–	3.89	TC	[1625]
Fe(111)	–	–	–	–	–	3.90	TC	[1619,1623]
Fe(111)	–	–	–	–	–	3.91	TC	[1619]
Fe(111)	–	–	–	–	–	3.95	TC	[1625]
Fe(111)	–	–	–	–	–	4.35	TC	[321]
Fe(111)	–	–	–	–	–	4.44	TC	[462]
Fe(111)	–	–	$\sim 10^{-9}$	~300 (720)	–	4.81 ± 0.02	PE	[487]
Recommended	–	–	–	–	–	**4.4 ± 0.3**	–	–
Fe(210)	–	–	–	–	–	4.20	TC	[1625]
Fe(210)	–	–	–	–	–	4.27	TC	[1625]
Fe(211)	–	–	–	–	–	4.06	TC	[1625]
Fe(211)	–	–	–	–	–	4.12	TC	[1625]
Fe(211)	–	–	–	–	–	4.85	TC	[321]
Fe(310)	–	–	–	–	–	3.95	TC	[1625]
Fe(310)	–	–	–	–	–	4.05	TC	[1625]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe(321)	–	–	–	–	–	4.27	TC	[1625]
Fe(321)	–	–	–	–	–	4.32	TC	[1625]
bcc ($\alpha - \beta$, $T < 1179$ K)								
Fe(100)	–	–	–	–	–	4.5 ± 0.3	TC	[1104]
bcc (β, $T = 1042–1179$ K)								
Fe(100)	–	–	–	–	–	4.07	TC	[463]
Fe(100)[427]	–	–	–	–	–	4.2	TC	[1104]
Fe(100)	–	–	–	–	–	4.77	TC	[1106,2650]
Fe(100)	–	–	–	–	–	4.86	TC	[549]
Fe(100)	–	–	–	–	–	5.06	TC	[229]
Fe(110)	–	–	–	–	–	5.78	TC	[229,334]
Fe(111)	–	–	–	–	–	4.81	TC	[462]
fcc (γ, $T = 1179–1674$ K)								
Fe(100)	–	–	–	–	–	4.53	TC	[463]
Fe(100)	–	–	–	–	–	4.86	TC	[549,1105,2777, 3614]
Fe(100)	–	–	–	–	–	5.00	TC	[1914]
Fe(100)	–	–	–	–	–	5.1	TC	[2650]
Fe(100)	–	–	–	–	–	5.28	TC	[321]
Fe(100)	–	–	–	–	–	5.3	TC	[1916,2650]
Fe(100)	–	–	–	–	–	5.45	TC	[1913]
Fe(100)	–	–	–	–	–	5.55	TC	[229]
Recommended	–	–	–	–	–	**5.28 ± 0.19**	–	–
Fe(110)	–	–	–	–	–	4.97	TC	[321]
Fe(111)	–	–	–	–	–	5.54	TC	[229,334]
Fe(111)	–	–	–	–	–	5.70	TC	[321]
fcc (metastable, $T < 1042$ K)[114,407]								
Fe(100)/Cu(100)[412]	Fe	–	?	~300	–	4.62	PE	[2673]
Fe(100)/Cu(100)[412]	Fe	–	?	~300 (500)	–	4.67	PE	[2673]
Fe(100)/Cu(100)	Fe	–	?	~300 (460)	–	4.95 ± 0.05	PE	[2650]
Fe(100)/Cu(100)	–	–	–	–	–	5.10	TC	[1914]
Fe(100)/Cu(100)	Fe	–	?	~300	–	5.4	PE	[1913,4386]
Fe(100)/Cu(100)	–	–	–	–	–	5.4	TC	[1914]
Fe(100)/Cu(100)	–	–	–	–	–	5.48	TC	[1913,4386]
Fe(100)/Cu(100)	Fe	–	?	~300	–	5.5 ± 0.1	PE	[1913,4386]
Fe(100)/Cu(100)	–	–	–	–	–	5.58	TC	[1913,4386]
Fe(100)/Cu(100)	–	–	–	–	–	5.6	TC	[1916]
Recommended	–	–	–	–	–	**5.38 ± 0.22**	–	–
bcc (α, $T < 1042$ K for bulk)								
Fe	–	–	–	–	–	3.7	TC	[2456]
Fe/quartz[51]	Fe	–	~10^{-5}	~300	–	3.86	PE	[1973]
Fe	–	–	~10^{-6}	~300	–	3.91	PE	[3389,3394]
Fe	–	–	?	~300	–	3.92 ± 0.02	PE	[3388,3394]
Fe/silica	Fe	–	~10^{-8}	~300	–	4.0	PE	[2010]
Fe/glass	Fe	–	<1×10^{-10}	78	–	4.06	PE	[414]
Fe	–	–	?	~300	–	4.06 ± 0.01	CPD	[2544]
Fe/glass[369]	Fe	–	~10^{-10}	77	–	4.10 ± 0.02	PE	[2132,2133,2147]
Fe/glass	Fe	–	<10^{-9}	90	–	4.11	PE	[1957]
Fe/glass	Fe	–	2×10^{-10}	273	–	4.12	PE	[2096,3053]
Fe/glass	Fe	–	<10^{-9}	273	–	4.12	PE	[2307,3048]
Fe/glass	Fe	–	~10^{-10}	77	–	4.13	PE	[3052]
Fe	–	–	?	~300	–	4.16*	CPD	[3621]
Fe/glass	Fe	–	<10^{-9}	90	–	4.16	PE	[2763,3046]
Fe/glass	Fe	–	~10^{-8}	~300	–	4.16 ± 0.02	CPD	[13,349]
Fe/glass	Fe	–	~10^{-8}	~300	–	4.17 ± 0.03	CPD	[133]
Fe/Ag(100)	Fe	–	?	?	–	4.2	?	[1696]
Fe/W	Fe	–	~10^{-10}	~300	–	4.2	FE	[2369]
Fe	–	–	<10^{-6}	~300	–	4.2	PE	[2919]
Fe/W(110)	–	–	–	–	–	4.20	TC	[1270]
Fe	K	K$^+$	~10^{-9}	~700–1100	4.24	–	PSI	[2115]
Fe/W	–	–	?	?	–	4.25	FE	[3346]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe/W(110)	–	–	–	–	–	4.26	TC	[1270]
Fe/W(100)	Fe	–	$<2 \times 10^{-10}$	~300	–	4.27	FE	[2257]
Fe/W(100)	Fe	–	$<2 \times 10^{-10}$	~600	–	4.27	FE	[2257]
Fe	–	–	6×10^{-3}	~300	–	4.30 ± 0.06	PE	[2079,2080]
Fe/W(111)	–	–	–	–	–	4.31	TC	[1270]
Fe/W(112)	–	–	3×10^{-10}	~300 (900)	–	4.31 ± 0.02	FE	[530]
Fe/W(111)	–	–	–	–	–	4.33	TC	[1270]
Fe/Ta(111)	Fe	–	$<1 \times 10^{-10}$	~300	–	4.35	CPD	[3302]
Fe/W(100)	Fe	–	$<5 \times 10^{-11}$	~300	–	4.35	CPD	[2035]
Fe/glass	Fe	–	$<1 \times 10^{-10}$	78 (293)	–	4.36	PE	[414]
Fe/glass	Fe	–	?	77	–	4.38	PE	[3075]
Fe/glass	Fe	–	$<10^{-10}$	77 (323)	–	4.38 ± 0.02	PE	[2147]
Fe	–	–	?	~300	–	4.40	CPD	[2297]
Fe	–	–	?	~300	–	4.40	PE	[4278]
Fe	–	–	–	–	–	4.40	TC	[1885]
Fe/glass[369]	Fe	–	$\sim 10^{-10}$	77 (323)	–	4.40	PE	[2133]
Fe/W(111)	Fe	–	$<5 \times 10^{-11}$	~300	–	4.40*	CPD	[2429]
Fe/glass	Fe	–	?	273	–	4.42	PE	[3075]
Fe	–	–	–	–	–	4.43	TC	[4031]
Fe/W(100)	Fe	–	3×10^{-10}	~300 (900)	–	4.43 ± 0.02	FE	[530]
Fe/W(110)	Fe	–	?	90	–	4.47	CPD	[2754]
Fe/W(100)	–	–	–	–	–	4.49	TC	[1270]
Fe	–	–	–	–	–	4.49	TC	[3476]
Fe/TiO$_2$(001)	Fe	–	$\sim 10^{-10}$	~300	–	4.5	CPD	[1567]
Fe	–	–	–	–	–	4.5	TC	[706]
Fe/Au(001)	–	–	–	–	–	4.5	TC	[1719]
Fe/W(110)	Fe	–	?	90	–	4.5	CPD	[2755]
Fe/Ag(001)	Fe	–	2×10^{-10}	30	–	4.5 ± 0.05	PE	[3145,4377]
Fe/quartz	Fe	–	$\sim 10^{-10}$	~300	–	4.5 ± 0.15	PE	[304]
Fe	–	–	–	–	–	4.51	TC	[2005]
Fe	–	–	–	–	–	4.51	TC	[1399]
Fe	–	–	–	–	–	4.52	TC	[1645]
Fe/W(100)	–	–	–	–	–	4.53	TC	[1270]
Fe	–	–	–	–	–	4.53	TC	[3318]
Fe	–	–	–	–	–	4.53	TC	[3476]
Fe	–	–	–	–	–	4.56	TC	[4031]
Fe/glass	Fe	–	$<10^{-9}$	273 (393)	–	4.56	PE	[2307]
Fe/W(110)	–	–	–	–	–	4.57	TC	[1270]
Fe/glass	Fe	–	$<10^{-9}$	90 (393)	–	4.57	PE	[3048]
Fe/W(116)	Fe	–	3×10^{-10}	~300 (900)	–	4.57 ± 0.03	FE	[530]
Fe/Si(111)	Fe	–	5×10^{-9}	~300	–	4.58 ± 0.05	CPD	[3270]
Fe	–	–	–	–	–	4.6	TC	[2583]
Fe	–	–	$\sim 10^{-7}$	~300 (750)	–	4.6 ± 0.03	CPD	[2346]
Fe/glass	Fe	–	2×10^{-10}	293 (393)	–	4.60	PE	[3052,3053]
Fe	–	–	?	~300	–	4.60	PE	[2924]
Fe	–	–	–	–	–	4.61	TC	[298]
Fe/glass	Fe	–	$<10^{-9}$	90 (393)	–	4.63	PE	[2096]
Fe	–	–	?	~300	–	4.63	PE	[2924]
Fe/W(111)	Fe	–	3×10^{-10}	~300 (900)	–	4.63 ± 0.02	FE	[530]
Fe	–	–	–	0	–	4.64	TC	[4419]
Fe	–	–	–	–	–	4.65	TC	[3352]
Fe	–	–	–	–	–	4.65	TC	[3264,3265,3267]
Fe[406]	–	–	$\sim 10^{-8}$	870	–	4.65 ± 0.01	PE	[305]
Fe/glass	Fe	–	3×10^{-10}	90 (393)	–	4.66	PE	[3053]
Fe/W(110)	Fe	–	?	90 (150)	–	4.66	CPD	[2754]
Fe/?	?	–	$\sim 10^{-6}$	~300	–	4.68	PE	[3027]
Fe	–	–	$\sim 10^{-10}$	~300	–	4.68	CPD	[3131]
Fe	–	–	–	–	–	4.68	TC	[3637]
Fe/W(111)	Fe	–	$<5 \times 10^{-11}$	~300	–	4.68	CPD	[2035]
Fe/W(111)	–	–	–	–	–	4.69	TC	[1270]
Fe/?	Fe	–	2×10^{-10}	4.2 (400)	–	4.7	PE	[1506]
Fe/glass	Fe	–	$<10^{-8}$	78	–	4.7 ± 0.02	CPD	[1646]
Fe/steel	Fe	–	$\sim 10^{-10}$	4.2	–	4.7 ± 0.1	PE	[1410]
Fe[406]	–	–	$\sim 10^{-8}$	~300	–	4.70 ± 0.01	PE	[305]
Fe/glass	Fe	–	$<10^{-9}$	90 (373)	–	4.71	PE	[2763,3046,3052]
Fe/W(112)	Fe	–	$<5 \times 10^{-11}$	~300	–	4.71	CPD	[2035]
Fe	–	–	1×10^{-8}	~300	–	4.71 ± 0.02	PE	[306]
Fe/silica	Fe	–	$<2 \times 10^{-10}$	290	–	4.71 ± 0.02	PE	[923,2113,2114]
Fe/glass	Fe	–	$<10^{-9}$	293 (373)	–	4.72	PE	[1957,3046]
Fe/W(110)	Fe	–	?	90 (600)	–	4.72	CPD	[2754]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe	–	–	$\sim10^{-8}$	~300	–	4.72 ± 0.07	PE	[1630]
Fe/W(110)	–	–	–	–	–	4.73	TC	[531]
Fe	–	–	?	~300	–	4.74	PE	[2464]
Fe	–	–	$\sim10^{-7}$	~300 (≤1070)	–	4.75 ± 0.08	CPD	[2346]
Fe/W(110)	Fe	–	?	90 (175, 250)	–	4.76	CPD	[2754]
Fe/W(100)	–	–	–	–	–	4.77	TC	[1270]
Fe	–	–	–	–	–	4.77	TC	[2949]
Fe	–	–	1×10^{-8}	~300	–	4.77	PE	[306]
Fe/W(110)	Fe	–	?	90 (~300)	–	4.77	CPD	[2754]
Fe	–	–	1×10^{-8}	~300	–	4.77 ± 0.02	PE	[306]
Fe/Al(001)	–	–	–	–	–	4.79	TC	[3003]
Fe/W	Fe	–	3×10^{-10}	~300 (900)	–	4.8	FE	[530]
Fe	–	–	–	–	–	4.8	TC	[944]
Fe/W(110)	Fe	–	$\sim10^{-11}$	~300	–	4.8	CPD	[2430]
Fe	–	–	$\sim10^{-8}$	~300	–	4.8 ± 0.05	CPD	[1542]
Fe	–	–	$\sim10^{-9}$	~300 (≤1070)	–	4.80 ± 0.04	CPD	[2346]
Fe	–	–	$<10^{-9}$	~300	–	4.81	PE	[307]
Fe	–	–	$<2 \times 10^{-10}$	~300	–	4.85 ± 0.04	CPD	[1898]
Fe/W(111)	–	–	–	–	–	4.86	TC	[531]
Fe/?	Fe	–	$\sim10^{-5}$	~300	–	4.9	CPD	[1376]
Fe/W(110)	Fe	–	?	~300	–	4.9	CPD	[2755]
Fe/W(110)	Fe	–	?	~300 (600)	–	4.9	CPD	[2755]
Fe/W(100)	–	–	–	–	–	4.92	TC	[531]
Fe	–	–	–	–	–	4.92	TC	[1066]
Fe	–	–	6×10^{-9}	~300	–	4.95	PE	[1139]
Fe/W(110)	Fe	–	$<5 \times 10^{-11}$	~300	–	4.98	CPD	[2035]
Fe	–	–	–	–	–	5.00	TC	[3476]
Fe/W(112)	–	–	–	–	–	5.05	TC	[531]
Fe/Mo(110)	Fe	–	3×10^{-11}	500	–	5.07	CPD	[3293]
Fe/Mo(110)	Fe	–	3×10^{-11}	~300	–	5.09	CPD	[3293]
Fe/W(110)	Fe	–	3×10^{-10}	~300 (900)	–	5.32 ± 0.02	FE	[530]
Recommended	–	–	–	–	–	**4.55 ± 0.05**	–	–

bcc (β, $T = 1042$–1179 K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe	–	–	$\leq1 \times 10^{-9}$	~1100–1160	–	4.33	TE	[179]
Fe	–	–	–	–	–	4.44	TC	[3318]
Fe	–	–	–	–	–	4.45	TC	[3318]
Fe	–	–	3×10^{-8}	1120–1180	–	4.48 ± 0.06	TE	[310]
Fe	Na	Na$^+$	$\sim10^{-9}$	1180	4.49[112]	–	PSI	[303]
Fe	K	K$^+$	$\sim10^{-9}$	1180	4.49[112]	–	PSI	[303]
Fe[406]	–	–	$\sim10^{-8}$	1125	–	4.62 ± 0.01	PE	[305]
Fe	–	–	3×10^{-8}	1120–1180	–	4.64 ± 0.06*	TE	[310]
Fe[113]	–	–	$<10^{-6}$	1110–1170	–	4.77	TE	[3024]
Recommended	–	–	–	–	–	**4.52 ± 0.17**	–	–

bcc–fcc (β–γ, $T = 1042$–1674 K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe[111]	–	Na$^+$	5×10^{-9} (O_2)	~1050–1350	3.6 ± 0.1	(4.0 ± 0.1)	PSI	[277]
Fe[111]	–	K$^+$	5×10^{-9} (O_2)	~1050–1350	3.8 ± 0.1	(4.0 ± 0.1)	PSI	[277]
Fe	–	–	5×10^{-9} (O_2)	~1050–1350	(3.6–4.3)	4.0 ± 0.1	TE	[277,2115]
Fe	–	–	$\sim10^{-9}$	~1100–1300	(4.4 ± 0.2)	4.0 ± 0.2	TE	[308]
Fe	–	–	$\sim10^{-9}$	~1100–1300	–	4.3	TE	[309]
Fe[111]	–	K$^+$	5×10^{-9} (O_2)	~1050–1350	4.3 ± 0.1*	(4.0 ± 0.1)	PSI	[277]
Fe	Na	Na$^+$	$\sim10^{-9}$	~1050–1350	4.4 ± 0.2	(4.0 ± 0.2)	PSI	[308]

fcc (γ, $T = 1179$–1674 K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe	–	–	?	~1300–1500	–	4.04	TE	[1762]
Fe[473]	–	–	3×10^{-8}	1180–1250	–	4.21 ± 0.05	TE	[310]
Fe	–	–	1×10^{-9}	1205–1494	–	4.28 ± 0.06	TE	[179]
Fe/graphite	Fe	–	$<10^{-5}$	~1400–1600	–	4.31 ± 0.02	TE	[769,2304]
Fe	–	–	$\leq1 \times 10^{-9}$	~1200–1550	–	4.47 ± 0.09	TE	[179,3413]
Fe	–	–	$\leq10^{-9}$	?	–	4.5	TE	[650]
Fe	–	–	$\leq1 \times 10^{-9}$	1240–1510	–	4.50 ± 0.05	TE	[179]
Fe	–	–	$\leq1 \times 10^{-9}$	1283–1492	–	4.52 ± 0.04	TE	[179]
Fe	Na	Na$^+$	$\sim10^{-9}$	1183	4.55[112]	–	PSI	[303]
Fe	K	K$^+$	$\sim10^{-9}$	1183	4.55[112]	–	PSI	[303]
Fe	–	–	$\leq1 \times 10^{-9}$	1350–1494	–	4.55 ± 0.06	TE	[179]
Fe	–	–	?	?	–	4.6	TE	[3402]
Fe[473]	–	–	3×10^{-8}	1180–1250	–	4.66 ± 0.05*	TE	[310]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Fe[406]	–	–	$\sim 10^{-8}$	1243	–	4.68 ± 0.01	PE	[305]
Fe[113]	–	–	$< 10^{-6}$	1170–1230	–	4.77	TE	[3024]
Recommended	–	–	–	–	–	**4.54 ± 0.05**	–	–
bcc (δ, $T > 1674$ K for bulk)								
Fe/graphite	Fe	–	?	1643–1763	–	4.76	TE	[2568]
Fe	–	–	?	1780–1850	–	4.76	TE	[2608]
fcc (metastable, $T < 1042$ K)[114]								
Fe/Cu(100)	Fe	–	$\sim 10^{-10}$	~ 300 (400)	–	4.46	PE	[2175]
Fe/Cu(100)	Fe	–	$\sim 10^{-10}$	~ 300	–	4.59	PE	[2175]
Fe/Cu(100)	Fe	–	?	30	–	4.7 ± 0.1	PE	[2878,4377]
Fe/Cu(100)	–	–	–	–	–	5.09	TC	[3654]

27. Cobalt Co

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, $T < 695$ K for bulk)[474]								
Co(0001)	–	–	–	–	–	5.00	TC	[2910]
Co(0001)	–	–	$< 2 \times 10^{-10}$	~ 300	–	5.1 ± 0.1	PE	[2036]
Co(0001)	–	–	–	–	–	5.18	TC	[2423]
Co(0001)	–	–	?	?	–	5.2	PE	[2173]
Co(0001)	–	–	4×10^{-11}	100–300	–	5.2*	PE	[2141]
Co(0001)	–	–	5×10^{-11}	~ 300	–	5.20 ± 0.03	PE	[922,969]
Co(0001)[115]	–	–	$< 4 \times 10^{-10}$	~ 300	–	5.264	CPD	[3192,3193]
Co(0001)/Mo(110)	Co	–	$< 6 \times 10^{-11}$	~ 300	–	5.45	CPD	[3293]
Co(0001)	–	–	–	–	–	5.48	TC	[334]
Co(0001)	–	–	–	–	–	5.53	TC	[229,317]
Co(0001)	–	–	$\leq 5 \times 10^{-10}$	160–300	–	5.55 ± 0.20	PE	[2537,3381,3633]
Co(0001)	–	–	–	–	–	5.62	TC	[4005]
Co(0001)	–	–	–	–	–	5.69	TC	[463]
Co(0001)	–	–	–	–	–	5.75	TC	[321]
Co(0001)	–	–	–	–	–	5.80	TC	[463]
Co(0001)	–	–	–	–	–	5.81	TC	[229,334]
Recommended	–	–	–	–	–	**5.30 ± 0.18**	–	–
Co(1010)	–	–	–	–	–	5.50	TC	[321]
Co(1011)	–	–	$< 4 \times 10^{-10}$	300	–	5.250	CPD	[3193]
Co(1120)	–	–	4×10^{-11}	100–300	–	4.1*	PE	[2141]
Co(1124)	–	–	–	–	–	4.83	TC	[321]
fcc (β, $T > 695$ K for bulk)[474]								
Co(100)	–	–	–	–	–	5.047	TC	[2510]
Co(100)	–	–	–	–	–	5.174	TC	[2510]
Co(100)	–	–	–	–	–	5.25	TC	[321]
Co(100)	–	–	–	–	–	5.52	TC	[229,317]
Co(100)	–	–	–	–	–	5.83	TC	[229]
Recommended	–	–	–	–	–	**5.25 ± 0.17**	–	–
Co(110)	–	–	–	–	–	4.95	TC	[321]
Co(111)	–	–	–	–	–	4.93	TC	[2068]
Co(111)	–	–	–	–	–	5.03	TC	[2910]
Co(111)	–	–	–	–	–	5.05	TC	[4421]
Co(111)[115]	–	–	$< 4 \times 10^{-10}$	$\sim 300^E$	–	5.266	CPD	[3192]
Co(111)	–	–	–	–	–	5.44	TC	[4174,4284]
Co(111)	–	–	–	–	–	5.55	TC	[229,317]
Co(111)	–	–	–	–	–	5.68	TC	[321]
Co(111)	–	–	–	–	–	5.76	TC	[229,334]
Recommended	–	–	–	–	–	**5.39 ± 0.23**	–	–
bcc (metastable phase, $T < 695$ K)[428]								
Co(100)/GaAs(110)	–	–	–	–	–	4.66[430]	TC	[4023]
Co(100)/GaAs(110)	–	–	–	–	–	4.75[430]	TC	[4023]
Co(100)/GaAs(110)	–	–	–	–	–	5.10[429]	TC	[4023]
Co(100)/GaAs(110)	–	–	–	–	–	5.20[430]	TC	[4023]
Co(100)/GaAs(110)	–	–	–	–	–	5.55[429]	TC	[4023]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
fcc (metastable phase, $T < 695$ K)								
Co(100)/Cu(100)[412]	Co	–	?	~300	–	4.72	PE	[2673]
hcp (α, $T < 695$ K for bulk)[474]								
Co	–	–	~10^{-6}	~300	–	3.90 ± 0.02	PE	[3389,3394]
Co	–	–	?	~300	–	3.92	PE	[3388]
Co/glass	Co	–	<10^{-8}	78	–	4.1 ± 0.02	CPD	[1646]
Co[116]	–	–	≤3 × 10^{-8}	~300 (1120)	–	4.12 ± 0.04	PE	[1631,1632]
Co	–	–	–	–	–	4.16	TC	[1399]
Co	–	–	–	–	–	4.2*	TC	[1955]
Co	–	–	?	~300	–	4.21	CPD	[2297]
Co	–	–	?	~300	–	4.25	CPD	[2469]
Co	–	–	?	~300	–	4.27 ± 0.01	CPD	[2544]
Co	–	–	~10^{-6}(Ar)	293	–	4.35 ± 0.02	CPD	[3977]
Co/W	Co	–	?	?	–	4.4	FE	[3346]
Co/W(100)	Co	–	1 × 10^{-10}	100 (1100)	–	4.4*	CPD	[2270]
Co/?[117]	Co	–	2 × 10^{-10}	4.2	–	4.4 ± 0.1	PE	[1506]
Co	–	–	–	–	–	4.41	TC	[3476]
Co/glass	Co	–	<10^{-10}	77	–	4.426	PE	[2136]
Co/glass	Co	–	<10^{-10}	77	–	4.43 ± 0.02	PE	[2132,2147]
Co/glass[369]	Co	–	~10^{-10}	77	–	4.44	PE	[2133]
Co	–	–	–	–	–	4.47	TC	[2005]
Co	–	–	–	–	–	4.48	TC	[3318]
Co/?	Co	–	5 × 10^{-9}	~300	–	4.5	PE	[3506]
Co	–	–	–	–	–	4.53	TC	[3476]
Co/glass	Co	–	<10^{-10}	77 (196)	–	4.54 ± 0.02	PE	[2147]
Co/glass	Co	–	<10^{-10}	77 (273)	–	4.544	PE	[2136]
Co	–	–	–	–	–	4.56	TC	[3318]
Co/glass	Co	–	2 × 10^{-10}	293	–	4.59	PE	[3053]
Co	–	–	–	–	–	4.60	TC	[3637]
Co/glass	Co	–	<10^{-9}	90	–	4.60	PE	[2096,3052,3053]
Co/glass	Co	–	2 × 10^{-10}	90	–	4.61	PE	[3053]
Co/glass	Co	–	<10^{-10}	77 (273)	–	4.63 ± 0.02	PE	[2147]
Co	–	–	–	–	–	4.7	TC	[706]
Co/Pt(110)	Co	–	~8 × 10^{-11}	100	–	4.7 ± 0.1	PE	[1923]
Co	–	–	–	–	–	4.70	TC	[3264,3265,3267]
Co	–	–	–	–	–	4.70	TC	[3352]
Co/W(110)	–	–	–	–	–	4.72	TC	[531]
Co/CoSi$_2$(111)	Co	–	?	~300	–	4.75	PE	[2872]
Co/glass	Co	–	<10^{-10}	77 (478)	–	4.82 ± 0.02	PE	[2147]
Co/glass	Co	–	<10^{-10}	77 (≤478)	–	4.83 ± 0.01	PE	[2136]
Co/Si(111)[118]	Co	–	4 × 10^{-11}	~300	–	4.86 ± 0.05	PE	[2451]
Co	–	–	–	–	–	4.87	TC	[2949]
Co/silica	Co	–	<2 × 10^{-10}	290	–	4.89 ± 0.04	PE	[923,2113,2114]
Co/?[117]	Co	–	2 × 10^{-10}	400	–	4.9 ± 0.1	PE	[1506]
Co/glass[369]	Co	–	~10^{-10}	77 (323)	–	4.91	PE	[2133]
Co	–	–	<2 × 10^{-10}	~300	–	4.92 ± 0.04	CPD	[1898]
Co[119]	–	–	<4 × 10^{-10}	663	–	4.923	CPD	[1148]
Co/Pt(111)	–	–	–	–	–	4.94	TC	[4024]
Co/glass	Co	–	2 × 10^{-10}	293 (393)	–	4.95	PE	[3053]
Co/CoSi$_2$(111)	Co	–	?	~300	–	4.95 ± 0.05	PE	[2169]
Co	–	–	–	–	–	4.96	TC	[3476]
Co[119]	–	–	<4 × 10^{-10}	300	–	4.960	CPD	[1148,3193]
Co/glass	Co	–	<10^{-9}	293 (393)	–	4.97	PE	[2096,3052]
Co	–	–	~10^{-10}	300	–	4.97	CPD	[3153]
Co/Si(111)	Co	–	<5 × 10^{-9}	~300	–	4.97 ± 0.05	CPD	[3270]
Co$_n$($n \to \infty$)	–	–	–	–	–	4.98 ± 0.09	TC	[4261]
Co/Pd(111)	Co	–	<3 × 10^{-10}	~300	–	5.0	PE	[3645]
Co/W(110)	Co	–	1 × 10^{-10}	100	–	5.0*	CPD	[2270]
Co	–	–	–	–	–	5.0	TC	[944]
Co/quartz	Co	–	~10^{-10}	~300	–	5.0 ± 0.1	PE	[304]
Co/glass	Co	–	2 × 10^{-10}	293 (393)	–	5.00	PE	[3053]
Co	–	–	–	–	–	5.00	TC	[298]
Co/Pd(111)	–	–	–	–	–	5.00	TC	[4024]
Co/glass	Co	–	?	77 (≤373)	–	5.05 ± 0.15	PE	[2127]
Co/W(111)	–	–	–	–	–	5.08	TC	[531]
Co/W(110)	Co	–	1 × 10^{-10}	100 (1100)	–	5.1*	CPD	[2270]
Co	–	–	–	–	–	5.10	TC	[4024]
Co/Cu/Co(0001)	–	–	–	–	–	5.12	TC	[3490]
Co/W(112)	–	–	–	–	–	5.17	TC	[531]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Co/Fe(001)	Co	–	$<5 \times 10^{-11}$	~300	–	5.20 ± 0.02	PE	[1831]
Co/Si(111)	Co	–	5×10^{-11}	~300	–	5.27	PE	[1820,2865]
Co/W(100)	–	–	–	–	–	5.28	TC	[531]
Co	–	–	–	–	–	5.32	TC	[950]
Co	–	–	–	–	–	5.44	TC	[1066]
Recommended	–	–	–	–	–	**4.71 ± 0.03**	–	–
fcc (β, $T > 695$ K for bulk)[474]								
Co/W(100)	Co	–	$<8 \times 10^{-11}$	~300	–	3.6	FE	[364]
Co/W	Co	–	$<8 \times 10^{-11}$	~300, 580	–	3.9	FE	[364]
Co/W(110)	Co	–	$<8 \times 10^{-11}$	~300	–	4.1	FE	[364]
Co[116]	–	–	$\leq 3 \times 10^{-8}$	~300 (1120)	–	4.25 ± 0.08	PE	[1632]
Co	–	–	?	?	–	4.3	TE	[3402]
Co/graphite	Co	–	$<10^{-6}$	~1400–1600	–	4.41 ± 0.02	TE	[769,2304]
Co	–	–	3×10^{-8}	>1120	–	4.41 ± 0.10	TE	[310]
Co/W(100)	–	–	$<8 \times 10^{-11}$	580	–	4.5	FE	[364]
Co[120]	–	–	?	1340–1390	–	4.6 ± 0.3	TE	[3604]
Co[120]	–	–	?	1390–1440	–	4.8 ± 0.3	TE	[3604]
Co[119]	–	–	$<4 \times 10^{-10}$	673	–	4.925	CPD	[1148]
Co	–	–	$<4 \times 10^{-10}$	720	–	4.93	CPD	[3153]
Co[119]	–	–	$<4 \times 10^{-10}$	300[E]	–	4.966	CPD	[1148]
Co/W(110)	Co	–	$<8 \times 10^{-11}$	580	–	5.1	FE	[364]
Recommended	–	–	–	–	–	**4.50 ± 0.13**	–	–
fcc (metastable, $T < 695$ K)								
Co/Cu(100)	Co	–	1×10^{-10}	<50	–	4.4	PE	[950]
Co/Cu(100)	Co	–	$\sim 1 \times 10^{-10}$	<50	–	4.5	PE	[950]
Co/Cu(100)	Co	–	$<8 \times 10^{-11}$	400	–	4.72 ± 0.03	PE	[3475]
Co/Cu(100)	Co	–	$<8 \times 10^{-11}$	400	–	4.78 ± 0.03	PE	[3475]
Co/Cu(100)	–	–	–	–	–	4.83	TC	[3377]
Co/Cu(100)	–	–	–	–	–	4.93	TC	[3377]
Co/Cu(111)	Co	–	$<8 \times 10^{-11}$	~300	–	5.02	PE	[968]
Co/Cu(001)	–	–	–	–	–	5.15	TC	[3377]
Co/Cu(001)	–	–	–	–	–	5.30	TC	[2897]
Co/Cu(001)	–	–	–	–	–	5.31	TC	[2897]
Co/Cu(001)[121]	Co	–	2×10^{-10}	30	–	5.0 ± 0.2	PE	[2879,4377]
Co/Cu(001)[122]	–	–	–	–	–	5.34	TC	[3654]
Recommended	–	–	–	–	–	**4.94 ± 0.30**	–	–

28. Nickel Ni

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
fcc								
Ni(100)	–	–	–	–	–	4	TC	[2884]
Ni(100)	–	–	–	–	–	4.7	TC	[935,1006]
Ni(100)	–	–	$\sim 10^{-10}$	~300	–	4.75 ± 0.1	CPD	[1983]
Ni(100){95%}	–	–	–	–	(5.21 ± 0.01)	4.80 ± 0.09	TC	[283,630,1351]
Ni(100)	–	–	2×10^{-10}	460 (750)	–	4.84 ± 0.03	PE	[1032]
Ni(100)	–	–	–	–	–	4.86	TC	[3224]
Ni(100)	–	–	2×10^{-10}	343 (705)	–	4.89 ± 0.03	PE	[1032]
Ni(100)	–	–	1×10^{-9}	~1400–1600	–	4.89 ± 0.03	TE	[312,837]
Ni(100)	–	–	?	~300	–	4.9	CPD	[1379]
Ni(100)	–	–	–	–	–	4.95 ± 0.02	TC	[4331]
Ni(100)	–	–	$<5 \times 10^{-11}$	~300	–	4.95 ± 0.05	CPD	[1005,2830]
Ni(100)	–	–	–	–	–	4.96	TC	[4454]
Ni(100)	–	–	–	–	–	4.97	TC	[311]
Ni(100)	–	–	–	–	–	5.0	TC	[935,3556]
Ni(100)	–	–	–	–	–	5.02	TC	[463]
Ni(100)	–	–	–	–	–	5.05	TC	[2701]
Ni(100)	–	–	–	–	–	5.05	TC	[4258]
Ni(100)[123]	–	–	$\sim 10^{-10}$	~300	–	5.08	PE	[903]
Ni(100)	–	–	?	~300	–	5.08	PE	[2673]
Ni(100)	–	–	–	–	–	5.09	TC	[4229]
Ni(100)	–	–	?	~300	–	5.09 ± 0.03	PE	[3180]
Ni(100)	–	–	–	–	–	5.1	TC	[1006,1108,1109]
Ni(100)	–	–	$<1 \times 10^{-10}$	~300	–	5.1 ± 0.1	CPD	[1110,1517]
Ni(100)[123]	–	–	$\sim 10^{-10}$	~300 (623)	–	5.12	PE	[903]
Ni(100)/mica[124]	Ni	–	2×10^{-9}	~300{593}	–	5.12 ± 0.02	PE	[314]
Ni(100)	–	–	$\sim 10^{-10}$	~300 (?)	–	5.135	PE	[903]
Ni(100)	–	–	$\sim 10^{-10}$	~300	–	5.14	PE	[3744]
Ni(100)	–	–	4×10^{-10}	273	–	5.15 ± 0.05	PE	[484]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni(100)/glass[125]	Ni	–	2×10^{-9}	77 (523)	–	5.17 ± 0.02	PE	[314]
Ni(100)	–	–	–	–	–	5.19	TC	[2548]
Ni(100)	–	–	1×10^{-10}	100, 300	–	5.2	PE	[1808]
Ni(100)	–	–	$\leq 3 \times 10^{-10}$	~300	–	5.2	CPD	[936]
Ni(100)	–	–	$\sim 10^{-10}$	350	–	5.2 ± 0.1	PE	[1919]
Ni(100)	–	–	6×10^{-11}	~300	–	5.2 ± 0.15	CPD	[1791]
Ni(100)	–	–	–	–	–	5.20	TC	[1159,1980,3067]
Ni(100)	–	–	2×10^{-10}	100	–	5.20	PE	[3139]
Ni(100)/glass[126]	Ni	–	2×10^{-9}	~300{573}	–	5.20 ± 0.02	PE	[314,315]
Ni(100)	–	–	4×10^{-10}	273	–	5.20 ± 0.05	PE	[484]
Ni(100)	–	–	$\sim 10^{-11}$	173	–	5.20 ± 0.11	CPD	[1417]
Ni(100){95%}	–	–	–	–	5.21 ± 0.01	(4.80 ± 0.09)	TC	[283,630,1351]
Ni(100)	–	–	–	–	–	5.22	TC	[463]
Ni(100)[123]	–	–	$\sim 10^{-10}$	~300 (1023)	–	5.22	PE	[903]
Ni(100)/glass[127]	Ni	–	5×10^{-10}	~300{523}	–	5.22	PE	[1513]
Ni(100)	–	–	5×10^{-10}	293	–	5.22 ± 0.04	PE	[314,315,2604]
Ni(100)	–	–	–	–	–	5.29	TC	[464]
Ni(100)	–	–	–	–	–	5.29	TC	[2701]
Ni(100)	–	–	$\sim 10^{-11}$	77	–	5.3	PE	[937]
Ni(100)	–	–	–	–	–	5.31	TC	[2804]
Ni(100)	–	–	–	–	–	5.31	TC	[1237]
Ni(100)	–	–	$\sim 10^{-10}$	~300	–	5.34	PE	[903]
Ni(100)	–	–	–	–	–	5.35	TC	[464]
Ni(100)	–	–	–	–	–	5.37	TC	[3614]
Ni(100)	–	–	–	–	–	5.37	TC	[466]
Ni(100)	–	–	–	–	–	5.4	TC	[2905]
Ni(100)	–	–	–	–	–	5.4	TC	[1918]
Ni(100)	–	–	–	–	–	5.5	TC	[465]
Ni(100)	–	–	$\sim 10^{-10}$	77, 300	–	5.53 ± 0.05	FE	[358]
Ni(100)	–	–	–	–	–	5.65	TC	[984]
Ni(100)	–	–	–	–	–	5.7	TC	[389]
Ni(100)	–	–	–	–	–	5.71	TC	[984]
Ni(100)	–	–	–	–	–	5.72	TC	[1234]
Ni(100)	–	–	–	–	–	5.73	TC	[464]
Ni(100)	–	–	–	–	–	5.75	TC	[229,317]
Ni(100)	–	–	–	–	–	5.84	TC	[229]
Recommended	–	–	–	–	–	**5.19 ± 0.05**	–	–
Ni(110)	–	–	$\sim 10^{-10}$	~300	–	4.20 ± 0.1	CPD	[1983]
Ni(110)	–	–	2×10^{-11}	20	–	4.45	PE	[2974,2977]
Ni(110)	–	–	–	–	–	4.46	TC	[4454]
Ni(110)	–	–	–	–	–	4.49	TC	[467]
Ni(110)	–	–	$\sim 10^{-11}$	20	–	4.55	PE	[1111,2259,3636]
Ni(110)	–	–	–	–	–	4.6	TC	[311]
Ni(110)	–	–	$\sim 1 \times 10^{-10}$	~300	–	4.62 ± 0.05	PE	[770]
Ni(110)	–	–	1×10^{-9}	~1200–1600	–	4.64 ± 0.03	TE	[312,837]
Ni(110)	–	–	$\sim 10^{-11}$	20	–	4.65 ± 0.1	PE	[2142]
Ni(110)	–	–	–	–	–	4.69	TC	[3224]
Ni(110)	–	–	$<1 \times 10^{-10}$	~300	–	4.7 ± 0.1	CPD	[1110]
Ni(110)	–	–	$\sim 1 \times 10^{-10}$	~300	–	4.7 ± 0.1	PE	[1112]
Ni(110)	–	–	$\sim 10^{-10}$	~300	–	4.82	PE	[2809]
Ni(110)	–	–	–	–	–	4.84	TC	[2548]
Ni(110)	–	–	–	–	–	4.84	TC	[1159,1980,3067]
Ni(110)	–	–	6×10^{-11}	~300	–	4.85 ± 0.15	CPD	[1791]
Ni(110)	–	–	1×10^{-10}	100, ~300	–	4.9	PE	[1808]
Ni(110)	–	–	–	–	–	4.90	TC	[1237]
Ni(110){97%}	–	–	–	–	(5.03 ± 0.01)	4.91 ± 0.04	TC	[630,1351]
Ni(110)	–	–	–	–	–	4.93	TC	[467]
Ni(110)	–	–	?	?	–	5.03	?	[2821]
Ni(110){97%}	–	–	–	–	5.03 ± 0.01	(4.91 ± 0.04)	TC	[630,1351]
Ni(110)	–	–	5×10^{-10}	293	–	5.04 ± 0.02	PE	[314,315,2604]
Ni(110)	–	–	–	–	–	5.1	TC	[2905]
Ni(110)	–	–	–	–	–	5.1	TC	[465]
Ni(110)	–	–	–	–	–	5.2	TC	[465]
Recommended	–	–	–	–	–	**4.96 ± 0.10**	–	–
Ni(111)	–	–	–	–	–	3.9	TC	[1043]
Ni(111)	Ca	Ca^+	$<10^{-6}$	~1300	4.5 ± 0.2	–	PSI	[126]
Ni(111)	Rb	Rb^+	$<10^{-6}$	1280	4.57 ± 0.05	–	PSI	[126]
Ni(111)	–	–	$\sim 10^{-10}$	~300	–	4.68 ± 0.1	CPD	[1983]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni(111){89%}	–	–	–	–	(5.33 ± 0.01)	4.68 ± 0.10	TC	[283,630,1351]
Ni(111)	–	–	$<1 \times 10^{-10}$	~300	–	4.9	PE	[249]
Ni(111)	–	–	–	–	–	5.00	TC	[4454]
Ni(111)	–	–	?	298	–	5.07	PE	[1392]
Ni(111)	–	–	–	–	–	5.11	TC	[311]
Ni(111)/Mo(110)	Ni	–	$<6 \times 10^{-11}$	~300	–	5.14*	CPD	[3293]
Ni(111)	–	–	–	–	–	5.15	TC	[2423]
Ni(111)	–	–	$<5 \times 10^{-11}$	~300	–	5.15 ± 0.1	PE	[938]
Ni(111)	–	–	$\sim 10^{-10}$	220	–	5.17 ± 0.05	PE	[2040]
Ni(111)	–	–	?	?	–	5.2	TE	[771]
Ni(111)	–	–	?	~300	–	5.2	PE	[1113]
Ni(111)/glass	Ni	–	$<10^{-9}$	77 (~600)	–	5.2	PE	[2934]
Ni(111)/Ru(0001)	Ni	–	?	~300	–	5.2*	PE	[3591]
Ni(111)	–	–	$\sim 1 \times 10^{-10}$	~300	–	5.2 ± 0.07	PE	[1114]
Ni(111)	–	–	?	?	–	5.20	?	[1994]
Ni(111)	–	–	?	1033	–	5.20	PE	[1392]
Ni(111)	–	–	–	–	–	5.22	TC	[3224]
Ni(111)	–	–	$\sim 1 \times 10^{-9}$	~1400–1600	–	5.22 ± 0.03	TE	[312,837]
Ni(111)	–	–	–	–	–	5.23	TC	[4258]
Ni(111)	–	–	–	–	–	5.23	TC	[4317]
Ni(111)	–	–	5×10^{-11}	~300	–	5.25	PE	[939,940,1920]
Ni(111)	–	–	5×10^{-11}	~300	–	5.25 ± 0.03	PE	[922]
Ni(111)	–	–	$<2 \times 10^{-10}$	~300	–	5.27 ± 0.04	CPD	[1898]
Ni(111)	–	–	–	–	–	5.28	TC	[2068]
Ni(111)	–	–	–	–	–	5.29	TC	[4056]
Ni(111)/glass	Ni	–	$\leq 3 \times 10^{-10}$	77 (~460)	–	5.29	PE	[3058]
Ni(111)	–	–	8×10^{-11}	100	–	5.3	PE	[772]
Ni(111)	–	–	1×10^{-10}	80, ~300	–	5.3	PE	[616,2962]
Ni(111)	–	–	$\sim 10^{-10}$	~300	–	5.3	PE	[313]
Ni(111)	–	–	$<1 \times 10^{-10}$	~300	–	5.3 ± 0.1	CPD	[1110]
Ni(111)	–	–	$\sim 10^{-10}$	350	–	5.3 ± 0.1	PE	[1919]
Ni(111)/glass	Ni	–	2×10^{-9}	~300{523}	–	5.30 ± 0.04	PE	[314,315]
Ni(111)/glass	Ni	–	2×10^{-9}	77 (523)	–	5.32 ± 0.05	PE	[314]
Ni(111){89%}	–	–	–	–	5.33 ± 0.01	(4.68 ± 0.10)	TC	[283,630,1351]
Ni(111)/glass[126]	Ni	–	2×10^{-9}	~300{523}	–	5.34 ± 0.02	PE	[314]
Ni(111)	–	–	?	?	–	5.35	?	[2821]
Ni(111)/glass[128]	Ni	–	5×10^{-10}	~300{523}	–	5.35	PE	[315,1513]
Ni(111)	–	–	5×10^{-10}	293	–	5.35 ± 0.05	PE	[314,315,2604]
Ni(111)	–	–	$<2 \times 10^{-10}$	~300	–	5.36	PE	[316]
Ni(111)	–	–	$\sim 10^{-10}$	85	–	5.36	PE	[773]
Ni(111)	–	–	–	–	–	5.39	TC	[4056]
Ni(111)	–	–	6×10^{-11}	~300	–	5.40 ± 0.15	CPD	[1791]
Ni(111)	–	–	$<2 \times 10^{-10}$	27, 90	–	5.42	CPD	[4107]
Ni(111)	–	–	$\leq 3 \times 10^{-9}$	~300	–	5.42 ± 0.04	PE	[1115]
Ni(111)/Mo(110)	Ni	–	$<6 \times 10^{-11}$	~300	–	5.43	CPD	[3293]
Ni(111)	–	–	?	<85	–	5.45 ± 0.1	PE	[1033]
Ni(111)	–	–	–	–	–	5.46	TC	[2804]
Ni(111)	–	–	–	–	–	5.47	TC	[4174,4284]
Ni(111)	–	–	–	–	–	5.50	TC	[1237]
Ni(111)	–	–	–	–	–	5.56	TC	[2548]
Ni(111)	–	–	–	–	–	5.56	TC	[1159,1980,3067]
Ni(111)	–	–	–	–	–	5.6	TC	[2905]
Ni(111)	–	–	–	–	–	5.68	TC	[334,3179]
Ni(111)	–	–	–	–	–	5.70	TC	[229,317]
Ni(111)	–	–	–	–	–	5.77	TC	[229,334]
Ni(111)	–	–	3×10^{-11}	80	–	6.27	FE	[2514]
Recommended	–	–	–	–	–	**5.32 ± 0.05**	–	–
Ni(113)	–	–	–	–	–	4.52	TC	[3224]
Ni(133)	–	–	–	–	–	4.43	TC	[3224]
Ni(fp)[130]	–	–	–	–	–	2.941	TC	[2887]
Ni(fp)[130]	–	–	–	–	–	2.955	TC	[2887]
Ni(fp)[130]	–	–	–	–	–	2.972	TC	[2887]
Ni/W	Ni	–	?	~300	–	3.4 ± 0.03	FE	[1856]
Ni	–	–	$\sim 10^{-5}$	≤ 1200	–	3.60	TE	[2216]
Ni/?	Ni	–	?	~300	–	3.67	PE	[2460]
Ni	–	–	$\sim 10^{-6}$	~300	–	4.05	PE	[3388]
Ni	–	–	$\sim 10^{-6}$	~300	–	4.05 ± 0.02	PE	[3394]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni	–	–	6×10^{-3}	~300	–	4.05 ± 0.07	PE	[2079,2080]
Ni	–	–	~10^{-6}	~300	–	4.06	PE	[3389,3394]
Ni	–	–	$<10^{-6}$	~300	–	4.12	PE	[2919]
Ni	–	–	?	~300	–	4.12 ± 0.02	CPD	[2544]
Ni$_3$(cluster)	–	–	–	–	–	4.16	TC	[2990]
Ni	–	–	?	~300	–	4.2	PE	[4278]
Ni/steel	Ni	–	3×10^{-10}	20 (~300)	–	4.2 ± 0.1	PE	[1410]
Ni	–	–	4×10^{-9}	673	–	4.23 ± 0.08	PE	[1116]
Ni	–	–	4×10^{-9}	533	–	4.24 ± 0.07	PE	[1116]
Ni/W(111)	Ni	–	$<2 \times 10^{-10}$	78 (375)	–	4.3*	FE	[1591]
Ni/W(100)	Ni	–	$<2 \times 10^{-10}$	78 (870)	–	4.3*	FE	[1591]
Ni/W(100)	Ni	–	$<2 \times 10^{-10}$	78 (375)	–	4.3*	FE	[1591]
Ni/W(112)	Ni	–	$<3 \times 10^{-10}$	~300 (580)	–	4.30	FE	[3213]
Ni	–	–	?	~300	–	4.32	CPD	[2297]
Ni/Si	–	–	–	–	–	4.33	TC	[1653]
Ni	–	–	?	~300	–	4.35	CPD	[2469]
Ni	–	–	–	–	–	4.36	TC	[1976]
Ni	–	–	?	90	–	4.37	CPD	[2294]
Ni/NaCl[131]	Ni	–	2×10^{-9}	~300{573}	–	4.39 ± 0.02	PE	[314]
Ni/W(111)	Ni	–	$<2 \times 10^{-10}$	78 (870)	–	4.4*	FE	[1591]
Ni	–	–	–	–	–	4.4*	TC	[1955]
Ni/steel	Ni	–	3×10^{-10}	20	–	4.4 ± 0.1	PE	[1410]
Ni[413]	–	–	~10^{-9}	1170–1250	–	4.41 ± 0.02	TE	[179,650,3410, 3413]
Ni	–	–	$<10^{-6}$	773	–	4.44 ± 0.05	CPD	[4142]
Ni/NaCl[131]	Ni	–	2×10^{-9}	~300{573}	–	4.47 ± 0.06	PE	[314]
Ni	–	–	–	–	–	4.49	TC	[3476]
Ni	–	–	–	–	–	4.5	TC	[3262]
Ni	–	–	–	–	–	4.5	TC	[3318]
Ni/W(111)	Ni	–	$<2 \times 10^{-10}$	78	–	4.5*	FE	[1591]
Ni/Re	Ni	–	$<4 \times 10^{-10}$	~300	–	4.5	CPD	[1586]
Ni/Al$_2$O$_3$/Si(100)	Ni	–	?	~300	–	4.5[48]	PE	[1442]
Ni[413]	–	–	?	~300	–	4.5	PE	[942]
Ni/graphite	Ni	–	$<10^{-5}$	~1400–1600	–	4.50 ± 0.02	TE	[769,2304]
Ni/W	Ni	–	$<2 \times 10^{-9}$	430	–	4.51	FE	[2239]
Ni	–	–	4×10^{-9}	294	–	4.51 ± 0.03	PE	[1116,3788,4082, 4134]
Ni/W[134]	Ni	–	2×10^{-10}	78, 300	–	4.52 ± 0.03	FE	[2249]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.54	PE	[3051]
Ni/glass	Ni	–	2×10^{-9}	77	–	4.54 ± 0.02	PE	[314]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.55	PE	[3051]
Ni/W	Ni	–	$<3 \times 10^{-10}$	~300 (580)	–	4.55	FE	[3213]
Ni/glass[369]	Ni	–	~10^{-10}	77	–	4.55 ± 0.02	PE	[2132,2133,2147]
Ni/glass	Ni	–	5×10^{-10}	~300{523}	–	4.56	PE	[1513]
Ni/glass	Ni	–	$<1 \times 10^{-10}$	78	–	4.56	PE	[414,2719]
Ni	–	–	12 (Ar)	?	–	4.56	PE	[4236]
Ni	–	–	–	–	–	4.57	TC	[3318]
Ni	–	–	–	–	–	4.57	TC	[3224]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.57	PE	[1469]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.58	PE	[2310]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.58	PE	[2929]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.59	PE	[1957]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.59	PE	[2929]
Ni	–	–	27 (Ne)	?	–	4.59	PE	[4236]
Ni/glass	Ni	–	$\leq 3 \times 10^{-10}$	77	–	4.59 ± 0.02	PE	[3058]
Ni	–	–	–	–	–	4.6	TC	[1645]
Ni	–	–	–	–	–	4.6	TC	[2583]
Ni/W(100)	Ni	–	$<2 \times 10^{-10}$	78	–	4.6*	FE	[1591]
Ni	–	–	?	~300	–	4.6	CPD	[1379]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.6	PE	[1469]
Ni/Ta(111)	Ni	–	$<1 \times 10^{-10}$	~300	–	4.60	CPD	[3302]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.60	PE	[2310]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.60	PE	[2934]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.60	PE	[1957]
Ni/glass	Ni	–	$\leq 3 \times 10^{-10}$	77	–	4.60 ± 0.02	PE	[1153]
Ni/quartz	Ni	–	$\leq 5 \times 10^{-10}$	78	–	4.60 ± 0.03	PE	[435]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.61	PE	[2763,3046]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.61	PE	[2929]
Ni/glass	Ni	–	$<10^{-9}$	77	–	4.61	PE	[2310]
Ni	–	–	3×10^{-8}	?	–	4.61 ± 0.05	TE	[310]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni	–	–	?	~1300–1500	–	4.63	TE	[1762]
Ni/glass	Ni	–	<10⁻¹⁰	77 (196)	–	4.64 ± 0.02	PE	[2147]
Ni[132]	–	–	4 × 10⁻¹⁰	~300	–	4.645	CPD	[503]
Ni	–	–	27 (Ne)	~300	–	4.65 ± 0.02	PE	[788]
Ni[132]	–	–	4 × 10⁻¹⁰	400	–	4.653	CPD	[503]
Ni	–	–	–	–	–	4.66	TC	[3476]
Ni[132]	–	–	4 × 10⁻¹⁰	400	–	4.660	CPD	[503]
Ni	–	–	12 (Ar)	~300	–	4.67 ± 0.02	PE	[788]
Ni{89%(111)}	–	–	–	–	(5.33 ± 0.01)	4.68 ± 0.10	TC	[283,630,1351]
Ni[132]	–	–	4 × 10⁻¹⁰	660	–	4.690	CPD	[503]
Ni/?	Ni	–	~10⁻⁵	~300	–	4.7	CPD	[1376]
Ni/W(110)	Ni	–	<2 × 10⁻¹⁰	78	–	4.7*	FE	[1591]
Ni/W(110)	Ni	–	<2 × 10⁻¹⁰	78 (375)	–	4.7*	FE	[1591]
Ni/W(110)	Ni	–	<2 × 10⁻¹⁰	78 (870)	–	4.7*	FE	[1591]
Ni/W(112)	Ni	–	<2 × 10⁻¹⁰	78	–	4.7*	FE	[1591]
Ni/W(112)	Ni	–	<2 × 10⁻¹⁰	78 (375)	–	4.7*	FE	[1591]
Ni/glass	Ni	–	?	77	–	4.7	CPD	[2577]
Ni/W(112)	Ni	–	<2 × 10⁻¹⁰	78 (870)	–	4.7*	FE	[1591]
Ni	–	–	~10⁻⁹	973	–	4.7	TE	[3112]
Ni/Mo(111)	Ni	–	<1 × 10⁻¹⁰	~300	–	4.7 ± 0.1*	CPD	[3307]
Ni[132]	–	–	4 × 10⁻¹⁰	740	–	4.700	CPD	[503]
Ni/W(111)	Ni	–	<5 × 10⁻¹¹	~300	–	4.72*	CPD	[2429]
Ni	–	–	–	–	–	4.73	TC	[3264,3265,3267]
Ni	–	–	–	–	–	4.73	TC	[3352]
Ni	–	–	?	~300	–	4.74	PE	[1371]
Ni	–	–	~10⁻¹⁰	~300	–	4.74	CPD	[3131]
Ni/W(110)	–	–	–	–	–	4.74	TC	[531]
Ni/glass	Ni	–	~10⁻⁸	~300	–	4.74 ± 0.04	CPD	[133]
Ni/ZrO₂/Si(100)	Ni	–	?	~300	–	4.75[48]	PE	[1442]
Ni/glass	Ni	–	<10⁻⁹	77 (195)	–	4.76	PE	[2310]
Ni	–	–	≤10⁻⁹	1500	–	4.77	TE	[179,650]
Ni/W(100)	Ni	–	<1 × 10⁻¹¹	77	–	4.78	FE	[1549]
Ni/W	Ni	–	<3 × 10⁻¹⁰	900, 1150	–	4.78	FE	[3684]
Ni	–	–	~10⁻¹¹	~300	–	4.79	CPD	[3338]
Ni/W(110)	Ni	–	?	90	–	4.8	CPD	[3732]
Ni	–	–	–	–	–	4.8	TC	[706]
Ni[413]	–	–	~10⁻⁹	1440–1490	–	4.80 ± 0.02	TE	[179,650,3410, 3413]
Ni{95%(100)}	–	–	–	–	(5.21 ± 0.01)	4.80 ± 0.09	TC	[283,630,1351]
Ni/TiO₂(110)	Ni	–	~4 × 10⁻¹¹	~300	–	4.80 ± 0.10	PE	[2788]
Ni/glass	Ni	–	<10⁻⁹	~300	–	4.8–5.1	PE	[1469]
Ni/W	Ni	–	<3 × 10⁻¹⁰	900, 1150	–	4.82	FE	[3684]
Ni/glass[129]	Ni	–	2 × 10⁻⁹	273	–	4.82 ± 0.04	PE	[314]
Ni/mica[133]	Ni	–	2 × 10⁻⁹	~300{593}	–	4.82 ± 0.04	PE	[314]
Ni	–	–	–	–	–	4.83	TC	[1399]
Ni₆(cluster)	–	–	–	–	–	4.83	TC	[2990]
Ni/W(111)	Ni	–	<3 × 10⁻¹⁰	~300 (580)	–	4.83	FE	[3213]
Ni/glass	Ni	–	<10⁻¹⁰	77 (293)	–	4.83 ± 0.02	PE	[2147]
Ni₁₀(cluster)	–	–	–	–	–	4.84	TC	[2990]
Ni/W[134]	Ni	–	2 × 10⁻¹⁰	78, 300	–	4.85	FE	[2249]
Ni₇(cluster)	–	–	–	–	–	4.85	TC	[2990]
Ni/quartz	Ni	–	≤5 × 10⁻¹⁰	293	–	4.86 ± 0.04	PE	[435]
Ni/glass	Ni	–	<10⁻⁹	77 (293)	–	4.87	PE	[3051]
Ni	–	–	?	~300	–	4.87	PE	[2924]
Ni/glass	Ni	–	2 × 10⁻⁹	~300 (573)	–	4.87 ± 0.04	PE	[314,315]
Ni/Ni(mono)[414]	Ni	–	<5 × 10⁻¹⁰	678{~300}	–	4.87 ± 0.04	PE	[3971]
Ni/glass[369]	Ni	–	~10⁻¹⁰	77 (323)	–	4.88	PE	[2133]
Ni/glass	Ni	–	<10⁻¹⁰	77 (293)	–	4.88 ± 0.02	PE	[2147]
Ni/glass	Ni	–	<10⁻⁹	77 (293)	–	4.89	PE	[2929]
Ni	–	–	≤10⁻⁹	1380	–	4.89	TE	[179,650]
Ni/glass	Ni	–	5 × 10⁻¹⁰	~300{523}	–	4.89	PE	[1513]
Ni/glass[135]	Ni	–	2 × 10⁻⁹	273	–	4.9	PE	[315]
Ni/?	Ni	–	2 × 10⁻¹⁰	4.2 (400)	–	4.9	PE	[1506]
Ni/SiO₂	Ni	–	?	~300	–	4.9	PE	[2899]
Ni	–	–	~10⁻⁹	~300	–	4.9	PE	[2667]
Ni	–	–	–	–	–	4.9	TC	[2667]
Ni/steel	Ni	–	3 × 10⁻¹⁰	4.2	–	4.9 ± 0.1	PE	[1410]
Ni/glass	Ni	–	3 × 10⁻¹⁰	78 (~300)	–	4.90	PE	[414,2722]
Ni/glass	Ni	–	<1 × 10⁻¹⁰	78 (293)	–	4.90 ± 0.02	PE	[414,2722]
Ni{97%(110)}	–	–	–	–	(5.03 ± 0.01)	4.91 ± 0.04	TC	[630,1351]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni	–	–	$\sim 10^{-10}$	~ 300	–	4.93	PE	[724]
Ni	–	–	1×10^{-8}	~ 300	–	4.93 ± 0.02	PE	[306]
Ni/mica[133]	Ni	–	2×10^{-9}	$\sim 300\{593\}$	–	4.93 ± 0.02	PE	[314]
Ni/glass	Ni	–	$<10^{-9}$	77 (293)	–	4.95	PE	[2310]
Ni/glass	Ni	–	$\sim 10^{-10}$	78 (293)	–	4.95	PE	[2719]
Ni/glass	Ni	–	2×10^{-10}	77	–	4.95 ± 0.01	CPD	[945]
Ni/glass	Ni	–	$<10^{-10}$	77 (373)	–	4.95 ± 0.02	PE	[2147]
Ni/mica	Ni	–	2×10^{-9}	$\sim 300\{593\}$	–	4.95 ± 0.03	PE	[314]
Ni/Si(110)	Ni	–	$\sim 10^{-10}$	220 (?)	–	4.95 ± 0.05*	CPD	[2737]
Ni/W	Ni	–	?	~ 300	–	4.96	CPD	[1460]
Ni/W(111)	–	–	–	–	–	4.97	TC	[531]
Ni/Ni(mono)[414]	Ni	–	$<5 \times 10^{-10}$	295	–	4.97 ± 0.02	PE	[3971]
Ni/glass	Ni	–	5×10^{-10}	~ 300 (523)	–	4.99	PE	[1513]
Ni	–	–	1×10^{-9}	~ 300	–	5	PE	[3511]
Ni/W	Ni	–	$\sim 10^{-9}$	~ 300	–	5–7	FE	[3619]
Ni	–	–	?	?	–	5.0	TE	[3402]
Ni[413]	–	–	?	~ 300	–	5.0	PE	[942]
Ni/W(110)	Ni	–	4×10^{-11}	~ 300 (1100)	–	5.0*	CPD	[2386]
Ni/glass[135]	Ni	–	$<2 \times 10^{-9}$	273	–	5.0	PE	[315]
Ni/glass	Ni	–	$<10^{-8}$	78	–	5.0 ± 0.02	CPD	[1646]
Ni/steel	Ni	–	3×10^{-10}	4.2	–	5.0 ± 0.1	PE	[1410]
Ni/glass[129]	Ni	–	2×10^{-9}	273	–	5.00 ± 0.02	PE	[314]
Ni/quartz	Ni	–	$\leq 5 \times 10^{-10}$	293 (~ 550)	–	5.01	PE	[435]
Ni	–	–	1×10^{-8}	~ 300	–	5.01	PE	[306]
Ni/glass	Ni	–	2×10^{-9}	$\sim 300\{523\}$	–	5.01 ± 0.04	PE	[314]
Ni	–	–	$\sim 10^{-10}$	~ 300	–	5.01 ± 0.07*	CPD	[2645]
Ni/SiO$_2$	Ni	–	?	~ 300	–	5.017	CPD	[1221]
Ni/glass	Ni	–	$<10^{-9}$	90 (380)	–	5.02	PE	[3045]
Ni/glass	Ni	–	$<10^{-9}$	90	–	5.02	PE	[3046]
Ni/W(110)	Ni	–	?	90 (800)	–	5.02	CPD	[3469]
Ni/glass	Ni	–	$<10^{-10}$	~ 300 (~ 370)	–	5.02 ± 0.02	PE	[1117]
Ni/quartz	Ni	–	$<10^{-8}$	77, 300	–	5.03	PE	[3032,3036]
Ni/quartz	Ni	–	$<5 \times 10^{-10}$	293	–	5.03	PE	[1102]
Ni/quartz	Ni	–	$<5 \times 10^{-10}$	293 (618)	–	5.03	PE	[1102]
Ni{97%(110)}	–	–	–	–	5.03 ± 0.01	(4.91 ± 0.04)	TC	[630,1351]
Ni	–	–	$\leq 3 \times 10^{-8}$	1370–1500	–	5.03 ± 0.05	TE	[3608]
Ni/glass	Ni	–	2×10^{-9}	$\sim 300\{573\}$	–	5.04 ± 0.04	PE	[314,315]
Ni/glass	Ni	–	$\leq 3 \times 10^{-10}$	77 (470)	–	5.04–5.24	PE	[1153]
Ni/glass	Ni	–	$<10^{-9}$	77 (373)	–	5.05	PE	[2763,3046]
Ni[405]	–	–	$\leq 8 \times 10^{-8}$	623	–	5.05	PE	[943]
Ni/glass	Ni	–	2×10^{-10}	77 (398)	–	5.05 ± 0.01	CPD	[945]
Ni[405]	–	–	$\leq 8 \times 10^{-8}$	623	–	5.05 ± 0.05	PE	[943]
Ni[405]	–	–	$\leq 8 \times 10^{-8}$	~ 300	–	5.06	PE	[943]
Ni/glass	Ni	–	$<10^{-9}$	77 (373)	–	5.06	PE	[2929]
Ni/glass	Ni	–	$<10^{-9}$	77 (373)	–	5.06	PE	[3051]
Ni/W	Ni	–	$<3 \times 10^{-10}$	~ 300 (580)	–	5.06	FE	[3213]
Ni/glass	Ni	–	2×10^{-9}	77{523}	–	5.06 ± 0.04	PE	[314]
Ni/SiO$_2$	Ni	–	?	~ 300	–	5.063	CPD	[1221]
Ni	–	–	$\sim 10^{-7}$	~ 300	–	5.07	CPD	[3513]
Ni/glass	Ni	–	$<10^{-9}$	90 (293)	–	5.07	PE	[3046]
Ni	–	–	–	–	–	5.09	TC	[1066]
Ni/glass	Ni	–	$\sim 10^{-10}$	90	–	5.09	PE	[3048]
Ni	–	–	–	–	–	5.1	TC	[944]
Ni(fp)[448]	–	–	$\sim 10^{-9}$	~ 300	–	5.1	PE	[2667]
Ni/W	Ni	–	3×10^{-10}	~ 300 (760)	–	5.1*	FE	[3680]
Ni/W	Ni	–	?	~ 300 (1070)	–	5.1 ± 0.03	FE	[1856]
Ni	–	–	–	–	–	5.10	TC	[3476]
Ni	–	–	–	–	–	5.10*	TC	[4185]
Ni[405]	–	–	$\leq 8 \times 10^{-8}$	770	–	5.10	PE	[943]
Ni/glass	Ni	–	$<10^{-9}$	77 (373)	–	5.10	PE	[1957]
Ni/glass	Ni	–	$\sim 10^{-10}$	78 (373)	–	5.10	PE	[2719]
Ni/Si(111)	Ni	–	$<1 \times 10^{-10}$	~ 300	–	5.10 ± 0.05	CPD	[3270]
Ni/glass	Ni	–	$<1 \times 10^{-10}$	78 (406)	–	5.11	PE	[414]
Ni/glass	Ni	–	$\sim 10^{-10}$	90	–	5.11	PE	[3048]
Ni/glass	Ni	–	$<10^{-10}$	77 (473)	–	5.11 ± 0.02	PE	[2147]
Ni/Ag(100)	–	–	–	–	–	5.12	TC	[2166]
Ni/glass	Ni	–	3×10^{-10}	78 (570)	–	5.12	PE	[2722]
Ni/mica[124]	Ni	–	2×10^{-9}	$\sim 300\{593\}$	–	5.12 ± 0.02[133]	PE	[314]
Ni/Mo(110)	Ni	–	$<6 \times 10^{-11}$	~ 300	–	5.14*	CPD	[3293]
Ni/glass	Ni	–	$<10^{-8}$	293	–	5.145	PE	[1386]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ni/W(110)	Ni	–	?	90	–	5.15	CPD	[3468,3469]
Ni/W(112)	–	–	–	–	–	5.15	TC	[531]
Ni	–	–	3×10^{-11}	~300	–	5.15	FE	[2227]
Ni	–	–	$<2 \times 10^{-10}$	27, 90	–	5.15	CPD	[4107]
Ni/W(110)	Ni	–	$<2 \times 10^{-10}$	27, 90	–	5.15	CPD	[4107]
Ni/quartz	Ni	–	$\sim10^{-10}$	~300	–	5.15 ± 0.1	PE	[304]
Ni/glass	Ni	–	$<1 \times 10^{-10}$	78 (589)	–	5.16	PE	[414]
Ni/glass[129]	Ni	–	2×10^{-9}	273	–	5.16 ± 0.03	PE	[314]
Ni/W(110)	Ni	–	4×10^{-11}	~300	–	5.16 ± 0.05*	CPD	[2386]
Ni/glass	Ni	–	$\sim10^{-10}$	78 (573)	–	5.17	PE	[2719]
Ni[405]	–	–	$\leq8 \times 10^{-8}$	975	–	5.17	PE	[943]
Ni/glass[125]	Ni	–	2×10^{-9}	77 (523)	–	5.17 ± 0.02	PE	[314]
Ni$_n$($n \to \infty$)	–	–	–	–	–	5.2	TC	[1866]
Ni/glass	Ni	–	$<10^{-9}$	77 (≤650)	–	5.2	PE	[2934]
Ni/glass[135]	Ni	–	$<2 \times 10^{-9}$	273	–	5.2	PE	[315]
Ni/ZnO(0001)Zn	Ni	–	$<5 \times 10^{-11}$	~300	–	5.2 ± 0.1	PE	[3119]
Ni/glass	Ni	–	$<10^{-9}$	77 (373)	–	5.20	PE	[2310]
Ni	–	–	–	–	–	5.20	TC	[3637]
Ni/glass	Ni	–	2×10^{-9}	~300 (523)	–	5.20 ± 0.02	PE	[314]
Ni/glass[126]	Ni	–	2×10^{-9}	~300{573}	–	5.20 ± 0.02	PE	[314,315]
Ni[405]	–	–	$\leq8 \times 10^{-8}$	1108	–	5.20 ± 0.05	PE	[943]
Ni/glass	Ni	–	$<10^{-10}$	~300 (~470)	–	>5.2	PE	[1117]
Ni/?	Ni	–	?	?	–	5.21	PE	[1403]
Ni/glass	Ni	–	$\leq3 \times 10^{-10}$	77 (373)	–	5.21	PE	[3058]
Ni	Cs	Cs$^+$	?	~300	–	5.21*	CPD	[611]
Ni{95%(100)}	–	–	–	–	5.21 ± 0.01	(4.80 ± 0.09)	TC	[283,630,1351]
Ni	–	–	3×10^{-10}	~300	–	5.21 ± 0.02	PE	[1504]
Ni/glass	Ni	–	$<10^{-9}$	77 (~600)	–	5.22	PE	[2934]
Ni/glass	Ni	–	2×10^{-9}	~300{523}	–	5.22 ± 0.02	PE	[314]
Ni/glass	Ni	–	$<10^{-9}$	77 (473)	–	5.23	PE	[2929]
Ni[405]	–	–	$\leq8 \times 10^{-8}$	≥1150	–	5.24	TE	[943]
Ni/glass	Ni	–	$<10^{-9}$	77 (423)	–	5.25	PE	[1957]
Ni/glass	Ni	–	2×10^{-10}	77	–	5.25 ± 0.03	FE	[945]
Ni	–	–	–	–	–	5.26	TC	[298]
Ni/glass	Ni	–	$<10^{-9}$	77 (423)	–	5.28	PE	[2310]
Ni/glass	Ni	–	$\leq3 \times 10^{-10}$	77 (~460)	–	5.29	PE	[3058]
Ni	–	–	?	~300	–	5.3	PE	[1371]
Ni$_{28}$(cluster)	–	–	–	–	–	5.30	TC	[4063]
Ni/glass	Ni	–	2×10^{-9}	~300{523}	–	5.30 ± 0.04	PE	[314,315]
Ni/glass	Ni	–	2×10^{-9}	77 (523)	–	5.32 ± 0.05	PE	[314]
Ni{89%(111)}	–	–	–	–	5.33 ± 0.01	(4.68 ± 0.10)	TC	[283,630,1351]
Ni/W(100)	–	–	–	–	–	5.34	TC	[531]
Ni/glass	Ni	–	$<2 \times 10^{-9}$	~300{523}	–	5.35	PE	[315]
Ni/W(110)	Ni	–	?	~300	–	5.36	CPD	[3469]
Ni/Mo(110)	Ni	–	$<6 \times 10^{-11}$	~300	–	5.43	CPD	[3293]
Ni/Cu(100)	–	–	–	–	–	5.45	TC	[1121]
Ni/W(110)	Ni	–	$<3 \times 10^{-10}$	~300 (580)	–	5.57	FE	[3213]
Ni/?	Ni	–	?	?	–	5.76	PE	[1403]
Ni/Cu(100)	–	–	–	–	–	6.10	TC	[1121]
Ni/W	Ni	–	$\sim10^{-9}$	~300	–	7.2	FE	[2225]
Recommended	–	–	–	–	**5.19 ± 0.12**	**5.06 ± 0.06**	–	–

29. Copper Cu

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(100)	–	–	–	–	–	3.80	TC	[475]
Cu(100)	–	–	–	–	–	3.855	TC	[2914]
Cu(100)/NaCl[137]	Cu	–	?	~300 (473)	–	3.96 ± 0.02	PE	[3328]
Cu(100)[138]	–	–	$\leq8 \times 10^{-9}$	~300	–	4.07	CPD	[1183]
Cu(100)	–	–	–	–	–	4.12	TC	[947]
Cu(100)	–	–	–	–	–	4.21	TC	[949]
Cu(100)	–	–	–	–	–	4.22	TC	[2523]
Cu(100)	–	–	–	–.	–	4.26	TC	[949]
Cu(100)	–	–	$\sim10^{-10}$	~300	–	4.27	PE	[1661]
Cu(100)	–	–	–	–.	–	4.30	TC	[4034]
Cu(100)	–	–	–	–	–	4.37	TC	[949]
Cu(100)	–	–	–	–	–	4.4	TC	[2646]
Cu(100)	–	–	–	–	–	4.412	TC	[1118]
Cu(100)[138]	–	–	$\leq8 \times 10^{-9}$	~300	–	4.43	CPD	[1183]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(100)	–	–	–	–	–	4.44	TC	[949]
Cu(100)	–	–	$<5 \times 10^{-8}$	~300	–	4.45 ± 0.03*	CPD	[2923]
Cu(100)	–	–	?	470–670	–	4.458 ± 0.010	CPD	[948,2841]
Cu(100)	–	–	–	–	–	4.47	TC	[949]
Cu(100)	–	–	–	–	–	4.473	TC	[4135]
Cu(100)	–	–	–	–	–	4.48	TC	[949]
Cu(100)	–	–	–	–	–	4.49	TC	[949]
Cu(100)	–	–	–	–	–	4.49	TC	[705]
Cu(100)	–	–	–	–	–	4.49	TC	[1184]
Cu(100)	–	–	–	–	–	4.5	TC	[1741,1742]
Cu(100)	–	–	–	–	–	4.5	TC	[951,1108,1109]
Cu(100)/TaN/Ta	–	–	$<10^{-7}$	~300	–	4.5 ± 0.02	PE	[1238,4210]
Cu(100)	–	–	1×10^{-10}	<50	–	4.5 ± 0.05	PE	[950]
Cu(100)	–	–	–	–	–	4.506	TC	[4091]
Cu(100)	–	–	–	–	–	4.51	TC	[343]
Cu(100)	–	–	–	–	–	4.52	TC	[949]
Cu(100)	–	–	$<10^{-10}$	~300	–	4.52	PE	[1239]
Cu(100)	–	–	$<5 \times 10^{-8}$	~300	–	4.53 ± 0.03*	CPD	[2923]
Cu(100)	–	–	–	–	–	4.54	TC	[2917]
Cu(100)/Ir(100)[139]	Cu	–	?	78 (380)	–	4.55 ± 0.02	FE	[2189]
Cu(100)	–	–	$\leq 10^{-10}$	~300	–	4.56	CPD	[952]
Cu(100)	–	–	–	–	–	4.56 ± 0.01	CT	[4135]
Cu(100)	–	–	$\leq 10^{-10}$	~300	–	4.58	CPD	[952]
Cu(100)	–	–	–	–	–	4.58	TC	[3477]
Cu(100)	–	–	–	–	–	4.58	TC	[3304]
Cu(100)	–	–	$<10^{-10}$	~300	–	4.59 ± 0.03	PE	[953,2006]
Cu(100)	–	–	1×10^{-10}	~300	–	4.6	PE	[3707]
Cu(100)	–	–	$\leq 1 \times 10^{-10}$	180	–	4.6	PE	[2678]
Cu(100)	–	–	–	–	–	4.6	TC	[3205]
Cu(100)	–	–	–	–	–	4.60	TC	[479]
Cu(100)	–	–	–	–	–	4.60	TC	[949]
Cu(100)	–	–	1×10^{-10}	~300	–	4.62	PE	[2673,3005]
Cu(100)	–	–	$\sim 1 \times 10^{-11}$	~300	–	4.63	PE	[1241]
Cu(100)	–	–	?	~300	–	4.63 ± 0.01	PE	[1240]
Cu(100)	–	–	$\sim 2 \times 10^{-10}$	~300	–	4.63 ± 0.02	PE	[957,958]
Cu(100)	–	–	$<8 \times 10^{-11}$	400	–	4.63 ± 0.03	PE	[3475]
Cu(100)	–	–	?	~300	–	4.63 ± 0.03	PE	[2903]
Cu(100)	–	–	2×10^{-10}	~300	–	4.65	PE	[1151]
Cu(100)	–	–	$<5 \times 10^{-11}$	95	–	4.65	PE	[1444]
Cu(100)	–	–	?	~300	–	4.65 ± 0.05	PE	[1913,2650]
Cu(100)/Pd(100)	–	–	$\sim 10^{-9}$	~300	–	4.65 ± 0.10	PE	[1424]
Cu(100)	–	–	–	–	–	4.67	TC	[3273]
Cu(100)	–	–	–	–	–	4.67	TC	[3477]
Cu(100)[140]	–	–	?	~300	–	4.68*	CPD	[959]
Cu(100)	–	–	–	–	–	4.7	TC	[2641]
Cu(100)	–	–	–	–	–	4.71	TC	[4189]
Cu(100)	–	–	$\sim 10^{-10}$	~300	–	4.75 ± 0.1	CPD	[1507]
Cu(100)	–	–	–	–	–	4.753	TC	[1119,2989]
Cu(100)	–	–	$\leq 10^{-10}$	~300	–	4.76	CPD	[952]
Cu(100)	–	–	$\sim 1 \times 10^{-10}$	~300	–	4.76 ± 0.05	PE	[950]
Cu(100)	–	–	$\sim 10^{-10}$	~300	–	4.77 ± 0.05	PE	[955]
Cu(100)	–	–	–	–	–	4.78	TC	[2897]
Cu(100)	–	–	$<5 \times 10^{-10}$	~300	–	4.79 ± 0.05	PE	[1555]
Cu(100)	–	–	–	–	–	4.81	TC	[3477]
Cu(100)	–	–	–	–	–	4.81	TC	[4405]
Cu(100)	–	–	–	–	–	4.82	TC	[2897]
Cu(100)	–	–	–	–	–	4.83	TC	[2897]
Cu(100)	–	–	$<1 \times 10^{-10}$	~300	–	4.83 ± 0.02	PE	[1554]
Cu(100)	–	–	–	–	–	4.85	TC	[480]
Cu(100)	–	–	–	–	–	4.88	TC	[463]
Cu(100)	–	–	–	–	–	4.88	TC	[1608]
Cu(100)	–	–	–	–	–	4.88	TC	[1237]
Cu(100)	–	–	–	–	–	4.89	TC	[3477]
Cu(100)	–	–	–	–	–	4.9	TC	[2646]
Cu(100)	–	–	–	–	–	4.90	TC	[2971]
Cu(100)	–	–	–	–	–	4.91	TC	[1120]
Cu(100)	–	–	–	–	–	4.91	TC	[2897]
Cu(100)	–	–	–	–	–	4.93	TC	[950]
Cu(100)	–	–	–	–	–	4.93	TC	[1106,4386]
Cu(100)	–	–	–	–	–	4.94	TC	[1121]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(100)	–	–	–	–	–	4.95	TC	[956]
Cu(100)	–	–	–	–	–	4.98	TC	[962]
Cu(100)	–	–	–	–	–	4.99	TC	[1159,1980,3067]
Cu(100)	–	–	–	–	–	4.99	TC	[2548]
Cu(100)	–	–	–	–	–	5.00	TC	[4405]
Cu(100)	–	–	–	–	–	5.01	TC	[2803]
Cu(100)	–	–	–	–	–	5.02	TC	[480,4398]
Cu(100)	–	–	–	–	–	5.02	TC	[3007]
Cu(100)	–	–	–	–	–	5.03	TC	[962]
Cu(100)	–	–	–	–	–	5.05	TC	[480,4398]
Cu(100)/Ni(100)	–	–	–	–	–	5.1	TC	[2641]
Cu(100)	–	–	–	–	–	5.1	TC	[389]
Cu(100)	–	–	$\leq 1 \times 10^{-10}$	~300	–	5.1	PE	[3298]
Cu(100)	–	–	$\sim 10^{-10}$	77, ~300	–	5.10 ± 0.05	FE	[358]
Cu(100)	–	–	–	–	–	5.13	TC	[3224]
Cu(100)	–	–	–	–	–	5.14	TC	[3382]
Cu(100)	–	–	$< 1 \times 10^{-10}$	77, ~300	–	5.155 ± 0.054	CPD	[963]
Cu(100)	–	–	–	–	–	5.16	TC	[321]
Cu(100)	–	–	–	–	–	5.20	TC	[1596]
Cu(100)	–	–	–	–	–	5.20	TC	[3382]
Cu(100)	–	–	–	–	–	5.21	TC	[1703]
Cu(100)	–	–	–	–	–	5.22	TC	[1234]
Cu(100)	–	–	–	–	–	5.25	TC	[2540]
Cu(100)	–	–	–	–	–	5.26	TC	[229,334]
Cu(100)	–	–	–	–	–	5.26	TC	[962]
Cu(100)	–	–	$< 5 \times 10^{-8}$	~300	–	5.29 ± 0.04*	CPD	[2923]
Cu(100)	–	–	–	–	–	5.31	TC	[962]
Cu(100)	–	–	$< 5 \times 10^{-8}$	~300	–	5.37 ± 0.04*	CPD	[2923]
Cu(100)	–	–	–	–	–	5.6	TC	[1122]
Cu(100)	–	–	$\sim 1 \times 10^{-8}$	~300	–	5.61	PE	[3308]
Cu(100)	–	–	–	–	–	5.95	TC	[1703]
Cu(100)	–	–	–	–	–	6.11	TC	[1703]
Cu(100)	–	–	–	–	–	6.3	TC	[2646]
Cu(100)	–	–	–	–	–	6.4	TC	[2646]
Cu(100)	–	–	–	–	–	6.9	TC	[2646]
Recommended	–	–	–	–	–	**4.58 ± 0.06**	–	–
Cu(110)	–	–	–	–	–	3.55	TC	[475]
Cu(110)	–	–	–	–	–	3.56	TC	[962]
Cu(110)	–	–	–	–	–	3.648	TC	[2914]
Cu(110)	–	–	–	–	–	3.85	TC	[321]
Cu(110)	–	–	–	–	–	3.98	TC	[947]
Cu(110)	–	–	–	–	–	4.1	TC	[967]
Cu(110)	–	–	–	–	–	4.10	TC	[962]
Cu(110)	–	–	–	–	–	4.2	TC	[967]
Cu(110)	–	–	–	–	–	4.20	TC	[962]
Cu(110)	–	–	$\sim 10^{-10}$	~300	–	4.23	PE	[1661]
Cu(110)	–	–	–	–	–	4.25	TC	[3477]
Cu(110)	–	–	–	–	–	4.27	TC	[4034]
Cu(110)	–	–	–	–	–	4.272	TC	[4091]
Cu(110)	–	–	–	–	–	4.33	TC	[3477]
Cu(110)	–	–	$\leq 10^{-10}$	~300	–	4.4	CPD	[952]
Cu(110)	–	–	?	~300	–	4.4	PE	[1242]
Cu(110)/TaN/Ta	–	–	?	~300	–	4.4 ± 0.02	PE	[1238,4210]
Cu(110)	–	–	$\leq 10^{-10}$	~300	–	4.40	CPD	[952]
Cu(110)	–	–	?	470–670	–	4.400 ± 0.010	CPD	[948,2841]
Cu(110)	–	–	–	–	–	4.408	TC	[1118]
Cu(110)	–	–	–	–	–	4.421	TC	[3574]
Cu(110)	–	–	–	–	–	4.43	TC	[2917]
Cu(110)	–	–	–	–	–	4.44	TC	[3304]
Cu(110)	–	–	$< 8 \times 10^{-10}$	~300	–	4.46 ± 0.04	PE	[4195]
Cu(110)	–	–	–	–	–	4.48	TC	[334]
Cu(110)[140]	–	–	?	~300	–	4.48*	CPD	[959]
Cu(110)	–	–	3×10^{-10}	20, 42	–	4.48	PE	[2140,2642]
Cu(110)	–	–	$< 10^{-10}$	~300	–	4.48 ± 0.03	PE	[953,2006]
Cu(110)	–	–	$< 7 \times 10^{-11}$	~300	–	4.5	PE	[1123]
Cu(110)	–	–	?	~300	–	4.5	PE	[1243]
Cu(110)	–	–	$\sim 4 \times 10^{-11}$	20–200	–	4.5	PE	[2143]
Cu(110)	–	–	–	–	–	4.508	TC	[1119,2989]
Cu(110)	–	–	$< 5 \times 10^{-11}$	90	–	4.52	PE	[1444]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(110)	–	–	–	–	–	4.53	TC	[962]
Cu(110)	–	–	–	–	–	4.53	TC	[3477]
Cu(110)	–	–	?	~300	–	4.59	CPD	[964]
Cu(110)	–	–	–	–	–	4.61	TC	[3477]
Cu(110)	–	–	–	–	–	4.625	TC	[4189]
Cu(110)	–	–	–	–	–	4.65	TC	[1159,1980,3067]
Cu(110)	–	–	–	–	–	4.66	TC	[2548]
Cu(110)	–	–	–	–	–	4.67	TC	[480]
Cu(110)	–	–	~10^{-10}	~300	–	4.7 ± 0.1	CPD	[1507]
Cu(110)	–	–	–	–	–	4.70	TC	[4405]
Cu(110)	–	–	–	–	–	4.71	TC	[1237]
Cu(110)	–	–	–	–	–	4.78	TC	[4405]
Cu(110)	–	–	–	–	–	4.81	TC	[480,4398]
Cu(110)	–	–	–	–	–	4.83	TC	[480,4398]
Cu(110)	–	–	–	–	–	4.84	TC	[1244]
Cu(110)	–	–	<5×10^{-11}	~300	–	4.87	PE	[1124]
Cu(110)	–	–	–	–	–	4.87	TC	[3007]
Cu(110)	–	–	–	–	–	4.88	TC	[3007]
Cu(110)	–	–	–	–	–	4.9	TC	[956]
Cu(110)	–	–	<1×10^{-10}	77, ~300	–	4.92 ± 0.019	CPD	[963]
Cu(110)	–	–	–	–	–	4.94	TC	[3224]
Cu(110)	–	–	–	–	–	4.98	TC	[962]
Cu(110)	–	–	–	–	–	5.04	TC	[962]
Recommended	–	–	–	–	–	**4.43 ± 0.04**	–	–
Cu(111)	–	–	–	–	–	3.55	TC	[3491]
Cu(111)	–	–	–	–	–	3.90	TC	[475]
Cu(111)	–	–	–	–	–	4.123	TC	[2914]
Cu(111)	–	–	–	–	–	4.17	TC	[2522]
Cu(111)/NaCl[137]	Cu	–	?	~300 (423)	–	4.20 ± 0.02	PE	[3328]
Cu(111)	–	–	–	–	–	4.24	TC	[947]
Cu(111)	–	–	–	–	–	4.381	TC	[1118]
Cu(111)/ZnO(0001)[409]	Cu	–	4×10^{-10}	~300	–	4.5	TCS	[2679]
Cu(111)	–	–	~10^{-10}	~300	–	4.50	PE	[1661]
Cu(111)	–	–	–	–	–	4.54	TC	[1608]
Cu(111)	–	–	–	–	–	4.58	TC	[4034]
Cu(111)	–	–	–	–	–	4.63	TC	[2077]
Cu(111)	–	–	?	470–670	–	4.632 ± 0.010	CPD	[948,2841]
Cu(111)/Au(111)	–	–	–	–	–	4.69 ± 0.02*	TC	[3214]
Cu(111)/Si(111)	Cu	–	~10^{-10}	~300	–	4.7	PE	[1801]
Cu(111)	–	–	–	–	–	4.714	TC	[4091]
Cu(111)	–	–	–	–	–	4.76	TC	[2971]
Cu(111)	–	–	–	–	–	4.78	TC	[1028,1179]
Cu(111)	–	–	–	–	–	4.79	TC	[3477]
Cu(111)/Ru(0001)	Cu	–	≤5×10^{-10}	400–640	–	4.8*	CPD	[3705,3706,3731]
Cu(111)/W(110)[141]	Cu	–	<5×10^{-11}	~300	–	4.8	CPD	[1519]
Cu(111)/TaN/Ta	–	–	?	~300	–	4.8	PE	[1238,4210]
Cu(111)/mica[420]	Cu	–	4×10^{-10}	~300{570}	–	4.8	PE	[4001]
Cu(111)	–	–	<1×10^{-10}	~300	–	4.8 ± 0.3	CPD	[1186,1245,2284]
Cu(111)	–	–	–	–	–	4.80	TC	[3304]
Cu(111)	–	–	–	–	–	4.80	TC	[2917]
Cu(111)	–	–	–	–	–	4.80	TC	[1246]
Cu(111)	–	–	–	–	–	4.80	TC	[4317]
Cu(111)	–	–	–	–	–	4.82	TC	[1179]
Cu(111)[140]	–	–	?	~300	–	4.85*	CPD	[959]
Cu(111)	–	–	<10^{-10}	~300	–	4.85	PE	[1239]
Cu(111)	–	–	<2×10^{-10}	~300	–	4.85 ± 0.1	PE	[2415,3631,3632]
Cu(111)	–	–	–	–	–	4.86	TC	[2077]
Cu(111)	–	–	~10^{-10}	35	–	4.86	PE	[2898]
Cu(111)	–	–	1×10^{-8}	~300	–	4.86	PE	[3308]
Cu(111)	–	–	–	–	–	4.86	TC	[3486]
Cu(111)	–	–	≤1×10^{-10}	~300	–	4.87	PE	[3571]
Cu(111)	–	–	–	–	–	4.876	TC	[1119,2989]
Cu(111)	–	–	2×10^{-10}	~300	–	4.88	PE	[939,1124]
Cu(111)	–	–	2×10^{-10}	100	–	4.88	PE	[2684,2686]
Cu(111)	–	–	7×10^{-11}	~300	–	4.88 ± 0.05	PE	[1125]
Cu(111)/W(110)	Cu	–	?	~300	–	4.9	CPD	[4231]
Cu(111)	–	–	7×10^{-11}	85	–	4.9	PE	[4033]
Cu(111)	–	–	?	?	–	4.9	?	[1247]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(111)	–	–	?	~300	–	4.9	PE	[2509,2512]
Cu(111)/Ru(0001)	–	–	–	–	–	4.9	TC	[2641]
Cu(111)/Ru(0001)	Cu	–	~10^{-10}	539	–	4.9	CPD	[1685]
Cu(111)	–	–	–	–	–	4.90	TC	[2068]
Cu(111)	–	–	~1×10^{-11}	~300	–	4.90	CPD	[2532]
Cu(111)/Pt(111)	Cu	–	~7×10^{-11}	450	–	4.90	CPD	[2747]
Cu(111)	–	–	~2×10^{-10}	~300	–	4.90	PE	[1151]
Cu(111)	–	–	?	95	–	4.90	PE	[2687]
Cu(111)	–	–	?	~300	–	4.90	PE	[4025]
Cu(111)/W(110)[142]	Cu	–	<2×10^{-10}	~300	–	4.90*	CPD	[2598]
Cu(111)/W(110)	Cu	–	<10^{-10}	~300 (?)	–	4.90 ± 0.05	CPD	[2262]
Cu(111)/Pt(111)	Cu	–	?	450–475	–	4.91*	CPD	[2862]
Cu(111)	–	–	–	–	–	4.91	TC	[3477]
Cu(111)	–	–	?	100	–	4.92	PE	[4025]
Cu(111)/Au(111)	Cu	–	–	–	–	4.92 ± 0.02*	TC	[3214]
Cu(111)	–	–	<8×10^{-11}	~300	–	4.93	PE	[968,969]
Cu(111)	–	–	<2×10^{-10}	~300	–	4.93	PE	[1187]
Cu(111)	–	–	–	–	–	4.93	TC	[2685]
Cu(111)	–	–	?	~300	–	4.93 ± 0.03	PE	[2903]
Cu(111)	–	–	?	~300	–	4.93 ± 0.03	PE	[3180]
Cu(111)/Pt(111)	Cu	–	~7×10^{-11}	350	–	4.93 ± 0.05	CPD	[897,2747]
Cu(111)	–	–	?	400	–	4.94	CPD	[3198]
Cu(111)	–	–	<2×10^{-10}	~300	–	4.94	PE	[316]
Cu(111)	–	–	1×10^{-10}	~300	–	4.94	PE	[2907,2915]
Cu(111)	–	–	7×10^{-11}	~300	–	4.94 ± 0.02	PE	[1922]
Cu(111)	–	–	<10^{-10}	~300	–	4.94 ± 0.03	PE	[953,2006]
Cu(111)	–	–	<2×10^{-11}	85	–	4.946 ± 0.010	PE	[970]
Cu(111)	–	–	≤10^{-10}	~300	–	4.95	CPD	[952]
Cu(111)	–	–	8×10^{-11}	50, 100	–	4.95	PE	[898,3197,3603]
Cu(111)/Ru(0001)[143]	Cu	–	1×10^{-10}	290–700	–	4.95*	CPD	[1683,1685]
Cu(111)/Pd(111)	Cu	–	5×10^{-9}	~300	–	4.95	CPD	[3364]
Cu(111)	–	–	<5×10^{-8}	~300	–	4.95 ± 0.08*	CPD	[2923]
Cu(111)	–	–	–	–	–	4.958	TC	[4189]
Cu(111)	–	–	–	–	–	4.98	TC	[3273]
Cu(111)	–	–	–	–	–	4.99	TC	[3477]
Cu(111)	–	–	–	–	–	5.0	TC	[1126]
Cu(111)	–	–	–	–	–	5.0	TC	[3593]
Cu(111)	–	–	?	~300	–	5.00 ± 0.03	PE	[4213]
Cu(111)/Ru(0001)	Cu	–	?	400	–	5.01	CPD	[3198]
Cu(111)	–	–	?	~300	–	5.01	PE	[3522]
Cu(111)	–	–	–	–	–	5.03	TC	[1179]
Cu(111)	–	–	<5×10^{-8}	~300	–	5.03 ± 0.08*	CPD	[2923]
Cu(111)/Nb(110)	Cu	–	7×10^{-11}	~300	–	5.05	PE	[2986]
Cu(111)	–	–	–	–	–	5.1	TC	[1126]
Cu(111)	–	–	–	–	–	5.10	TC	[480]
Cu(111)	–	–	–	–	–	5.10	TC	[1178]
Cu(111)	–	–	–	–	–	5.17	TC	[1237]
Cu(111)	–	–	–	–	–	5.17	TC	[3491]
Cu(111)	–	–	–	–	–	5.19	TC	[956]
Cu(111)	–	–	–	–	–	5.19	TC	[2803]
Cu(111)	–	–	–	–	–	5.19	TC	[4402]
Cu(111)	–	–	–	–	–	5.22	TC	[1028,1179]
Cu(111)	–	–	–	–	–	5.22	TC	[4174,4284]
Cu(111)	–	–	–	–	–	5.24	TC	[3486,3491]
Cu(111)	–	–	–	–	–	5.25	TC	[3217]
Cu(111)	–	–	~10^{-10}	~300	–	5.25 ± 0.1	CPD	[1507]
Cu(111)	–	–	–	–	–	5.30	TC	[229,334,3179]
Cu(111)	–	–	–	–	–	5.305	TC	[2971]
Cu(111)	–	–	–	–	–	5.31	TC	[480,4398]
Cu(111)	–	–	–	–	–	5.32	TC	[480,4398]
Cu(111)	–	–	–	–	–	5.32	TC	[1159,1980,3067]
Cu(111)	–	–	–	–	–	5.32	TC	[2548]
Cu(111)	–	–	–	–	–	5.43	TC	[962]
Cu(111)	–	–	–	–	–	5.44	TC	[962]
Cu(111)	–	–	–	–	–	5.46	TC	[2540]
Cu(111)	–	–	<1×10^{-10}	77, 300	–	5.54 ± 0.012	CPD	[963]
Cu(111)	–	–	–	–	–	5.55	TC	[962]
Cu(111)	–	–	–	–	–	5.55	TC	[3224]
Cu(111)	–	–	–	–	–	5.56	TC	[962]
Recommended	–	–	–	–	–	**4.92 ± 0.05**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu(112)	–	–	?	470–670	–	4.438 ± 0.010	CPD	[948,2841]
Cu(112)	–	–	–	–	–	4.45	TC	[3304]
Cu(112)	–	–	≲10^{-10}	~300	–	4.48	CPD	[952]
Cu(112)	–	–	–	–	–	4.48	TC	[4405]
Cu(112)	–	–	≲10^{-10}	~300	–	4.49	CPD	[952]
Cu(112)	–	–	<10^{-10}	~300	–	4.53 ± 0.03	PE	[953,2006]
Cu(112)	–	–	?	~300	–	4.54 ± 0.03	PE	[2903]
Cu(112)	–	–	?	~300	–	4.56	CPD	[964]
Recommended	–	–	–	–	–	**4.52 ± 0.03**	–	–
Cu(113)	–	–	–	–	–	4.31	TC	[479,1249]
Cu(113)	–	–	?	470–670	–	4.418 ± 0.010	CPD	[948,2841]
Cu(113)	–	–	–	–	–	4.74	TC	[3224]
Cu(114)	–	–	≲10^{-10}	~300	–	4.59	CPD	[952]
Cu(119)	–	–	~1 × 10^{-11}	~300	–	4.60	PE	[1241]
Cu(122)	–	–	≲10^{-10}	~300	–	4.54	CPD	[952]
Cu(122)	–	–	–	–	–	4.56	TC	[3304]
Cu(124)	–	–	≲10^{-10}	~300	–	4.48	CPD	[952]
Cu(210)	–	–	–	–	–	4.24	TC	[3304]
Cu(210)	–	–	?	470–670	–	4.370 ± 0.010	CPD	[948,2841]
Cu(233)	–	–	≲1 × 10^{-10}	95	–	4.35 ± 0.05	PE	[1604]
Cu(233)	–	–	≲10^{-10}	~300	–	4.57	CPD	[952]
Cu(234)	–	–	≲10^{-10}	~300	–	4.50	CPD	[952]
Cu(234)	–	–	≲10^{-10}	~300	–	4.52	CPD	[952]
Cu(236)	–	–	≲10^{-10}	~300	–	4.41	CPD	[952]
Cu(321)	–	–	?	~300	–	4.12	CPD	[964]
Cu(345)	–	–	≲10^{-10}	~300	–	4.50	CPD	[952]
Cu(356)	–	–	≲10^{-10}	~300	–	4.45	CPD	[952]
Cu(413)	–	–	?	~300	–	4.00	CPD	[964]
Cu(018)	–	–	≲10^{-10}	~300	–	4.70	CPD	[952]
Cu(???)/W	Cu	–	<1 × 10^{-9}	~300	–	4.54 ± 0.01	PE	[2313,2317]
Cu	–	–	–	–	–	3.20	TC	[2493]
Cu	–	–	–	–	–	3.21	TC	[2493]
Cu	–	–	–	–	–	3.24	TC	[1150]
Cu	–	–	–	–	–	3.32	TC	[521]
Cu	–	–	–	–	–	3.65	TC	[475]
Cu	–	–	–	–	–	3.65	TC	[2629]
Cu	–	–	–	–	–	3.66	TC	[2474]
Cu	–	–	?	~1350	–	3.85	TE	[3385]
Cu/W(100)	Cu	–	<2 × 10^{-10}	~300	–	3.9*	CPD	[1519]
Cu/Ti	Cu	–	3 × 10^{-11}	77 (400)	–	3.92	FE	[2424,3749]
Cu	–	–	?	~300	–	3.95 ± 0.02	CPD	[2544]
Cu/Ti	Cu	–	3 × 10^{-11}	77	–	3.96 ± 0.04	FE	[2424,3749]
Cu	–	–	–	–	–	4.0	TC	[2456]
Cu	–	–	~10^{-10}	~300	–	4.0	PE	[1661]
Cu	–	–	?	~300	–	4.05 ± 0.04	PE	[3394]
Cu/?	Cu	–	?	~300	–	4.07	PE	[2460]
Cu	–	–	?	?	–	4.1	TE	[3402]
Cu/Ti	Cu	–	3 × 10^{-11}	77 (800)	–	4.15	FE	[2424]
Cu/W(100)	Cu	–	<2 × 10^{-10}	78 (600)	–	4.16	FE	[2255]
Cu	–	–	~10^{-6}	~300	–	4.18	PE	[3389,3394]
Cu/glass	Cu	–	<1 × 10^{-10}	78	–	4.19	PE	[414,2728]
Cu	–	–	? (N_2)	~300	–	4.19	CPD	[2634]
Cu	–	–	–	–	–	4.2	TC	[944]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu/W	Cu	–	4×10^{-10}	77	–	4.2	FE	[2586]
Cu	–	–	?	~300	–	4.22	CPD	[2626]
Cu	–	–	–	–	–	4.22	TC	[3352]
Cu	–	–	$\sim 10^{-7}$	~300 (753)	–	4.22 ± 0.01	CPD	[2627]
Cu/Ir	Cu	–	?	78 (~550)	–	4.23	FE	[2189]
Cu/W(310)	Cu	–	$<2 \times 10^{-10}$	78 (550)	–	4.23	FE	[2253]
Cu	–	–	4×10^{-9}	673	–	4.23 ± 0.08	PE	[1116]
Cu/W(310)	Cu	–	$<2 \times 10^{-10}$	78 (650)	–	4.24	FE	[2253]
Cu/Mo(100)	Cu	–	$<2 \times 10^{-10}$	~300 (≤965)	–	4.24*	CPD	[3121]
Cu	–	–	$\sim 4 \times 10^{-9}$	533	–	4.24 ± 0.07	PE	[1116]
Cu	–	–	$\sim 10^{-10}$	~300	–	4.25	CPD	[2426]
Cu	–	–	?	~300	–	4.25 ± 0.01	PE	[4190]
Cu/V(100)	Cu	–	$<8 \times 10^{-11}$	~300	–	4.25 ± 0.07*	PE	[3380]
Cu	–	–	?	?	–	4.26	TE	[1362]
Cu	–	–	–	–	–	4.26	TC	[1626]
Cu	–	–	–	–	–	4.26	TC	[2914]
Cu	–	–	–	–	–	4.3	TC	[706]
Cu/Ru(0001)	Cu	–	$\sim 1 \times 10^{-10}$	100	–	4.3	CPD	[2159]
Cu/Pt(111)	Cu	–	$\sim 10^{-10}$	293	–	4.3	PE	[3138]
Cu/GaP	–	–	–	–	–	4.30	TC	[1653]
Cu/Ti	Cu	–	3×10^{-11}	77 (?)	–	4.31	FE	[2424]
Cu/W(111)	Cu	–	$<2 \times 10^{-10}$	~300 (?)	–	4.32	FE	[2831]
Cu/W	Cu	–	5×10^{-10}	78 (700)	–	4.32 ± 0.01	FE	[1673,2238]
Cu/quartz	Cu	–	$\leq 5 \times 10^{-10}$	78	–	4.33 ± 0.01	PE	[435]
Cu	–	–	–	0	–	4.34	TC	[4419]
Cu	–	–	–	–	–	4.35	TC	[1885]
Cu/W(100)	Cu	–	$<2 \times 10^{-10}$	~300 (?)	–	4.35	FE	[2831]
Cu/Ni	Cu	–	4×10^{-10}	~300	–	4.35 ± 0.16*	CPD	[3367]
Cu/W	Cu	–	$<2 \times 10^{-10}$	~300 (?)	–	4.36	FE	[2831]
Cu	–	–	–	–	–	4.37	TC	[1976]
Cu	–	–	?	~1200	–	4.38	TE	[1944]
Cu/W(112)	Cu	–	$<2 \times 10^{-10}$	~300 (?)	–	4.38	FE	[2831]
Cu	–	–	–	–	–	4.39	TC	[3318]
Cu/glass	Cu	–	$<10^{-9}$	90	–	4.39	PE	[1957]
Cu/glass	Cu	–	$<10^{-8}$	78	–	4.39 ± 0.02	CPD	[1646]
Cu/glass	Cu	–	$<10^{-9}$	77–90	–	4.395	PE	[3052]
Cu[144]	–	–	$\sim 8 \times 10^{-8}$	~1350	–	4.4	TE	[1465]
Cu/W(100)	Cu	–	$<2 \times 10^{-10}$	78	–	4.4	FE	[2255]
Cu/glass[88]	Cu	–	$<10^{-9}$	~300{77}	–	4.4	CPD	[1526]
Cu/Mo(100)	Cu	–	$<2 \times 10^{-10}$	~300	–	4.4*	CPD	[3121]
Cu/W(100)	Cu	–	$<2 \times 10^{-10}$	78 (850)	–	4.40	FE	[2253]
Cu/glass[369]	Cu	–	$\sim 10^{-10}$	77	–	4.40	PE	[2133,2155]
Cu/glass	Cu	–	$\sim 10^{-10}$	90	–	4.40	PE	[2763,3046]
Cu	–	–	$\sim 10^{-9}$	~1100–1300	(4.42)	4.41 ± 0.02	TE	[179,3425]
Cu	–	–	4×10^{-9}	296	–	4.41 ± 0.03	PE	[1116]
Cu	–	–	$\leq 10^{-9}$	~1100–1250	–	4.415 ± 0.03	TE	[650]
Cu	–	–	?	~300	–	4.42*	CPD	[3621]
Cu	–	–	? (Cs)	~1100–1250	–	4.42	TE	[650,3413]
Cu	Cs	Cs$^+$	?	1073	4.42	(4.41 ± 0.02)	PSI	[179,3425]
Cu	–	–	?	~300	–	4.42 ± 0.04	PE	[1250]
Cu/W(112)	Cu	–	$<2 \times 10^{-10}$	78 (700)	–	4.43	FE	[2253]
Cu	–	–	$\sim 10^{-10}$	~300	–	4.43	PE	[724]
Cu/Si	–	–	–	–	–	4.43	TC	[1653]
Cu	–	–	–	–	–	4.45	TC	[1399]
Cu	–	–	?	~300	–	4.45	PE	[4278]
Cu	–	–	$\sim 10^{-9}$	~1100–1200	–	4.45 ± 0.05	TE	[650,3419]
Cu	–	–	2×10^{-7} (O$_2$)	~1100–1200	–	4.45 ± 0.05	TE	[3419]
Cu	–	–	–	–	–	4.46	TC	[1645]
Cu/Si	–	–	–	–	–	4.46	TC	[1653]
Cu	–	–	1×10^{-5}	~300	–	4.46	CPD	[1883]
Cu	–	–	?	~300	–	4.46	CPD	[2297]
Cu/W(110)	Cu	–	$<2 \times 10^{-10}$	78 (750)	–	4.46	FE	[2253]
Cu/glass	Cu	–	?	~300	–	4.46 ± 0.03	CPD	[243]
Cu/Ni[145]	–	–	?	~80	–	4.47	CPD	[2294]
Cu	–	–	$\leq 1 \times 10^{-10}$	~300	–	4.47	CPD	[2198]
Cu	–	–	?	~300	–	4.48	CPD	[1883]
Cu	–	–	–	–	–	4.48	TC	[4441]
Cu/W(110)	Cu	–	$<2 \times 10^{-10}$	78 (600)	–	4.48	FE	[2253]
Cu/quartz	Cu	–	$\leq 5 \times 10^{-10}$	293	–	4.48 ± 0.02	PE	[435]
Cu[146]	–	–	$\sim 10^{-6}$	~300	–	4.48 ± 0.06*	CPD	[2087]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu	–	–	–	–	–	4.49	TC	[3515]
Cu	–	–	~10^{-7}	~300 (1173)	–	4.49 ± 0.02	CPD	[2627]
Cu/ZnO(0001)[409]	Cu	–	4×10^{-10}	~300	–	4.5	TCS	[2679]
Cu	–	–	1×10^{-9}	~300	–	4.5	PE	[3511]
Cu	–	–	–	–	–	4.5	TC	[1993]
Cu	–	–	–	–	–	4.5	TC	[2583]
Cu/Cu,Ag,Au	Cu	–	2×10^{-9}	~300	–	4.5	PE	[1155]
Cu/W(110)[141]	Cu	–	<2×10^{-10}	~300{800}	–	4.5	CPD	[1519]
Cu/Al(100)	Cu	–	1×10^{-10}	~300	–	4.5	PE	[1572]
Cu/W(100)	Cu	–	5×10^{-10}	400, 450	–	4.5	FE	[3129]
Cu/W(110)	Cu	–	≤7×10^{-11}	~300 (≤1200)	–	4.5	CPD	[2388]
Cu/W(100)	Cu	–	<2×10^{-10}	78 (700)	–	4.5	FE	[1674]
Cu	–	–	2×10^{-9}	~300	–	4.5	PE	[1155]
Cu	–	–	2×10^{-11}	~300	–	4.5 ± 0.1	PE	[1251]
Cu	–	–	–	–	–	4.50	TC	[2629]
Cu	–	–	<5×10^{-8}	~1150–1350	–	4.50	TE	[1466]
Cu	–	–	?	~300	–	4.5 ± 0.1	PE	[1461]
Cu	–	–	2×10^{-11}	~300	–	4.5 ± 0.1	PE	[1251]
Cu/Mo(110)	Cu	–	5×10^{-11}	~300–750	–	4.5 ± 0.1	CPD	[3287]
Cu/graphite	Cu	–	?	~1200–1300	–	4.50 ± 0.02	TE	[2236]
Cu	–	–	–	–	–	4.50 ± 0.05	TC	[3358]
Cu	–	–	–	–	–	4.51	TC	[3515]
Cu	–	–	–	–	–	4.51	TC	[3318]
Cu	–	–	≤1×10^{-10}	~300	–	4.51	CPD	[2198]
Cu/W(110)	Cu	–	<2×10^{-10}	78 (522)	–	4.51	FE	[2253]
Cu[463]	–	–	?	~300	–	4.52	CPD	[931,2547]
Cu/glass	Cu	–	<1×10^{-10}	78 (293)	–	4.52	PE	[414,2722,2728]
Cu/glass	Cu	–	~10^{-8}	~300	–	4.52 ± 0.04	CPD	[133]
Cu	–	–	5×10^{-10}	~300	–	4.53	AI[38]	[4027]
Cu/glass	Cu	–	5×10^{-11}	~300	–	4.53 ± 0.05	CPD	[1071]
Cu/Si(111)	Cu	–	~10^{-10}	~300	–	4.54	PE	[1801]
Cu	–	–	?	?	–	4.55	TE	[1764]
Cu	–	–	–	–	–	4.55	TC	[3264,3265]
Cu/TaN/Ta	–	–	?	~300	–	4.55 ± 0.02	PE	[1238,4210]
Cu/Ir(100)[139]	Cu	–	?	78 (380)	–	4.55 ± 0.02	FE	[2189]
Cu/Si(111)	Cu	–	~10^{-10}	~300	–	4.55 ± 0.05	CPD	[613,636,3270]
Cu/V(100)	Cu	–	<8×10^{-11}	~300	–	4.55 ± 0.05	PE	[3380]
Cu/glass	Cu	–	5×10^{-11}	~300	–	4.55 ± 0.06*	CPD	[1071]
Cu	–	–	<5×10^{-8}	~1150–1350	–	4.56	TE	[1466]
Cu/glass	Cu	–	5×10^{-11}	~300	–	4.57 ± 0.07*	CPD	[1071]
Cu/W(110)	Cu	–	<2×10^{-10}	90	–	4.58	CPD	[3983,4107]
Cu/W(110)	Cu	–	<2×10^{-10}	78 (600)	–	4.58	FE	[2253]
Cu/W(110)[147]	Cu	–	<2×10^{-10}	~300 (?)	–	4.58 ± 0.05*	FE	[2831]
Cu/Mo(110)	Cu	–	~10^{-10}	~300	–	4.6	CPD	[3679]
Cu/W[142]	Cu	–	≤2×10^{-10}	~300	–	4.6*	CPD	[2598]
Cu/Ru(0001)	Cu	–	~1×10^{-10}	100 (900)	–	4.6	CPD	[2159]
Cu	–	–	–	–	–	4.6	TC	[3556]
Cu/?	Cu	–	~10^{-5}	~300	–	4.6	CPD	[1376]
Cu/W(110)	Cu	–	?	90 (850)	–	4.6	CPD	[1701,1706]
Cu/quartz	Cu	–	≤5×10^{-10}	293 (~550)	–	4.60 ± 0.02	PE	[435]
Cu/Pt(111)	Cu	–	~10^{-10}	293	–	4.60 ± 0.08*	PE	[3138]
Cu/Ni	Cu	–	<10^{-10}	~300 (~370)	–	4.61	PE	[1152]
Cu/glass	Cu	–	<10^{-10}	~300 (~370)	–	4.61 ± 0.02	PE	[1117]
Cu/W	Cu	–	≤5×10^{-8}	~300	–	4.61 ± 0.04	CPD	[690]
Cu[144]	–	–	8×10^{-8}	1356 (m.p.)	–	4.62	TE	[1465,1466]
Cu	–	–	–	–	–	4.62	TC	[339]
Cu/W(110)	Cu	–	<1×10^{-10}	~300	–	4.62 ± 0.03	FE	[2054]
Cu/glass	Cu	–	5×10^{-11}	~300	–	4.62 ± 0.07*	CPD	[1071]
Cu/Au(111)	–	–	–	–	–	4.63	TC	[3217]
Cu	–	–	6×10^{-3}	~300	–	4.63 ± 0.05	PE	[2079,2080]
Cu/glass[369]	Cu	–	~10^{-10}	77 (323)	–	4.64	PE	[2133,2155]
Cu/glass[148]	Cu	–	?	273	–	4.64	PE	[3075]
Cu/steel	Cu	–	<6×10^{-9}	~300	–	4.64 ± 0.02	CPD	[1540]
Cu/W	Cu	–	<5×10^{-8}	~300	–	4.64 ± 0.07	CPD	[2570]
Cu	–	–	–	–	–	4.647	TC	[2649]
Cu/Au(100)	–	–	–	–	–	4.65	TC	[3217]
Cu	–	–	–	–	–	4.65	TC	[3016]
Cu	–	–	1×10^{-10}	~300	–	4.65	PE	[2907]
Cu/glass[148]	Cu	–	?	77	–	4.65	PE	[3075]
Cu	–	–	<2×10^{-10}	90	–	4.65	CPD	[4107]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cu/W(110)	Cu	–	$<2 \times 10^{-10}$	90	–	4.65	CPD	[3983]
Cu/quartz	Cu	–	$\sim10^{-10}$	~300	–	4.65 ± 0.05	PE	[304]
Cu/W(100)	Cu	–	$\leq10^{-10}$	78	–	4.66	FE	[356]
Cu/glass	Cu	–	$<10^{-10}$	~300 (~470)	–	4.66 ± 0.01	PE	[1117]
Cu/W(112)	Cu	–	?	77, 650	–	4.66 ± 0.01	FE	[4319,4320]
Cu/W(110)	Cu	–	$<1 \times 10^{-10}$	~300	–	4.66 ± 0.03	FE	[2054]
Cu/glass	Cu	–	$<10^{-9}$	90 (343)	–	4.67	PE	[2096]
Cu/Ni	Cu	–	$<10^{-10}$	~300 (~470)	–	4.68	PE	[1152]
Cu	–	–	–	–	–	4.69	TC	[3476]
Cu	–	–	–	–	–	4.69	TC	[298]
Cu/Al(111)	Cu	–	1×10^{-10}	~300	–	4.7	PE	[1572]
Cu/Ni(100)	–	–	–	–	–	4.7	TC	[3556]
Cu/Ag(110)	Cu	–	$<4 \times 10^{-9}$	~300	–	4.7	CPD	[2749]
Cu/W(110)	–	–	–	–	–	4.7*	TC	[2975]
Cu	–	–	? (H_2)	~300	–	4.70	PE	[2207]
Cu	–	–	–	–	–	4.70	TC	[3267]
$Cu_n(n \to \infty)$	–	–	?	~300	–	4.70	IP, TC	[4197]
Cu	–	–	$\sim1 \times 10^{-6}$	~300	–	4.71	CPD	[2742]
Cu/glass	–	–	$\sim10^{-10}$	90	–	4.71 ± 0.03	PE	[3048]
Cu	–	–	?	~300	–	4.71 ± 0.05	PE	[2903]
Cu	–	–	1×10^{-9}	~300	–	4.73	CPD	[1252]
Cu/Co/Cu(100)	–	–	–	–	–	4.74	TC	[2897]
Cu/W(112)	Cu	–	?	~300	–	4.74	FE	[4319]
Cu	–	–	3×10^{-11}	~300	–	4.75	FE	[2227]
Cu/Mo(110)	Cu	–	2×10^{-10}	~300	–	4.75	PE	[3288]
Cu	–	–	–	–	–	4.76	TC	[3637]
Cu	–	–	?	~300	–	4.76	PE	[3027]
Cu/Si(111)	Cu	–	$<4 \times 10^{-10}$	~300	–	4.76	PE	[3282]
Cu[463]	–	–	?	~300	–	4.76	CPD	[931,2547]
Cu/Mo(110)	Cu	–	$<6 \times 10^{-11}$	~300	–	4.79*	CPD	[3293]
Cu/W(110)[141]	Cu	–	$<2 \times 10^{-10}$	~300	–	4.8	CPD	[1519,3588]
Cu/Ru(0001)	Cu	–	$\leq5 \times 10^{-10}$	400–640	–	4.8*	CPD	[3705,3706,3731]
Cu	–	–	?	~300	–	4.8 ± 0.2	CPD	[3867]
Cu(fp)[149]	–	–	$<10^{-9}$	~300	–	4.80 ± 0.1	PE	[3190]
Cu/Co/Co(0001)	–	–	–	–	–	4.86	TC	[3490]
Cu[146]	–	–	$\sim10^{-6}$	~300	–	4.86 ± 0.01	CPD	[2087]
Cu/SiO$_2$/Si	Cu	–	?	~300 (570)	–	4.87	PE	[2355]
Cu	–	–	?	~1350	–	4.87	PE	[4139]
Cu/glass	Cu	–	$<10^{-9}$	90, 293	–	4.89	PE	[3046]
Cu	–	–	–	–	–	4.89	TC	[3476]
Cu/Co/Cu(100)	–	–	–	–	–	4.89	TC	[2897]
Cu/W(110)	Cu	–	?	90 (~300)	–	4.9	CPD	[1701,1706]
Cu/Pt(100)	–	–	–	–	–	4.90	TC	[2530]
Cu/W(110)	Cu	–	$<2 \times 10^{-10}$	90	–	4.90	CPD	[3983]
Cu/glass	Cu	–	$<10^{-9}$	90 (380)	–	4.92	PE	[3045]
Cu	–	–	–	–	–	4.93	TC	[4031]
Cu/glass	Cu	–	$\sim10^{-10}$	90 (348)	–	4.94	PE	[2763,3046]
Cu	–	–	–	–	–	4.95	TC	[1066]
Cu	–	–	–	–	–	4.95	TC	[4031]
Cu[58]	–	–	?	~300	–	4.99	CPD	[2550]
Cu/Pt(100)	–	–	–	–	–	5.02	TC	[3382]
Cu/Nb(110)	–	–	7×10^{-11}	~300	–	5.05	PE	[2986]
Cu/Mo(110)	Cu	–	$<6 \times 10^{-11}$	~300	–	5.08	CPD	[3293]
Cu$_4$(cluster)	–	–	–	–	–	5.10	TC	[3205]
Cu/glass	Cu	–	$<10^{-9}$	90 (333)	–	5.11	PE	[1957]
Cu/Co/Cu(100)	–	–	–	–	–	5.14	TC	[950]
Cu$_4$(cluster)	–	–	–	–	–	5.16	TC	[3205]
Cu/Pt(100)	–	–	–	–	–	5.16	TC	[3382]
Cu/W(110)[147]	Cu	–	$<2 \times 10^{-10}$	~300 (?)	–	5.20	FE	[2831]
Cu	–	–	–	–	–	5.24	TC	[3476]
Cu	–	–	–	–	–	5.3	TC	[1432]
Recommended	–	–	–	–	–	**4.51 ± 0.04**	–	–
Liquid ($T > 1356$ K)								
Cu[144]	–	–	8×10^{-8}	~1356	–	4.5 ± 0.1	TE	[1465,1466]
Cu	–	–	?	~1360	–	4.75	PE	[4139]
Cu	–	–	$<5 \times 10^{-8}$	1356–1520	–	5.3	TE	[1466]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				30. Zinc Zn				
hcp								
Zn(0001)	–	–	–	–	–	3.0	TC	[3137]
Zn(0001)	–	–	–	–	–	3.24	TC	[3211]
Zn(0001)	–	–	–	–	–	3.500	TC	[2914]
Zn(0001)	–	–	2×10^{-7}	~300	–	3.56	PE	[1758]
Zn(0001)[150]	–	–	10^{-9}	45–290	–	3.63	PE	[2591,2601]
Zn(0001)	–	–	–	–	–	3.65	TC	[1030,1089]
Zn(0001)	–	–	?	~300	–	3.7	PE	[2264]
Zn(0001)	–	–	–	–	–	3.74	TC	[1089]
Zn(0001)	–	–	–	–	–	3.77	TC	[3467]
Zn(0001)	–	–	–	–	–	3.79	TC	[3004]
Zn(0001)	–	–	–	–	–	3.83	TC	[231,556]
Zn(0001)	–	–	–	–	–	3.92	TC	[4461][490]
Zn(0001)	–	–	–	–	–	4.00	TC	[1089]
Zn(0001)	–	–	–	–	–	4.07	TC	[1030]
Zn(0001)	–	–	–	–	–	4.075	TC	[4460][490]
Zn(0001)	–	–	–	–	–	4.15	TC	[1159,3067]
Zn(0001)	–	–	–	–	–	4.15	TC	[475,1095]
Zn(0001)	–	–	–	–	–	4.19	TC	[3004]
Zn(0001)	–	–	–	–	–	4.2	TC	[1088]
Zn(0001)	–	–	–	–	–	4.20	TC	[593]
Zn(0001)	–	–	–	–	–	4.21	TC	[4461][490]
Zn(0001)	–	–	–	–	–	4.24	TC	[553]
Zn(0001)	–	–	?	100	–	4.25	CPD	[2370,2633]
Zn(0001)	–	–	~10^{-7}	~300	–	4.26 ± 0.01	PE	[2298]
Zn(0001)	–	–	–	–	–	4.30	TC	[556]
Zn(0001)	–	–	~10^{-11}	~300	–	4.4	PE	[2137]
Zn(0001)	–	–	–	–	–	4.43	TC	[4005]
Zn(0001)	–	–	–	–	–	4.442	TC	[4460][490]
Zn(0001)	–	–	–	–	–	4.7	TC	[2375]
Zn(0001)	–	–	–	–	–	4.81	TC	[1087]
Zn(0001)	–	–	–	–	–	4.85	TC	[1095]
Zn(0001)	–	–	≤1×10^{-10}	70	–	4.9 ± 0.6	CPD	[1508]
Zn(0001)	–	–	–	–	–	6.88	TC	[321]
Recommended	–	–	–	–	–	**4.35 ± 0.28**	–	–
Zn(1010)	–	–	–	–	–	5.04	TC	[4005]
Zn(1010)	–	–	–	–	–	6.57	TC	[321]
Zn(1124)	–	–	–	–	–	5.76	TC	[321]
Zn	–	–	?	~300	–	3.08	PE	[2460]
Zn	–	–	?	~300	–	3.09 ± 0.01	PE	[2703]
Zn	–	–	?	~300	–	3.1	PE	[1454]
Zn	–	–	–	–	–	3.14	TC	[1744]
Zn	–	–	–	–	–	3.2	TC	[944]
Zn	–	–	?	648	–	3.24	PE	[1454]
Zn	–	–	?	~300	–	3.28 ± 0.01	PE	[2703]
Zn	–	–	2×10^{-7}	~300	–	3.32	PE	[1758]
Zn	–	–	–	–	–	3.4	TC	[2456]
Zn	–	–	?	~300	–	3.40	CPD	[2761]
Zn/Pt(100)	–	–	–	–	–	3.45	TC	[3168]
Zn/Au(100)	–	–	–	–	–	3.45	TC	[3168]
Zn	–	–	–	–	–	3.50	TC	[521]
Zn	–	–	–	–	–	3.51	TC	[231]
Zn	–	–	?	~300	–	3.52	PE	[4278]
Zn	–	–	2×10^{-7}	~300	–	3.57	PE	[1758]
Zn	–	–	6×10^{-3}	~300	–	3.60 ± 0.08	PE	[2079,2080]
Zn	–	–	–	–	–	3.62	TC	[1924]
Zn	–	–	?	~300	–	3.66	CPD	[2297]
Zn	–	–	–	–	–	3.68	TC	[3467]
Zn	–	–	–	0	–	3.69	TC	[4419]
Zn	–	–	?	~300	–	3.69 ± 0.09	CPD	[2544]
Zn	–	–	?	~300	–	3.72	PE	[4159]
Zn	–	–	–	–	–	3.73	TC	[231]
Zn	–	–	<10^{-6}	~300	–	3.74	PE	[2919]
Zn	–	–	–	–	–	3.77	TC	[230]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Zn	–	–	–	–	–	3.77	TC	[3467]
Zn	–	–	–	–	–	3.79	TC	[3168]
Zn	–	–	–	–	–	3.8*	TC	[1955]
Zn	–	–	–	–	–	3.80	TC[3]	[475]
Zn	–	–	–	–	–	3.80	TC	[3352]
Zn	–	–	? (N_2)	~300	–	3.80 ± 0.02	CPD	[2624,4226,4232]
Zn	–	–	?	~300	–	3.84*	CPD	[3621]
Zn	–	–	?	~300	–	3.85 ± 0.01	PE	[3394]
Zn	–	–	~10^{-6}	~300	–	3.89	PE	[3389,3394]
Zn	–	–	–	–	–	3.93	TC	[2629]
Zn	–	–	–	–	–	3.95	TC	[1399]
Zn/ins/Al[47]	Zn	–	?	~300	–	3.98 ± 0.09	CPD	[2028]
Zn	–	–	1×10^{-5}	~300	–	4.01	CPD	[1883]
Zn	–	–	–	–	–	4.02	TC	[1924]
Zn	–	–	–	–	–	4.04	TC	[3318]
Zn	–	–	–	–	–	4.07	TC	[1901]
Zn	–	–	–	–	–	4.09	TC	[553]
Zn	–	–	–	–	–	4.09	TC	[3477]
Zn	–	–	–	–	–	4.1 ± 0.09	TC	[1990]
Zn	–	–	–	–	–	4.10	TC	[1626,2914]
Zn/glass[151]	Zn	–	?	~300	–	4.11 ± 0.03	CPD	[1370]
Zn	–	–	–	–	–	4.12	TC	[738]
Zn/brass	Zn	–	≤10^{-8}	~300	–	4.16 ± 0.12	PE	[2848]
Zn	–	–	–	–	–	4.18	TC	[3318]
Zn	–	–	–	–	–	4.2	TC	[1993]
Zn/steel	Zn	–	≤10^{-10}	~300	–	4.2 ± 0.05	PE	[1523]
Zn	–	–	?	~300	–	4.2 ± 0.1	CPD	[2364]
Zn/SrTiO$_3$(100)	Zn	–	?	~300	–	4.2 ± 0.1	TCS	[4220]
Zn/Mo	Zn	–	~2×10^{-8}	~300	–	4.24	PE	[1763]
Zn	–	–	–	–	–	4.24	TC	[298]
Zn[152]	–	–	~10^{-6}	~300	–	4.27 ± 0.06*	CPD	[2087]
Zn/glass[151]	Zn	–	?	~300	–	4.28 ± 0.02	CPD	[1370]
Zn	–	–	–	–	–	4.3*	TC	[706]
Zn$_n$($n \to \infty$)[472]	–	–	–	–	–	4.3*	TC	[4329]
Zn:ZnO(0001)	–	–	<5×10^{-11}	~300	–	4.3 ± 0.1	PE	[3119]
Zn	–	–	–	–	–	4.30	TC	[3264,3265,3267]
Zn/glass	Zn	–	?	90, 300	–	4.307	PE	[3031]
Zn	–	–	–	–	–	4.31	TC	[2005]
Zn	–	–	–	–	–	4.317	TC	[2649]
Zn/glass	Zn	–	<10^{-9}	90, 293	–	4.32	PE	[3046]
Zn/glass	Zn	–	~10^{-10}	77–90	–	4.33	PE	[2763,3046,3052]
Zn/glass	Zn	–	~10^{-10}	77–90 (373)	–	4.33	PE	[2763,3046]
Zn/glass	Zn	–	<10^{-9}	77–90	–	4.335	PE	[3031]
Zn/glass	Zn	–	<10^{-9}	77–90 (293)	–	4.335	PE	[3031]
Zn/glass	Zn	–	<10^{-9}	77–90	–	4.34	PE	[2307,3048]
Zn/glass	Zn	–	<10^{-9}	77–90 (383)	–	4.34	PE	[2307,3048]
Zn	–	–	–	–	–	4.34	TC	[4418,4420]
Zn	–	–	~4×10^{-9}	294	–	4.35 ± 0.03	PE	[1116]
Zn[152]	–	–	~10^{-6}	~300	–	4.65 ± 0.01	CPD	[2087]
Zn	–	–	–	–	–	4.76	TC	[3477]
Zn	–	–	–	–	–	4.85	TC	[2629]
Zn	–	–	?	~300	–	4.9*	CPD	[3867]
Zn	–	–	–	–	–	5.35	TC	[1066]
Recommended	–	–	–	–	–	**4.22 ± 0.11**	–	–

31. Gallium Ga

fcc

Ga(100)	–	–	–	–	–	3.35	TC	[3211]
Ga(110)	–	–	–	–	–	4.08	TC	[3211]
Ga(111)	–	–	–	–	–	3.79	TC	[3211]

Rhombic ($T < 303$ K for bulk)

Ga	–	–	–	–	–	3.55	TC	[3211]
Ga	–	–	–	–	–	3.56	TC	[521]
Ga	–	–	–	–	–	3.57	TC	[3211]
Ga	–	–	–	–	–	3.58	TC	[1744]
Ga	–	–	–	–	–	3.7	TC	[3318]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ga	–	–	–	–	–	3.8*	TC	[1955]
Ga	–	–	?	~300	–	3.80	CPD	[2297]
Ga	–	–	–	–	–	3.84	TC	[3211]
Ga	–	–	–	0	–	3.84	TC	[4419]
Ga	–	–	–	–	–	3.94	TC	[3318]
Ga/Au/Cu	Ga	–	5×10^{-11}	10	–	4.0	PE	[3130]
Ga	–	–	–	–	–	4.0 ± 0.05	TC	[1990]
Ga	–	–	–	–	–	4.02	TC	[1399]
Ga	–	–	–	–	–	4.02	TC	[2629]
Ga	–	–	?	293	–	4.07	PE	[4139]
Ga	–	–	–	–	–	4.1	TC	[944]
Ga	–	–	–	–	–	4.1	TC	[2583]
Ga	–	–	?	~300	–	4.12	PE	[3027]
Ga	–	–	–	–	–	4.16	TC	[298]
Ga	–	–	?	187	–	4.19	PE	[4249]
Ga	–	–	–	–	–	4.2	TC	[706]
Ga	–	–	–	–	–	4.20	TC	[1885]
Ga	–	–	$\sim10^{-7}$	~300	–	4.20 ± 0.03	CPD	[2767]
Ga	–	–	–	–	–	4.21	TC	[4418]
Ga	–	–	–	–	–	4.22	TC	[1613]
Ga	–	–	–	–	–	4.25	TC	[3267]
Ga/Cu	Ga	–	$\sim10^{-11}$	20	–	4.3	PE	[1111]
Ga	–	–	–	–	–	4.3	TC	[1645]
Ga/Au/Cu	Ga	–	5×10^{-11}	<10	–	4.3 ± 0.1	PE	[2267]
Ga	–	–	–	–	–	4.30	TC	[3264,3265]
Ga	–	–	?	~290	–	4.31	PE	[4139]
Ga/Si(111)	Ga	–	$<8 \times 10^{-11}$	~300	–	4.33	PE	[1904]
Ga	–	–	10^{-6}	~300	–	4.34 ± 0.06	CPD	[2942]
Ga	–	–	?	273	–	4.35 ± 0.03	PE	[2770,2771]
Ga/Si(111)	Ga	–	$<8 \times 10^{-11}$	~300	–	4.36	PE	[1904]
Ga	–	–	–	–	–	4.36	TC	[1901]
Ga	–	–	$<10^{-10}$	273	–	4.36 ± 0.03	PE	[2026]
Ga/Si(111)	Ga	–	5×10^{-11}	~300	–	4.37 ± 0.1	PE	[2623,2625]
Ga/glass	Ga	–	$<10^{-9}$	90	–	4.40	PE	[3046]
Ga/Al(100)	–	–	–	–	–	4.41	TC	[1932]
Ga	–	–	–	–	–	4.44	TC	[2005]
Ga/glass	Ga	–	$<10^{-9}$	90 (<273)	–	4.45	PE	[2763,3046]
Ga/glass	Ga	–	$<10^{-9}$	293	–	4.45	PE	[3052]
Ga/Si(111)	Ga	–	$<4 \times 10^{-10}$	~300	–	4.45	PE	[1566]
Ga/W(110)	Ga	–	$\sim10^{-11}$	20	–	4.5	FE	[2218]
Ga/W(112)	Ga	–	$\sim10^{-11}$	20	–	4.5	FE	[2218]
Ga/Al(100)	–	–	–	–	–	4.57	TC	[1932]
Ga/W(111)	Ga	–	$\sim10^{-11}$	20	–	4.6	FE	[2218]
Ga/Mo(111)	Ga	–	$\sim10^{-11}$	20	–	4.6	FE	[2218]
Ga/W	Ga	–	?	78 (?)	–	4.65 ± 0.1	FE	[2725]
Ga/W(114)	Ga	–	$\sim10^{-11}$	20	–	4.7	FE	[2218]
Ga/Mo(112)	Ga	–	$\sim10^{-11}$	20	–	4.7	FE	[2218]
Ga/W	Ga	–	$<2 \times 10^{-10}$	77 (≤500)	–	4.75	FE	[2727]
Ga/W	Ga	–	?	78 (?)	–	4.75 ± 0.1	FE	[2725]
Ga/Mo(110)	Ga	–	$\sim10^{-11}$	20	–	4.9	FE	[2218]
Ga	–	–	–	–	–	4.96	TC	[2629]
Recommended	–	–	–	–	–	**4.27 ± 0.06**	–	–

Liquid ($T > 303$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ga	–	–	?	323	–	4.30 ± 0.01	PE	[2770,2771]
Ga	–	–	$<10^{-10}$	323	–	4.30 ± 0.02	PE	[2026]
Ga	–	–	$\leq10^{-9}$	473	–	4.31	SP	[2349]
Ga	–	–	8×10^{-10}	320–820	–	4.33 ± 0.05	PE	[2726]
Ga	–	–	$\leq10^{-9}$	473	–	4.35 ± 0.05	PE	[2345,2349,2353]
Ga	–	–	?	313	–	4.37	PE	[4139]
Ga	–	–	$\leq3 \times 10^{-9}$	>300	–	4.39 ± 0.06	CPD	[1542,3106]
Recommended	–	–	–	–	–	**4.33 ± 0.03**	–	–

32. Germanium Ge

Diamond structure

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ge(100)	–	–	$<2 \times 10^{-10}$	~300	–	4.46[484]	FE	[3539]
Ge(100)	–	–	?	~300 (770)	–	4.55	CPD	[1768]
Ge(100)	–	–	?	~300 (870)	–	4.55	CPD	[1768]
Ge(100)	–	–	–	–	–	4.649	TC	[3499,3500]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ge(100)	–	–	?	?	–	4.7	?	[1857]
Ge(100)	–	–	?	~300 (620)	–	4.72	CPD	[1768]
Ge(100)	–	–	?	~300	–	4.75	CPD	[1768]
Ge(100)	–	–	$\leq 2 \times 10^{-8}$	~300	–	4.76 ± 0.3	CPD	[1382]
Ge(100)	–	–	5×10^{-10}	~300	–	4.77 ± 0.015	CPD	[1769,1770]
Ge(100)	–	–	$\sim 10^{-11}$	~300	–	4.9	FE	[3097]
Ge(100)	–	–	$\sim 10^{-11}$	~300	–	5.0	FE	[3097]
Recommended	–	–	–	–	–	**4.68 ± 0.08**	–	–
Ge(110)[436]	–	–	$\leq 2 \times 10^{-8}$	~300	–	4.72 ± 0.3	CPD	[1382]
Ge(110)[n]	–	–	5×10^{-10}	~300	–	4.73 ± 0.015	CPD	[1770]
Ge(110)	–	–	$\sim 10^{-10}$	~300	–	4.77	CPD	[3696]
Ge(110)	–	–	5×10^{-10}	~300	–	4.78 ± 0.015	CPD	[1770]
Ge(110)	–	–	$<2 \times 10^{-10}$	~300	–	4.85[484]	FE	[3539]
Ge(110)	–	–	$\sim 10^{-10}$	~300	–	4.88	PE	[3696]
Recommended	–	–	–	–	–	**4.79 ± 0.06**	–	–
Ge(111)	–	–	$\sim 10^{-6}$	~900–1050	–	4.01 ± 0.05	TE	[3272]
Ge(111)	–	–	$\sim 10^{-6}$	~900–1050	–	4.07 ± 0.05	TE	[3272]
Ge(111)	–	–	?	~1070–1170	–	4.1	TE	[1660]
Ge(111)[n153]	–	–	$\sim 10^{-9}$	~300	–	4.12	PE	[2093]
Ge(111)	–	–	–	–	–	4.5	TC	[2213]
Ge(111)[n154]	–	–	4×10^{-10}	~300 (≤470)	–	4.5	PE	[2620]
Ge(111)[n]	–	–	5×10^{-11}	~300 (623)	–	4.53 ± 0.02	PE, CPD	[2023,2029]
Ge(111)	–	–	–	–	–	4.548	TC	[4424]
Ge(111)	–	–	–	–	–	4.569	TC	[4425]
Ge(111)[p]	–	–	2×10^{-10}	~300 (450)	–	4.61	CPD	[1969]
Ge(111)[n]	–	–	5×10^{-11}	~300	–	4.65 ± 0.02	PE, CPD	[2023,2029,3109, 3819]
Ge(111)[n154]	–	–	4×10^{-10}	~300 (570)	–	4.7	PE	[2620]
Ge(111)	–	–	$\sim 10^{-10}$	~300	–	4.7	CPD	[2948]
Ge(111)	–	–	$\leq 2 \times 10^{-8}$	~300	–	4.70 ± 0.3	CPD	[1382]
Ge(111)[p]	–	–	5×10^{-11}	~300	–	4.72 ± 0.02	PE, CPD	[2029,3819]
Ge(111)[421]	–	–	$<2 \times 10^{-9}$	~300	–	4.73 ± 0.05	CPD	[1991]
Ge(111)[p]	–	–	2×10^{-10}	~300 (450)	–	4.74	CPD	[1969]
Ge(111)[n153]	–	–	$\sim 10^{-9}$	~300	–	4.75	PE	[2093]
Ge(111)[n]	–	–	5×10^{-10}	~300	–	4.79 ± 0.015	CPD	[1769,1770]
Ge(111)[p]	–	–	?	~300	–	4.8	FE	[2955]
Ge(111)[p]	–	–	$\leq 10^{-9}$	~300	–	4.8 ± 0.1	FE	[1496]
Ge(111)[p155]	–	–	2×10^{-10}	~300	–	4.80	PE	[1971]
Ge(111)[p155]	–	–	2×10^{-10}	~300	–	4.80 ± 0.05	CPD	[1969,1971]
Ge(111)/W	Ge	–	2×10^{-10}	480	–	4.85 ± 0.05	FE	[2248]
Ge(111)[n154]	–	–	4×10^{-10}	~300	–	4.9	PE	[2620]
Ge(111)	–	–	–	–	–	5.1	TC	[3151]
Ge(111)	–	–	–	–	–	5.4	TC	[3151]
Ge(111)[421]	–	–	$<2 \times 10^{-9}$	~300	–	5.45 ± 0.05	CPD	[1991]
Recommended	–	–	–	–	–	**4.60 ± 0.09**	–	–
Ge(112)	–	–	–	–	–	4.72	TC	[1627]
Ge(112)	–	–	$<2 \times 10^{-10}$	~300	–	4.94	FE	[3539]
Ge(113)	–	–	$<2 \times 10^{-10}$	~300	–	4.88	FE	[3539]
Ge(114)	–	–	$<2 \times 10^{-10}$	~300	–	4.90	FE	[3539]
Ge(122)	–	–	$<2 \times 10^{-10}$	~300	–	4.90	FE	[3539]
Ge(133)	–	–	$<2 \times 10^{-10}$	~300	–	4.85	FE	[3539]
Ge(155)	–	–	$<2 \times 10^{-10}$	~300	–	4.80	FE	[3539]
Ge(???)[p]	–	–	?	~300	–	4.87	PE	[1229]
Ge(???)	–	–	$<10^{-10}$	~300	–	5.1 ± 0.1	PE	[3333]
Ge/graphite[461]	–	–	$<5 \times 10^{-8}$	670–1230	–	2.4–3.5	TE	[1466]
Ge[n]	–	–	?	273	–	3.52	PE	[3688]
Ge/Nb	Ge	–	$<10^{-10}$	~300	–	3.55	FE	[3796]
Ge[n]	–	–	?	493	–	3.62	PE	[3688]
Ge	–	–	?	~300 (?)	–	3.82 ± 0.05	PE	[3577]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ge	–	–	?	900	–	3.97	TE	[3274]
Ge	–	–	–	–	–	4.00	TC	[298]
Ge	–	–	?	~300	–	4.00 ± 0.05	PE	[3577]
Ge/W(111)	Ge	–	1×10^{-8}	~1550–1650	–	4.1	TE	[1499]
Ge[p]	–	–	?	613–943	–	4.10 ± 0.05	PE	[3688]
Ge	–	–	?	1050	–	4.16	TE	[3274]
Ge	–	–	?	~300	–	4.16 ± 0.02	PE	[3394]
Ge	–	–	$\sim10^{-6}$	~300	–	4.29	PE	[3389,3394]
Ge[n]	–	–	?	298 (903)	–	4.32	PE	[3688]
Ge[n]	–	–	–	–	–	4.33 ± 0.05	TC	[3860]
Ge[p]	–	–	?	298	–	4.34 ± 0.05	PE	[3688]
Ge	–	–	?	~300 (?)	–	4.35	PE	[1470]
Ge[p]	–	–	?	298 (≤943)	–	4.36	PE	[3688]
Ge	–	–	–	–	–	4.4*	TC	[1955]
Ge[n]	–	–	$\sim10^{-10}$	~300	–	4.43 ± 0.05	FE	[3069]
Ge(nanowire)[71]	–	–	?	~300	–	4.43	PE	[2200]
Ge	–	–	?	~300	–	4.45	PE	[1470]
Ge/W(110)	Ge	–	1×10^{-8}	1550–1650	–	4.5	TE	[1499]
Ge[n]	–	–	$<2 \times 10^{-6}$	523	–	4.5	CPD	[1310]
Ge[n]	–	–	$<2 \times 10^{-6}$	1023	–	4.5	CPD	[1310]
Ge	–	–	?	~300	–	4.50	CPD	[2297]
Ge	–	–	–	–	–	4.59	TC	[3318]
Ge[p]	–	–	–	–	–	4.65 ± 0.03	TC	[3860]
Ge	–	–	?	~300	–	4.73	PE	[3027]
Ge/Mo	Ge	–	$<3 \times 10^{-8}$	~300	–	4.73 ± 0.07	PE	[1371]
Ge	–	–	?	~300	–	4.77	PE	[3387]
Ge	–	–	$\leq5 \times 10^{-8}$	~300	–	4.77 ± 0.04	CPD	[3658]
Ge	–	–	5×10^{-10}	~300	–	4.78 ± 0.015	CPD	[1770]
Ge	–	–	–	–	–	4.8	TC	[1993]
Ge	–	–	–	–	–	4.8	TC	[706]
Ge	–	–	$\leq10^{-10}$	~300	–	4.8	FE	[1502]
Ge/W	Ge	–	?	~300	–	4.8	FE	[3594]
Ge/W	Ge	–	?	~300	–	4.8	CPD	[2577]
Ge/W	Ge	–	$\sim10^{-9}$	~300	–	4.85 ± 0.05	CPD	[1954]
Ge/W	Ge	–	2×10^{-10}	480	–	4.85 ± 0.05	FE	[2248]
Ge[p]	–	–	$\sim10^{-10}$	~300	–	4.90 ± 0.05	FE	[3069]
Ge/W	Ge	–	$\leq10^{-10}$	~300	–	4.90 ± 0.06	FE	[3545]
Ge/Ti/W	Ge	–	$\leq10^{-10}$	~300	–	4.90 ± 0.06	FE	[3545]
Ge/W	Ge	–	$\sim10^{-10}$	~300 (~380)	–	4.95 ± 0.05	FE	[2588]
Ge/glass	Ge	–	$<10^{-9}$	77–90	–	4.98	PE	[2311]
Ge/glass	Ge	–	2×10^{-10}	77	–	4.98 ± 0.02	PE	[3052,3056,3059, 3060]
Ge/W	Ge	–	$\sim10^{-9}$	~300	–	5.0	FE	[3554]
Ge/W	Ge	–	?	~300 (400)	–	5.0	FE	[3594]
Ge/glass	Ge	–	5×10^{-10}	273 (293)	–	5.00 ± 0.02	PE	[3056]
Ge/W	Ge	–	2×10^{-10}	460	–	5.01 ± 0.02	FE	[2248]
Ge/glass	Ge	–	2×10^{-10}	273 (≤373)	–	5.02 ± 0.02	PE	[3059,3060]
Ge/glass	Ge	–	2×10^{-10}	77 (293)	–	5.03 ± 0.02	PE	[3052,3059,3060]
Ge/glass	Ge	–	$<10^{-9}$	77 (293)	–	5.04	PE	[2311]
Ge/glass	Ge	–	5×10^{-10}	293 (373)	–	5.04 ± 0.02	PE	[3056]
Ge/W(110)	Ge	–	$\leq1 \times 10^{-9}$	293	–	5.05	CPD	[1520]
Ge/glass	Ge	–	5×10^{-10}	77 (293)	–	5.05 ± 0.03	PE	[3056]
Ge	–	–	–	–	–	5.08	TC	[2554]
Ge/W	Ge	–	?	~300 (1130)	–	5.1 ± 0.05	FE	[3553,3555,3903]
Ge/W	Ge	–	$\leq10^{-9}$	~300 (380)	–	5.15 ± 0.05	FE	[3063]
Ge/W	Ge	–	$<10^{-9}$	~300 (≤400)	–	5.2	FE	[2580,2584,2596]
Ge/O/W	Ge	–	$<10^{-9}$	~300 (≤400)	–	5.2	FE	[2596]
Ge/W	Ge	–	$\leq3 \times 10^{-10}$	~300	–	5.2 ± 0.1	FE	[3544]
Ge/Mo	Ge	–	$\leq3 \times 10^{-10}$	~300	–	5.2 ± 0.1	FE	[3544]
Ge/W	Ge	–	2×10^{-10}	395	–	5.21 ± 0.01	FE	[2248]
Ge[n]	–	–	?	~300	–	5.8	FE	[1855]
Ge[p]	–	–	$\leq10^{-9}$	77	–	6.2	FE	[1395]
Ge[n]	–	–	$\leq10^{-9}$	77	–	6.2	FE	[1395]
Recommended	–	–	–	–	–	**4.76 ± 0.05**	–	–

Liquid ($T > 1232$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ge/graphite[461]	–	–	$<5 \times 10^{-8}$	~1300–1500	–	3.60*	TE	[1466]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.

33. Arsenic As

Rhombohedral (arsenic structure)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
As(111)	–	–	$\sim10^{-9}$	~300	–	3.75 ± 0.05	PE	[2952]
As	–	–	–	–	–	3.23	TC	[1744]
As	–	–	–	–	–	4.64	TC	[3318]
As/Cu,Ni,Ta,C	As	–	$\sim10^{-6}$	~300	–	4.66	PE	[3251,3252]
As/Ni,Mo,etc.	As	–	$<5 \times 10^{-8}$	~300	–	4.72	CPD	[1375]
As	–	–	–	–	–	4.77	TC	[298]
As/Nb,Pt,etc.	As	–	$<5 \times 10^{-8}$	~300	–	4.79	PE	[1375]
As	–	–	–	–	–	4.8 ± 0.2	TC	[1903,1905]
As	–	–	–	–	–	4.9*	TC	[1955]
As	–	–	–	–	–	5.02	TC	[1901]
As	–	–	?	~300	–	5.11	PE	[3027]
As/glass	As	–	$\sim3 \times 10^{-7}$	~300	–	5.17 ± 0.04	PE	[2950]
As	–	–	–	–	–	5.2	TC	[706]
As/Si(001)	–	–	–	–	–	5.56	TC	[2525]
Recommended	–	–	–	–	–	**4.85 ± 0.14**	–	–

34. Selenium Se

Hexagonal

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Se(1010)	–	–	$\sim10^{-10}$	~300	–	5.9	PE	[3429]
Se(1010)	Se	–	5×10^{-11}	~300	–	5.9 ± 0.1	PE	[4247]
Se	–	–	?	~300	–	4.42	CPD	[2297]
Se	–	–	?	~300	–	4.62	PE	[2080]
Se	–	–	–	–	–	4.8	TC	[3318]
Se/W(111)	Se	–	$<10^{-10}$	~300	–	4.80	FE	[1677]
Se/W(110)	Se	–	$<5 \times 10^{-11}$	~300	–	4.9*	CPD	[4102]
Se/W(100)	Se	–	$<10^{-10}$	~300	–	4.95	FE	[1677]
Se/W	Se	–	$<10^{-9}$	~300 (1000)	–	4.96 ± 0.03	FE	[2333]
Se/W(100)	Se	–	$<5 \times 10^{-11}$	~300	–	5.0*	CPD	[2852]
Se/W(100)	Se	–	$<5 \times 10^{-11}$	~300 (≤800)	–	5.1*	CPD	[2852]
Se/Si(111)	–	–	–	–	–	5.1*	TC	[2062,4073]
Se/GaAs(001)	Se	–	?	~300 (670)	–	5.1	PE	[3216]
Se/W	Se	–	$<10^{-10}$	~300	–	5.1 ± 0.1	FE	[1677]
Se/Ni(110)	H_2Se	–	$<1 \times 10^{-10}$	~300 (~1270)	–	5.10	CPD	[1110]
Se/?	Se	–	?	~300	–	5.11	PE	[3027]
Se/Si(100)	Se	–	?	~300	–	5.16*	CPD	[2896]
Se/Si(111)	Se	–	$<10^{-10}$	~300	–	5.17 ± 0.04*	CPD	[4160]
Se/Ni(100)	Se	–	$<5 \times 10^{-10}$	~300	–	5.26 ± 0.06*	CPD	[1790]
Se	–	–	–	–	–	5.3 ± 0.3	TC	[1905]
Se/Fe(100)	Se	–	2×10^{-11}	~300	–	5.34 ± 0.05*	CPD	[4327]
Se/Ni(100)	H_2Se	–	$<1 \times 10^{-10}$	~300 (~1270)	–	5.35	CPD	[1110]
Se/W	Se	–	$\sim10^{-9}$	~300	–	5.4	FE	[394,3342,4052]
Se/Ni(111)	H_2Se	–	$<1 \times 10^{-10}$	~300 (~1270)	–	5.43	CPD	[1110]
Se	–	–	–	–	–	5.6	TC	[706]
Se/W(112)	Se	–	$<10^{-10}$	~300	–	5.65	FE	[1677]
Se	–	–	–	–	–	5.68	TC	[1901]
Se	–	–	?	?	–	5.74 ± 0.15	PE	[3659]
Se	–	–	–	–	–	5.8*	TC	[1955]
Se/brass	Se	–	?	~300 (333)	–	5.86	PE	[2479]
Se/ss	Se	–	$\sim10^{-10}$	~300	–	5.9	PE	[3429]
Se	–	–	–	–	–	5.9	TC	[298]
Se/W(110)	Se	–	$<10^{-10}$	~300	–	6.3	FE	[1677]
Recommended	–	–	–	–	–	**5.27 ± 0.18**	–	–

37. Rubidium Rb

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rb(100)	–	–	–	–	–	2.01	TC	[1254]
Rb(100)	–	–	–	–	–	2.10	TC	[475]
Rb(100)	–	–	–	–	–	2.115	TC	[4091]
Rb(100)	–	–	–	–	–	2.12	TC	[231]
Rb(100)	–	–	–	–	–	2.15	TC	[3467]
Rb(100)	–	–	–	–	–	2.16	TC	[2427]
Rb(100)	–	–	–	–	–	2.17	TC	[553]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rb(100)	–	–	–	–	–	2.177	TC	[2947]
Rb(100)	–	–	–	–	–	2.22	TC	[334]
Rb(100)	–	–	–	–	–	2.28	TC	[711]
Rb(100)	–	–	–	–	–	2.3	TC	[763]
Rb(100)	–	–	–	–	–	2.35	TC	[475]
Rb(100)	–	–	–	–	–	2.36	TC	[1030]
Rb(100)	–	–	–	–	–	2.40	TC	[472]
Rb(100)	–	–	–	–	–	2.40	TC	[321]
Rb(100)	–	–	–	–	–	2.41	TC	[3814]
Rb(100)	–	–	–	–	–	2.45	TC	[476,711]
Rb(100)	–	–	–	–	–	2.47	TC	[1095]
Rb(100)	–	–	–	–	–	2.53	TC	[476]
Rb(100)	–	–	–	–	–	2.54	TC	[1030]
Rb(100)	–	–	–	–	–	2.6	TC	[1088]
Recommended	–	–	–	–	–	**2.31 ± 0.08**	–	–
Rb(110)	–	–	–	–	–	2.2	TC	[1086]
Rb(110)	–	–	–	–	–	2.2	TC	[3137]
Rb(110)	–	–	–	–	–	2.20	TC	[475]
Rb(110)	–	–	–	–	–	2.230	TC	[2947]
Rb(110)	–	–	–	–	–	2.243	TC	[4091]
Rb(110)	–	–	–	–	–	2.25	TC	[593]
Rb(110)	–	–	–	–	–	2.28	TC	[231]
Rb(110)	–	–	–	–	–	2.32	TC	[334,3179]
Rb(110)	–	–	–	–	–	2.32	TC	[2427]
Rb(110)	–	–	–	–	–	2.33	TC	[3467]
Rb(110)	–	–	–	–	–	2.33	TC	[553]
Rb(110)	–	–	–	–	–	2.40	TC	[472]
Rb(110)	–	–	–	–	–	2.46	TC	[711]
Rb(110)	–	–	–	–	–	2.48	TC	[1086]
Rb(110)	–	–	–	–	–	2.49	TC	[1030]
Rb(110)	–	–	–	–	–	2.56	TC	[2402]
Rb(110)	–	–	–	–	–	2.56	TC	[3814]
Rb(110)	–	–	–	–	–	2.57	TC	[1095]
Rb(110)	–	–	–	–	–	2.6	TC	[763]
Rb(110)	–	–	–	–	–	2.6	TC	[1088]
Rb(110)	–	–	–	–	–	2.63	TC	[1086]
Rb(110)	–	–	–	–	–	2.63	TC	[476,711]
Rb(110)	–	–	–	–	–	2.63	TC	[2385]
Rb(110)	–	–	–	–	–	2.65	TC	[475]
Rb(110)	–	–	–	–	–	2.70	TC	[476]
Rb(110)	–	–	–	–	–	2.71	TC	[2835]
Rb(110)	–	–	–	–	–	2.72	TC	[1087]
Rb(110)	–	–	–	–	–	2.72	TC	[1030,1089]
Rb(110)	–	–	–	–	–	2.741	TC	[4069]
Rb(110)	–	–	–	–	–	2.79	TC	[321]
Rb(110)	–	–	–	–	–	2.81	TC	[3693]
Rb(110)	–	–	–	–	–	2.81	TC	[1089]
Rb(110)	–	–	–	–	–	2.83	TC	[3713]
Rb(110)	–	–	–	–	–	2.84	TC	[1086]
Rb(110)	–	–	–	–	–	2.84	TC	[1089]
Rb(110)	–	–	–	–	–	2.87	TC	[1086]
Rb(110)	–	–	–	–	–	2.88	TC	[1086]
Rb(110)	–	–	–	–	–	2.9	TC	[1088]
Rb(110)	–	–	–	–	–	2.9	TC	[1086]
Rb(110)	–	–	–	–	–	2.93	TC	[3693]
Rb(110)	–	–	–	–	–	2.94	TC	[3712]
Rb(110)	–	–	–	–	–	2.94	TC	[3713]
Rb(110)	–	–	–	–	–	2.96	TC	[3692]
Rb(110)	–	–	–	–	–	3.04	TC	[3692]
Rb(110)	–	–	–	–	–	4.96	TC	[3622]
Recommended	–	–	–	–	–	**2.65 ± 0.05**	–	–
Rb(111)	–	–	–	–	–	2.05	TC	[475]
Rb(111)	–	–	–	–	–	2.06	TC	[711]
Rb(111)	–	–	–	–	–	2.08	TC	[231]
Rb(111)	–	–	–	–	–	2.09	TC	[3467]
Rb(111)	–	–	–	–	–	2.096	TC	[4091]
Rb(111)	–	–	–	–	–	2.10	TC	[593]
Rb(111)	–	–	–	–	–	2.12	TC	[553]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rb(111)	–	–	–	–	–	2.22	TC	[472]
Rb(111)	–	–	–	–	–	2.23	TC	[476,711]
Rb(111)	–	–	–	–	–	2.25	TC	[3814]
Rb(111)	–	–	–	–	–	2.26	TC	[1030]
Rb(111)	–	–	–	–	–	2.28	TC	[1030]
Rb(111)	–	–	–	–	–	2.3	TC	[1088]
Rb(111)	–	–	–	–	–	2.30	TC	[475]
Rb(111)	–	–	–	–	–	2.30	TC	[321]
Rb(111)	–	–	–	–	–	2.32	TC	[476]
Rb(111)	–	–	–	–	–	2.42	TC	[1095]
Recommended	–	–	–	–	–	**2.21 ± 0.09**	–	–
Rb(112)	–	–	–	–	–	2.56	TC	[321]
Rb	–	–	–	~300	–	1.4	TC	[3737]
Rb/Si(100)	Rb	–	<3 × 10⁻¹⁰	~300	–	1.5*	PE	[1729,3803,3804]
Rb/Pt	Rb	–	?	~300	–	1.55	PE	[2206]
Rb/Si(100)	–	–	–	–	–	1.906*	TC	[3501]
Rb/Hf	Rb	–	?	~300	–	1.9 ± 0.1	PE	[1691]
Rb	–	–	?	302	–	1.99	PE	[4139]
Rb/Cu(110)	Rb	–	5 × 10⁻¹¹	140	–	2.0 ± 0.1	PE	[3454]
Rb	–	–	–	–	–	2.01	TC	[1254]
Rb	–	–	–	–	–	2.04	TC	[1066]
Rb/W(100)	Rb	–	<1 × 10⁻¹⁰	~150	–	2.05	PE	[2120]
Rb	–	–	–	–	–	2.06	TC	[1951]
Rb/Ni	Rb	–	<10⁻⁹	77	–	2.08	CPD	[2139,3128,3698]
Rb/Ag/glass	Rb	–	~10⁻⁸	~80	–	2.09	PE	[1452]
Rb/quartz	Rb	–	~10⁻¹⁰	90	–	2.1	PE	[2605]
Rb/Cu	Rb	–	3 × 10⁻¹¹	~300	–	2.1 ± 0.1	PE	[3091]
Rb/Ag	Rb	–	3 × 10⁻¹¹	~300	–	2.1 ± 0.1	PE	[3091]
Rb/Y	Rb	–	?	~300	–	2.1 ± 0.1	PE	[1691]
Rb	–	–	–	–	–	2.11	TC	[3728]
Rb/GaAs(110)	Rb	–	<1 × 10⁻¹⁰	~300	–	2.12	CPD	[2793]
Rb	–	–	–	–	–	2.13*	TC	[1955]
Rb	–	–	–	–	–	2.14	TC	[4150]
Rb	–	–	~10⁻⁹	310	–	2.15	PE	[4241]
Rb	–	–	–	–	–	2.16	TC	[2949]
Rb	–	–	~10⁻¹⁰	300	–	2.16	PE	[4297]
Rb/?	Rb	–	?	?	–	2.16	?	[3785]
Rb¹⁵⁶	–	–	<10⁻⁸	298	–	2.16 ± 0.03	PE	[2470,4208,4209]
Rb	–	–	~10⁻⁹	298	–	2.16 ± 0.05	PE	[2612,2613]
Rb	–	–	–	–	–	2.17	TC	[3352]
Rb	–	–	?	303	–	2.17 ± 0.02*	PE	[4141]
Rb/graphene	–	–	–	–	–	2.18	TC	[4079]
Rb	–	–	–	–	–	2.19	TC	[3467,3477]
Rb(cluster)	–	–	–	–	–	2.19	TC	[3479]
Rb	–	–	–	–	–	2.2*	TC	[1955]
Rb	–	–	–	–	–	2.20	TC	[3725]
Rb/glass	Rb	–	≤3 × 10⁻¹¹	195	–	2.20 ± 0.01	PE	[2615]
Rb/glass	Rb	–	≤10⁻¹⁰	77	–	2.21 ± 0.02	PE	[1489]
Rb/glass	Rb	–	<10⁻¹⁰	77	–	2.21 ± 0.05	PE	[2815]
Rb	–	–	–	–	–	2.22	TC	[3312]
Rb	–	–	–	–	–	2.25	TC	[298]
Rb/quartz	Rb	–	<10⁻¹⁰	140–155	–	2.261 ± 0.015	PE	[2119]
Rb	–	–	–	–	–	2.29	TC	[1744]
Rb	–	–	–	–	–	2.3	TC	[1993]
Rb	–	–	–	–	–	2.3	TC	[706]
Rb/glass	Rb	–	≤3 × 10⁻¹¹	77, 195	–	2.31 ± 0.01	PE	[2615]
Rb	–	–	–	–	–	2.33	TC	[3312]
Rb	–	–	–	–	–	2.36	TC	[231]
Rb	–	–	–	–	–	2.37	TC	[2061]
Rb	–	–	–	–	–	2.39	TC	[3477]
Rb	–	–	–	–	–	2.39	TC	[553,2427]
Rb	–	–	–	–	–	2.40	TC	[1924]
Rb/O/W	Rb	–	≤440 (Rb)	~600–700	–	2.41	TE	[2292]
Rb	–	–	–	–	–	2.41	TC	[3467]
Rb	–	–	–	–	–	2.42	TC	[767]
Rb	–	–	–	–	–	2.43	TC	[231]
Rb	–	–	–	–	–	2.45	TC	[1924]
Rb	–	–	–	–	–	2.47	TC	[2427]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rb	–	–	–	–	–	2.48	TC	[4101]
Rb	–	–	–	–	–	2.49	TC	[1613]
Rb/Al(111)	Rb	–	?	~300	–	2.52	CPD	[734]
Rb	–	–	–	–	–	2.54	TC	[738]
Rb	–	–	–	–	–	2.55	TC	[1578]
Rb	–	–	–	–	–	2.6	TC	[2845]
Rb	–	–	–	–	–	2.61	TC	[2629]
Rb	–	–	–	–	–	2.61	TC	[2382]
Rb	–	–	–	–	–	2.63	TC[3]	[475,519,2474]
Rb	–	–	–	–	–	2.64	TC	[230]
Rb	–	–	–	–	–	2.7	TC	[944]
Rb/W	Rb	–	≤440 (Rb)	~650–850	–	2.76	TE	[2292]
Recommended	–	–	–	–	–	**2.17 ± 0.05**	–	–

Liquid (*T > 312 K*)

Rb	–	–	–	–	–	1.80	TC	[4249]
Rb	–	–	?	322	–	1.93	PE	[4139]
Rb	–	–	?	350	–	2.13 ± 0.02*	PE	[4141]
Rb	–	–	~10^{-9}	313	–	2.15	PE	[4241]
Rb	–	–	~10^{-8}	313	–	2.16	PE	[4208]
Rb	–	–	~10^{-10}	313	–	2.16	PE	[4297]
Rb[156]	–	–	?	313	–	2.17 ± 0.03	PE	[2470]
Recommended	–	–	–	–	–	**2.15 ± 0.02**	–	–

38. Strontium Sr

fcc (*α, T < 488 K*)

Sr(100)	–	–	–	–	–	2.43	TC	[1254]
Sr(100)	–	–	–	–	–	2.473	TC	[4091]
Sr(100)	–	–	–	–	–	2.79	TC	[231]
Sr(100)	–	–	–	–	–	2.8	TC	[1712,1714]
Sr(100)	–	–	–	–	–	2.95	TC	[3467]
Sr(100)	–	–	–	–	–	3.42	TC	[1030]
Sr(100)	–	–	–	–	–	3.81	TC	[321]
Sr(100)	–	–	–	–	–	3.82	TC	[1030]
Recommended	–	–	–	–	–	**3.3 ± 0.4**	–	–
Sr(110)	–	–	–	–	–	2.545	TC	[4091]
Sr(110)	–	–	–	–	–	2.75	TC	[231]
Sr(110)	–	–	–	–	–	2.76	TC	[3467]
Sr(110)	–	–	–	–	–	3.05	TC	[1030]
Sr(110)	–	–	–	–	–	3.31	TC	[1030]
Sr(110)	–	–	–	–	–	3.57	TC	[321]
Recommended	–	–	–	–	–	**3.1 ± 0.3**	–	–
Sr(111)	–	–	–	–	–	2.22	TC	[3369]
Sr(111)	–	–	–	–	–	2.3	TC	[3179]
Sr(111)	–	–	–	–	–	2.38	TC	[1722]
Sr(111)	–	–	–	–	–	2.42	TC	[334]
Sr(111)	–	–	–	–	–	2.569	TC	[4091]
Sr(111)	–	–	–	–	–	2.94	TC	[231]
Sr(111)	–	–	–	–	–	3.07	TC	[2427]
Sr(111)	–	–	–	–	–	3.21	TC	[3467]
Sr(111)	–	–	–	–	–	3.57	TC	[1030,1089]
Sr(111)	–	–	–	–	–	3.61	TC	[1030]
Sr(111)	–	–	–	–	–	3.65	TC	[1089]
Sr(111)	–	–	–	–	–	3.78	TC	[1089]
Sr(111)	–	–	–	–	–	4.10	TC	[321]
Recommended	–	–	–	–	–	**3.4 ± 0.3**	–	–

hcp (*β, T = 488–878 K*)

Sr(0001)	–	–	–	–	–	4.17	TC	[321]
Sr(1010)	–	–	–	–	–	3.99	TC	[321]
Sr(1124)	–	–	–	–	–	3.49	TC	[321]

bcc (*γ, T > 878 K*)

Sr(100)	–	–	–	–	–	2.71	TC	[1159,3067]
Sr(100)	–	–	–	–	–	3.27	TC	[321]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Sr(110)	–	–	–	–	–	2.39	TC	[334]
Sr(110)	–	–	–	–	–	2.63	TC	[1159,3067]
Sr(110)	–	–	–	–	–	3.81	TC	[321]
Sr(111)	–	–	–	–	–	2.80	TC	[1159,3067]
Sr(111)	–	–	–	–	–	3.13	TC	[321]
Sr(112)	–	–	–	–	–	3.61	TC	[321]
fcc (α, $T < 488$ K for bulk)								
Sr/glass	Sr	–	?	~300	–	2.06	PE	[1748]
Sr	–	–	–	–	–	2.08	TC	[1744]
Sr/?	Sr	–	?	~300	–	2.24	PE	[3027]
Sr/W	Sr	–	(~10^{-12})	~300 (819)	–	2.24	FE	[2585]
Sr/Mo(112)	Sr	–	~10^{-9}	~300	–	2.25	PE	[2398]
Sr/W	Sr	–	$\leq 1 \times 10^{-9}$	~300 (773)	–	2.35 ± 0.05	FE	[2587]
Sr/Mo(112)	–	–	–	–	–	2.43	TC	[702]
Sr	–	–	–	–	–	2.43	TC	[1254]
Sr	–	–	–	–	–	2.46	TC	[3318]
Sr	–	–	–	–	–	2.46	TC	[1066]
Sr/W	Sr	–	?	~300	–	2.5	FE	[1471]
Sr/W	Sr	–	?	~300 ($\leq$700)	–	2.5–2.6	CPD	[2578]
Sr/Mo(100)	Sr	–	$\geq 10^{-6}$(Sr)	~800–900	–	2.59	TE	[1401,1402]
Sr/?	Sr	–	5×10^{-11}	~300	–	2.6	PE	[2116]
Sr	–	–	–	–	–	2.6*	TC	[1955]
Sr	–	–	–	–	–	2.61	TC	[3318]
Sr	–	–	–	–	–	2.64	TC	[298]
Sr/W[244]	Sr	–	$\leq 2 \times 10^{-9}$	~900	–	2.64	CPD	[3530]
Sr/quartz	Sr	–	5×10^{-10}	~300	–	2.64 ± 0.05	PE	[2014,2021,2024]
Sr	–	–	–	0	–	2.68	TC	[4419]
Sr	–	–	–	–	–	2.7	TC	[1993]
Sr/?	Sr	–	?	~300	–	2.7	PE	[2115]
Sr/W[244]	Sr	–	$\leq 2 \times 10^{-9}$	~300	–	2.73	CPD	[3530]
Sr/?	Sr	–	?	~300	–	2.74	PE	[1639]
Sr/W(100)	Sr	–	$\leq 10^{-2}$(Sr)	~900–1000	–	2.74	TE	[1792]
Sr	–	–	–	–	–	2.77	TC	[3729]
Sr/Mo(112)	Sr	–	($\leq 10^{-11}$)	77	–	2.8	CPD	[2631]
Sr/glass[88]	Sr	–	<10^{-9}	~300{77}	–	2.8	CPD	[1526]
Sr	–	–	–	–	–	2.8	TC	[1711]
Sr/W(110)	Sr	–	($\leq 10^{-11}$)	5	–	2.8	CPD	[2347]
Sr/Mo(112)	Sr	–	2×10^{-11}	100 (500)	–	2.8	CPD	[2431]
Sr	–	–	–	–	–	2.81	TC	[1901]
Sr/Re(1010)	Sr	–	(<10^{-11})	77 (~300)	–	2.85	CPD	[4275]
Sr	–	–	–	–	–	2.9	TC	[706]
Sr	–	–	–	–	–	2.93	TC	[3476]
Sr	–	–	–	–	–	2.96	TC	[231]
Sr	–	–	–	–	–	2.97	TC	[3467]
Sr/W(110)[157]	Sr	–	$\leq 10^{-10}$	77	–	3.0	FE	[2344]
Sr	–	–	–	–	–	3.03	TC	[231]
Sr	–	–	–	–	–	3.04	TC	[3476]
Sr	–	–	–	–	–	3.08	TC	[1924]
Sr	–	–	–	–	–	3.09	TC	[1924]
Sr	–	–	–	–	–	3.12	TC	[1613]
Sr/W(110)	Sr	–	($\leq 10^{-11}$)	290	–	3.2	CPD	[2347]
Sr/W(110)	Sr	–	($\leq 10^{-11}$)	5 ($\leq$400)	–	3.2	CPD	[2347]
Sr/W(110)[157]	Sr	–	($\leq 10^{-10}$)	77 (300)	–	3.2	CPD	[2344]
Sr	–	–	–	–	–	3.30	TC	[3476]
Sr	–	–	–	–	–	3.33	TC	[3467]
Recommended	–	–	–	–	–	**2.71 ± 0.08**	–	–
hcp (β, $T = 488$–878 K for bulk)								
Sr/W[244]	Sr	–	$\leq 2 \times 10^{-9}$	750–850	–	2.64	CPD	[3530]
Sr	–	–	–	–	–	2.77	TC	[3729]
Sr	–	–	–	–	–	2.92	TC	[1578]
Sr/Mo(110)	Sr	–	$\leq 10^{-10}$	5 ($\leq$300)	–	3.1	CPD	[3350]
bcc (γ, $T > 878$ K for bulk)								
Sr/W	Sr	–	(<10^{-14})	~850–950	–	2.3	TE	[2572]
Sr/?	Sr	–	?	?	–	2.4	TE	[3402]

(*continued on next page*)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				39. Yttrium Y[399]				
hcp (α, T < 1540 K)								
Y(0001)	–	–	<10^{-9}	? (~1700)	–	3.0 ± 0.1	TE,PE	[4230]
Y(0001){90%}	–	–	?	~300	–	3.1 ± 0.1	PE	[1691]
Y(0001)	–	–	–	–	–	3.38	TC	[334]
Y(0001)	–	–	2×10^{-9}	1400	–	3.47	TE	[3105]
Y(0001)	–	–	–	–	–	3.60	TC	[4005]
Y(0001)	–	–	2×10^{-9}	1250–1500	–	3.62	TE	[3105]
Y(0001)	–	–	–	–	–	4.67	TC	[321]
Y(1010)	–	–	–	–	–	3.08	TC	[4005]
Y(1010)	–	–	–	–	–	4.47	TC	[321]
Y(1124)	–	–	2×10^{-9}	1250–1500	–	3.27	TE	[3105]
Y(1124)	–	–	2×10^{-9}	1400	–	3.28	TE	[3105]
Y(1124)	–	–	–	–	–	3.92	TC	[321]
bcc (β, T > 1540 K)								
Y(100)	–	–	–	–	–	3.67	TC	[321]
Y(110)	–	–	–	–	–	4.28	TC	[321]
Y(111)	–	–	–	–	–	3.52	TC	[321]
Y(112)	–	–	–	–	–	3.92	TC	[321]
hcp (α, T < 1540 K for bulk)								
Y	–	–	? (N_2)	~300	–	2.54 ± 0.02	CPD	[4066]
Y	–	–	–	–	–	2.6	TC	[1744]
Y/W[158]	Y	–	≤7 × 10^{-8}	~300	–	2.6	FE	[1804]
Y/W[158]	Y	–	≤7 × 10^{-8}	~300	–	2.7	FE	[1804]
Y/W(111)	Y	–	≤10^{-9}	~300	–	2.8	FE	[1987,2011]
Y/W	Y	–	~10^{-9}	500	–	2.85	FE	[2817]
Y/W(116)	Y	–	≤10^{-9}	~300	–	2.9	FE	[1987]
Y/W(111)	Y	–	≤10^{-9}	300 (>400)	–	2.9	FE	[1975,1987]
Y/W	Y	–	~10^{-9}	~300	–	2.9	FE	[2817]
Y/W	Y	–	≤10^{-9}	~300	–	2.95 ± 0.05	FE	[2816]
Y(foil)[255]	–	–	~10^{-7}	1300	–	2.98	TE	[3071]
Y/Re–Y(4%)	–	–	~10^{-8}	1300	–	2.98	TE	[4240]
Y	–	–	–	–	–	2.99	TC	[1066]
Y[379]	–	–	–	–	–	3.0*	TC	[1955]
Y/W(116)	Y	–	≤10^{-9}	300 (>400)	–	3.0	FE	[1975,1987]
Y/W	Y	–	~10^{-9}	78	–	3.0	FE	[2817]
Y	–	–	2×10^{-10}	~300	–	3.0 ± 0.1	PE	[1813]
Y/W(111)	Y	–	(<10^{-10})	77	–	3.00	FE	[3335]
Y/W(100)	Y	–	(<10^{-10})	77	–	3.06	FE	[3335]
Y	–	–	–	–	–	3.07	TC	[1956]
Y/W	Y	–	~10^{-9}	~300	–	3.1	FE	[2819]
Y/W(100)[159]	Y	–	1×10^{-9}	~300	–	3.1	CPD	[1985]
Y/W(110)	Y	–	1×10^{-9}	~300	–	3.1	CPD	[1986]
Y/W(100)	Y	–	≤10^{-9}	~300	–	3.1	FE	[1987]
Y/W(112)	Y	–	≤10^{-9}	~300	–	3.1	FE	[1987]
Y/W(112)	Y	–	≤10^{-9}	300 (>400)	–	3.1	FE	[1987]
Y	–	–	–	–	–	3.1	TC	[1955]
Y/W	Y	–	~10^{-9}	~300	–	3.1	FE	[2819]
Y/Nb(100)	Y	–	≤10^{-8}	~1000–1150	–	3.1 ± 0.03	TE	[2359]
Y	–	–	?	~300	–	3.1 ± 0.1	PE	[1691]
Y/quartz	Y	–	~10^{-10}	~300	–	3.1 ± 0.15	PE	[304]
Y_n(n→ ∞)	–	–	–	–	–	3.11 ± 0.10	TC	[4261]
Y/W(111)	Y	–	≤10^{-8}	~1150–1250	–	3.12 ± 0.03	TE	[2330]
Y/Nb	Y	–	≤10^{-8}	~1000–1150	–	3.16 ± 0.03	TE	[2359]
Y/Ta	Y	–	≤10^{-8}	~1000–1150	–	3.16 ± 0.03	TE	[2359]
Y/W(112)	Y	–	(<10^{-10})	77	–	3.18	FE	[3335]
Y[174]	–	–	–	0^E	–	3.19	TC	[1747]
Y/W	Y	–	<10^{-9}	300 (>400)	–	3.2	FE	[1987]
Y	–	–	–	–	–	3.2	TC	[1993]
Y/W(111)	Y	–	~10^{-9}	~300	–	3.2	FE	[3082]
Y/W(012)	Y	–	~10^{-9}	~300	–	3.2	FE	[3082]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Y	–	–	–	–	–	3.20	TC	[298]
Y/Zr	Y	–	≤10⁻⁸	~1000–1150	–	3.25 ± 0.03	TE	[2359]
Y/Hf	Y	–	≤10⁻⁸	~1000–1150	–	3.25 ± 0.03	TE	[2359]
Y/Ru	Y	–	≤10⁻⁸	~1000–1150	–	3.25 ± 0.03	TE	[2359]
Y/Os	Y	–	≤10⁻⁸	~1000–1150	–	3.25 ± 0.03	TE	[2359]
Y/Ir	Y	–	≤10⁻⁸	~1000–1150	–	3.25 ± 0.03	TE	[2359]
Y/Mo	Y	–	≤10⁻⁸	~1000–1150	–	3.26 ± 0.03	TE	[2359]
Y/W	Y	–	≤10⁻⁸	~1000–1150	–	3.26 ± 0.03	TE	[2359]
Y/Re	Y	–	≤10⁻⁸	~1000–1150	–	3.26 ± 0.03	TE	[2359]
Y	–	–	–	–	–	3.27	TC	[3318]
Y	–	–	~10⁻⁹	~1300–1500	–	3.27	TE	[4356]
Y[160]	–	–	–	–	–	3.3	TC	[1355]
Y/W(112)	Y	–	~10⁻⁹	~300	–	3.3	FE	[3082]
Y/Nb(110)	Y	–	≤10⁻⁸	~1000–1150	–	3.3 ± 0.03	TE	[2359]
Y/W(100)	Y	–	≤10⁻⁸	~1150–1250	–	3.38 ± 0.03	TE	[2330,2359]
Y	–	–	–	–	–	3.4	TC	[706]
Y/W(100)	Y	–	≤10⁻⁹	~300 (>400)	–	3.4	FE	[1975,1987]
Y	–	–	–	–	–	3.42	TC	[3476]
Y	–	–	–	–	–	3.51	TC	[3476]
Y/W(110)	Y	–	≤10⁻⁸	~1150–1250	–	3.53 ± 0.03	TE	[2330,2359]
Y	–	–	–	–	–	3.54	TC	[3318]
Y/W(110)	Y	–	≤10⁻⁹	~300	–	3.6	FE	[1987]
Y/W(110)	Y	–	≤10⁻⁹	~300 (>400)	–	3.7	FE	[1975,1987]
Y	–	–	–	–	–	3.8	TC	[944]
Recommended	–	–	–	–	–	**3.16 ± 0.06**	–	–
bcc (β, $T > 1540$ K for bulk)								
Y	–	–	~10⁻⁹	~1550–1650	–	3.17	TE	[4356]

40. Zirconium Zr[451]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, $T < 1135$ K)								
Zr(0001)	–	–	–	–	–	4.04	TC	[1980]
Zr(0001)	–	–	–	–	–	4.15	TC	[334]
Zr(0001)	–	–	–	–	–	4.16	TC	[4417]
Zr(0001)	–	–	–	–	–	4.24	TC	[3493]
Zr(0001)	–	–	–	–	–	4.26	TC	[1091,3516]
Zr(0001)	–	–	–	–	–	4.37	TC	[1091,3516]
Zr(0001)	–	–	–	–	–	4.42	TC	[4005]
Zr(0001)	–	–	–	–	–	4.43	TC	[892]
Zr(0001)	–	–	–	–	–	4.49	TC	[893]
Zr(0001)	–	–	–	–	–	4.51	TC	[2519]
Zr(0001)	–	–	–	–	–	5.00	TC	[321]
Recommended	–	–	–	–	–	**4.36 ± 0.09**	–	–
Zr(1010)	–	–	–	–	–	3.59	TC	[4005]
Zr(1010)	–	–	–	–	–	3.89	TC	[1980]
Zr(1010)	–	–	–	–	–	4.78	TC	[321]
Zr(1124)	–	–	–	–	–	4.18	TC	[321]
bcc (β, $T > 1135$ K)								
Zr(100)	–	–	–	–	–	3.94	TC	[321]
Zr(110)	–	–	–	–	–	4.57	TC	[321]
Zr(111)	–	–	–	–	–	3.76	TC	[321]
Zr(112)	–	–	–	–	–	4.18	TC	[321]
hcp (α, $T < 1135$ K for bulk)								
Zr/Mo–Zr(5%)[161]	–	–	1 × 10⁻¹⁰	~300 (~1000)	–	2.94 ± 0.02	FE	[790]
Zr	–	–	<10⁻³	~300	–	3.10 ± 0.07	PE	[2571]
Zr/W	Zr	–	<10⁻¹¹	?	–	3.25	FE	[3039,3042]
Zr[174]	–	–	–	0ᴱ	–	3.28	TC	[1747]
Zr	–	–	–	–	–	3.42	TC	[3476]
Zr	–	–	–	–	–	3.47	TC	[1066]
Zr	–	–	–	–	–	3.51	TC	[3476]
Zr	–	–	?	~300	–	3.60	CPD	[2297]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Zr/Mo	Zr	–	$\sim 10^{-10}$	~ 300	–	3.63	CPD	[2134]
Zr/W(310)	Zr	–	$< 10^{-10}$	295	–	3.65 ± 0.03	FE	[1665]
Zr/W(100)	Zr	–	5×10^{-10}	~ 300	–	3.65 ± 0.05	CPD	[2526]
Zr	–	–	–	–	–	3.7	TC	[1993]
Zr/Ni	Zr	–	?	~ 300	–	3.73	PE	[2922]
Zr	–	–	–	–	–	3.74	TC	[3318]
Zr/W(100)	Zr	–	?	~ 300	–	3.75	CPD	[3076]
Zr	–	–	–	–	–	3.77	TC	[3318]
Zr	–	–	–	–	–	3.8*	TC	[1955]
Zr	–	–	$< 10^{-3}$	~ 300	–	3.81 ± 0.12	PE	[2571]
Zr/W	Zr	–	$< 10^{-10}$	295	–	3.84 ± 0.03	FE	[1656,1665]
Zr	–	–	–	–	–	3.85	TC	[3476]
Zr/W(100)	Zr	–	$< 10^{-10}$	295	–	3.87 ± 0.03	FE	[1665]
Zr/W	Zr	–	?	~ 300	–	3.87 ± 0.05	CPD	[3073,3076]
Zr	–	–	3×10^{-10}	~ 300	–	3.89 ± 0.05	CPD	[1812]
Zr	–	–	–	–	–	3.90	TC	[2949]
Zr/W(112)	Zr	–	$< 10^{-10}$	295	–	3.92 ± 0.03	FE	[1665]
Zr	–	–	–	–	–	3.94	TC	[1744]
Zr	–	–	–	0	–	3.94	TC	[4419]
Zr/W(111)	Zr	–	$< 10^{-10}$	295	–	3.98 ± 0.03	FE	[1665]
Zr	–	–	–	–	–	4.0	TC	[2117]
Zr/W(100)	Zr	–	$< 8 \times 10^{-11}$	~ 300	–	4.0	CPD	[1806]
Zr	–	–	?	~ 300	–	4.00	PE	[2927]
Zr	–	–	2×10^{-10}	~ 300	–	4.05	PE	[1814]
Zr/quartz	Zr	–	$\sim 10^{-10}$	~ 300	–	4.05 ± 0.1	PE	[304]
Zr/W(100)	Zr	–	$< 8 \times 10^{-11}$	<450 (1400)	–	4.1	CPD	[1806]
Zr/W(100)	Zr	–	?	~ 300	–	4.12	CPD	[3204]
Zr	–	–	–	–	–	4.19	TC	[298]
Zr	–	–	–	–	–	4.3	TC	[706]
Zr	–	–	–	–	–	4.3	TC	[944]
Zr/W(110)	Zr	–	?	~ 300	–	4.33	CPD	[3076]
Zr	–	–	–	–	–	4.33	TC	[3637]
Zr	–	–	$< 10^{-3}$	~ 300	–	4.33 ± 0.07	PE	[2571]
Zr/W(110)	Zr	–	$< 10^{-10}$	295	–	4.46 ± 0.03	FE	[1665]
Recommended	–	–	–	–	–	**3.85 ± 0.06**	–	–
bcc (β, $T > 1135$ K for bulk)								
Zr/W	Zr	–	?	?	–	3.15	TE	[1750]
Zr	–	–	$\leq 10^{-8}$	?	–	3.80	TE	[1778]
Zr	–	–	?	~ 1000–1400	–	3.95	TE	[1773]
Zr	–	–	$\sim 10^{-8}$	~ 1300–1800	–	3.95	TE	[4221]
Zr	–	–	3×10^{-9}	960–1370	–	4.0	TE	[159]
Zr	–	–	?	?	–	4.01	TE	[2117]
Zr/W	Zr	–	$< 1 \times 10^{-10}$	? (≥ 1600)	–	4.04 ± 0.03	FE	[1656]
Zr	–	–	?	?	–	4.1	TE	[3402]
Zr	–	–	?	~ 2000	–	4.12	TE	[3527]
Zr	–	–	?	?	–	4.13	TE	[3524,3525]
Recommended	–	–	–	–	–	**4.01 ± 0.05**	–	–

41. Niobium Nb

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc								
Nb(100)	–	–	–	–	–	3.552	TC	[4091]
Nb(100)	–	–	–	–	–	3.6	TC	[1154,1188]
Nb(100)	–	–	–	–	–	3.68	TC	[320]
Nb(100)	–	–	?	~ 300	–	3.76	FE	[4339]
Nb(100)	–	–	5×10^{-8}	~ 1800–2100	–	3.86 ± 0.05	TE	[774]
Nb(100)	–	–	–	–	–	3.87	TC	[4316,4412]
Nb(100)	–	–	?	77	–	3.87 ± 0.01	FE	[1303]
Nb(100)	–	–	1×10^{-9}	?	(4.04*)	3.90	TE	[739]
Nb(100)	–	–	$\sim 10^{-9}$	~ 1400–1800	–	3.95 ± 0.03	TE	[775]
Nb(100)	–	–	–	–	–	3.96	TC	[321]
Nb(100)	–	–	$\leq 5 \times 10^{-11}$	~ 300	–	3.97 ± 0.02	PE	[336]
Nb(100)	–	–	$\leq 2 \times 10^{-9}$	~ 1700–2000	–	4.0	TE	[127]
Nb(100)	–	–	$\sim 10^{-9}$	?	–	4.00	TE	[3096]
Nb(100)	–	–	$< 1 \times 10^{-10}$	~ 300	–	4.02	CPD	[1253]
Nb(100)	–	–	$\sim 10^{-10}$	~ 1600–1850	–	4.02 ± 0.06	TE	[779]
Nb(100){68%}[162]	–	–	–	–	(4.39 ± 0.08)	4.02 ± 0.07	TC	[803]
Nb(100)	Cs	Cs^+	1×10^{-9}	?	4.04*	(3.90)	PSI	[739]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Nb(100)	–	–	–	–	–	4.06	TC	[2548]
Nb(100)	–	–	–	–	–	4.07	TC	[1159,1980,3067]
Nb(100)	–	–	($\leq 10^{-11}$)	~300	–	4.1	CPD	[776]
Nb(100){68%}[162]	–	–	? (Cs)	~1100–1800	–	4.1	TE	[650,3414]
Nb(100)	–	–	~10^{-10}	77, ~300	–	4.18 ± 0.02	FE	[358]
Nb(100){70%}	–	–	~10^{-9}	~1050–2100	–	4.19 ± 0.04	TE	[124]
Nb(100)	–	–	–	–	–	4.23	TC	[1254]
Nb(100){68%}[162]	–	–	–	–	4.39 ± 0.08	(4.02 ± 0.07)	TC	[803]
Recommended	–	–	–	–	–	**4.02 ± 0.05**	–	–
Nb(110)	–	–	~10^{-10}	~300	–	4.33	PE	[2764]
Nb(110)	–	–	~10^{-10}	~300	–	4.37 ± 0.01	CPD	[777]
Nb(110)	–	–	–	–	–	4.488	TC	[4091]
Nb(110)	–	–	$\leq 5 \times 10^{-11}$	~300	–	4.51 ± 0.02	PE	[336]
Nb(110)	–	–	~10^{-8}	?	–	4.57	TE	[3353]
Nb(110)	–	–	–	–	–	4.61	TC	[321]
Nb(110)	–	–	–	–	–	4.61	TC	[2913]
Nb(110)	–	–	4×10^{-10}	~300	–	4.62 ± 0.05	CPD	[2672]
Nb(110)	Cs	Cs$^+$	1×10^{-9}	?	4.64*	(4.80)	PSI	[739]
Nb(110)	–	–	~10^{-8}	~1450–1750	–	4.65 ± 0.07	TE	[960]
Nb(110)	–	–	–	–	–	4.66	TC	[320]
Nb(110)	–	–	~10^{-9}	?	–	4.67	TE	[3096]
Nb(110)	–	–	–	–	–	4.74	TC	[2548]
Nb(110)	–	–	–	–	–	4.75	TC	[1159,1980,3067]
Nb(110)	–	–	~10^{-10}	~300	–	4.75 ± 0.05	CPD	[2381]
Nb(110)	–	–	1×10^{-10}	~300	–	4.75 ± 0.05*	CPD	[2839]
Nb(110)	–	–	~10^{-9}	1290–1540	–	4.75 ± 0.08	TE	[778]
Nb(110)	–	–	1×10^{-9}	?	(4.84 ± 0.05)	4.80	TE	[726,739]
Nb(110)	–	–	~10^{-7}–10^{-9}	2200	–	4.80	TE	[3357]
Nb(110)	–	–	–	–	–	4.80	TC	[334,3179]
Nb(110)	–	–	5×10^{-9}	1673–2073	–	4.80 ± 0.02	TE	[2000,2016]
Nb(110)	–	–	?	?	–	4.80 ± 0.04	TE	[3347]
Nb(110)	–	–	~10^{-9}	~1500–1800	–	4.80 ± 0.05	TE	[775]
Nb(110)	–	–	~10^{-9}	?	–	4.82 ± 0.05	TE	[1409]
Nb(110)	–	–	–	–	–	4.82	TC	[2073]
Nb(110)	–	–	–	–	–	4.84	TC	[722]
Nb(110)	Na	Na$^+$	1×10^{-9}	925–1680	4.84 ± 0.05	(4.80)	PSI	[726]
Nb(110)	–	–	~10^{-8}	?	–	4.85	TE	[3353]
Nb(110)	–	–	?	~300	–	4.87	PE	[722]
Nb(110)	–	–	~10^{-10}	1650–1850	–	4.87 ± 0.07	TE	[779]
Nb(110)/W(110)	–	–	–	–	–	4.9	TC	[2073]
Nb(110)	–	–	5×10^{-8}	~1800–2100	–	4.90 ± 0.05	TE	[774]
Nb(110)	–	–	7×10^{-11}	~300	–	4.93	PE	[2986]
Nb(110)	–	–	7×10^{-11}	~300	–	4.98	PE	[2874]
Recommended	–	–	–	–	–	**4.77 ± 0.05**	–	–
Nb(111)	–	–	–	–	–	3.775	TC	[4091]
Nb(111)	Cs	Cs$^+$	1×10^{-9}	?	3.78*	(3.88)	PSI	[739]
Nb(111)	–	–	–	–	–	3.80	TC	[321]
Nb(111)	–	–	~10^{-9}	2200	–	3.80	TE	[3357]
Nb(111)	–	–	5×10^{-8}	~1800–2100	–	3.84 ± 0.05	TE	[774]
Nb(111)	–	–	~10^{-8}	?	–	3.85	TE	[3353]
Nb(111)	–	–	1×10^{-9}	?	(3.90 ± 0.05)	3.88	TE	[726,739]
Nb(111)	–	–	~10^{-9}	~1600–2050	–	3.88 ± 0.03	TE	[775]
Nb(111)	–	–	~10^{-8}	1450–1750	–	3.88 ± 0.07	TE	[960,3096]
Nb(111)	Na	Na$^+$	1×10^{-9}	1630–1940	3.90 ± 0.05	(3.88)	PSI	[726]
Nb(111)	–	–	–	–	–	3.93	TC	[2548]
Nb(111)	–	–	–	–	–	3.94	TC	[1159,1980,3067]
Nb(111)	–	–	?	~300	–	4.05	FE	[4339]
Nb(111)	–	–	$\leq 5 \times 10^{-11}$	~300	–	4.08 ± 0.02	PE	[336]
Nb(111)[163]	–	–	~10^{-10}	~300	–	4.09	PE	[780]
Nb(111)	–	–	~10^{-8}	?	–	4.14	TE	[3353]
Nb(111)	–	–	1×10^{-10}	~300	–	4.30 ± 0.05*	CPD	[2839]
Nb(111)	–	–	~10^{-10}	~1600–1850	–	4.36 ± 0.06	TE	[779]
Nb(111)[163]	–	–	~10^{-10}	~300	–	4.66	PE	[780,2764]
Recommended	–	–	–	–	–	**3.95 ± 0.09**	–	–
Nb(112)	–	–	–	–	–	4.20	TC	[2818]
Nb(112)	–	–	–	–	–	4.23	TC	[321]
Nb(112)	–	–	–	–	–	4.33	TC	[1980,3067]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Nb(112)	Cs	Cs$^+$	1×10^{-9}	?	4.44*	(4.45)	PSI	[739]
Nb(112)	–	–	5×10^{-8}	~1800–2100	(4.44*)	4.45 ± 0.05	TE	[739,774]
Nb(112)	–	–	~10^{-10}	~1600–1850	–	4.63 ± 0.06	TE	[779]
Recommended	–	–	–	–	–	**4.33 ± 0.10**	–	–
Nb(113)	–	–	~10^{-10}	~1600–1850	–	4.29 ± 0.06	TE	[779]
Nb(116)	–	–	≤2 × 10^{-9}	~1700–2000	–	3.7	TE	[127]
Nb(116)	–	–	~10^{-9}	1450–1800	–	3.70 ± 0.03	TE	[775]
Nb(116)	–	–	–	–	–	3.94	TC	[1980,3067]
Nb(116)	–	–	~10^{-10}	~1600–1850	–	3.95 ± 0.06	TE	[779]
Nb(310)	–	–	~10^{-10}	~1600–1850	–	4.18 ± 0.05	TE	[779]
Nb(335)	–	–	~10^{-10}	~300	–	4.55	PE	[2764]
Nb/quartz[164]	Nb	–	≤10^{-8}	28	–	3.8 ± 0.2	CPD	[1686]
Nb	–	–	–	–	–	3.81	TC	[521]
Nb	–	–	–	–	–	3.83	TC	[3476]
Nb	–	–	–	–	–	3.87	TC	[3476]
Nb[165]	CsI	Cs$^+$, I$^-$	~10^{-8}	1879–1942	3.88 ± 0.04	–	PSI, NSI	[120]
Nb[165]	CsI	Cs$^+$, I$^-$	~10^{-8}	1879–1942	3.88 ± 0.04^N	–	PSI, NSI	[120]
Nb	–	–	?	295	–	3.89	CPD	[2943]
Nb/quartz[164]	Nb	–	≤10^{-8}	4.2	–	3.9 ± 0.2	CPD	[1686]
Nb/quartz[164]	Nb	–	≤10^{-8}	293	–	3.9 ± 0.2	CPD	[1686]
Nb[165]	KCl	K$^+$, Cl$^-$	~10^{-8}	1853–2025	3.90 ± 0.07	–	PSI, NSI	[120]
Nb[165]	KCl	K$^+$, Cl$^-$	~10^{-8}	1853–2025	3.90 ± 0.07^N	–	PSI, NSI	[120]
Nb[165]	RbBr	Rb$^+$, Br$^-$	~10^{-8}	1928–1940	3.91 ± 0.05	–	PSI, NSI	[120]
Nb[165]	RbBr	Rb$^+$, Br$^-$	~10^{-8}	1928–1940	3.91 ± 0.05^N	–	PSI, NSI	[120]
Nb	–	–	5×10^{-9}	1373–2073	–	3.95 ± 0.02	TE	[2000,2016]
Nb	–	–	7×10^{-8}	~1300–1600	–	3.96	TE	[121,3401]
Nb	–	–	?	295	–	3.97	CPD	[2943]
Nb	–	–	?	~300	–	3.97 ± 0.07	PE	[974]
Nb	–	–	<2 × 10^{-7}	1870	–	3.98	TE	[1970]
Nb	–	–	–	–	–	4.0	TC	[2583]
Nb	–	–	?	?	–	4.0	TE	[3402,3404]
Nb	–	–	~700 (Ar)	?	–	4.0	TE	[2007]
Nb	–	–	~10^{-9}	~1400–2100	–	4.0 ± 0.05	TE	[1775]
Nb	–	–	~10^{-5}	≤1200	–	4.00	TE	[2216]
Nb	–	–	–	–	–	4.01	TC	[4433]
Nb	–	–	?	1470–1980	–	4.01$_3$	TE	[122]
Nb	–	–	~10^{-9}	~1200–1800	–	4.02	TE	[975]
Nb	–	–	2×10^{-7}	~1800–2100	(4.76–4.88)	4.02 ± 0.05	TE	[23]
Nb{68%(100)}	–	–	–	–	(4.39 ± 0.08)	4.02 ± 0.07	TC	[803]
Nb	–	–	~10^{-8}	~1450–1750	–	4.02 ± 0.07	TE	[960]
Nb	–	–	~10^{-9}	?	–	4.03	TE	[3096]
Nb	–	–	–	–	–	4.05	TC	[2949]
Nb	–	–	≤10^{-8}	?	–	4.05	TE	[1778]
Nb/W(111)	–	–	–	–	–	4.06	TC	[531]
Nb[163]	–	–	~10^{-10}	~300	–	4.09	PE	[780,2764]
Nb	–	–	–	–	–	4.1	TC	[1993]
Nb{68%(100)}	–	–	? (Cs)	≤1100	–	4.1	TE	[650,3414]
Nb/Si(111)[166]	Nb	–	?	~300	–	4.12	PE	[1430]
Nb	–	–	?	~300	–	4.13*	PE	[3602]
Nb	–	–	~10^{-9}	~1200–1800	–	4.13 ± 0.06	TE	[975]
Nb/W(112)	–	–	–	–	–	4.15	TC	[531]
Nb	–	–	~10^{-9}	973	–	4.15	TE	[3112]
Nb	–	–	?	?	–	4.16	TE	[2117]
Nb	–	–	–	–	–	4.18	TC	[3318]
Nb{68%(100)}	–	–	~10^{-9}	~1050–2100	–	4.19 ± 0.04	TE	[124,650]
Nb	–	–	–	–	–	4.2*	TC	[1955]
Nb	–	–	–	–	–	4.20	TC	[3264,3265,3267]
Nb	–	–	–	–	–	4.22	TC	[3318]
Nb{68%(100)}	–	–	–	–	–	4.23	TC	[1254]
Nb	–	–	–	–	–	4.25	TC	[298]
Nb	–	–	–	–	–	4.28	TC	[3476]
Nb	–	–	–	–	–	4.3	TC	[706]
Nb	–	–	<10^{-7}	2200	–	4.3	TE	[2582]
Nb/quartz	Nb	–	~10^{-10}	~300	–	4.3 ± 0.15	PE	[304]
Nb	–	–	?	~300	–	4.33	PE	[2622]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Nb/W(100)	–	–	–	–	–	4.37	TC	[531]
Nb	–	–	$<1 \times 10^{-9}$	~300	–	4.37 ± 0.03	CPD	[123,349]
Nb	–	–	?	~300	–	$4.39 \pm 0.02^*$	CPD	[4277]
Nb{68%(100)}	–	–	–	–	4.39 ± 0.08	(4.02 ± 0.07)	TC	[803]
Nb/W(100)	Nb	–	1×10^{-11}	77	–	4.40	FE	[2965]
Nb	–	–	$\sim10^{-11}$	~300	–	4.41	CPD	[3338]
Nb	–	–	$\sim10^{-10}$	~300	–	4.41 ± 0.1	FE	[996]
Nb	–	–	–	–	–	4.45	TC	[2629]
Nb	RbI	Rb^+	2×10^{-7}	~1800–2100	4.76 ± 0.03	(4.02 ± 0.05)	PSI	[23]
Nb/W(110)	–	–	–	–	–	4.84	TC	[531]
Nb	RbBr	Rb^+	2×10^{-7}	~1800–2100	4.87 ± 0.06	(4.02 ± 0.05)	PSI	[23]
Nb	RbCl	Rb^+	2×10^{-7}	~1800–2100	4.88 ± 0.06	(4.02 ± 0.05)	PSI	[23]
Nb[164]	–	–	$\leq10^{-8}$	5	–	5.01	FE	[1686]
Recommended	–	–	–	–	–	**4.11 ± 0.05**	–	–

42. Molybdenum Mo

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo(100)	–	–	–	–	–	3.842	TC	[4091]
Mo(100)	–	–	12 (Ar)	?	–	3.94	PE	[4236]
Mo(100)	–	–	–	–	–	3.98 ± 0.02	TC	[4428]
Mo(100)	–	–	–	–	–	4.01	TC	[4057]
Mo(100)	–	–	–	–	–	4.03	TC	[639]
Mo(100)	–	–	–	–	–	4.05	TC	[320]
Mo(100)	–	–	–	–	–	4.06	TC	[4057]
Mo(100)	–	–	5–50 (Ne)	?	–	4.1 ± 0.1	TE	[643]
Mo(100)	–	–	–	–	–	4.10	TC	[321]
Mo(100){70%}	–	–	$\sim10^{-9}$	2000	–	4.10 ± 0.07	TE	[124]
Mo(100)	–	–	–	–	–	4.11	TC	[4407]
Mo(100)	–	–	–	–	–	4.19	TC	[1034]
Mo(100){80%}	–	–	$\sim10^{-9}$	~300	–	4.2	FE	[3231]
Mo(100)	–	–	–	–	–	4.20	TC	[2181]
Mo(100)	–	–	–	–	–	4.20	TC	[639]
Mo(100)[167]	Li	Li^-, Li^+	2×10^{-8}	1964–2048	4.20 ± 0.20^N	–	NSI, PSI	[125]
Mo(100){70%}	–	–	$\sim10^{-9}$	1400	–	4.21 ± 0.09	TE	[124]
Mo(100)	–	–	$<1 \times 10^{-11}$	78	–	4.26	FE	[648]
Mo(100)	–	–	6×10^{-10}	~300	–	4.26 ± 0.03	FE	[999]
Mo(100)	Cs	Cs^+	$<10^{-6}$	1190	4.26 ± 0.05	–	PSI	[126]
Mo(100)	–	–	–	–	–	4.28	TC	[1624]
Mo(100)	–	–	–	–	–	4.28	TC	[3224]
Mo(100)	–	–	6×10^{-10}	~300	–	4.28 ± 0.01	FE	[999,1668]
Mo(100)[167]	Li	Li^+	2×10^{-8}	~1250–1450	4.28 ± 0.05	–	PSI	[129,572,573]
Mo(100)[167]	CsI	I^-	2×10^{-8}	~1750–1850	4.29 ± 0.02^N	–	NSI	[572,573]
Mo(100){80%}	–	–	$\sim10^{-9}$	~300	–	4.3	FE	[2756,2757]
Mo(100)	–	–	$<1 \times 10^{-10}$	77	–	4.3 ± 0.2	PE	[4002]
Mo(100)[168]	–	–	?	1980	–	4.33 ± 0.03	TE	[729]
Mo(100)	–	–	7×10^{-10}	77	–	4.35 ± 0.02	FE	[3691]
Mo(100)	–	–	$\leq10^{-4}$ (Br_2)	~1400–2100	(4.36 ± 0.06^N)	4.35 ± 0.05	TE	[925]
Mo(100)	–	–	$\leq10^{-5}$ (I_2)	~1500–2000	(4.36 ± 0.05^N)	4.35 ± 0.05	TE	[571]
Mo(100)	–	–	$\leq5 \times 10^{-8}$	~1600–1900	–	4.35 ± 0.07	TE	[128,3096]
Mo(100)	–	–	–	–	–	4.36	TC	[3224]
Mo(100)	I_2	I^-	$\leq10^{-5}$ (I_2)	~1500–2000	4.36 ± 0.05^N	(4.35 ± 0.05)	NSI	[571]
Mo(100)	Br_2	Br^-	$\leq10^{-4}$ (Br_2)	~1400–2100	4.36 ± 0.06^N	(4.35 ± 0.05)	NSI	[925]
Mo(100)	–	–	–	–	–	4.37	TC	[4034]
Mo(100)[168]	–	–	?	1980	–	4.37 ± 0.03	TE	[729]
Mo(100)	–	–	$\sim10^{-10}$	77	–	4.38	FE	[1304]
Mo(100)[167]	Li	Li^+	2×10^{-8}	~1400–2000	4.38 ± 0.01	–	PSI	[125]
Mo(100){72%}[172]	–	–	–	–	(4.51 ± 0.03)	4.38 ± 0.01	TC	[803]
Mo(100)[168]	–	–	?	1980	–	4.38 ± 0.03	TE	[729]
Mo(100)	–	–	$\leq10^{-5}$ (Sr)	~1400–1800	–	4.40	TE	[1401]
Mo(100)	–	–	$<2 \times 10^{-9}$	?	–	4.40	TE	[2235]
Mo(100)	–	–	$\sim10^{-10}$	?	–	4.40	?	[322]
Mo(100)	–	–	–	–	–	4.40	TC	[2701]
Mo(100)	–	–	?	77	–	4.40	FE	[1303]
Mo(100)	–	–	$\leq2 \times 10^{-9}$	~1700–2000	–	4.40 ± 0.02	TE	[127,144,323]
Mo(100)	–	–	$\sim10^{-9}$	?	(4.44 ± 0.03)	4.40 ± 0.03	TE	[727,2210,3103]
Mo(100)	–	–	3×10^{-7}	1943	–	4.40 ± 0.04	TE	[1402]
Mo(100)	–	–	$\leq10^{-9}$	~1700–2100	–	4.40 ± 0.05	TE	[323]
Mo(100)	–	–	–	–	–	4.43	TC	[2548]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo(100)	–	–	$\leq 4 \times 10^{-9}$	~1800–2100	–	4.43 ± 0.05	TE	[739,781,1407]
Mo(100)	–	–	–	–	–	4.44	TC	[1159,1980,3067]
Mo(100)	Na	Na$^+$	~10^{-9}	~900–1700	4.44 ± 0.03	(4.40 ± 0.03)	PSI	[727,2210,3103]
Mo(100)	–	–	$\leq 1 \times 10^{-10}$	200, 300	–	4.45	FE	[783,1416]
Mo(100)	–	–	<10^{-10}	~1200–2000	–	4.45	TE	[324,527,784]
Mo(100)	–	–	$\leq 1 \times 10^{-10}$	?	(4.45)	4.45	TE	[278]
Mo(100)	Na	Na$^+$	$\leq 1 \times 10^{-10}$	?	4.45	(4.45)	PSI	[278]
Mo(100)	K	K$^+$	$\leq 1 \times 10^{-10}$	?	4.45	(4.45)	PSI	[278]
Mo(100)	–	–	~10^{-9}	~1484–1788	–	4.46 ± 0.02	CPD	[2963]
Mo(100)	–	–	~10^{-9}	~1484–1788	–	4.47 ± 0.02	TE	[2963]
Mo(100)	–	–	$\leq 10^{-6}$	~1770–2170	–	4.5	TE	[2339]
Mo(100)	–	–	~10^{-8}	~1600–1900	–	4.5 ± 0.04	TE	[3344]
Mo(100)	–	–	~10^{-10}	–1700–	–	4.5 ± 0.1	TE	[335,1650,1651, 1967]
Mo(100){72%}[172]	–	–	–	–	4.51 ± 0.03	(4.38 ± 0.01)	TC	[803]
Mo(100)[168]	–	–	?	1980	–	4.52 ± 0.03	TE	[729]
Mo(100)	–	–	~1×10^{-10}	~300	–	4.53	CPD	[2632]
Mo(100)	–	–	<1×10^{-10}	~300	–	4.53 ± 0.02	PE	[325]
Mo(100)	–	–	–	–	–	4.58	TC	[3224]
Mo(100)	–	–	2×10^{-10}	~300	–	4.60	FE	[275,440]
Mo(100)	–	–	$\leq 1 \times 10^{-8}$	1789	–	4.60 ± 0.04	TE	[2244]
Mo(100)	–	–	~10^{-11}	~300	–	4.65	PE	[326]
Mo(100)	–	–	~10^{-10}	~300	–	4.67 ± 0.03	PE	[2607]
Mo(100)	–	–	–	–	–	4.84	TC	[2701]
Recommended	–	–	–	–	**4.38 ± 0.08**	**4.38 ± 0.03**	–	–
Recommended	–	–	–	–	**4.34 ± 0.03^N**	–	–	–
Mo(110)	–	–	12 (Ar)	?	–	4.18	PE	[4236]
Mo(110)	–	–	5–50 (Ne)	?	–	4.32 ± 0.07	TE	[643]
Mo(110)	–	–	–	–	–	4.510	TC	[4091]
Mo(110)	–	–	–	–	–	4.59	TC	[4057]
Mo(110)	–	–	–	–	–	4.64	TC	[4057]
Mo(110)	–	–	~10^{-8}	~1600–1900	–	4.7 ± 0.04	TE	[3344]
Mo(110)/Si$_3$N$_4$	–	–	–	–	–	4.71	TC	[3517]
Mo(110)/Si$_3$N$_4$	Mo	–	?	~300	–	4.72	CPD	[3517]
Mo(110)	–	–	~10^{-8}	?	–	4.75	TE	[3353,3357]
Mo(110)	–	–	–	–	–	4.77	TC	[321]
Mo(110)/W(110)[169]	–	–	–	–	–	4.8	TC	[2074]
Mo(110)	–	–	7×10^{-10}	77	–	4.81 ± 0.09	FE	[3691]
Mo(110)	–	–	–	–	–	4.82	TC	[3224]
Mo(110)	–	–	–	–	–	4.820	TC	[3573,4046]
Mo(110)	–	–	<1×10^{-11}	78	–	4.83	FE	[648]
Mo(110)[169]	–	–	–	–	–	4.83	TC	[2074]
Mo(110)	–	–	–	–	–	4.84	TC	[1624]
Mo(110)	–	–	5×10^{-9}	?	–	4.85	TE	[2786]
Mo(110)	–	–	–	–	–	4.85	TC	[639]
Mo(110)	–	–	$\leq 10^{-9}$	?	–	4.85 ± 0.05	TE	[323]
Mo(110)	–	–	~10^{-9}	?	–	4.87 ± 0.03	TE	[3348]
Mo(110)	–	–	–	–	–	4.88	TC	[639]
Mo(110)	–	–	$\leq 5 \times 10^{-8}$	~1600–1900	–	4.9 ± 0.07	TE	[128,3096]
Mo(110)	–	–	?	?	–	4.9 ± 0.1	TE	[1962]
Mo(110)	–	–	~10^{-9}	?	–	4.90 ± 0.02	TE	[3331]
Mo(110)	–	–	$\leq 1 \times 10^{-8}$	1789	–	4.90 ± 0.04	TE	[2244]
Mo(110)	–	–	$\leq 4 \times 10^{-9}$	~1800–2100	–	4.90 ± 0.05	TE	[781]
Mo(110)	–	–	?	~1700–2200	–	4.90 ± 0.05	TE	[785]
Mo(110)	–	–	5×10^{-8}	?	–	4.90 ± 0.05[485]	TE	[1400]
Mo(110)	–	–	~10^{-8}	?	–	4.91	TE	[3353,3357]
Mo(110)	–	–	~10^{-10}	~300	–	4.92 ± 0.02	CPD	[777]
Mo(110)	–	–	–	–	–	4.94	TC	[320]
Mo(110)	–	–	–	–	–	4.94	TC	[3224]
Mo(110)	–	–	?	?	–	4.94 ± 0.03	TE	[3107]
Mo(110)	–	–	~10^{-8}	~1800–2100	–	4.94 ± 0.05	TE	[782]
Mo(110)	–	–	7×10^{-11}	~300	–	4.95	PE	[1035]
Mo(110)	–	–	<1×10^{-10}	~300	–	4.95 ± 0.02	PE	[325]
Mo(110)	–	–	$\leq 4 \times 10^{-9}$	~1800–2100	–	4.95 ± 0.05	TE	[739,1407]
Mo(110)	–	–	$\leq 10^{-3}$ (Cs)	>1800	–	5.0	TE	[976]
Mo(110)	–	–	$\leq 10^{-10}$	77, ~300	–	5.0	CPD	[327–329]
Mo(110)	–	–	$\leq 10^{-11}$	~300	–	5.0	CPD	[2380]
Mo(110)/W(110)	Mo	–	?	~300	–	5.0	CPD	[4231]
Mo(110)	–	–	$\leq 1 \times 10^{-10}$	200, 300	–	5.00	FE	[1416]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo(110)	–	–	($\sim10^{-12}$)	~300	–	5.00 ± 0.02	CPD	[1795]
Mo(110)	–	–	5×10^{-9}	1673–2073	–	5.00 ± 0.02	TE	[2000,2016]
Mo(110)	–	–	$\sim10^{-9}$	?	–	5.00 ± 0.03	TE	[3331,3348]
Mo(110)	–	–	$\leq2 \times 10^{-9}$	?	–	5.00 ± 0.03	TE	[3099]
Mo(110)	–	–	3×10^{-9}	?	–	5.00 ± 0.05	TE	[2212,2214]
Mo(110)	–	–	$\sim10^{-9}$	?	–	5.00 ± 0.05	TE	[1409]
Mo(110)	–	–	$\leq2 \times 10^{-9}$	$\sim1700–2000$	–	5.00 ± 0.05	TE	[127,144]
Mo(110)	–	–	$\leq3 \times 10^{-10}$	?	–	5.00 ± 0.05	TE	[330,331,640]
Mo(110)	–	–	$\leq5 \times 10^{-9}$	?	–	5.05 ± 0.05	TE	[3084]
Mo(110)	–	–	$\leq10^{-11}$	~300	–	5.05 ± 0.07	CPD	[977]
Mo(110)	–	–	?	~300	–	5.07	FE	[2676]
Mo(110)/W(110)	Mo	–	2×10^{-10}	1023	–	5.09*	CPD	[2293]
Mo(110)	–	–	$\leq1 \times 10^{-6}$	1770–2270	–	5.1	TE	[2339]
Mo(110)	–	–	$\sim10^{-11}$	20–200	–	5.1	FE	[2218]
Mo(110)	–	–	$\sim10^{-9}$	?	(5.13 ± 0.03)	5.10 ± 0.03	TE	[727,2210,3103]
Mo(110)	–	–	$\sim10^{-9}$	?	–	5.10 ± 0.03	TE	[3331,3348]
Mo(110)	–	–	$\leq10^{-9}$	$\sim1700–2100$	–	5.10 ± 0.05	TE	[323]
Mo(110)	–	–	4×10^{-10}	~300	–	5.10 ± 0.15	FE	[999]
Mo(110)	–	–	4×10^{-10}	~300	–	5.11 ± 0.07	FE	[999,1668]
Mo(110)	–	–	7×10^{-10}	77	–	5.12 ± 0.16	FE	[3691]
Mo(110)	–	–	–	–	–	5.13	TC	[4034]
Mo(110)	Na	Na^+	$\sim10^{-9}$	$\sim900–1600$	5.13 ± 0.03	(5.10 ± 0.03)	PSI	[727,2210,3103]
Mo(110)	–	–	$\sim10^{-9}$	?	–	5.20 ± 0.02	TE	[3331]
Mo(110)	–	–	–	–	–	5.23	TC	[2548]
Mo(110)	–	–	–	–	–	5.23	TC	[1159,1980,3067]
Mo(110)	–	–	5×10^{-11}	350	–	5.25	CPD	[332,333]
Mo(110)	–	–	$\sim10^{-10}$	80	–	5.32 ± 0.02	FE	[2499]
Mo(110)	–	–	–	–	–	5.34	TC	[334,3179]
Mo(110)	–	–	$\sim10^{-10}$	–1700–	–	5.4 ± 0.2	TE	[335,1650,1651, 1967]
Mo(110)	–	–	$\sim10^{-10}$	300, 550	–	5.46 ± 0.02	FE	[2499]
Mo(110)	–	–	–	–	–	5.90	TC	[3224]
Recommended	–	–	–	–	–	**4.98 ± 0.03**	–	–
Mo(111)	–	–	–	–	–	3.86	TC	[4057]
Mo(111)	Cs	Cs^+	?	$\sim800–1050$	3.89	–	PSI	[135]
Mo(111)	–	–	–	–	–	3.93	TC	[321]
Mo(111)	–	–	6×10^{-10}	~300	–	3.94 ± 0.05	FE	[999]
Mo(111)	–	–	–	–	–	3.940	TC	[4091]
Mo(111)[170]	Cs	Cs^+	?	$\sim800–1050$	3.95*	–	PSI	[135]
Mo(111)	–	–	$\sim10^{-9}$	?	–	3.95 ± 0.02	TE	[3331]
Mo(111)	–	–	6×10^{-10}	~300	–	3.99 ± 0.02	FE	[999,1668]
Mo(111)	–	–	–	–	–	4.00	TC	[4057]
Mo(111)	–	–	7×10^{-10}	77	–	4.00 ± 0.08	FE	[1304,3691]
Mo(111)	–	–	$<1 \times 10^{-11}$	78	–	4.06	FE	[648]
Mo(111)	–	–	–	–	–	4.07	TC	[4034]
Mo(111)	–	–	$\leq2 \times 10^{-9}$	$\sim1700–2000$	–	4.10 ± 0.02	TE	[127,144]
Mo(111)	–	–	$\sim10^{-9}$	?	(4.13 ± 0.03)	4.10 ± 0.03	TE	[727,2210,3103, 3348]
Mo(111)	–	–	$\sim10^{-9}$	$\sim1100–1800$	(4.10 ± 0.03)	4.10 ± 0.03	TE	[786]
Mo(111)	Li	Li^+	$\sim10^{-9}$	$\sim1100–1800$	4.10 ± 0.03	(4.10 ± 0.03)	PSI	[786]
Mo(111)	–	–	3×10^{-9}	?	–	4.10 ± 0.05	TE	[2212,2214]
Mo(111)	–	–	$\leq4 \times 10^{-9}$	$\sim1800–2100$	–	4.10 ± 0.05	TE	[739,781,782,1407]
Mo(111)	–	–	10^{-8}	?	–	4.13	TE	[3353,3357]
Mo(111)	Na	Na^+	$\sim10^{-9}$	$\sim1600–2000$	4.13 ± 0.03	(4.10 ± 0.03)	PSI	[727,2210,3103]
Mo(111)	–	–	$\leq5 \times 10^{-9}$	?	–	4.14 ± 0.04	TE	[3084]
Mo(111)	–	–	5×10^{-8}	?	–	4.14 ± 0.05[485]	TE	[1400]
Mo(111)	–	–	2×10^{-10}	$\sim1480–1850$	–	4.15 ± 0.02	TE	[678]
Mo(111)	–	–	$\leq10^{-9}$	$\sim1700–2100$	–	4.15 ± 0.05	TE	[323]
Mo(111)	–	–	$\leq1 \times 10^{-10}$	~300	–	4.19	FE	[783]
Mo(111)	–	–	$\sim10^{-9}$	?	–	4.19 ± 0.02	TE	[3331]
Mo(111)	–	–	5×10^{-7}	$\sim1870–2270$	–	4.2	TE	[2339]
Mo(111)	–	–	$\leq1 \times 10^{-10}$	200, 300	–	4.20	FE	[1416]
Mo(111)	–	–	–	–	–	4.23	TC	[3224]
Mo(111)	–	–	–	–	–	4.25	TC	[2548]
Mo(111)	–	–	$\sim10^{-9}$	?	–	4.25 ± 0.03	TE	[3348]
Mo(111)	–	–	–	–	–	4.27	TC	[1159,1980,3067]
Mo(111)	–	–	–	–	–	4.27	TC	[639]
Mo(111)	?	?	?	?	4.3	–	PSI	[135]
Mo(111)	–	–	$\leq5 \times 10^{-10}$	~300	–	4.3	CPD	[2621]

(*continued on next page*)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo(111)	–	–	≤10⁻⁹	1650–1850	–	4.3 ± 0.03	TE	[787]
Mo(111)	–	–	~10⁻¹⁰	–1700–	–	4.3 ± 0.1	TE	[335,1650,1651, 1967]
Mo(111)	–	–	–	–	–	4.30	TC	[1624]
Mo(111)	–	–	5 × 10⁻⁹	?	–	4.30	TE	[2786]
Mo(111)	–	–	–	–	–	4.32	TC	[639]
Mo(111)	–	–	5–50 (Ne)	?	–	4.33 ± 0.01	TE	[643]
Mo(111)	–	–	≤1 × 10⁻⁸	1789	–	4.35 ± 0.04	TE	[2244]
Mo(111)	–	–	–	–	–	4.4	TC	[1739]
Mo(111)	–	–	~10⁻⁹	?	–	4.40 ± 0.03	TE	[3348]
Mo(111)	–	–	~10⁻⁹	?	–	4.46 ± 0.03	TE	[3348]
Mo(111)[171]	–	–	<6 × 10⁻¹⁰	293	–	4.49 ± 0.06	PE	[3421]
Mo(111)	–	–	≤5 × 10⁻¹¹	~300	–	4.52 ± 0.02	PE	[336]
Mo(111)	–	–	–	–	–	4.55	TC	[3224]
Mo(111)	–	–	<1 × 10⁻¹⁰	~300	–	4.55 ± 0.02	PE	[325]
Mo(111)	–	–	~10⁻⁸	?	–	4.58	TE	[3353,3357]
Mo(111)	–	–	~10⁻¹¹	20–200	–	4.6	FE	[2218]
Mo(111)	–	–	?	~300	–	4.6*	FE	[1518]
Mo(111)[171]	–	–	<6 × 10⁻¹⁰	293	–	4.67 ± 0.02	PE	[3421]
Mo(111)	–	–	1 × 10⁻⁵	1820–2270	–	4.7	TE	[2339]
Mo(111)	–	–	~10⁻⁸	~1600–1900	–	4.8 ± 0.04	TE	[3344]
Recommended	–	–	–	–	–	**4.29 ± 0.03**	–	–
Mo(112)	–	–	–	–	–	4.11	TC	[702]
Mo(112)	–	–	–	–	–	4.12	TC	[702]
Mo(112)	–	–	–	–	–	4.25	TC	[468]
Mo(112)	–	–	–	–	–	4.28	TC	[1034]
Mo(112)	–	–	–	–	–	4.35	TC	[468]
Mo(112)	–	–	<1 × 10⁻¹⁰	~300	–	4.36 ± 0.03	PE	[325]
Mo(112)	–	–	–	–	–	4.37	TC	[3224]
Mo(112)	–	–	–	–	–	4.38	TC	[321]
Mo(112)	–	–	7 × 10⁻¹⁰	77	–	4.45 ± 0.07	FE	[3691]
Mo(112)	–	–	<1 × 10⁻¹¹	78	–	4.46	FE	[648]
Mo(112)	–	–	~10⁻⁹	~300	–	4.5	PE	[2398]
Mo(112)	–	–	~10⁻¹⁰	–1700–	–	4.5 ± 0.1	TE	[335,1643,1650, 1651,1967]
Mo(112)	–	–	≤10⁻¹¹	~300	–	4.50	CPD	[2533]
Mo(112)	–	–	≤1 × 10⁻⁸	1789	–	4.50 ± 0.04	TE	[2244]
Mo(112)	–	–	7 × 10⁻¹⁰	77	–	4.51 ± 0.07	FE	[1304,3691]
Mo(112)	–	–	≤2 × 10⁻⁹	~1700–2000	–	4.55 ± 0.05	TE	[127,144]
Mo(112)	–	–	≤4 × 10⁻⁹	~1800–2100	–	4.55 ± 0.05	TE	[726,739,781,1407]
Mo(112)	–	–	≤1 × 10⁻¹⁰	~300	–	4.58	FE	[783]
Mo(112)	–	–	~1 × 10⁻¹¹	90	–	4.6	CPD	[505]
Mo(112)	–	–	(≤10⁻¹¹)	77	–	4.6	CPD	[1255,2027,2030]
Mo(112)	–	–	~10⁻¹¹	~300	–	4.6	CPD	[2535]
Mo(112)	–	–	?	~300	–	4.6	CPD	[2404,2407]
Mo(112)	–	–	~10⁻¹⁰	200, 300	–	4.60	FE	[1416]
Mo(112)	–	–	~10⁻⁹	?	(4.63 ± 0.03)	4.60 ± 0.03	TE	[727,2210]
Mo(112)	–	–	≤5 × 10⁻⁹	?	–	4.60 ± 0.05	TE	[3084]
Mo(112)	–	–	–	–	–	4.61	TC	[3224]
Mo(112)	–	–	(<10⁻¹¹)	~300	–	4.61*	CPD	[2637]
Mo(112)	Na	Na⁺	~10⁻⁹	~800–1500	4.63 ± 0.03	(4.60 ± 0.03)	PSI	[727,2210]
Mo(112)	–	–	–	–	–	4.64	TC	[3224]
Mo(112)	–	–	2 × 10⁻¹⁰	1480–1850	–	4.67 ± 0.02	TE	[678]
Mo(112)	–	–	~10⁻¹¹	20–200	–	4.7	FE	[2218]
Mo(112)	–	–	–	–	–	4.71	TC	[1159,1980,3067]
Mo(112)	–	–	–	–	–	4.8	TC	[1739]
Recommended	–	–	–	–	–	**4.51 ± 0.03**	–	–
Mo(114)	–	–	–	–	–	4.02	TC	[3224]
Mo(114)	–	–	–	–	–	4.16	TC	[3224]
Mo(114)	–	–	≤5 × 10⁻⁸	~1600–1900	–	4.18 ± 0.07	TE	[128]
Mo(114-116)	–	–	?	?	–	4.3 ± 0.1	TE	[1962]
Mo(114)	–	–	–	–	–	4.50	TC	[3224]
Mo(114)	–	–	<1 × 10⁻¹⁰	~300	–	4.50 ± 0.04	PE	[325]
Recommended	–	–	–	–	–	**4.33 ± 0.15**	–	–
Mo(116)	–	–	–	–	–	3.90	TC	[3224]
Mo(116)	–	–	7 × 10⁻¹⁰	77	–	3.96 ± 0.01	FE	[3691]
Mo(116)	–	–	≤2 × 10⁻⁹	~1700–2000	–	4.00	TE	[127,144]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo(116)	–	–	$\leq 5 \times 10^{-9}$	?	–	4.02 ± 0.04	TE	[3084]
Mo(116)	–	–	–	–	–	4.11	TC	[3224]
Mo(116)	–	–	$\leq 5 \times 10^{-8}$	~1600–1900	–	4.18 ± 0.07	TE	[128]
Mo(116)	–	–	~10^{-10}	–1700–	–	4.2 ± 0.1	TE	[335,1650,1651, 1967]
Mo(116)	–	–	–	–	–	4.27	TC	[1159,1980,3067]
Mo(116-114)	–	–	?	?	–	4.3 ± 0.1	TE	[1962]
Mo(116)	–	–	$<2 \times 10^{-9}$	?	–	4.33	TE	[134]
Mo(116)	–	–	$<2 \times 10^{-9}$	293, 1000	–	4.41	PE	[134]
Mo(116)	–	–	–	–	–	4.47	TC	[3224]
Recommended	–	–	–	–	–	**4.23 ± 0.08**	–	–
Mo(310)	–	–	$\leq 1 \times 10^{-10}$	~300	–	4.13	FE	[783]
Mo(310)	–	–	–	–	–	4.13	TC	[3224]
Mo(310)	–	–	–	–	–	4.20	TC	[3224]
Mo(310)	–	–	–	–	–	4.53	TC	[3224]
Mo(321)	–	–	$\leq 1 \times 10^{-10}$	~300	–	4.14	FE	[783]
Mo(321)	–	–	–	–	–	4.15	TC	[3224]
Mo(321)	–	–	–	–	–	4.20	TC	[3224]
Mo(321)	–	–	–	–	–	4.53	TC	[3224]
Mo(331)	–	–	$<2 \times 10^{-9}$	?	–	4.33	TE	[134]
Mo(331)	–	–	$<2 \times 10^{-9}$	293, 1000	–	4.41	PE	[134]
Mo(332)	–	–	–	–	–	4.04	TC	[3224]
Mo(332)	–	–	–	–	–	4.16	TC	[3224]
Mo(332)	–	–	–	–	–	4.51	TC	[3224]
Mo(332)	–	–	$<1 \times 10^{-10}$	~300	–	4.55 ± 0.02	PE	[325]
Mo(431)	–	–	7×10^{-10}	77	–	4.02 ± 0.06	FE	[3691]
Mo(431)	–	–	7×10^{-10}	77	–	4.32 ± 0.14	FE	[3691]
Mo	–	–	$\leq 2 \times 10^{-8}$	~300	–	3.22 ± 0.16	PE	[2558]
Mo	–	–	$\leq 2 \times 10^{-8}$	~1300–1600	–	3.48 ± 0.07	TE	[2558]
Mo(porous)	–	–	?	>1600	(4.15)	3.8	TE	[3762]
Mo	–	–	–	–	–	3.92	TC	[521]
Mo[170]	–	(Mo$^+$)	~10^{-7}	~2400–2550	4.0 ± 0.1	(4.19 ± 0.02)	PSI	[954]
Mo	–	–	?	?	–	4.04	TE	[1486]
Mo	–	–	$<10^{-9}$	~300	–	4.04	PE	[337]
Mo	–	–	12 (Ar)	~300	–	4.04 ± 0.02	PE	[788,1647]
Mo	–	–	27 (Ne)	~300	–	4.06 ± 0.02	PE	[788,1647]
Mo	–	–	–	–	–	4.07	TC	[3476]
Mo	–	–	12 (Ar)	?	–	4.07 ± 0.03	PE	[4236]
Mo	–	–	–	–	–	4.08	TC	[1066]
Mo	–	–	?	~300	–	4.08	CPD	[2761]
Mo/W	Mo	–	5×10^{-10}	77	–	4.1	FE	[2318]
Mo	–	–	?	~300	–	4.10	CPD	[2761]
Mo	–	–	–	–	–	4.10	TC	[3476]
Mo	–	–	27 (Ne)	?	–	4.10 ± 0.02	PE	[4236]
Mo	–	–	?	~300	–	4.11	PE	[4190]
Mo{70%(100)}[172]	–	–	~10^{-9}	1950–2070	–	4.11 ± 0.08	TE	[124]
Mo	–	–	?	~300	–	4.12 ± 0.03	PE	[1635]
Mo	–	–	?	~300	–	4.15	PE	[2237]
Mo	–	–	?	?	–	4.15	TE	[1949]
Mo(porous)	Cs	Cs$^+$	?	~1100–1400	4.15	(3.8)	PSI	[3762]
Mo[262]	–	–	$<10^{-7}$	~1400–2000	–	4.15 ± 0.01	TE	[338]
Mo[262]	–	–	$<10^{-7}$	303, 940	–	4.15 ± 0.02	PE	[338]
Mo	–	–	$\leq 2 \times 10^{-10}$	~300	–	4.15 ± 0.05	CPD	[3077]
Mo	–	–	2×10^{-7}	~300	–	4.16	CPD	[642]
Mo	–	–	$<2 \times 10^{-7}$	1870	–	4.16	TE	[1970]
Mo	–	5–50 (Ne)	?	?	–	4.16 ± 0.02	TE	[643]
Mo	–	–	$<3 \times 10^{-8}$	~1400–1700	(4.50)	4.17	TE	[131]
Mo	–	–	1×10^{-8}	~300	–	4.17	PE	[1433]
Mo	–	–	–	–	–	4.18	TC	[339]
Mo[262]	–	–	–	940$^\mathrm{E}$	–	4.18	TC	[3586]
Mo	–	–	~10^{-7}	~2400–2550	(4.0, 4.5)	4.19 ± 0.02	TE	[954]
Mo{70%(100)}[172]	–	–	~10^{-9}	1360–1460	–	4.19 ± 0.09	TE	[124]
Mo	–	–	–	–	–	4.2	TC	[1645]
Mo	–	–	–	–	–	4.2	TC	[1993]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo	–	–	–	–	–	4.2	TC	[2583]
Mo{80%(100)}	–	–	$\sim10^{-9}$	~300	–	4.2	FE	[3231]
Mo/W	Mo	–	5×10^{-10}	800	–	4.2	FE	[2318]
Mo	–	–	4×10^{-9}	~1600–1950	–	4.2 ± 0.05	TE	[341]
Mo	–	–	?	~1000–1400	–	4.20	TE	[1773]
Mo	–	–	$\leq10^{-9}$	~1800–2200	–	4.20	TE	[66]
Mo	–	–	$\sim10^{-8}$	~1600–1800	–	4.20	TE	[4221]
Mo	–	–	?	?	(4.3, 5.1)	4.20 ± 0.02	TE	[132]
Mo	–	–	$<10^{-8}$	~300	–	4.20 ± 0.03	CPD	[1163]
Mo	–	–	$<10^{-9}$	~300	–	4.21	PE	[337]
Mo/W(100)	Mo	–	1×10^{-11}	77	–	4.21	FE	[2965]
Mo	RbC	Rb$^+$	?	?	4.21 ± 0.02	–	PSI	[2306]
Mo/glass	Mo	–	$\sim10^{-8}$	~300	–	4.21 ± 0.04	CPD	[349]
Mo	–	–	?	~300	–	4.21 ± 0.07	PE	[974]
Mo	–	–	$\sim10^{-10}$	~300	–	4.22	PE	[789]
Mo	–	–	$\sim10^{-7}$	~300	–	4.22	CPD	[3513]
Mo	–	–	$\sim10^{-9}$	~1300–2100	–	4.22 ± 0.05	TE	[1775,1777]
Mo	–	–	$\sim10^{-8}$	~300	–	4.22 ± 0.05	CPD	[133]
Mo	–	–	?	~1600–1900	–	4.23	TE	[634]
Mo	K	K$^+$	?	?	$4.23 \pm 0.10^*$	(4.41 ± 0.01)	PSI	[645]
Mo	–	–	$\sim10^{-9}$	?	–	4.24	TE	[979]
Mo{70%(100)}[172]	–	–	–	–	–	4.25	TC	[1254]
Mo	–	–	$\leq10^{-9}$	?	–	4.25 ± 0.05	TE	[650]
Mo	–	–	$\sim10^{-6}$	~1900–2100	–	4.25–4.7	TE	[1779]
Mo	–	–	$\leq4 \times 10^{-10}$	?	–	4.26	TE	[2091]
Mo	–	–	1×10^{-10}	~300	–	4.27 ± 0.02	FE	[790]
Mo	–	–	–	–	–	4.28	TC	[3224]
Mo[17]	–	–	$<10^{-9}$	1650–1950	–	4.28 ± 0.6	TE	[791]
Mo/W(100)	Mo	–	1×10^{-11}	77 (750)	–	4.3	FE	[2965]
Mo	–	–	–	–	–	4.3	TC	[2456]
Mo{80%(100)}	–	–	$\sim10^{-9}$	~300	–	4.3	PE	[2757]
Mo	–	–	?	~300	–	4.3	PE	[3640]
Mo	–	–	700 (Ar)	~2800	–	4.3	TE	[2007]
Mo	–	–	$<1 \times 10^{-6}$	?	–	4.3	TE	[3035]
Mo	–	–	?	?	–	4.3 ± 0.1	?	[3780]
Mo	–	–	–	–	–	4.30	TC	[3264,3265,3267]
Mo	–	–	?	?	–	4.30	FE	[3544]
Mo	–	–	5×10^{-9}	1373–2073	–	4.30 ± 0.02	TE	[2016]
Mo[170]	–	(Mo$^+$)	?	~2350–2500	4.3 ± 0.1	(4.20 ± 0.02)	PSI	[132]
Mo	–	–	?	?	–	4.31	TE	[2455]
Mo	–	–	$<10^{-6}$	?	–	4.31	TE	[2919]
Mo	–	–	6×10^{-7}	?	–	4.31	TE	[1521]
Mo[174]	–	–	–	0^E	–	4.31	TC	[1747]
Mo	–	–	?	~1500–2100	–	4.31 ± 0.04	TE	[792]
Mo	–	–	$\leq2 \times 10^{-8}$	~1400–1800	–	4.32	TE	[130,1363]
Mo	–	–	$<10^{-6}$	~300	–	4.33	PE	[2919]
Mo	–	–	?	~80	–	4.33	CPD	[2294]
Mo	–	–	$\leq10^{-7}$	0^E (~1800)	–	4.33	TE	[1878]
Mo[173]	–	–	$<2 \times 10^{-9}$	?	–	4.33	TE	[134]
Mo	–	–	?	~300	–	4.33	PE	[2924]
Mo	–	–	1×10^{-7}	~1900–2300	(5.02 ± 0.05)	4.33 ± 0.07	TE	[76,77]
Mo[17]	–	–	$<10^{-9}$	1650–1950	–	4.33 ± 0.16	TE	[791]
Mo	–	–	$\leq10^{-9}$	1800–2200	–	4.34	TE	[66]
Mo	–	–	?	~1600–2000	–	4.34	TE	[3526]
Mo/Re	Mo	–	$\sim10^{-9}$	~1200–1800	–	4.35	TE	[975]
Mo	–	–	$\leq4 \times 10^{-10}$	?	–	4.35	TE	[2091]
Mo{72%(100)}[172]	–	–	? (Cs)	~1200–1800	–	4.35 ± 0.05	TE	[650,3414]
Mo	–	–	4×10^{-9}	~1600–1950	–	4.35 ± 0.05	TE	[341]
Mo	–	–	$\sim10^{-11}$	~300	–	4.36	CPD	[3338]
Mo	–	–	?	?	–	4.36	TE	[2088]
Mo	–	–	$\sim10^{-10}$	–1700–	–	4.36	TE	[335,1650,1651, 1967]
Mo	–	–	?	~2350–2500	$(4.6, 5.4^*)$	4.37 ± 0.02	TE	[132]
Mo	–	–	$<3 \times 10^{-8}$	~1400–1700	(4.50)	4.38	TE	[131]
Mo	–	–	?	?	–	4.38	TE	[3524,3525]
Mo	–	–	? (Cs)	~1500–2200	–	4.38	TE	[1390,3840]
Mo	–	–	6×10^{-10}	~1400–2100	–	4.38	TE	[2091,2092]
Mo	–	–	? (Cs)	~1500–2500	–	4.38	TE	[3798,3799]
Mo{72%(100)}[172]	–	–	–	–	(4.51 ± 0.03)	4.38 ± 0.01	TC	[803]
Mo	KCl	K$^+$	?	?	4.39 ± 0.02	–	PSI	[2306]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Mo	–	–	2×10^{-7}	~2000–2100	(4.90 ± 0.06)	4.39 ± 0.05	TE	[23,39]
Mo	–	–	(~10^{-12})	~300	–	4.4 ± 0.02	CPD	[1795]
Mo	–	–	?	?	–	4.40	TE	[3402]
Mo	–	–	?	~1800	–	4.40	TE	[2567]
Mo	–	–	–	–	–	4.40	TC	[2949]
Mo	–	–	≤1×10^{-6}	2055–2140	–	4.40 ± 0.01	TE	[2296]
Mo[173]	–	–	<2×10^{-9}	293	–	4.41	PE	[134]
Mo	–	–	–	–	–	4.41	TC	[3637]
Mo	–	–	?	?	(4.23 ± 0.10*)	4.41 ± 0.01	TE	[645]
Mo	–	–	1×10^{-8}	1590–2100	(4.96 ± 0.01)	4.41 ± 0.02	TE	[78]
Mo/SiO$_2$	Mo	–	?	~300	–	4.42	CPD	[3687]
Mo	–	–	–	–	–	4.42	TC	[3318]
Mo	K	K$^+$	? (K)	1000	4.42	–	PSI	[1845]
Mo	–	–	2×10^{-6}	2200	–	4.44	TE	[39]
Mo	–	–	≤1×10^{-7}	~1700–2500	–	4.45 ± 0.01	TE	[978]
Mo	–	–	–	–	–	4.46	TC	[298]
Mo	–	–	–	–	–	4.46	TC	[3318]
Mo[173]	–	–	<2×10^{-9}	1000	–	4.47 ± 0.03	PE	[134]
Mo	–	–	≤10^{-7}	~1450–2150	–	4.48	TE	[1878]
Mo	–	–	?	~300	–	4.48	CPD	[2297]
Mo	–	–	~10^{-7}	~2000	–	4.49	TE	[1398]
Mo	–	–	–	–	–	4.49	TC	[531]
Mo	Li$^+$	Li$^+$	~10^{-9}	~500–1800	4.5	–	PSI	[1440]
Mo	Na$^+$	Na$^+$	~10^{-9}	~500–1800	4.5	–	PSI	[1440]
Mo	K$^+$	K$^+$	~10^{-9}	~500–1800	4.5	–	PSI	[1440]
Mo	–	–	<1×10^{-9}	~300	–	4.5	PE	[2211]
Mo	–	–	~10^{-8}	833	–	4.5	CPD	[2050]
Mo[170]	–	(Mo$^+$)	~10^{-7}	~2400–2550	4.5 ± 0.1	(4.19 ± 0.02)	PSI	[954]
Mo	–	–	~10^{-6}	~1900–2100	–	4.5 ± 0.2	TE	[1779]
Mo[170]	–	(Mo$^+$)	<3×10^{-8}	2150–2630	4.50	(4.17, 4.38)	PSI	[131]
Mo	–	–	<8×10^{-11}	~300	–	4.500 ± 0.100	CPD	[342,3868]
Mo{72%(100)}[172]	–	–	–	–	4.51 ± 0.03	(4.38 ± 0.01)	TC	[803]
Mo	–	–	–	–	–	4.53	TC	[3476]
Mo/W(112)	–	–	–	–	–	4.55	TC	[531]
Mo	–	–	3×10^{-10}	~300	–	4.55 ± 0.03	PE	[1504]
Mo[170]	–	(Mo$^+$)	?	2350–2500	4.6 ± 0.1	(4.37 ± 0.02)	PSI	[132]
Mo	–	–	–	–	–	4.6	TC	[944]
Mo/quartz	Mo	–	~10^{-10}	~300	–	4.6 ± 0.15	PE	[304]
Mo	–	–	?	77	–	4.61 ± 0.02	PE	[793]
Mo	–	–	2×10^{-5}	2080–2200	–	4.64	TE	[3017]
Mo	–	–	? (K)	1350–1550	–	4.66	TE	[2559]
Mo	–	–	–	–	–	4.7	TC	[706]
Mo[170]	–	(Mo$^+$)	~10^{-7}	~2400–2550	4.7 ± 0.1*	(4.19 ± 0.02)	PSI	[954]
Mo/W(111)	–	–	–	–	–	4.70	TC	[531]
Mo	–	–	–	–	–	4.70	TC	[2629]
Mo	–	–	5×10^{-10}	~300	–	4.72	AI	[4027]
Mo/Si(111)[166]	Mo	–	4×10^{-11}	~300	–	4.76	PE	[1430]
Mo	–	–	–	0	–	4.78	TC	[4419]
Mo	KBr	K$^+$	2×10^{-7}	~2000–2100	4.90 ± 0.06	(4.39 ± 0.05)	PSI	[23,39,57,2422]
Mo[170]	–	(Mo$^+$)	~10^{-10}	2350–2500	4.93 ± 0.03*	–	PSI	[3886]
Mo/HfO$_2$	Mo	–	?	~300	–	4.95	CPD	[3519,3656]
Mo	Bi	Bi$^+$	1×10^{-8}	1830–2240	4.96 ± 0.01	(4.41 ± 0.02)	PSI	[78]
Mo	–	–	–	–	–	4.97	TC	[531]
Mo	In	In$^+$	1×10^{-7}	~1900–2300	5.02 ± 0.05	(4.33 ± 0.07)	PSI	[76,77]
Mo/SiO$_2$	Mo	–	?	~300 (~900)	–	5.05 ± 0.05	CPD	[3519,3687]
Mo[170]	–	(Mo$^+$)	?	2350–2500	5.1 ± 0.1*	(4.20 ± 0.02)	PSI	[132]
Mo[170]	–	(Mo$^+$)	~10^{-7}	~2100–2400	5.1 ± 0.4	(4.33 ± 0.07)	PSI	[77]
Mo	KCl	K$^+$	2×10^{-7}	~2000–2100	5.10 ± 0.07	(4.39 ± 0.05)	PSI	[23,39,2422]
Mo[170]	–	(Mo$^+$)	?	2350–2500	5.4 ± 0.1*	(4.37 ± 0.02)	PSI	[132]
Mo	–	–	–	–	–	5.80	TC	[2629]
Mo/W	Mo	–	?	~300	–	6.0	FE	[2225]
Recommended	–	–	–	–	**5.03 ± 0.06**	**4.31 ± 0.02**	–	–

43. Technetium Tc

hcp

Tc(0001)	–	–	–	–	–	4.69	TC	[4004]
Tc(0001)	–	–	–	–	–	4.95	TC	[4004]
Tc(0001)	–	–	–	–	–	5.15	TC	[4005]
Tc(0001)	–	–	–	–	–	5.30	TC	[321]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tc(0001)	–	–	–	–	–	5.36	TC	[334]
Tc(1010)	–	–	–	–	–	4.31	TC	[4005]
Tc(1010)	–	–	–	–	–	4.50	TC	[4004]
Tc(1010)	–	–	–	–	–	4.83	TC	[4004]
Tc(1010)	–	–	–	–	–	5.13	TC	[321]
Tc(1011)	–	–	–	–	–	4.70	TC	[4004]
Tc(1011)	–	–	–	–	–	5.05	TC	[4004]
Tc(1012)	–	–	–	–	–	4.31	TC	[4004]
Tc(1012)	–	–	–	–	–	4.67	TC	[4004]
Tc(1013)	–	–	–	–	–	4.25	TC	[4004]
Tc(1013)	–	–	–	–	–	4.60	TC	[4004]
Tc(1121)	–	–	–	–	–	4.09	TC	[4004]
Tc(1121)	–	–	–	–	–	4.44	TC	[4004]
Tc(1122)	–	–	–	–	–	4.28	TC	[4004]
Tc(1122)	–	–	–	–	–	4.63	TC	[4004]
Tc(1123)	–	–	–	–	–	4.23	TC	[4004]
Tc(1123)	–	–	–	–	–	4.56	TC	[4004]
Tc(1124)	–	–	–	–	–	4.43	TC	[321]
Tc(2130)	–	–	–	–	–	4.26	TC	[4004]
Tc(2130)	–	–	–	–	–	4.58	TC	[4004]
Tc(3140)	–	–	–	–	–	4.32	TC	[4004]
Tc(3140)	–	–	–	–	–	4.64	TC	[4004]
Tc	–	–	–	–	–	3.91	TC	[3476]
Tc	–	–	–	–	–	4.01	TC	[3476]
Tc[160]	–	–	–	–	–	4.4	TC	[1355]
Tc	–	–	–	–	–	4.41	TC	[3476]
Tc(wire)	–	–	5×10^{-8}	1970–2120	–	4.51 ± 0.02	TE	[3700]
Tc	–	–	–	–	–	4.66	TC	[3318]
Tc	–	–	–	–	–	4.66 ± 0.02	TC	[1045]
Tc	–	–	–	–	–	4.67	TC	[2949]
Tc	–	–	–	–	–	4.67	TC	[3318]
Tc	–	–	–	–	–	4.7	TC	[706]
Tc	–	–	–	–	–	4.8	TC	[298]
Tc	–	–	–	–	–	4.82	TC	[4270]
Tc	–	–	–	–	–	4.86 ± 0.01	TC	[895]
Tc	–	–	–	–	–	4.88 ± 0.05	TC	[895]
Tc	–	–	$\leq 1 \times 10^{-10}$	~300	–	4.9 ± 0.4	PE	[1695]
Tc	–	–	$\leq 1 \times 10^{-10}$	~300	–	5.1 ± 0.1	PE	[1695]
Tc	–	–	–	–	–	5.2	TC	[944]
Recommended	–	–	–	–	–	**4.67 ± 0.02**	–	–

44. Ruthenium Ru[435]

hcp

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ru(0001)[143]	–	–	?	?	–	4.5	FE	[2348]
Ru(0001)	–	–	~10^{-10}	~300	–	4.7	PE	[4340]
Ru(0001)	–	–	–	–	–	4.97	TC	[4004]
Ru(0001)	–	–	–	–	–	5.0	TC	[3011]
Ru(0001)	–	–	–	–	–	5.03	TC	[343]
Ru(0001)	–	–	~10^{-9}	1600	–	5.04 ± 0.07	TE	[3087]
Ru(0001)	–	–	$<2 \times 10^{-10}$	~300	–	5.1	PE	[2374]
Ru(0001)	–	–	–	–	–	5.18	TC	[3734]
Ru(0001)/Mo(110)	Ru	–	1×10^{-10}	~300 (800)	–	5.26	CPD	[2876]
Ru(0001)	–	–	$\leq 1 \times 10^{-10}$	~300	–	5.26	PE	[1606]
Ru(0001)	–	–	4×10^{-11}	100	–	5.27 ± 0.08	PE	[344]
Ru(0001)	–	–	–	–	–	5.3	TC	[1707]
Ru(0001)	–	–	$\leq 1 \times 10^{-10}$	~300	–	5.3	PE	[1614]
Ru(0001)[175]	–	–	–	–	–	5.3	TC	[542]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ru(0001)	–	–	$<10^{-10}$	~300	–	5.3	PE	[3782]
Ru(0001)	–	–	?	~300	–	5.3 ± 0.1	PE	[3359]
Ru(0001)	–	–	?	~300	–	5.30	PE	[4020]
Ru(0001)	–	–	–	–	–	5.31	TC	[4004]
Ru(0001)	–	–	–	–	–	5.37	TC	[4005]
Ru(0001)	–	–	–	–	–	5.37	TC	[3473]
Ru(0001)	–	–	1×10^{-10}	100	–	5.38	PE	[759]
Ru(0001)	–	–	–	–	–	5.4	TC	[456]
Ru(0001)[175]	–	–	~10^{-11}	~300	–	5.4	PE	[542]
Ru(0001)	–	–	$<2 \times 10^{-10}$	115	–	5.4 ± 0.1	PE	[4335]
Ru(0001)	–	–	$<8 \times 10^{-11}$	130	–	5.4 ± 0.1	PE	[528]
Ru(0001)	–	–	~10^{-10}	~300	–	5.4 ± 0.1	PE	[2138]
Ru(0001)	–	–	3×10^{-10}	295	–	5.40	CPD	[1822,1827]
Ru(0001)	–	–	~10^{-9}	~1600–2000	–	5.40 ± 0.07	TE	[3085,3087,3096]
Ru(0001)	–	–	?	?	–	5.42	?	[2652]
Ru(0001)	–	–	–	–	–	5.43	TC	[1106]
Ru(0001)	–	–	~10^{-10}	~300	–	5.45	PE	[4199]
Ru(0001)	–	–	–	–	–	5.46	TC	[3224]
Ru(0001)/Mo(110)	Ru	–	1×10^{-10}	~300 (800)	–	5.48	CPD	[2876]
Ru(0001)	–	–	1×10^{-10}	100	–	5.50 ± <0.10	PE	[672]
Ru(0001)[143]	–	–	1×10^{-10}	100	–	5.52 ± 0.1	PE	[529,759,2266, 3198]
Ru(0001)	–	–	$\leq 2 \times 10^{-10}$	85	–	5.53	CPD	[2176]
Ru(0001)	–	–	?	?	–	5.58	?	[3160]
Ru(0001)	–	–	–	–	–	5.84	TC	[334]
Recommended	–	–	–	–	–	**5.35 ± 0.06**	–	–
Ru(1010)	–	–	–	–	–	4.59	TC	[4005]
Ru(1010)	–	–	3×10^{-10}	~300	–	4.6 ± 0.1	PE	[846]
Ru(1010)	–	–	–	–	–	4.79	TC	[4004]
Ru(1010)	–	–	–	–	–	4.88	TC	[703]
Ru(1010)	–	–	~10^{-9}	1600	–	5.08 ± 0.05	TE	[3087]
Ru(1010)	–	–	–	–	–	5.13	TC	[4004]
Ru(1010)	–	–	~10^{-9}	~1600–1900	–	5.14 ± 0.05	TE	[3085,3087,3096]
Recommended	–	–	–	–	–	**4.9 ± 0.2**	–	–
Ru(1011)	–	–	–	–	–	4.91	TC	[4004]
Ru(1011)	–	–	–	–	–	5.26	TC	[4004]
Ru(1012)	–	–	–	–	–	4.50	TC	[4004]
Ru(1012)	–	–	–	–	–	4.85	TC	[4004]
Ru(1013)	–	–	–	–	–	4.45	TC	[4004]
Ru(1013)	–	–	–	–	–	4.82	TC	[4004]
Ru(1121)	–	–	–	–	–	4.39	TC	[4004]
Ru(1121)	–	–	–	–	–	4.76	TC	[4004]
Ru(1122)[435]	–	–	~10^{-9}	~1510–1540	–	4.12 ± 0.05$^\beta$	TE	[3686]
Ru(1122)[435]	–	–	~10^{-9}	~1400–1500	–	4.45 ± 0.05$^\alpha$	TE	[3686]
Ru(1122)[435]	–	–	~10^{-9}	~1580–1730	–	4.45 ± 0.05$^\gamma$	TE	[3686]
Ru(1123)	–	–	–	–	–	4.43	TC	[4004]
Ru(1123)	–	–	–	–	–	4.80	TC	[4004]
Ru(1124)	–	–	~10^{-9}	~1600–1900	–	4.52 ± 0.05	TE	[3087,3096]
Ru(1124)	–	–	~10^{-9}	1600	–	4.55 ± 0.05	TE	[3085,3087]
Ru(1125)[435]	–	–	~10^{-9}	~1510–1540	–	4.10 ± 0.05$^\beta$	TE	[3686]
Ru(1125)[435]	–	–	~10^{-9}	~1400–1480	–	4.65 ± 0.05$^\alpha$	TE	[3686]
Ru(1125)[435]	–	–	~10^{-9}	~1560–1730	–	4.65 ± 0.05$^\gamma$	TE	[3686]
Ru(2130)	–	–	–	–	–	4.47	TC	[4004]
Ru(2130)	–	–	–	–	–	4.86	TC	[4004]
Ru(3140)	–	–	–	–	–	4.37	TC	[4004]
Ru(3140)	–	–	–	–	–	4.96	TC	[4004]
Ru	–	–	–	–	–	4.10	TC	[3476]
Ru	–	–	–	–	–	4.21	TC	[3476]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ru	–	–	7×10^{-10}	~300	–	4.3	PE	[2328]
Ru/glass	Ru	–	$<1 \times 10^{-10}$	78	–	4.50	PE	[414]
Ru/glass	Ru	–	5×10^{-10}	78	–	4.51	PE	[1495]
Ru/glass[363]	Ru	–	$\sim10^{-10}$	~78	–	4.52	PE	[436]
Ru	–	–	?	~300	–	4.52	CPD	[2297]
Ru	–	–	–	–	–	4.52	TC	[1399]
Ru/glass	Ru	–	$<5 \times 10^{-10}$	78	–	4.52 ± 0.03	PE	[1256]
Ru/Mo	Ru	–	$\sim10^{-8}$	~1600–2000	–	4.55 ± 0.05	TE	[794,2824]
Ru	–	–	? (Cs)	?	–	4.57	TE	[2099]
Ru	–	–	? (Cs)	?	–	4.57	TE	[2936]
Ru/Mo	Ru	–	$\sim10^{-4}$–1 (Cs)	≥2000	–	4.57 ± 0.05	TE	[794,2824]
Ru	–	–	–	–	–	4.60	TC	[1066]
Ru	–	–	–	–	–	4.61	TC	[3476]
Ru/H$_f$SiO$_x$/Si	Ru	–	2×10^{-10}	~300{620}	–	4.62	PE	[4186]
Ru	–	–	$\sim10^{-9}$	?	–	4.64	TE	[3112]
Ru	–	–	–	–	–	4.66	TC	[3318]
Ru	–	–	–	–	–	4.67	TC	[3318]
Ru	–	–	–	–	–	4.68	TC	[2949]
Ru	–	–	$\sim10^{-9}$	1600	–	4.68	TE	[3087,3096]
Ru	–	–	–	–	–	4.7	TC	[706]
Ru/glass	Ru	–	$<1 \times 10^{-10}$	78 (293)	–	4.71	PE	[414]
Ru	–	–	?	~300	–	4.730 ± 0.01	CPD	[13]
Ru/H$_f$SiO$_x$/Si	Ru	–	2×10^{-10}	~300 (700)	–	4.74 ± 0.01	CPD	[4186]
Ru	–	–	$\sim10^{-8}$	~1600–2300	–	4.75	TE	[1776,2322,2327]
Ru/82%Ru–Ta	–	–	$\sim10^{-8}$	~1700 (~2200)	–	4.75	TE	[2327]
Ru/glass	Ru	–	$<1 \times 10^{-10}$	78 (373)	–	4.76	PE	[414]
Ru	–	–	–	–	–	4.80	TC	[3264,3265,3267]
Ru	–	–	–	–	–	4.81	TC	[298]
Ru/SiO$_2$/Si	Ru	–	2×10^{-10}	~300 (700)	–	4.81	CPD	[4186]
Ru/glass	Ru	–	$<1 \times 10^{-10}$	78 (473)	–	4.82	PE	[414]
Ru	–	–	–	–	–	4.83	TC	[3224]
Ru/glass	Ru	–	$<5 \times 10^{-10}$	78 (373)	–	4.83 ± 0.03	PE	[1256]
Ru/SiO$_2$	Ru	–	?	~300	–	4.84 ± 0.1	CPD	[2906]
Ru/W	Ru	–	?	~300	–	4.865 ± 0.005	CPD	[13]
Ru	–	–	?	?	–	4.89	TE	[2105]
Ru/glass	Ru	–	$<1 \times 10^{-10}$	78 (573)	–	4.89	PE	[414]
Ru	–	–	–	–	–	4.9*	TC	[1955]
Ru	–	–	–	–	–	5.1	TC	[944]
Ru/HfO$_2$/SiO$_x$/Si	Ru	–	?	~300 (593)	–	5.1	CPD	[1835]
Ru/quartz[363]	Ru	–	$<5 \times 10^{-10}$	~78 (≥2800)	–	5.10 ± 0.05	PE	[436,1256]
Ru/glass	Ru	–	5×10^{-10}	78 (800)	–	5.11	PE	[1495]
Ru/?	Ru	–	7×10^{-10}	~300	–	5.4	PE	[2328]
Ru	–	–	–	–	–	5.46	TC	[1744]
Recommended	–	–	–	–	–	**4.71 ± 0.05**	–	–

45. Rhodium Rh

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rh(100)	–	–	–	–	–	4.4	TC	[1109]
Rh(100)	–	–	?	~300	–	4.6 ± 0.1	?	[1257]
Rh(100)	–	–	–	–	–	$4.8 \pm <0.3$	TC	[1014,1108]
Rh(100)	–	–	–	–	–	4.91	TC	[980]
Rh(100)	–	–	–	–	–	4.92	TC	[981]
Rh(100)	–	–	1×10^{-10}	~300	–	4.94 ± 0.03	PE	[2396]
Rh(100)	–	–	–	–	–	4.99	TC	[321]
Rh(100)	–	–	–	–	–	5.040	TC	[4091]
Rh(100)	–	–	–	–	–	5.087	TC	[2229,2447]
Rh(100)	–	–	2×10^{-10}	100	–	5.11	PE	[1017,2859,3821]
Rh(100)	–	–	–	–	–	5.15	TC	[1008]
Rh(100)	–	–	–	–	–	5.16	TC	[705]
Rh(100)	–	–	–	–	–	5.17	TC	[2912]
Rh(100)	–	–	–	–	–	5.17	TC	[4333,4334]
Rh(100)	–	–	?	~300	–	5.2	PE	[2158]
Rh(100)	–	–	?	~300	–	5.2 ± 0.2	PE	[1127]
Rh(100)	–	–	–	–	–	5.24	TC	[1928]
Rh(100)	–	–	–	–	–	5.25	TC	[320,1012,1015]
Rh(100)	–	–	–	–	–	5.26	TC	[981]
Rh(100)	–	–	–	–	–	5.30	TC	[980]
Rh(100)[176]	–	–	–	–	–	5.36	TC	[1258]
Rh(100)	–	–	$\sim10^{-11}$	~300	–	5.38 ± 0.05	FE	[853]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rh(100)	–	–	?	40–298	–	5.40 ± 0.02	CPD	[2832]
Rh(100)	–	–	<10⁻¹⁰	80, 144, 298	–	5.41 ± 0.01	FE	[1010]
Rh(100)	–	–	–	–	–	5.43 ± 0.1	TC	[916]
Rh(100)	–	–	–	–	–	5.45	TC	[4228]
Rh(100)	–	–	–	–	–	5.46	TC	[4228]
Rh(100)	–	–	–	–	–	5.49	TC	[982]
Rh(100)	–	–	–	–	–	5.5	TC	[1009,1016]
Rh(100)[176]	–	–	–	–	–	5.57	TC	[1258]
Rh(100)	–	–	–	–	–	5.6 ± >0.2	TC	[1016,1909]
Recommended	–	–	–	–	–	**5.24 ± 0.07**	–	–
Rh(110)	–	–	–	–	–	4.53	TC	[2442]
Rh(110)	–	–	–	–	–	4.57	TC	[2442]
Rh(110)	–	–	–	–	–	4.59	TC	[980]
Rh(110)	–	–	–	–	–	4.615	TC	[2229,2447]
Rh(110)	–	–	–	–	–	4.62	TC	[2442]
Rh(110)	–	–	–	–	–	4.635	TC	[4091]
Rh(110)	–	–	–	–	–	4.67	TC	[2912]
Rh(110)	–	–	–	–	–	4.69	TC	[321]
Rh(110)[177]	–	–	~10⁻¹¹	~300	–	4.70 ± 0.05	FE	[853]
Rh(110)	–	–	–	–	–	4.72	TC	[2442]
Rh(110)	–	–	–	–	–	4.77	TC	[523]
Rh(110)	–	–	–	–	–	4.78	TC	[523]
Rh(110)	–	–	1 × 10⁻¹⁰	80	–	4.8	FE	[2146,2163]
Rh(110)[177]	–	–	~10⁻¹¹	~300	–	4.80 ± 0.05	FE	[853]
Rh(110)	–	–	<10⁻¹⁰	144, 195	–	4.86 ± 0.01	FE	[1010]
Rh(110)	–	–	–	–	–	4.94	TC	[320,980]
Rh(110)	–	–	–	–	–	4.98	TC	[523]
Rh(110)	–	–	–	–	–	4.99	TC	[523]
Rh(110)	–	–	–	–	–	5.07	TC	[4228]
Rh(110)	–	–	?	40–298	–	5.12 ± 0.02	CPD	[2832]
Recommended	–	–	–	–	–	**4.75 ± 0.06**	–	–
Rh(111)[178]	–	–	~10⁻¹¹	~300	–	4.95 ± 0.05	FE	[853]
Rh(111)	–	–	1 × 10⁻¹⁰	~300	–	5.04 ± 0.03	PE	[2396]
Rh(111)[179]	–	–	~10⁻¹⁰	~300	–	5.1	PE	[1544,1546]
Rh(111)	–	–	–	–	–	5.105	TC	[2229,2447]
Rh(111)	–	–	–	–	–	5.11	TC	[1722]
Rh(111)	–	–	–	–	–	5.12	TC	[2068]
Rh(111)	–	–	–	–	–	5.132	TC	[4008]
Rh(111)	–	–	–	–	–	5.138	TC	[4091]
Rh(111)	–	–	–	–	–	5.20	TC	[2913]
Rh(111)	–	–	–	–	–	5.21	TC	[2912]
Rh(111)	–	–	–	–	–	5.23	TC	[1013]
Rh(111)	–	–	–	–	–	5.26	TC	[3369]
Rh(111)	–	–	1 × 10⁻¹⁰	80	–	5.3	FE	[2146,2163]
Rh(111)	–	–	4 × 10⁻¹¹	40	–	5.3	PE	[1019]
Rh(111)/Mo(110)[180]	Rh	–	7 × 10⁻¹¹	~300	–	5.36	PE	[1035]
Rh(111)	–	–	–	–	–	5.39	TC	[321]
Rh(111)	–	–	<1 × 10⁻¹⁰	~300	–	5.4	PE	[568,2282]
Rh(111)	–	–	<5 × 10⁻¹¹	~300	–	5.4	PE	[1018]
Rh(111)	–	–	4 × 10⁻¹¹	~300	–	5.4 ± 0.1	PE	[2048]
Rh(111)	–	–	–	–	–	5.40	TC	[1011]
Rh(111)	–	–	–	–	–	5.44	TC	[320,1178]
Rh(111)	–	–	–	–	–	5.44	TC	[2534]
Rh(111)/W(110)	Rh	–	4 × 10⁻¹¹	350	–	5.47	CPD	[2408]
Rh(111)	–	–	–	–	–	5.56	TC	[4228]
Rh(111)	–	–	–	–	–	5.59	TC	[4228]
Rh(111)	–	–	–	–	–	5.59	TC	[1011]
Rh(111)	–	–	<10⁻¹⁰	298	–	5.59 ± 0.01	FE	[1010]
Rh(111)	–	–	–	–	–	5.6	TC	[1009,1011]
Rh(111)	–	–	~10⁻¹¹	80	–	5.6	FE	[3460]
Rh(111)	–	–	<10⁻¹⁰	195	–	5.60 ± 0.01	FE	[1010]
Rh(111)	–	–	1 × 10⁻¹⁰	45	–	5.60 ± 0.04	PE	[1128,1204,2280]
Rh(111)	–	–	<10⁻¹⁰	195	–	5.61 ± 0.01	FE	[1010]
Rh(111)	–	–	–	–	–	5.63	TC	[1011]
Rh(111)	–	–	–	–	–	5.64	TC	[1011]
Rh(111)	–	–	?	40–298	–	5.66 ± 0.02	CPD	[2832]
Rh(111)	–	–	<10⁻¹⁰	144	–	5.67 ± 0.01	FE	[1010]
Rh(111)	–	–	<10⁻¹⁰	80	–	5.69 ± 0.01	FE	[1010]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rh(111)	–	–	–	–	–	5.79	TC	[1011]
Rh(111)	–	–	–	–	–	5.91	TC	[334,3179]
Rh(111)	–	–	–	–	–	6.51	TC	[1011]
Recommended	–	–	–	–	–	**5.40 ± 0.08**	–	–
Rh(112)	–	–	$\sim 10^{-11}$	80	–	5.1	FE	[3460]
Rh(113)	–	–	1×10^{-10}	80	–	5.0	FE	[2146,2163]
Rh(210)	–	–	$\sim 10^{-11}$	~ 300	–	4.64 ± 0.05	FE	[853,2511]
Rh(310)	–	–	$\sim 10^{-11}$	~ 300	–	4.76 ± 0.05	FE	[853,2511]
Rh(320)	–	–	1×10^{-10}	80	–	4.70	FE	[2146,2163]
Rh(321)	–	–	$\sim 10^{-11}$	~ 300	–	4.75 ± 0.05	FE	[853,2511]
Rh(410)	–	–	$\sim 10^{-11}$	~ 300	–	4.90 ± 0.05	FE	[853]
Rh(430)	–	–	$\sim 10^{-11}$	~ 300	–	4.72 ± 0.05	FE	[853,2511]
Rh(520)	–	–	$\sim 10^{-11}$	~ 300	–	4.74 ± 0.05	FE	[853,2511]
Rh(531)	–	–	$\sim 10^{-11}$	~ 300	–	4.69 ± 0.05	FE	[853,2511]
Rh	–	–	–	–	–	4.19	TC	[3476]
Rh	–	–	–	–	–	4.35	TC	[3476]
Rh	–	–	?	~ 300	–	4.52	CPD	[2297]
Rh	–	–	3×10^{-11}	~ 300	–	4.53	FE	[2227]
Rh/Nb(110)	–	–	–	–	–	4.56	TC	[2913]
Rh	–	–	–	–	–	4.57	TC	[1399]
Rh	–	–	$\sim 10^{-8}$	513	–	4.57 ± 0.09	PE	[1757]
Rh	–	–	$\sim 10^{-8}$	$\sim 1300–1500$	–	4.58 ± 0.09	TE	[1757]
Rh	–	–	?	?	–	4.6	TE	[3402]
Rh	–	–	–	–	–	4.62	TC	[1066]
Rh	–	–	–	–	–	4.64	TC	[3318]
Rh	–	–	–	–	–	4.7	TC	[3318]
Rh	–	–	3×10^{-9}	$\sim 1100–1700$	–	4.72	TE	[159]
Rh	–	–	–	–	–	4.74	TC	[2949]
Rh	–	–	–	–	–	4.76	TC	[3476]
Rh	–	–	–	–	–	4.8	TC	[706]
Rh	–	–	–	–	–	4.80	TC	[298]
Rh	–	–	$\leq 2 \times 10^{-6}$	$\sim 1150–1300$	–	4.80	TE	[3396]
Rh	–	–	1×10^{-10}	~ 300	–	4.85	PE	[3125]
Rh/glass	Rh	–	$\sim 10^{-10}$	78	–	4.87	PE	[2719]
Rh/glass	Rh	–	$< 1 \times 10^{-10}$	78	–	4.88	PE	[414,2723]
Rh	–	–	?	$\sim 1550–1950$	–	4.9	TE	[668]
Rh/W(110)	Rh	–	5×10^{-11}	$\sim 300\ (1200)$	–	4.9*	CPD	[2420]
Rh/W(111)	Rh	–	$\leq 10^{-8}$	~ 300	–	4.90 ± 0.04*	CPD	[2338]
Rh/glass	Rh	–	$< 1 \times 10^{-10}$	78 (293)	–	4.98	PE	[414,2722,2723]
Rh	–	–	–	–	–	4.99	TC	[3264]
Rh/quartz	Rh	–	5×10^{-11}	~ 300	–	5.0	PE	[1022]
Rh	–	–	–	–	–	5.0	TC	[2583]
Rh	–	–	1×10^{-10}	~ 300	–	5.0	PE	[570,2368,3125]
Rh/glass	Rh	–	$\sim 10^{-10}$	78 (293)	–	5.06	PE	[2719]
Rh/W(110)	Rh	–	3×10^{-11}	200–560	–	5.1*	?	[1930]
Rh	–	–	–	–	–	5.1*	TC	[1955]
Rh/glass	Rh	–	$\sim 10^{-10}$	78 (373)	–	5.11	PE	[414,2719,2723]
Rh/W(100)	Rh	–	$\leq 10^{-8}$	~ 300	–	5.12 ± 0.03*	CPD	[2338]
Rh	–	–	–	–	–	5.15 ± 0.05	TC	[1256]
Rh/glass	Rh	–	$< 3 \times 10^{-10}$	78 (458)	–	5.18	PE	[414,2723]
Rh	–	–	$< 5 \times 10^{-9}$	?	–	5.2 ± 0.1	TE	[647]
Rh/HfO$_2$/Si[181]	Rh(ac)$_3$	–	5×10^{-6}	$\sim 300\ (423)$	–	5.25	CPD	[2908]
Rh	–	–	?	?	–	5.25	TE	[2105]
Rh	–	–	–	–	–	5.3	TC	[944]
Rh/SiO$_2$/Si[181]	Rh(ac)$_3$	–	5×10^{-6}	$\sim 300\ (423)$	–	5.43	CPD	[2908]
Rh/W(110)	Rh	–	$\leq 10^{-8}$	~ 300	–	5.51 ± 0.05*	CPD	[2338]
Recommended	–	–	–	–	–	**4.87 ± 0.07**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				46. Palladium Pd				
fcc								
Pd(100)	–	–	–	–	–	4.3	TC	[2033]
Pd(100)	–	–	–	–	–	5.0	TC	[1023,1108,1109, 3126]
Pd(100)	–	–	?	~300	–	5.0 ± 0.2	PE	[1692]
Pd(100)	–	–	–	–	–	5.080	TC	[4091]
Pd(100)	–	–	–	–	–	5.11	TC	[4087]
Pd(100)	–	–	–	–	–	5.115	TC	[2229,2447]
Pd(100)	–	–	–	–	–	5.14	TC	[602,1008]
Pd(100)	–	–	–	–	–	5.16	TC	[4434]
Pd(100)/Fe(100)	–	–	–	–	–	5.2	TC	[2157]
Pd(100)	–	–	–	–	–	5.22	TC	[705]
Pd(100)	–	–	–	–	–	5.25	TC	[1024,3284]
Pd(100)	–	–	?	?	–	5.3	?	[1025]
Pd(100)	–	–	–	–	–	5.30	TC	[320,1012,1015, 1928]
Pd(100)	–	–	~10^{-11}	~300	–	5.5	PE	[2379]
Pd(100)[182]	–	–	–	–	–	5.50	TC	[704,795]
Pd(100)	–	–	–	–	–	5.50	TC	[2701]
Pd(100)	–	–	?	20	–	5.51	PE	[2642]
Pd(100)	–	–	–	–	–	5.54	TC	[2701]
Pd(100)	–	–	<10^{-9}	~300	–	5.55	PE	[1424]
Pd(100)[183]	–	–	2×10^{-11}	40–140	–	5.55 ± <0.1	PE	[1129]
Pd(100)	–	–	–	–	–	5.56	TC	[321]
Pd(100)	–	–	–	–	–	5.6	TC	[1734]
Pd(100)	–	–	?	80	–	5.60	PE	[3176]
Pd(100)	–	–	–	–	–	5.61	TC	[2405]
Pd(100)	–	–	?	?	–	5.65	?	[1809]
Pd(100)	–	–	1×10^{-10}	100	–	5.65 ± <0.1	PE	[672,914,1026, 3449]
Pd(100)	–	–	–	–	–	5.68	TC	[1259]
Pd(100)	–	–	–	–	–	5.72	TC	[704]
Pd(100)	–	–	?	110	–	5.8	PE	[2980]
Pd(100)	–	–	2×10^{-10}	~300	–	5.8 ± 0.2*	PE	[997]
Pd(100)	–	–	–	–	–	5.80	TC	[1027]
Pd(100)[182]	–	–	–	–	–	5.80	TC	[704,795]
Pd(100)	–	–	–	–	–	5.81	TC	[2405]
Pd(100)	–	–	–	–	–	5.82	TC	[704]
Pd(100)	–	–	~10^{-11}	77	–	5.9	PE	[3845]
Pd(100)	–	–	–	–	–	5.96	TC	[334]
Pd(100)	–	–	–	–	–	6.11	TC	[1259]
Recommended	–	–	–	–	–	**5.48 ± 0.04**	–	–
Pd(110)	–	–	–	–	–	4.781	TC	[2229,2447]
Pd(110)	–	–	–	–	–	4.860	TC	[4091]
Pd(110)	–	–	–	–	–	4.87	TC	[4087,4410]
Pd(110)	–	–	–	–	–	4.88	TC	[2916]
Pd(110)	–	–	–	–	–	4.90	TC	[602]
Pd(110)	–	–	–	–	–	4.98	TC	[602]
Pd(110)[184]	–	–	1×10^{-10}	100	–	~5	PE	[610]
Pd(110)	–	–	–	–	–	5.13	TC	[320]
Pd(110)	–	–	–	–	–	5.16	TC	[1931]
Pd(110)	–	–	?	110	–	5.2	PE	[2980]
Pd(110)	–	–	?	~300	–	5.2	PE	[1243]
Pd(110)[184]	–	–	1×10^{-10}	100	–	5.20 ± <0.1	PE	[672,914,1026, 3444]
Pd(110)	–	–	–	–	–	5.24	TC	[321]
Pd(110)	–	–	1×10^{-10}	100	–	5.25 ± 0.1	PE	[3449]
Pd(110)/Al(110)[185]	Pd	–	1×10^{-10}	~300	–	5.5	PE	[3495]
Pd(110)	–	–	4×10^{-10}	~300	–	5.83	PE	[1599]
Recommended	–	–	–	–	–	**5.12 ± 0.09**	–	–
Pd(111)	–	–	–	–	–	5.165	TC	[4308]
Pd(111)	–	–	–	–	–	5.18	TC	[602]
Pd(111)	–	–	–	–	–	5.198	TC	[2229,2447]
Pd(111)	–	–	–	–	–	5.20	TC	[2063]
Pd(111)	–	–	–	–	–	5.22	TC	[1028,1179]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pd(111)	–	–	–	–	–	5.23	TC	[4091]
Pd(111)	–	–	–	–	–	5.239	TC	[3657]
Pd(111)	–	–	–	–	–	5.25	TC	[1029,3991]
Pd(111)	–	–	–	–	–	5.25	TC	[4087,4410]
Pd(111)	–	–	–	–	–	5.26	TC	[1179]
Pd(111)	–	–	–	–	–	5.27	TC	[2913]
Pd(111)	–	–	–	–	–	5.30	TC	[1722]
Pd(111)	–	–	–	–	–	5.31	TC	[2068]
Pd(111)	–	–	–	–	–	5.33	TC	[3369]
Pd(111)	–	–	$<2 \times 10^{-10}$	~300	–	5.44 ± 0.03	PE	[985]
Pd(111)/Nb(110)	Pd	–	?	~300	–	5.48 ± 0.05*	PE	[3439]
Pd(111)/W(110)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.5	CPD	[2857,3123]
Pd(111)/Si(111)	Pd	–	~1×10^{-10}	298 (423)	–	5.5	PE	[2972]
Pd(111)/Ta(111)	Pd	–	$<3 \times 10^{-10}$	~300	–	5.5	CPD	[3232]
Pd(111)	–	–	–	–	–	5.53	TC	[320,2534]
Pd(111)[182]	–	–	–	–	–	5.53	TC	[704]
Pd(111)	–	–	–	–	–	5.53	TC	[1720]
Pd(111)/W(100)	Pd	–	$<5 \times 10^{-11}$	~300	–	5.55	CPD	[2847]
Pd(111)/Mo(110)	Pd	–	$\leq 7 \times 10^{-11}$	~300	–	5.55	CPD	[2861]
Pd(111)	–	–	$<2 \times 10^{-10}$	27, 90	–	5.55	CPD	[4107]
Pd(111)	–	–	~1×10^{-10}	~300	–	5.55 ± 0.1	PE	[998]
Pd(111)	–	–	–	–	–	5.57	TC	[2916]
Pd(111)	–	–	–	–	–	5.58	TC	[1720]
Pd(111)	–	–	–	–	–	5.59	TC	[1720]
Pd(111)	–	–	–	–	–	5.59	TC	[4282]
Pd(111)	–	–	$<3 \times 10^{-10}$	~300	–	5.6	PE	[3645]
Pd(111)	–	–	~1×10^{-10}	80	–	5.6	PE	[616,1799]
Pd(111)	–	–	?	~300	–	5.6	PE	[1243]
Pd(111)	–	–	?	140	–	5.6*	PE	[4067]
Pd(111)/Nb(110)	Pd	–	~10^{-10}	~300	–	5.6	PE	[1864]
Pd(111)	–	–	–	–	–	5.61	TC	[4024]
Pd(111)/Cu(111)[186]	Pd	–	5×10^{-9}	~300	–	5.61	CPD	[3364]
Pd(111)/Al(111)	Pd	–	4×10^{-10}	~300	–	5.62 ± 0.02	CPD	[1826]
Pd(111)	–	–	–	–	–	5.63	TC	[1179]
Pd(111)	–	–	–	–	–	5.64	TC	[1028,1179]
Pd(111)	–	–	–	–	–	5.64	TC	[1931]
Pd(111)/Al(111)	Pd	–	4×10^{-10}	~300	–	5.66 ± 0.04*	CPD	[1826]
Pd(111)	–	–	–	–	–	5.67	TC	[1931]
Pd(111)	–	–	–	–	–	5.67	TC	[4174,4284]
Pd(111)	–	–	–	–	–	5.75	TC	[1259]
Pd(111)	–	–	–	–	–	5.76	TC	[704]
Pd(111)	–	–	–	–	–	5.8	TC	[624]
Pd(111)[182]	–	–	–	–	–	5.86	TC	[704,795]
Pd(111)	–	–	–	–	–	5.90	TC	[334,3179]
Pd(111)	–	–	1×10^{-10}	100	–	5.90 ± <0.1	PE	[672]
Pd(111)/Al(111)	Pd	–	5×10^{-11}	~300	–	5.95	PE	[1915]
Pd(111)	–	–	~1×10^{-10}	100	–	5.95 ± <0.1	PE	[914,1026,3449]
Pd(111)	–	–	–	–	–	6.02	TC	[321]
Pd(111)	–	–	–	–	–	6.18	TC	[1259]
Recommended	–	–	–	–	–	**5.58 ± 0.05**	–	–
Pd(113)	–	–	–	–	–	5.64	TC	[704,795]
Pd	–	–	–	–	–	4.01	TC	[3476]
Pd	–	–	–	–	–	4.17	TC	[3476]
Pd	–	–	1×10^{-8}	~300	–	4.2	PE	[3325]
Pd	–	–	–	–	–	4.38	TC	[2990]
Pd/Al/Ta(111)[398]	Pd	–	8×10^{-8}	~300	–	4.38	PE	[2271]
Pd/Si(111)	–	–	–	–	–	4.4	TC	[2219]
Pd/Nb(110)	–	–	–	–	–	4.44	TC	[2913]
Pd	–	–	–	–	–	4.47	TC	[2005]
Pd	–	–	?	~300	–	4.49	CPD	[2297]
Pd/Si	–	–	–	–	–	4.50	TC	[1653]
Pd	–	–	–	–	–	4.51	TC	[1976]
Pd	–	–	–	–	–	4.52	TC	[3318]
Pd/Si	–	–	–	–	–	4.53	TC	[1653]
Pd	–	–	–	–	–	4.54	TC	[3318]
Pd	–	–	~10^{-8}	~300	–	4.54 ± 0.20	PE	[3104]
Pd	–	–	–	–	–	4.57	TC	[3476]
Pd[187]	–	–	~10^{-10}	~300	–	4.6 ± 0.15	PE	[350]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pd$_6$(cluster)	–	–	–	–	–	4.61	TC	[2990]
Pd^{188}	–	–	?	~300	–	4.61*	CPD	[1953]
Pd^{188}	–	–	?	~300	–	4.69 ± 0.06*	CPD	[1953]
Pd/Nb(110)	–	–	–	–	–	4.72	TC	[722]
Pd	–	–	–	–	–	4.72	TC	[1066]
Pd	–	–	–	–	–	4.73	TC	[1399]
Pd	–	–	–	–	–	4.77	TC	[2949]
Pd/C	Pd	–	<2 × 10^{-10}	~300	–	4.8	PE	[2392]
Pd/W	Pd	–	~10^{-10}	1180	–	4.8	FE	[2779]
Pd	–	–	–	–	–	4.80	TC	[1590]
Pd	–	–	~10^{-5}	≤1200	–	4.80	TE	[2216]
Pd/W	Pd	–	<10^{-10}	800	–	4.83	FE	[2964]
Pd$_4$(cluster)	–	–	–	–	–	4.855	TC	[2990]
Pd$_4$(cluster)	–	–	–	–	–	4.858	TC	[2990]
Pd$_{10}$(cluster)	–	–	–	–	–	4.87	TC	[2990]
Pd$_7$(cluster)	–	–	–	–	–	4.875	TC	[2990]
Pd/glass	Pd	–	<3 × 10^{-10}	78	–	4.88 ± 0.02	PE	[1031]
Pd$_7$(cluster)	–	–	–	–	–	4.882	TC	[2990]
Pd/W(110)	Pd	–	?	90 (900)	–	4.9*	CPD	[3560]
Pd	–	–	–	–	–	4.9*	TC	[1955]
Pd/Re	Pd	–	<4 × 10^{-10}	~300	–	4.9*	CPD	[1586]
Pd/Nb	Pd	–	≤3 × 10^{-9}	~300	–	4.9*	CPD	[3263]
Pd/W(100)	Pd	–	?	~300 (≤500)	–	4.9*	PE	[2039]
Pd/W(110)	Pd	–	?	~300 (≤500)	–	4.9*	PE	[2039]
Pd	–	–	–	–	–	4.9	TC	[706]
Pd	–	–	–	–	–	4.9	TC	[944]
Pd	–	–	?	?	–	4.9	TE	[3402]
Pd/glass	Pd	–	<1 × 10^{-10}	78	–	4.90	PE	[414]
Pd/quartz	Pd	–	≤5 × 10^{-10}	78	–	4.93 ± 0.02	PE	[435]
Pd/glass	Pd	–	<10^{-9}	77	–	4.95	PE	[2763,3046,3052]
Pd/Ta^{187}	Pd	–	~10^{-10}	~300	–	4.95 ± 0.05	PE	[350]
Pd	–	–	?	~300	–	4.96	PE	[1760]
Pd$_7$(cluster)	–	–	–	–	–	4.96	TC	[2990]
Pd^{264}	–	–	–	400	–	4.966	TC	[3586]
Pd^{264}	–	–	<10^{-7}	400	–	4.97	PE	[1189]
Pd^{264}	–	–	<10^{-7}	925	–	4.98	PE	[1189]
Pd^{264}	–	–	–	305–1078^E	–	4.985 ± 0.016	TC	[3586]
Pd^{264}	–	–	<10^{-7}	~1200–1400	–	4.99 ± 0.04	TE	[1189]
Pd^{264}	–	–	–	925	–	4.997	TC	[3586]
Pd/Si(111)	Pd	–	1 × 10^{-10}	~300	–	5.0*	CPD	[2732]
Pd/W	Pd	–	~10^{-10}	1180	–	5.0	FE	[2779,2780]
Pd/Ru(0001)	–	–	–	–	–	5.00	TC	[2554]
Pd	–	–	–	–	–	5.00	TC	[3264,3265,3267]
Pd	–	–	–	–	–	5.01	TC	[3264]
Pd/Ta(110)	–	–	–	–	–	5.05	TC	[3473]
Pd/glass	Pd	–	<3 × 10^{-10}	77 (298)	–	5.05 ± 0.03	PE	[1031]
Pd/cnt/Si(111)^{25}	–	–	~10^{-10}	~300	–	5.05 ± 0.06	PE	[3246]
Pd/Ta(112)	Pd	–	<1 × 10^{-10}	90, 300	–	5.06	CPD	[3314]
Pd/cnt/Si(111)^{25}	–	–	~10^{-10}	~300	–	5.06 ± 0.04	CPD	[3246]
Pd^{188}	–	–	?	~300	–	5.07 ± 0.01	CPD	[1953]
Pd	–	–	–	–	–	5.08	TC	[298]
Pd/W(110)	–	–	–	–	–	5.08	TC	[3473]
Pd/Re(0001)	–	–	–	–	–	5.09	TC	[3473]
Pd/W	Pd	–	~10^{-10}	980	–	5.1	FE	[2779]
Pd	–	–	–	–	–	5.1	TC	[2583]
Pd	–	–	–	–	–	5.1	TC	[1645]
Pd/Ta(110)^{398}	Pd	–	8 × 10^{-11}	~300	–	5.1	PE	[2271]
Pd/Mo(112)	Pd	–	<1 × 10^{-10}	100	–	5.1	CPD	[3210]
Pd/glass	Pd	–	~10^{-10}	293	–	5.11	PE	[1509]
Pd/glass	Pd	–	<1 × 10^{-10}	78 (293)	–	5.12	PE	[414]
Pd/quartz	Pd	–	≤5 × 10^{-10}	293	–	5.12 ± 0.03	PE	[435]
Pd/Cu(100)	Pd	–	2 × 10^{-10}	~300	–	5.14*	PE	[2041]
Pd/W(111)	Pd	–	<5 × 10^{-11}	~300	–	5.17	CPD	[2429]
Pd/SiO$_2$/Si	Pd	–	?	~300	–	5.18	CPD	[4330]
Pd/cnt/Si(111)^{25}	–	–	~10^{-10}	~300	–	5.19 ± 0.08	CPD	[3246]
Pd/Nb(100)	Pd	–	<1 × 10^{-10}	~300	–	5.2	CPD	[1253]
Pd	–	–	–	–	–	5.20	TC	[3016]
Pd/glass	Pd	–	<1 × 10^{-10}	78 (383)	–	5.20	PE	[414]
Pd/quartz	Pd	–	≤5 × 10^{-10}	293 (550)	–	5.20 ± 0.01	PE	[435]
Pd	–	–	<8 × 10^{-11}	~300	–	5.200 ± 0.100	CPD	[342]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pd/glass	Pd	–	$<1 \times 10^{-10}$	78 (483)	–	5.22	PE	[414,1031]
Pd/glass	Pd	–	$\sim10^{-10}$	293 (573)	–	5.22	PE	[1509]
Pd/glass	Pd	–	$<1 \times 10^{-10}$	78 (583)	–	5.22	PE	[414]
Pd	–	–	$<2 \times 10^{-10}$	27, 90	–	5.22	CPD	[4107]
Pd	–	–	–	–	–	5.22	TC	[3993]
Pd/Mo(111)	Pd	–	$\leq1 \times 10^{-10}$	300	–	5.24 ± 0.07*	CPD	[1836]
Pd	–	–	–	–	–	5.25	TC	[2205]
Pd/Al/Ta(110)[398]	Pd	–	8×10^{-11}	~300	–	5.25	PE	[2271]
Pd	–	–	–	–	–	5.27	TC	[3978]
Pd/Ru(0001)	–	–	–	–	–	5.29	TC	[3473]
Pd/Ir	Pd	–	$\sim10^{-9}$	~300	–	5.3	CPD	[417]
Pd/Mo(112)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.3	CPD	[3210]
Pd	–	–	1×10^{-10}	100	–	5.30 ± <0.1	PE	[672]
Pd	–	–	$\sim10^{-10}$	90	–	5.4	PE	[3048]
Pd/Au(111)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.4	PE	[3140]
Pd/Mo(111)	Pd	–	$\leq1 \times 10^{-10}$	~300	–	5.4	CPD	[1836]
Pd/Au(111)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.4	PE	[3140]
Pd/glass	Pd	–	$<10^{-9}$	293 (388)	–	5.40	PE	[3046,3052]
Pd(fp)[149]	–	–	$<10^{-9}$	~300	–	5.45 ± 0.1	PE	[3190]
Pd/W(110)	Pd	–	$<2 \times 10^{-10}$	27, 90	–	5.46	CPD	[4107]
Pd/Ag(111)	–	–	–	–	–	5.49	TC	[1720]
Pd	–	–	5×10^{-9}	~300	–	5.5	PE	[1020]
Pd/Ta(111)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.5	CPD	[3232]
Pd/Rh(100)	–	–	–	–	–	5.5	TC	[1009]
Pd/Ag(111)	–	–	–	–	–	5.51	TC	[1720]
Pd/Ru(0001)	Pd	–	1×10^{-10}	~300	–	5.53 ± 0.06*	TC	[2880]
Pd	–	–	$<10^{-9}$	~300	–	5.55 ± 0.05	PE	[2968]
Pd/quartz	Pd	–	$\sim10^{-10}$	~300	–	5.55 ± 0.1	PE	[304]
Pd	–	–	–	–	–	5.59	TC	[1744]
Pd/W(110)	Pd	–	?	90	–	5.6	PE	[2513,3563]
Pd/Si(111)	Pd	–	$\sim1 \times 10^{-10}$	298	–	5.6	PE	[1900,1906]
Pd/Ag(111)	Pd	–	$<4 \times 10^{-11}$	~300	–	5.6	PE	[3133]
Pd/Cu(111)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.6 ± 0.2	CPD	[1245,3417]
Pd/Ag(100)	–	–	–	–	–	5.67	TC	[2405]
Pd	–	–	–	–	–	5.7	TC	[944]
Pd/Cu(111)	Pd	–	$<1 \times 10^{-10}$	~300	–	5.9 ± 0.2	CPD	[1245,3417]
Recommended	–	–	–	–	–	**5.17 ± 0.06**	–	–

47. Silver Ag[404]

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag(100)	–	–	–	–	–	3.55	TC	[475]
Ag(100)	–	–	–	–	–	3.8	TC	[1260]
Ag(100)	–	–	–	–	–	3.89	TC	[2516]
Ag(100)	–	–	–	–	–	4.14	TC	[705]
Ag(100)	–	–	–	–	–	4.18	TC	[1193]
Ag(100)	–	–	–	–	–	4.19	TC	[4421]
Ag(100)	–	–	–	–	–	4.2	TC	[971,1108,1109, 2981]
Ag(100)	–	–	–	–	–	4.2	TC	[1261]
Ag(100)[189]	–	–	$<2 \times 10^{-10}$	~300	–	4.2	PE	[2128]
Ag(100)	–	–	–	–	–	4.20	TC	[4258]
Ag(100)	–	–	–	–	–	4.22	TC	[1190]
Ag(100)	–	–	$\sim10^{-10}$	~300	–	4.22 ± 0.04	PE	[625]
Ag(100)	–	–	–	–	–	4.246	TC	[4091]
Ag(100)	–	–	–	–	–	4.29	TC	[947]
Ag(100)	–	–	–	–	–	4.3	TC	[1692]
Ag(100)/V(100)	Ag	–	2×10^{-11}	250	–	4.3	PE	[3368]
Ag(100)	–	–	–	–	–	4.30	TC	[1034]
Ag(100)/NaCl[137]	Ag	–	?	~300 (473)	–	4.30 ± 0.02	PE	[3328,3330]
Ag(100)	–	–	2×10^{-10}	~300	–	4.3 ± 0.1	PE	[1263]
Ag(100)	–	–	–	–	–	4.31	TC	[4429]
Ag(100)	–	–	–	–	–	4.32 ± 0.03	TC	[3280]
Ag(100)	–	–	–	–	–	4.33	TC	[3280]
Ag(100)	–	–	–	–	–	4.33	TC	[1191,1264]
Ag(100)	–	–	$<10^{-10}$	~300	–	4.34 ± 0.03	PE	[1192]
Ag(100)	–	–	–	–	–	4.35	TC	[4117]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag(100)	–	–	2×10^{-10}	30	–	4.35 ± 0.05	PE	[3154]
Ag(100)	–	–	–	–	–	4.38	TC	[1190]
Ag(100)	–	–	?	?	–	4.4	?	[1262]
Ag(100)	–	–	$\sim 10^{-10}$	~ 300	–	4.41 ± 0.04	PE	[2064]
Ag(100)	–	–	2×10^{-10}	~ 300	–	4.42 ± 0.02	PE	[957,958]
Ag(100)	–	–	–	–	–	4.43	TC	[320]
Ag(100)	–	–	$\sim 10^{-10}$	~ 300	–	4.43	PE	[3703]
Ag(100)	–	–	–	–	–	4.43	TC	[1928]
Ag(100)	–	–	?	~ 300	–	4.43 ± 0.01	PE	[1131]
Ag(100)	–	–	–	–	–	4.44	TC	[1190]
Ag(100)[190]	–	–	–	–	–	4.45	TC	[2405]
Ag(100)	–	–	–	–	–	4.45	TC	[1159,3067]
Ag(100)	–	–	–	–	–	4.5	TC	[1261]
Ag(100)	–	–	4×10^{-11}	~ 300	–	4.5	PE	[2164]
Ag(100)	–	–	?	50	–	4.5	PE	[2909]
Ag(100)	–	–	–	–	–	4.50	TC	[2523]
Ag(100)/Ag(100)[191]	Ag	–	?	308–313	–	4.50*	PE	[2302]
Ag(100)	–	–	–	–	–	4.53	TC	[2524]
Ag(100)/NaCl	Ag	–	?	473	–	$\leq 4.58 \pm 0.01$	CPD	[1369]
Ag(100)	–	–	–	–	–	4.60	TC	[1193]
Ag(100)/NaCl[192]	Ag	–	?	~ 300	–	4.62 ± 0.03	CPD	[1157]
Ag(100)	–	–	$< 4 \times 10^{-11}$	~ 300	–	4.64	PE	[3134]
Ag(100)[193]	–	–	$< 1 \times 10^{-9}$	290	–	4.64 ± 0.02	PE	[626]
Ag(100)/Ag(100)[193]	Ag	–	$< 2 \times 10^{-9}$	290 (525)	–	4.64 ± 0.02	PE	[626]
Ag(100)	–	–	$< 4 \times 10^{-11}$	~ 300	–	4.65	PE	[3133]
Ag(100)/Ag(100)[194]	Ag	–	$\leq 3 \times 10^{-8}$	~ 300 (red)	–	4.72 ± 0.03	PE	[1132]
Ag(100)	–	–	–	–	–	4.74	TC	[627]
Ag(100)	–	–	–	–	–	4.75	TC	[1684]
Ag(100)/Ag(100)	Ag	–	?	~ 300	–	≤ 4.76	PE	[1158]
Ag(100)[190]	–	–	–	–	–	4.78	TC	[2405]
Ag(100)/NaCl[192]	Ag	–	?	~ 300	–	4.79	CPD	[1157]
Ag(100)[194]	–	–	$\leq 3 \times 10^{-8}$	~ 300	–	4.81 ± 0.01	PE	[1132,1881]
Ag(100)/Ag(100)[194]	Ag	–	$\leq 3 \times 10^{-8}$	~ 300	–	4.81 ± 0.03	PE	[1132]
Ag(100)	–	–	–	–	–	4.82	TC	[1237]
Ag(100)	–	–	–	–	–	4.82	TC	[1264]
Ag(100)	–	–	–	–	–	4.94	TC	[1428]
Ag(100)	–	–	–	–	–	4.95	TC	[1428]
Ag(100)	–	–	–	–	–	5.02	TC	[334]
Ag(100)/V(100)[195]	–	–	–	–	–	5.02	TC	[1876]
Ag(100)	–	–	–	–	–	5.06	TC	[321]
Recommended	–	–	–	–	–	**4.46 ± 0.05**	–	–
Ag(110)	–	–	–	–	–	3.35	TC	[475]
Ag(110)	–	–	–	–	–	3.66	TC	[2516]
Ag(110)	–	–	$< 2 \times 10^{-10}$	~ 300	–	3.9	PE	[1265]
Ag(110)	–	–	–	–	–	4.059	TC	[4091]
Ag(110)	–	–	–	–	–	4.06	TC	[3480]
Ag(110)/Re(1122)	Ag	–	$(< 1 \times 10^{-11})$	78 (≤ 650)	–	4.1 ± 0.02	FE	[1421]
Ag(110)	–	–	–	–	–	4.10	TC	[947]
Ag(110)	–	–	$\sim 10^{-10}$	~ 300	–	4.14 ± 0.04	PE	[625]
Ag(110)	–	–	–	–	–	4.17	TC	[1159,3067]
Ag(110)	–	–	–	–	–	4.19	TC	[3280]
Ag(110)	–	–	?	~ 300	–	4.2	PE	[2144]
Ag(110)	–	–	1×10^{-10}	~ 300	–	4.2 ± 0.1	PE	[1678]
Ag(110)	–	–	–	–	–	4.20	TC	[4117]
Ag(110)	–	–	–	–	–	4.23	TC	[320]
Ag(110)	–	–	$< 10^{-10}$	~ 300	–	4.25 ± 0.03	PE	[1192]
Ag(110)	–	–	4×10^{-11}	~ 300	–	4.3 ± 0.1	PE	[2164]
Ag(110)	–	–	–	–	–	4.30	TC	[1264]
Ag(110)	–	–	?	570	–	4.40	PE	[3169]
Ag(110)	–	–	–	–	–	4.40	TC	[334]
Ag(110)/Ag(110)[196]	Ag	–	$< 2 \times 10^{-9}$	290 (525)	–	4.51 ± 0.01	PE	[626]
Ag(110)/mica[196]	Ag	–	$< 2 \times 10^{-9}$	290 (525)	–	4.51 ± 0.02	PE	[626]
Ag(110)[196]	–	–	$< 1 \times 10^{-9}$	290	–	4.52 ± 0.02	PE	[626]
Ag(110)	–	–	?	570	–	4.53 ± 0.05	PE	[3169]
Ag(110)	–	–	–	–	–	4.66	TC	[1264]
Ag(110)	–	–	–	–	–	4.68	TC	[1237]
Ag(110)	–	–	?	570	–	4.70 ± 0.03	PE	[3169]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag(110)	–	–	–	–	–	4.75	TC	[1684]
Ag(110)	–	–	–	–	–	4.76	TC	[321]
Recommended	–	–	–	–	–	**4.28 ± 0.08**	–	–
Ag(111)	–	–	–	–	–	3.56	TC	[1194]
Ag(111)	–	–	–	–	–	3.70	TC	[475]
Ag(111)	–	–	–	–	–	3.96	TC	[2516]
Ag(111)/NaCl[137]	Ag	–	?	~300 (423)	–	3.98 ± 0.02	PE	[3328,3330]
Ag(111)[197]	–	–	~10^{-10}	~300	–	4.03	CPD	[1693]
Ag(111)[197]	–	–	~10^{-10}	~300	–	4.18	PE	[1693]
Ag(111)	–	–	–	–	–	4.25	TC	[4117]
Ag(111)	–	–	–	–	–	4.26	TC	[2077]
Ag(111)/quartz[198]	Ag	–	~10^{-9}	~300	–	4.35	PE	[3313]
Ag(111)	–	–	–	–	–	4.368	TC	[4091]
Ag(111)	–	–	–	–	–	4.38	TC	[2077]
Ag(111)/mica(111)	Ag	–	<5 × 10^{-11}	~300{~700}	–	4.38*	CPD	[1897]
Ag(111)	–	–	–	–	–	4.40	TC	[3280]
Ag(111)	–	–	–	–	–	4.40	TC	[947]
Ag(111)	–	–	–	–	–	4.44	TC	[2541]
Ag(111)	–	–	–	–	–	4.45	TC	[2541]
Ag(111)	–	–	–	–	–	4.45	TC	[2068]
Ag(111)	–	–	–	–	–	4.45	TC	[2983]
Ag(111)	–	–	~10^{-10}	~300	–	4.45	PE	[4143]
Ag(111)	–	–	<10^{-10}	~300	–	4.45 ± 0.03	PE	[1192]
Ag(111)	–	–	–	–	–	4.46	TC	[343]
Ag(111)[197]	–	–	~10^{-10}	~300	–	4.46 ± 0.02	PE	[625,1693]
Ag(111)	–	–	–	–	–	4.48	TC	[2523]
Ag(111)	–	–	–	–	–	4.49	TC	[2694]
Ag(111)	–	–	2 × 10^{-10}	~300	–	4.49 ± 0.02	PE	[1000]
Ag(111)	–	–	<4 × 10^{-11}	~300	–	4.5	PE	[3133]
Ag(111)	–	–	2 × 10^{-10}	~300	–	4.5	PE	[274,1196]
Ag(111)/mica[420]	Ag	–	4 × 10^{-10}	~300{570}	–	4.5	PE	[4001]
Ag(111)/Si(111)	Ag	–	1 × 10^{-10}	~300	–	4.5	PE	[1551]
Ag(111)	–	–	–	–	–	4.5 ± 0.1	TC	[3494]
Ag(111)	–	–	–	–	–	4.50	TC	[1197,4215,4413]
Ag(111)	–	–	1 × 10^{-10}	~300	–	4.50 ± 0.10	PE	[1195]
Ag(111)/W(110)	Ag	–	<10^{-10}	~300 (363)	–	4.53 ± 0.05	CPD	[2262]
Ag(111)/W(110)	Ag	–	?	~300	–	4.55	CPD	[4231]
Ag(111)/Cu(111)	Ag	–	<8 × 10^{-11}	~300	–	4.56	PE	[968]
Ag(111)	–	–	<2 × 10^{-10}	90	–	4.56	PE	[1266]
Ag(111)	–	–	<2 × 10^{-10}	~300	–	4.56	PE	[1133]
Ag(111)	–	–	–	–	–	4.56	TC	[3369]
Ag(111)	–	–	2 × 10^{-10}	~300	–	4.56	PE	[939,958]
Ag(111)	–	–	–	–	–	4.57	TC	[1722]
Ag(111)	–	–	4 × 10^{-11}	~300	–	4.6	PE	[2164]
Ag(111)/Re(1011)	Ag	–	(<1 × 10^{-11})	78 (≤650)	–	4.6 ± 0.02	FE	[1421]
Ag(111)	–	–	?	~300	–	4.60 ± 0.03	PE	[4213]
Ag(111)/W(110)	Ag	–	3 × 10^{-10}	~300	–	4.61 ± 0.05*	CPD	[2373]
Ag(111)/PTCDA[476]	Ag	–	2 × 10^{-10}	~300	–	4.61 ± 0.05	PE	[4341]
Ag(111)/quartz[198]	Ag	–	~10^{-9}	~300 (773)	–	4.64	PE	[3313]
Ag(111)	–	–	–	–	–	4.65	TC	[1264]
Ag(111)/W(110)	Ag	–	<7 × 10^{-11}	78 (450)	–	4.65 ± 0.03	FE	[2279]
Ag(111)/H:Si(111)[199]	Ag	–	~10^{-10}	~300	–	4.65 ± 0.15	PE	[1198]
Ag(111)/W(110)	Ag	–	≤2 × 10^{-10}	~300	–	4.66*	CPD	[1538]
Ag(111)	–	–	<1 × 10^{-10}	~300	–	4.66	CPD	[990]
Ag(111)/Ag(111)[194]	Ag	–	≤3 × 10^{-8}	~300 (red)	–	4.66 ± 0.03	PE	[1132]
Ag(111)	–	–	–	–	–	4.67	TC	[320,1178]
Ag(111)/W(110)	Ag	–	≤2 × 10^{-10}	500	–	4.68*	CPD	[1538]
Ag(111)	–	–	4 × 10^{-10}	100	–	4.68 ± 0.08	PE	[1579,2988]
Ag(111)/Nb(110)	Ag	–	7 × 10^{-11}	~300	–	4.69	PE	[2986]
Ag(111)	–	–	<5 × 10^{-11}	~300	–	4.69	PE	[1124]
Ag(111)/Re(0001)	Ag	–	4 × 10^{-10}	300, 740	–	4.7	CPD	[836]
Ag(111)/Si(100)	Ag	–	?	~300	–	4.7	PE	[1199]
Ag(111)/Pt(111)[200]	Ag	–	?	~300 (600)	–	4.7	PE	[2182]
Ag(111)	–	–	–	–	–	4.702 ± 0.017	TC	[2352]
Ag(111)[198]	–	–	–	–	–	4.72	TC	[3313]
Ag(111)/Ag[201]	Ag	–	?	58 (330)	–	4.72	PE	[1422]
Ag(111)/mica[202]	Ag	–	<2 × 10^{-9}	290 (525)	–	4.72 ± 0.01	PE	[626]
Ag(111)	–	–	~10^{-10}	~300	–	4.73	PE	[4340]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag(111)/Si(100)	Ag	–	?	110 (~300)	–	4.74	PE	[3238]
Ag(111)	–	–	–	–	–	4.74	TC	[1159,3067]
Ag(111)	–	–	–	–	–	4.74	TC	[2551]
Ag(111)	–	–	<2 × 10⁻¹⁰	27, 90	–	4.74	CPD	[4107]
Ag(111)[202]	–	–	<2 × 10⁻⁹	~300	–	4.74 ± 0.02	PE	[626,1134]
Ag(111)	–	–	?	~300	–	4.75	PE	[3779]
Ag(111)	–	–	–	–	–	4.75	TC	[1720]
Ag(111)/W(112)	Ag	–	≤7 × 10⁻¹¹	~300 (800)	–	4.75	CPD	[2385]
Ag(111)[194]	–	–	≤3 × 10⁻⁸	~300	–	4.75 ± 0.01	PE	[1132,1881]
Ag(111)/Ag(111)[194]	Ag	–	≤3 × 10⁻⁸	~300	–	4.75 ± 0.03*	PE	[1132]
Ag(111)/W(110)	Ag	–	3 × 10⁻¹⁰	330–390	–	4.75 ± 0.08*	CPD	[2373]
Ag(111)[203]	–	–	2 × 10⁻¹¹	50–60	–	4.76 ± 0.1	PE	[2266]
Ag(111)	–	–	–	–	–	4.80	TC	[1720]
Ag(111)	–	–	~10⁻¹⁰	100–670	–	4.84 ± 0.03	PE	[3142]
Ag(111)	–	–	–	–	–	4.85	TC	[1684]
Ag(111)	–	–	–	–	–	4.85	TC	[233]
Ag(111)/Ru(001)[203]	Ag	–	2 × 10⁻¹¹	~60 (500)	–	4.90 ± 0.1	PE	[2266]
Ag(111)	–	–	?	~300	–	≥4.9 ± 0.1*	CPD	[1879]
Ag(111)	–	–	–	–	–	4.92	CT	[4174,4284]
Ag(111)	–	–	–	–	–	4.95	TC	[1237]
Ag(111)	–	–	–	–	–	4.98	TC	[1264]
Ag(111)	–	–	–	–	–	4.99	TC	[1720]
Ag(111)	–	–	–	–	–	5.01	TC	[334,3179]
Ag(111)	–	–	–	–	–	5.46	TC	[321]
Recommended	–	–	–	–	–	**4.64 ± 0.06**	–	–
Ag	–	–	?	~1230 (~m.p.)	–	3.09	TE	[3385]
Ag	–	–	–	–	–	3.19	TC	[521]
Ag	–	–	–	–	–	3.43	TC	[2629]
Ag	–	–	–	–	–	3.49	TC	[475]
Ag	–	–	?	~1230 (~m.p.)	–	3.56	TE	[1362]
Ag	–	–	–	–	–	3.6	TC	[3590]
Ag	–	–	6 × 10⁻³	~300	–	3.64 ± 0.07	PE	[2079,2080]
Ag	–	–	?	~300	–	3.67	PE	[2460]
Ag/W(100)	Ag	–	?	415, 550	–	3.7*	FE	[2263]
Ag	–	–	–	–	–	3.72	TC	[2523]
Ag/W(100)	Ag	–	?	370	–	3.8*	FE	[2263]
Ag/W	Ag	–	<5 × 10⁻¹⁰	~300	–	3.8	FE	[3116]
Ag	–	–	?	~300	–	3.80	PE	[3018]
Ag	–	–	–	–	–	3.82	TC	[1150]
Ag	–	–	<10⁻⁶	~300	–	3.85	PE	[2919]
Ag/W(100)	Ag	–	?	415, 550	–	3.9	FE	[2263]
Ag/W(100)	Ag	–	?	650	–	3.9*	FE	[2263]
Ag	–	–	~10⁻¹⁰	373,	–	3.94	CPD	[2118]
Ag/glass	Ag	–	~10⁻⁶	373, 473	–	3.94 ± 0.01	PE	[3507]
Ag	–	–	?	~300	–	4.0	PE	[3639]
Ag/silica	Ag	–	~10⁻⁸	~300	–	4.0	PE	[1989]
Ag/W(100)	Ag	–	?	370	–	4.0	FE	[2263]
Ag/Mo(111)	Ag	–	<1 × 10⁻¹⁰	~300	–	4.0	CPD	[1842]
Ag	–	–	–	–	–	4.0 ± 0.05	TC	[1990]
Ag/quartz	Ag	–	~10⁻¹⁰	~300	–	4.0 ± 0.15	PE	[304]
Ag	–	–	–	–	–	4.00	TC	[1885]
Ag	–	–	–	–	–	4.00 ± 0.05	TC	[3358]
Ag/glass	Ag	–	~10⁻⁶	373	–	4.01 ± 0.01	PE	[3507]
Ag	–	–	~10⁻⁶	296	–	4.01 ± 0.05	CPD	[1487,1505]
Ag	–	–	5 × 10⁻⁸	296	–	4.03 ± 0.04	CPD	[1487]
Ag	–	–	4 × 10⁻⁹	733	–	4.04 ± 0.07	PE	[1116]
Ag	–	–	5 × 10⁻⁸	296	–	4.05 ± 0.05	CPD	[1542]
Ag[209]	–	–	?	~300	–	4.06 ± 0.05	PE	[2729]
Ag	–	–	?	~1200	–	4.08	TE	[1944]
Ag₄(cluster)	–	–	–	–	–	4.08	TC	[2990]
Ag	–	–	4 × 10⁻⁹	533	–	4.08 ± 0.07	PE	[1116]
Ag/W(100)	Ag	–	?	650	–	4.1	FE	[2263]
Ag/Ta(111)	Ag	–	<1 × 10⁻¹⁰	~300	–	4.1	CPD	[2441]
Ag/W(111)	Ag	–	5 × 10⁻¹⁰	~300	–	4.1	CPD	[2363]
Ag	–	–	–	–	–	4.1	TC	[944]
Ag	–	–	–	–	–	4.1	TC	[2456]
Ag/Si(111)ⁿ	Ag	–	3 × 10⁻¹¹	60 (750)	–	4.11	PE	[2660]
Ag	–	–	–	–	–	4.13	TC	[2005]
Ag	–	–	–	–	–	4.16	TC	[3476]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag	–	–	–	–	–	4.18	TC	[1066]
Ag/glass	Ag	–	$<1 \times 10^{-10}$	78	–	4.18	PE	[414,2723]
Ag/glass	Ag	–	$\sim 10^{-6}$	373	–	4.18 ± 0.01	PE	[3507]
Ag/W	Ag	–	8×10^{-11}	300 (450)	–	4.18 ± 0.02	FE	[3430]
Ag$_n$(n → ∞)	–	–	?	~300	–	4.19	IP, TC	[4197]
Ag	–	–	–	–	–	4.2	TC	[1993]
Ag/H:Si(111)[199]	Ag	–	$\sim 10^{-10}$	~300{210}	–	4.2	PE	[1198]
Ag/W	Ag	–	$\sim 10^{-10}$	78{920}	–	4.2	FE	[3089]
Ag/W	Ag	–	$<5 \times 10^{-10}$	800	–	4.2	FE	[3116]
Ag/Ir	Ag	–	?	78 (589)	–	4.20	FE	[2189]
Ag/glass	Ag	–	?	77–90	–	4.20	PE	[2763,3046]
Ag	–	–	?	~300	–	4.21	CPD	[3405]
Ag/W	Ag	–	8×10^{-11}	~300 (780)	–	4.22 ± 0.02	FE	[3430]
Ag/glass	Ag	–	$<10^{-9}$	77–90	–	4.23	PE	[1389]
Ag/W	Ag	–	$<5 \times 10^{-8}$	~300	–	4.23 ± 0.08*	CPD	[2570]
Ag	–	–	–	–	–	4.24	TC	[2629]
Ag/Ag[201]	Ag	–	?	60	–	4.25	PE	[1422]
Ag	–	–	?	~300	–	4.25	PE	[2992]
Ag[431]	–	–	$<5 \times 10^{-8}$	1150–1230	–	4.25*	TE	[1466]
Ag/W	Ag	–	?	~300	–	4.25	FE	[3108]
Ag(fp)[204]	–	–	? (He)	?	–	4.25 ± 0.1	PE	[1562]
Ag[205]	–	–	–	–	–	4.26	TC	[3280,3720]
Ag	–	–	–	–	–	4.26	TC	[3318]
Ag	–	–	–	–	–	4.26	TC	[339]
Ag/quartz	Ag	–	$<2 \times 10^{-9}$	290 (473)	–	4.26 ± 0.02	PE	[626]
Ag[447]	–	–	4×10^{-9}	296 (≤773)	–	4.26 ± 0.03	PE	[1116,3788,4082, 4114,4132–4134]
Ag/KBr	Ag	–	?	~300	–	4.28	PE	[1952]
Ag/W	Ag	–	($<1 \times 10^{-11}$)	78 (490)	–	4.28 ± 0.02	FE	[1421]
Ag	–	–	–	–	–	4.29	TC	[3318]
Ag	–	–	?	~300	–	4.29 ± 0.02	CPD	[2810]
Ag	–	–	$<10^{-8}$	~300	–	4.29 ± 0.02	CPD	[1163]
Ag/V(100)	Ag	–	2×10^{-11}	250	–	4.3	PE	[3368]
Ag/W(100)	Ag	–	5×10^{-10}	~300	–	4.3	CPD	[2363]
Ag/W	Ag	–	$<5 \times 10^{-10}$	680, 930	–	4.3	FE	[3116]
Ag/Fe(100)	–	–	–	–	–	4.3	TC	[2901]
Ag	–	–	–	–	–	4.3	TC	[706]
Ag	–	–	2×10^{-11}	~300	–	4.3 ± 0.1	PE	[1251]
Ag/glass	Ag	–	?	~300	–	4.30	CPD	[1157]
Ag	–	–	–	–	–	4.30	TC	[3264,3265,3267]
Ag	–	–	$<1 \times 10^{-10}$	~300	–	4.30	CPD	[2198]
Ag	–	–	–	–	–	4.30	TC	[298]
Ag/GaP	–	–	–	–	–	4.30	TC	[1653]
Ag/glass	Ag	–	$<10^{-8}$	~300	–	4.30 ± 0.02	CPD	[349]
Ag	–	–	$\sim 10^{-10}$	~300	–	4.30 ± 0.04	PE	[2064]
Ag/glass	Ag	–	5×10^{-11}	~300	–	4.30 ± 0.05	CPD	[1071]
Ag/various[404]	–	–	–	–	–	4.30 ± 0.13*	TC	[3280]
Ag	–	–	–	–	–	4.31	TC	[3637]
Ag/graphite	Ag	–	?	~1160–1200	–	4.31 ± 0.03	TE	[2236]
Ag/Ta[242]	Ag	–	?	~300	–	4.31 ± 0.03	CPD	[1050]
Ag/glass	Ag	–	$\sim 10^{-8}$	~300	–	4.31 ± 0.03	CPD	[133]
Ag	–	–	–	–	–	4.32	TC	[3476]
Ag/Ta	–	–	$<5 \times 10^{-8}$	1234(m.p.)	–	4.32	TE	[1466]
Ag/Re	Ag	–	($<1 \times 10^{-11}$)	78 (490)	–	4.32 ± 0.02	FE	[1421]
Ag/V(100)	–	–	–	–	–	4.32 ± 0.03	TC	[2437]
Ag	–	–	$<10^{-10}$	~300	–	4.32 ± 0.03	PE	[1192]
Ag/W	Ag	–	$\leq 5 \times 10^{-8}$	~300	–	4.32 ± 0.03	CPD	[690]
Ag/Mo(100)	Ag	–	$<2 \times 10^{-10}$	~300	–	4.32 ± 0.03*	CPD	[2252]
Ag/glass	Ag	–	5×10^{-11}	~300	–	4.32 ± 0.07*	CPD	[1071]
Ag/NaCl	Ag	–	?	90	–	4.33	PE	[1952]
Ag/glass	Ag	–	$<1 \times 10^{-10}$	78 (293)	–	4.33	PE	[414,1509,2723]
Ag/W	Ag	–	$<5 \times 10^{-9}$	298	–	4.33	FE	[2245]
Ag/W	Ag	–	?	~300 (550)	–	4.33	FE	[3345]
Ag	–	–	–	–	–	4.33	TC	[3931]
Ag/W	Ag	–	$\leq 8 \times 10^{-10}$	~300 (550)	–	4.33 ± 0.03	FE	[1689]
Ag/W	Ag	–	$\leq 5 \times 10^{-8}$	~300	–	4.33 ± 0.05	CPD	[690]
Ag	–	–	?	90	–	4.33 ± 0.05	CPD	[1366]
Ag/Si(111)	Ag	–	?	~300	–	4.33 ± 0.07	PE	[2776]
Ag(fp, r → ∞)[460]	–	–	?	~300	–	4.34*	IP	[4198]
Ag(fp, r → ∞)[460]	–	–	?	~300	–	4.35*	IP	[4198]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag/glass	Ag	–	$<1 \times 10^{-10}$	78 (378)	–	4.35	PE	[414,2723]
Ag/quartz[198]	Ag	–	$\sim10^{-9}$	~300	–	4.35	PE	[3313]
Ag	–	–	?	~300	–	4.35	PE	[4159]
Ag/W	Ag	–	$\leq5 \times 10^{-8}$	~300	–	4.35 ± 0.05	CPD	[690]
Ag/Ta	Ag	–	?	~300	–	4.35 ± 0.05	CPD	[1050]
Ag	–	–	6×10^{-9}	~300	–	4.36	PE	[1139]
Ag/Ta	Ag	–	$\sim10^{-8}$	~300	–	4.36 ± 0.05	CPD	[1385]
Ag/VO$_2$(100)	–	–	–	–	–	4.365	TC	[1934]
Ag/glass	Ag	–	$<1 \times 10^{-10}$	78 (485)	–	4.37	PE	[414,2723]
Ag(fp, $r \to \infty$)[206]	–	–	–	–	–	4.37	TC	[3442]
Ag/DiMe[476]	Ag	–	2×10^{-10}	~300	–	4.37 ± 0.05	PE	[4341]
Ag/glass	Ag	–	5×10^{-11}	~300	–	$4.37 \pm 0.06^*$	CPD	[1071]
Ag/glass	Ag	–	$\sim10^{-10}$	90	–	4.38	PE	[3048]
Ag/Ir	Ag	–	?	78 (442)	–	4.38	FE	[2189]
Ag/glass	Ag	–	$<5 \times 10^{-10}$	78 (573)	–	4.38	PE	[1509]
Ag/glass	Ag	–	$<10^{-8}$	78	–	4.38 ± 0.02	CPD	[1646]
Ag/glass	Ag	–	$<10^{-9}$	90 (293)	–	4.39	PE	[2763,3046]
Ag/W	Ag	–	5×10^{-10}	78 (740)	–	4.39 ± 0.01	FE	[1673]
Ag/quartz	Ag	–	$<1 \times 10^{-9}$	323	–	4.39 ± 0.05	CPD	[1536]
Ag/glass	Ag	–	5×10^{-11}	~300	–	$4.39 \pm 0.07^*$	CPD	[1071]
Ag/Ag(100)[191]	Ag	–	?	≤300	–	4.4^*	PE	[2302]
Ag/Fe(100)	Ag	–	?	~300	–	4.4	PE	[2901]
Ag/Pd(100)	–	–	–	–	–	4.4	TC	[1692]
Ag/Mo(100)	Ag	–	$<2 \times 10^{-10}$	~300	–	4.4^*	CPD	[3121]
Ag	–	–	$<2 \times 10^{-10}$	~300	–	4.4	CPD	[4214]
Ag/glass[367]	Ag	–	$<10^{-9}$	~300 (520)	–	4.4	CPD	[1893]
Ag/Pt(111)	Ag	–	?	~300	–	4.4	CPD	[2869]
Ag/Pt(111)[200]	Ag	–	?	~300	–	4.4	PE	[2182]
Ag/Pd(100)	–	–	–	–	–	4.4	TC	[1692]
Ag	–	–	?	~300	–	4.4	PE	[1838]
Ag	–	–	$\sim10^{-9}$	~300	–	4.4 ± 0.1	PE	[1267]
Ag	–	–	$\sim10^{-6}$	623	–	4.40 ± 0.02	PE	[3098]
Ag/GaP	–	–	–	–	–	4.41	TC	[1653]
Ag/Mo[207]	Ag	–	$<5 \times 10^{-8}$	~300	–	4.41	PE	[1051]
Ag/quartz	Ag	–	$<5 \times 10^{-8}$	~300	–	4.41	PE	[1051]
Ag/Si	–	–	–	–	–	4.41	TC	[1653]
Ag/Si(111)	Ag	–	5×10^{-11}	~300	–	4.41 ± 0.05	CPD	[613,636]
Ag	–	–	–	–	–	4.42	TC	[1976]
Ag	–	–	–	–	–	4.43^*	TC	[1955]
Ag/Si	–	–	–	–	–	4.44	TC	[1653]
Ag	–	–	?	~300	–	4.44	CPD	[2297]
Ag/Ta	Ag	–	$<10^{-8}$	~300	–	4.44 ± 0.01	CPD	[349]
Ag	–	–	$\sim10^{-6}$	523	–	4.44 ± 0.03	PE	[3098]
Ag	–	–	–	–	–	4.46	TC	[1645]
Ag/Mo	Ag	–	$\sim10^{-8}$	~300	–	4.46	CPD	[299]
Ag	–	–	1×10^{-9}	~300	–	4.46	CPD	[1252]
Ag/glass	Ag	–	?	~300	–	4.46 ± 0.01	CPD	[1369]
Ag/Si	Ag	–	$<6 \times 10^{-9}$	~300	–	4.46 ± 0.02	CPD	[1540]
Ag/glass	Ag	–	?	~300	–	4.47	CPD	[1157]
Ag/W(110)	Ag	–	?	90	–	4.47	CPD	[3565]
Ag/Re(1010)[211]	Ag	–	$(<1 \times 10^{-11})$	78 (≤770)	–	$4.47 \pm 0.05^*$	FE	[1421]
Ag/Pt(111)	Ag	–	$<8 \times 10^{-11}$	$\sim300(\sim800)$	–	$4.47 \pm 0.06^*$	CPD	[4180]
Ag/W	Ag	–	$(<1 \times 10^{-12})$	800	–	4.48	FE	[1676]
Ag/glass	Ag	–	$<10^{-9}$	77 (295)	–	4.48	PE	[1389]
Ag/Si(111)	Ag	–	4×10^{-10}	~300	–	4.48	PE	[3589]
Ag	–	–	4×10^{-10}	~300	–	4.48 ± 0.02	PE	[1552]
Ag/C	Ag	–	$<10^{-9}$	~300	–	4.49	CPD	[2958]
Ag/Ta	Ag	–	$\sim10^{-8}$	~300	–	4.49 ± 0.02	CPD	[1385]
Ag/Si(111)	Ag	–	4×10^{-10}	~300	–	4.49 ± 0.02	PE	[1552]
Ag	–	–	–	–	–	4.5	TC	[2583]
Ag/W(110)	Ag	–	$\leq1 \times 10^{-10}$	90	–	4.5	CPD	[3472]
Ag	–	–	–	–	–	4.50	TC	[1399]
Ag	–	–	$<2 \times 10^{-9}$	~300	–	4.50	PE	[1575]
Ag/Ag	Ag	–	$<5 \times 10^{-8}$	~300	–	4.50 ± 0.02	PE	[1051]
Ag/Re(1010)	Ag	–	$(<1 \times 10^{-11})$	78 (≤770)	–	4.50 ± 0.05	FE	[1421]
Ag(fp)[149]	–	–	$<10^{-9}$	~300	–	4.50 ± 0.1	PE	[3190]
Ag	–	–	?	~300	–	4.51 ± 0.01	PE	[3609]
Ag/Pd(111)	–	–	–	–	–	4.54	TC	[985]
Ag/W(111)	–	–	–	–	–	4.54	TC	[531]
Ag	–	–	$\leq1 \times 10^{-9}$	~300	–	4.55	PE	[3383]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag/W(110)	Ag	–	$<7 \times 10^{-11}$	78 (450)	–	4.55	FE	[2279]
Ag/quartz	Ag	–	?	~300	–	4.55	PE	[4202]
Ag/Pd(111)	Ag	–	$<2 \times 10^{-10}$	~300	–	4.55	PE	[985]
Ag/Mo[207]	Ag	–	$<5 \times 10^{-8}$	~300 (≤370)	–	4.55 ± 0.05	PE	[1051]
Ag/Ta(112)	Ag	–	$<1 \times 10^{-10}$	~300	–	4.56	CPD	[878]
Ag/W(110)	Ag	–	?	~300 (700)	–	4.56	CPD	[3565]
Ag[263]	–	–	$\leq 3 \times 10^{-8}$	873	–	4.56 ± 0.06	PE	[3391]
Ag/Pd(111)	–	–	–	–	–	4.57	TC	[985]
Ag/Cu(111)	Ag	–	?	~300	–	4.57 ± 0.05*	CPD	[2692]
Ag/glass	Ag	–	?	~300	–	4.58	PE	[3029]
Ag/Pt(111)	Ag	–	2×10^{-10}	350	–	4.58 ± 0.05*	CPD	[4366]
Ag	–	–	?	~300	–	4.59	PE	[4278]
Ag(fp)[208]	–	–	?	~300	–	4.59 ± 0.05	PE	[3127]
Ag	–	–	–	–	–	4.594	TC	[2649]
Ag[209]	–	–	?	~300	–	4.6	PE	[2729]
Ag/W(110)[210]	Ag	–	$<10^{-10}$	~300	–	4.6	FE	[1828]
Ag/W(110)[210]	Ag	–	5×10^{-10}	~300	–	4.6	CPD	[2363]
Ag/O/V(100)	Ag	–	4×10^{-11}	220 (≤700)	–	4.6 ± 0.1	PE	[3375]
Ag/Pd(100)[210]	Ag	–	?	~300	–	4.6 ± 0.2	PE	[1692]
Ag	–	–	~10^{-5}	<1200	–	4.60	TE	[2216]
Ag/glass	Ag	–	~10^{-10}	77 (373)	–	4.60	PE	[2155]
Ag/Pd(111)	–	–	–	–	–	4.60	TC	[985]
Ag	–	–	?	296	–	4.61	PE	[1455]
Ag/Ir(100)	Ag	–	?	78 (≤518)	–	4.63 ± 0.02	FE	[2189]
Ag/quartz[198]	Ag	–	~10^{-9}	~300 (773)	–	4.64	PE	[3313]
Ag/Ta(112)[210]	Ag	–	$<1 \times 10^{-10}$	~300	–	4.65	CPD	[878]
Ag/W(110)[210]	Ag	–	$\leq 1 \times 10^{-10}$	90 (700)	–	4.67	CPD	[3472]
Ag	–	–	?	~300	–	4.68	PE	[3025]
Ag	–	–	$<5 \times 10^{-8}$	~300	–	4.68 ± 0.01	PE	[1051]
Ag/Nb(110)[210]	Ag	–	7×10^{-11}	~300	–	4.69	PE	[2986]
Ag/W(110)[210]	Ag	–	?	~300	–	4.7	CPD	[3565]
Ag/Re(0001)	Ag	–	4×10^{-10}	~300, 740	–	4.7	CPD	[836]
Ag	–	–	?	?	–	4.7	TE	[3402]
Ag/W(110)	Ag	–	$\leq 7 \times 10^{-11}$	~300 (~950)	–	4.7	CPD	[2388]
Ag/Ru(001)	Ag	–	$<5 \times 10^{-10}$	60	–	4.7 ± 0.05	PE	[2651]
Ag	–	–	–	–	–	4.70	TC	[3476]
Ag	–	–	1×10^{-8}	~300	–	4.7 ± 0.2	PE	[3325]
Ag/Pt(100)	Ag	–	1×10^{-10}	~300	–	4.71 ± 0.15	PE	[174]
Ag	–	–	–	–	–	4.72	TC	[2990]
Ag/W(100)	–	–	–	–	–	4.72	TC	[531]
Ag	–	–	1×10^{-5}	~300	–	4.73	CPD	[1883]
Ag[263]	–	–	–	296	–	4.73 ± 0.02	TC	[1135]
Ag[263]	–	–	$\leq 3 \times 10^{-8}$	298	–	4.73 ± 0.07	PE	[3391]
Ag[263]	–	–	–	873	–	4.75 ± 0.00	TC	[1135]
Ag/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	4.75 ± 0.06	PE	[3246]
Ag/Ag(100)	Ag	–	?	~300	–	≤4.76	PE	[1158]
Ag/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	4.76 ± 0.09	CPD	[3246]
Ag/Pd(111)	–	–	–	–	–	4.77	TC	[985]
Ag/glass	Ag	–	–	~300	–	4.78	PE	[3023]
Ag/Mo[207]	Ag	–	$<5 \times 10^{-8}$	~300 (red)	–	4.78	PE	[1051]
Ag/W(112)	–	–	–	–	–	4.78	TC	[531]
Ag/Si(111)ⁿ	Ag	–	3×10^{-11}	~300	–	4.79	PE	[2660]
Ag/Si(111)	Ag	–	?	770	–	4.80 ± 0.08	PE	[2776]
Ag/Pt(997)	Ag	–	1×10^{-10}	~300	–	4.82 ± 0.15	PE	[174]
Ag/W(110)	–	–	–	–	–	4.84	TC	[531]
Ag/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	4.84 ± 0.10	CPD	[3246]
Ag/Pd(111)	–	–	–	–	–	4.86	TC	[1720]
Ag/Si(111)ᵖ	Ag	–	3×10^{-11}	~300	–	4.87	PE	[2660]
Ag	–	–	?	~300	–	4.90	PE	[3127]
Ag/Pd(111)	–	–	–	–	–	4.91	TC	[1720]
Ag/Pd(111)	–	–	–	–	–	4.92	TC	[1720]
Ag/Fe(100)	–	–	–	–	–	4.92	TC	[1105]
Ag/SiO₂/Si	Ag	–	?	~300 (570)	–	4.97	PE	[2355]
Ag/Rh(100)	–	–	–	–	–	5.0	TC	[1009]
Ag/Si(111)ᵖ	Ag	–	3×10^{-11}	60 (750)	–	5.02	PE	[2660]
Ag/Ru(0001)	–	–	–	–	–	5.03	TC	[2554]
Ag/Fe(100)	–	–	–	–	–	5.05	TC	[1105]
Ag/Rh(111)	–	–	–	–	–	5.2	TC	[1009]
Ag/Ru(0001)	Ag	–	1×10^{-10}	~300	–	5.26*	CPD	[2880]
Ag/Re(1010)[211]	Ag	–	$<1 \times 10^{-11}$	78 (≤770)	–	5.30 ± 0.02	FE	[1421]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ag	–	–	–	–	–	5.41	TC	[2551]
Recommended	–	–	–	–	–	**4.39 ± 0.02**	–	–
Liquid ($T > 1234$ **K**)								
Ag[456]	–	–	$<5 \times 10^{-8}$	1240	–	4.32*	TE	[1466]

48. Cadmium Cd

hcp

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cd(0001)	–	–	–	–	–	4.17	TC	[4005]
Cd(0001)	–	–	–	–	–	4.3	TC	[1711]
Cd(0001)	–	–	–	–	–	4.6	TC	[2375]
Cd(0001)	–	–	–	–	–	6.52	TC	[321]
Cd(1010)	–	–	–	–	–	4.76	TC	[4005]
Cd(1010)	–	–	–	–	–	6.30	TC	[321]
Cd(1124)	–	–	–	–	–	5.52	TC	[321]
Cd	–	–	–	–	–	3.36	TC	[521]
Cd	–	–	–	–	–	3.36	TC	[3211]
Cd	–	–	–	–	–	3.4	TC	[944]
Cd	–	–	$\sim 10^{-8}$	~ 300	–	3.4 ± 0.6	PE	[3433]
Cd/Pt(100)	–	–	–	–	–	3.43	TC	[3168]
Cd/Au(100)	–	–	–	–	–	3.43	TC	[3168]
Cd$_n$($n \to \infty$)	–	–	–	–	–	3.54 ± 0.27	TC	[4261]
Cd	–	–	–	–	–	3.6	TC	[2583]
Cd	–	–	?	~ 300	–	3.68	PE	[3027]
Cd	–	–	–	–	–	3.68	TC	[3168]
Cd	–	–	–	–	–	3.70	TC	[2629]
Cd	–	–	?	~ 300	–	3.73	PE	[2460]
Cd	–	–	? (N$_2$)	~ 300	–	3.80 ± 0.02	CPD	[4251]
Cd	–	–	? (Ar)	~ 300	–	3.83	CPD	[4253]
Cd/ins/Al[47]	Cd	–	?	~ 300	–	3.88 ± 0.08	CPD	[2028]
Cd	–	–	–	–	–	3.89	TC	[1744]
Cd	–	–	–	–	–	3.9*	TC	[1645]
Cd	–	–	–	–	–	3.9	TC	[3318]
Cd	–	–	–	–	–	3.93	TC	[3318]
Cd	–	–	6×10^{-3}	~ 300	–	3.94 ± 0.06	PE	[2079,2080]
Cd	–	–	–	–	–	3.96	TC	[1399]
Cd	–	–	–	–	–	3.97	TC	[3264,3265]
Cd	–	–	–	–	–	4.0	TC	[1993,2005]
Cd	–	–	–	–	–	4.0 ± 0.05	TC	[1990]
Cd	–	–	?	~ 300	–	4.00	CPD	[2297]
Cd	–	–	–	–	–	4.01	TC	[3352]
Cd	–	–	? (N$_2$)	~ 300	–	4.01 ± 0.02	CPD	[2361,2626,4226]
Cd	–	–	$<1 \times 10^{-5}$	~ 300	–	4.04	CPD	[1883]
Cd[212]	–	–	$\sim 10^{-6}$	~ 300	–	4.05 ± 0.06*	CPD	[1953]
Cd/glass	Cd	–	$<10^{-6}$	~ 300	–	4.06	PE	[1451]
Cd/brass	Cd	–	$\leq 10^{-8}$	~ 300	–	4.07 ± 0.2	PE	[2848]
Cd/Ta[214]	Cd	–	?	~ 300	–	4.08 ± 0.02	CPD	[1380]
Cd/glass	Cd	–	?	90	–	4.099	PE	[3031]
Cd/glass	Cd	–	?	90 (~ 300)	–	4.099	PE	[3031]
Cd	–	–	–	–	–	4.1	TC	[706]
Cd/W	Cd	–	$\leq 3 \times 10^{-9}$	375	–	4.1 ± 0.1	FE	[3047]
Cd	–	–	–	–	–	4.10	TC	[1885]
Cd	–	–	–	–	–	4.10	TC	[738]
Cd	–	–	–	–	–	4.11	TC	[298]
Cd[213]	–	–	$\sim 10^{-6}$	~ 300	–	4.11 ± 0.06*	CPD	[2087]
Cd	–	–	–	–	–	4.12	TC	[3267]
Cd	–	–	–	–	–	4.14	TC	[1901]
Cd/Ta[214]	Cd	–	?	~ 300	–	4.22 ± 0.01	CPD	[1380]
Cd[212]	–	–	$\sim 10^{-6}$	–	–	4.43 ± 0.01	CPD	[1953]
Cd	–	–	–	–	–	4.47	TC	[1066]
Cd[213]	–	–	?	~ 300	–	4.49 ± 0.01	CPD	[2087]
Cd	–	–	–	–	–	4.57	TC	[2629]
Recommended	–	–	–	–	–	**4.06 ± 0.05**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
						49. Indium In		
fcc								
In(100)	–	–	–	–	–	4.2	TC	[2375]
In(100)	–	–	–	–	–	4.6	TC	[2375]
In(100)	–	–	–	–	–	4.6	TC	[1714]
In(110)/PTCDA[477]	In	–	2×10^{-10}	~300	–	4.44 ± 0.05	PE	[4341]
In(111)	–	–	5×10^{-9}	~300	–	4.14 ± 0.05	PE	[2336]
In[379]	–	–	–	–	–	3.6	TC	[1955]
In	–	–	–	–	–	3.6	TC	[3318]
In	–	–	–	–	–	3.62	TC	[1744]
In	–	–	$\sim 10^{-7}$	~300	–	3.82 ± 0.05	PE	[2814]
In	–	–	$\sim 10^{-7}$	~300	–	3.825 ± 0.01	CPD	[2814]
In	–	–	–	–	–	3.84	TC	[2629]
In/Au(111)	In	–	$<10^{-10}$	80	–	3.85	CPD	[2661]
In/quartz[215]	In	–	$\sim 10^{-6}$	~300	–	3.85 ± 0.01	PE	[1475]
In	–	–	?	293	–	3.90	PE	[4139]
In	–	–	?	~300	–	3.90	PE	[4249]
In/quartz[215]	In	–	$\sim 10^{-6}$	~300	–	3.94 ± 0.01	PE	[1475]
In	–	–	?	419	–	3.96	PE	[4139]
In	–	–	–	–	–	3.97	TC	[1613]
In	–	–	–	–	–	3.97	TC	[2005]
In[160]	–	–	–	–	–	4.0	TC	[1355]
In	–	–	–	–	–	4.0	TC	[944]
In	–	–	–	–	–	4.0	TC	[3928]
In	–	–	$<10^{-9}$	~300	–	4.0	PE	[2321]
In	–	–	–	–	–	4.0	TC	[298]
In	–	–	–	–	–	4.0	TC	[706]
In	–	–	$\sim 10^{-9}$	~430	–	4.00	PE	[4241]
In	–	–	? (N_2)	~300	–	4.00 ± 0.02	CPD	[4251]
$In_n (n \to \infty)$	–	–	–	–	–	4.04	TC	[4244]
In	–	–	–	–	–	4.05	TC	[3352]
In	–	–	? (N_2)	~300	–	4.05 ± 0.02	CPD	[2624,2626,4083]
In	–	–	?	~430	–	4.07	PE	[4328]
In	–	–	–	–	–	4.08	TC	[3264,3265,3267]
In/glass	In	–	5×10^{-11}	77–90	–	4.08 ± 0.01	PE	[3319]
In	–	–	?	403	–	4.09 ± 0.01	PE	[2770,2771]
In	–	–	–	–	–	4.1	TC	[1993]
In/DiMe[477]	In	–	2×10^{-10}	~300	–	4.10 ± 0.05	PE	[4341]
$In_n (n \to \infty)$	–	–	?	~300	–	4.12	IP, TC	[4197]
In/quartz	In	–	$<3 \times 10^{-9}$	~153	–	4.12 ± 0.02	PE	[3672]
In	–	–	–	–	–	4.13	TC	[4418,4420]
In	–	–	–	–	–	4.16	TC	[3264]
In/W(110)	In	–	1×10^{-9}	~300	–	4.25 ± 0.05	CPD	[1986]
In	–	–	–	–	–	4.30	TC	[1901]
In/Au(111)	In	–	$<10^{-10}$	80	–	4.32	CPD	[2661]
In/Si(111)	In	–	2×10^{-10}	~300	–	4.34 ± 0.1	PE	[2623]
In/Si(111)	In	–	$<4 \times 10^{-10}$	~300	–	4.35	PE	[1566]
In/W	In	–	?	78 (?)	–	4.35 ± 0.1	FE	[2725]
In/Si(111)	In	–	$<3 \times 10^{-10}$	~300	–	4.39	PE	[3285]
In/W	In	–	$<2 \times 10^{-10}$	77 (≤500)	–	4.63	FE	[2727]
In	–	–	–	–	–	4.74	TC	[2629]
In	–	–	–	–	–	4.88	TC	[738]
Recommended	–	–	–	–	–	**4.05 ± 0.06**	–	–
Liquid ($T > 430$ K)								
In[438]	–	–	?	470	–	3.88	PE	[2111]
In	–	–	?	439	–	3.93	PE	[4139]
In	–	–	10^{-9}	~430	–	3.93	PE	[4241]
In	–	–	?	~430	–	4.03	PE	[4328]
In	–	–	?	447	–	4.06 ± 0.01	PE	[2770,2771]
In	–	–	$\leq 10^{-9}$	473	–	4.08 ± 0.04	PE	[2345,2349,2353]
In	–	–	$\leq 10^{-9}$	473	–	4.10	SP	[2349]
Recommended	–	–	–	–	–	**4.00 ± 0.08**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				50. Tin Sn				
bcc (α, T < 291 K)								
Sn(100)	–	–	–	–	–	3.47	TC	[3211]
Sn(100)	–	–	–	–	–	4.42	TC	[2536]
Sn(100)	–	–	–	–	–	4.43	TC	[2536]
Sn(100)	–	–	–	–	–	4.68	TC	[2536]
Sn(110)	–	–	–	–	–	4.77	TC	[3211]
Sn(111)	–	–	–	–	–	4.01	TC	[3211]
Sn(111)	–	–	$\leq 10^{-6}$	?	–	4.26	PE	[3580]
Sn(112)	–	–	–	–	–	4.46	TC	[1627]
bcc (α, T < 291 K for bulk)								
Sn	–	–	–	–	–	3.45	TC	[3211]
Sn	–	–	–	–	–	3.57	TC	[3211]
Sn/Au	Sn	–	$< 5 \times 10^{-10}$	173–203	–	4.13	CPD	[3561]
Sn	–	–	–	–	–	4.27	TC	[3211]
Sn/quartz	Sn	–	$< 10^{-6}$	20 (200)	–	4.288 ± 0.005	PE	[1467]
Sn/quartz	Sn	–	$< 10^{-6}$	14	–	4.306 ± 0.006	PE	[1467]
Sn/quartz	Sn	–	$< 10^{-6}$	20 (90)	–	4.309 ± 0.005	PE	[1467]
Sn/quartz	Sn	–	$< 10^{-6}$	90	–	4.309 ± 0.005	PE	[1467]
Sn/W	Sn	–	?	78 (?)	–	4.85 ± 0.1	FE	[2725]
Sn/W	Sn	–	$< 2 \times 10^{-10}$	77 ($\leq$500)	–	5.10	FE	[2725,2727]
Recommended	–	–	–	–	–	**4.27 $\pm$ 0.06**	–	–
Tetragonal (β, T = 291–473 K for bulk)								
Sn	–	–	?	~300	–	3.41	PE	[3683]
Sn/SiO$_2$/Si	Sn	–	?	~300 (570)	–	3.42	PE	[2355]
Sn	–	–	?	~300	–	3.62	PE	[2460]
Sn	–	–	–	–	–	3.8	TC	[2456]
Sn	–	–	–	–	–	3.8	TC	[3727]
Sn	–	–	–	–	–	3.85	TC	[2629]
Sn	–	–	6×10^{-3}	~300	–	3.87 ± 0.07	PE	[2079,2080]
Sn/Mo(110)	Sn	–	$\leq 5 \times 10^{-11}$	350	–	4.0*	CPD	[3290]
Sn	–	–	?	~300	–	4.06*	CPD	[3621]
Sn	–	–	?	~300	–	4.09	CPD	[2297]
Sn	–	–	–	–	–	4.1	TC	[298]
Sn	–	–	–	–	–	4.1	TC	[2583]
Sn	–	–	–	–	–	4.1	TC	[1993]
Sn/GaAs	–	–	–	–	–	4.10	TC	[3054]
Sn	–	–	–	–	–	4.13	TC	[2005]
Sn	–	–	?	~300	–	4.14	PE	[4159]
Sn	–	–	$\sim 10^{-9}$	293	–	4.16	PE	[2362]
Sn	–	–	?	~300	–	4.17	PE	[4249]
Sn	–	–	–	–	–	4.17	TC	[1613]
Sn	–	–	–	–	–	4.17	TC	[3352]
Sn	–	–	? (N$_2$)	~300	–	4.17 ± 0.02	CPD	[2361,2624,2628]
Sn	–	–	?	293	–	4.18	PE	[4139]
Sn	–	–	$\sim 10^{-9}$	293	–	4.18	PE	[1445]
Sn/steel	Sn	–	2×10^{-10}	~300	–	4.2 ± 0.1	PE	[1537]
Sn	–	–	?	~300	–	4.2 ± 0.2	PE	[2086]
Sn	–	–	–	–	–	4.23	TC	[1976]
Sn	–	–	$\sim 10^{-9}$	504	–	4.23	PE	[4241]
Sn	–	–	1×10^{-5}	~300	–	4.25	CPD	[1883]
Sn[216]	–	–	$\sim 10^{-6}$	~300	–	4.26 ± 0.06*	CPD	[2087]
Sn	–	–	?	~300	–	4.27 ± 0.04*	CPD	[4159]
Sn/ins/Al[47]	Sn	–	?	~300	–	4.28 ± 0.06	CPD	[2028]
Sn	–	–	–	–	–	4.29	TC	[1399]
Sn	–	–	–	–	–	4.3 ± 0.05	TC	[1990]
Sn/steel	Sn	–	($< 2 \times 10^{-10}$)	~300	–	4.3 ± 0.1	PE	[2838]
Sn/Mo	Sn	–	($< 2 \times 10^{-10}$)	~300	–	4.3 ± 0.1	PE	[2838]
Sn/Si(111)	Sn	–	$< 3 \times 10^{-10}$	~300	–	4.32	PE	[3281]
Sn	–	–	–	–	–	4.35	TC	[3264,3265,3267]
Sn	–	–	–	–	–	4.37	TC	[1885]
Sn	–	–	?	~300	–	4.38	CPD	[3256]
Sn[217]	–	–	–	358	–	4.39	TC	[1135]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Sn/brass	Sn	–	≤10^{-8}	~300	–	4.39 ± 0.13	PE	[2848]
Sn/Al(111)	Sn	–	<1 × 10^{-10}	~300	–	4.4	PE	[249]
Sn/Ni(111)	Sn	–	<1 × 10^{-10}	~300	–	4.4	PE	[249]
Sn/steel	Sn	–	(<2 × 10^{-10})	~300	–	4.4 ± 0.1	PE	[2838]
Sn/Mo	Sn	–	(<2 × 10^{-10})	~300	–	4.4 ± 0.1	PE	[2838]
Sn/Al$_2$O$_3$/Al	Sn	–	?	~300	–	4.42	CPD	[3057]
Sn	–	–	4 × 10^{-9}	299	–	4.42 ± 0.03	PE	[1116]
Sn	–	–	?	~300	–	4.47	CPD	[4159]
Sn	–	–	<1 × 10^{-10}	~300	–	4.5	PE	[249]
Sn	–	–	–	–	–	4.5	TC	[706]
Sn[217]	–	–	?	358	–	4.51 ± 0.02	PE	[1945–1947]
Sn/Si(111)	Sn	–	≤3 × 10^{-10}	~300	–	4.55	PE	[3285]
Sn/Al$_2$O$_3$/Al	Sn	–	?	~300	–	4.57 ± 0.06*	CPD	[3057]
Sn	–	–	–	–	–	4.63	TC	[1901]
Sn[216]	–	–	?	~300	–	4.63 ± 0.01	CPD	[2087]
Sn/W	Sn	–	?	400	–	4.67 ± 0.07*	FE	[3741]
Sn	–	–	–	–	–	4.76	TC	[2629]
Recommended	–	–	–	–	–	**4.34 ± 0.06**	–	–

Hexagonal (γ, T = 473–505 K for bulk)

Sn	–	–	?	495	–	4.22	PE	[4139]
Sn[218]	–	–	?	483	–	4.28	PE	[1135]
Sn[218]	–	–	?	483	–	4.38 ± 0.02	PE	[1945–1947]

Liquid (T > 505 K)

Sn[218]	–	–	–	673	–	4.17	TC	[1135]
Sn	–	–	?	515	–	4.18	PE	[4139]
Sn	–	–	~10^{-9}	506	–	4.19	PE	[4241]
Sn	–	–	?	>505	–	4.21*	CPD	[3575]
Sn[218]	–	–	?	673	–	4.22 ± 0.01	PE	[1945–1947]

51. Antimony Sb

Rhombohedral (arsenic structure)

Sb(100)	–	–	?	?	–	4.69	?	[3141]
Sb(100)/W(110)[219]	Sb	–	~10^{-9}	~300 (373)	–	4.7	CPD	[1272]
Sb(111)	–	–	≤10^{-6}	~300	–	4.26	PE	[3580]
Sb	–	–	1 × 10^{-5}	~300	–	4.01	PE	[2563]
Sb/Si(001)	–	–	–	–	–	4.03	TC	[2525]
Sb	–	–	–	–	–	4.05	TC	[1885]
Sb/W	Sb	–	<10^{-8}	~300	–	4.10 ± 0.03	CPD	[1163]
Sb	–	–	?	~300	–	4.14	CPD	[2297]
Sb	–	–	? (N$_2$)	~300	–	4.18 ± 0.02	CPD	[2624,2626,4226]
Sb	–	–	–	–	–	4.19	TC	[3352]
Sb	–	–	–	–	–	4.2	TC	[298]
Sb	–	–	–	–	–	4.3	TC	[1993]
Sb/Si	–	–	–	–	–	4.35	TC	[1653]
Sb	–	–	–	–	–	4.38	TC	[1653,1976]
Sb/Si(111)	Sb	–	≤8 × 10^{-11}	~300	–	4.43	PE	[1904]
Sb	–	–	–	–	–	4.48	TC	[2005]
Sb/quartz	Sb	–	<5 × 10^{-8}	~300	–	4.52	PE	[3625]
Sb/W(100)[219]	Sb	–	~10^{-9}	~300	–	4.55	CPD	[1955]
Sb	–	–	–	–	–	4.56	TC	[3264,3265,3267]
Sb/Ni,Mo,etc.	Sb	–	<5 × 10^{-8}	~300	–	4.56	PE	[1375]
Sb/?	Sb	–	?	~300 (473)	–	4.60	PE	[3255]
Sb/Si(111)	Sb	–	<3 × 10^{-10}	~300	–	4.61	PE	[3285]
Sb/Si(111)	Sb	–	?	~300	–	4.65	PE	[2849]
Sb/W	Sb	–	?	78 (>600)	–	4.65	FE	[3642]
Sb/Au(111)	Sb	–	3 × 10^{-10}	~300	–	4.65 ± 0.04	CPD	[2690]
Sb	–	–	–	–	–	4.7	TC	[1905,1906]
Sb	–	–	–	–	–	4.79	TC	[1901]
Sb	–	–	–	–	–	4.8	TC	[706]
Sb/W(100)[219]	Sb	–	~10^{-9}	423	–	4.98	CPD	[1995]
Recommended	–	–	–	–	–	**4.45 ± 0.09**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Amorphous								
Sb	–	–	–	–	–	3.92	TC	[1744]
Sb/?	Sb	–	?	~300	–	4.49	PE	[3255]
Sb/W(100)[219]	Sb	–	~10^{-9}	~300	–	4.55	CPD	[1995]
Sb/quartz	Sb	–	<5 × 10^{-8}	~300	–	4.7 ± 0.1	PE	[3625]

52. Tellurium Te

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hexagonal								
Te(1010)	–	–	~10^{-11}	~300	–	4.65 ± 0.05	PE	[2482,4248]
Te(1010)	–	–	~10^{-10}	~300	–	4.95	PE	[3429]
Te/ins/Al[47]	Te	–	?	~300	–	3.95 ± 0.08	CPD	[2028]
Te	–	–	?	~300	–	4.04	PE	[3609]
Te/silica	Te	–	<2 × 10^{-10}	100 (~300)	–	4.1	PE	[4248]
Te/W(110)	Te	–	<5 × 10^{-11}	~300	–	4.5	CPD	[2855]
Te/W(100)	Te	–	<2 × 10^{-10}	~300	–	4.54	FE	[1682]
Te/W	Te	–	<2 × 10^{-10}	~300	–	4.61 ± 0.03	FE	[1680]
Te/glass[220]	Te	–	0.1 (Ar)	~300 (573)	–	4.62	CPD	[2246]
Te/Mo(100)	Te	–	<2 × 10^{-10}	~300	–	4.63	FE	[1682]
Te/W	Te	–	<2 × 10^{-10}	~300	–	4.63	FE	[1682]
Te	–	–	–	–	–	4.7	TC	[1993]
Te	–	–	?	300	–	4.70	CPD	[2297]
Te/Mo	Te	–	<2 × 10^{-10}	~300	–	4.72 ± 0.01	FE	[1680]
Te/W	Te	–	<10^{-9}	~300 (≤800)	–	4.74 ± 0.03	FE	[2333]
Te/glass[220]	Te	–	0.1 (Ar)	~300 (573)	–	4.76	CPD	[2246]
Te/glass	Te	–	<3 × 10^{-8}	~300	–	4.76	PE	[1371]
Te	–	–	–	–	–	4.78	TC	[1644]
Te/W(100)	Te	–	~10^{-11}	~300	–	4.8	CPD	[2853]
Te/Ni(100)	Te	–	<5 × 10^{-10}	~300	–	4.80 ± 0.10*	CPD	[1788,1790]
Te/Mo	Te	–	<2 × 10^{-10}	~300	–	4.81	FE	[1682]
Te/W(112)	Te	–	<2 × 10^{-10}	~300	–	4.82	FE	[1682]
Te/steel/ss	Te	–	~10^{-10}	~300	–	4.85	PE	[3429]
Te	–	–	–	–	–	4.88	TC	[1901]
Te/Cu	Te	–	5 × 10^{-6}	123, 300	–	4.89	PE	[2589]
Te/W	Te	–	<2 × 10^{-9}	1200	–	4.9	FE	[2367]
Te	–	–	–	–	–	4.9 ± 0.3	TC	[1905]
Te	–	–	–	0	–	4.92	TC	[4419]
Te/Ni(100)	Te	–	<5 × 10^{-10}	~300	–	4.94 ± 0.10*	CPD	[1790]
Te/Ni(100)	Te	–	<4 × 10^{-10}	~300	–	4.98	PE	[2693]
Te/Fe(100)	Te	–	<8 × 10^{-11}	573	–	4.98*	CPD	[2730]
Te/Ni(100)	Te	–	<5 × 10^{-10}	~300	–	4.99 ± 0.10*	CPD	[1790]
Te	–	–	–	–	–	5.0	TC	[298]
Te/glass	Te	–	?	~300	–	5.0	PE	[3254]
Te/Fe(100)	Te	–	<8 × 10^{-11}	473	–	5.07*	CPD	[2730]
Te/Ni(100)	Te	–	<5 × 10^{-10}	~300	–	5.07 ± 0.10*	CPD	[1790]
Te/quartz	Te	–	?	~300	–	5.1	PE	[3321]
Te	–	–	–	–	–	5.1*	TC	[1955]
Te/W	Te	–	<2 × 10^{-9}	900	–	5.1	FE	[2367]
Te/Fe(100)	Te	–	<8 × 10^{-11}	~300	–	5.10*	CPD	[2730]
Recommended	–	–	–	–	–	**4.86 ± 0.06**	–	–

53. Iodine I

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Rhombic								
I_2/Pt	I_2	–	?	~90	–	2.78 ± 0.03	PE	[3403]
Monoclinic								
I_2/Pt	I_2	–	?	~90	–	5.41 ± 0.02	PE	[3403]
Iodine Film								
I/Mo(100)	CsI	Cs^+	?	~1400–2000	4.65 ± 0.20	–	PSI	[584]
I/W(100)	I_2	–	<10^{-6} (I_2)	~300	–	4.73 ± 0.04	CPD	[581]
I/W(110)	I_2	–	?	~300	–	4.9*	CPD	[2486]
I/W(100)	I_2	–	?	~300	–	5.0*	?	[3820]
I/Fe(110)	I_2	–	5 × 10^{-11}	~300	–	5.00 ± 0.01	CPD	[4399]
I/Fe(100)	I_2	–	5 × 10^{-11}	~300	–	5.07	CPD	[4399]
I/Au[437]	I_2	–	0.20 (I_2)	~300	–	5.1	PE	[2760]
I/Fe(100)	I_2	–	<10^{-7} (I_2)	~300	–	5.1 ± 0.1*	CPD	[3760]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
I/Hg/Au[437]	I_2	–	0.20 (I_2)	~300	–	5.25	PE	[2760]
I/W	KI	K^+	?	<1600	5.27	–	PSI	[46]
I/W	KI	–	?	1200 (2350)	–	5.43	CPD	[3748]
Recommended	–	–	–	–	–	**5.1 ± 0.1**	–	–
Amorphous								
I_2	–	–	–	–	–	5.88	TC	[1901]
I_2/Pt	I_2	–	?	~90	–	6.75 ± 0.02	PE	[3403]

55. Cesium Cs[444]

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs(100)	–	–	–	–	–	1.881	TC	[2947]
Cs(100)	–	–	–	–	–	1.90	TC	[475]
Cs(100)	–	–	–	–	–	1.90	TC	[1254]
Cs(100)	–	–	–	–	–	1.974	TC	[4091]
Cs(100)	–	–	–	–	–	2.01	TC	[231]
Cs(100)	–	–	–	–	–	2.03	TC	[2427]
Cs(100)	–	–	–	–	–	2.03	TC	[334]
Cs(100)	–	–	–	–	–	2.03	TC	[3467]
Cs(100)	–	–	–	–	–	2.04	TC	[553]
Cs(100)	–	–	–	–	–	2.14	TC	[711]
Cs(100)	–	–	–	–	–	2.14	TC	[1159,3067]
Cs(100)	–	–	–	–	–	2.23	TC	[1030]
Cs(100)	–	–	–	–	–	2.24	TC	[1095]
Cs(100)	–	–	–	–	–	2.24	TC	[321]
Cs(100)	–	–	–	–	–	2.28	TC	[3814]
Cs(100)	–	–	–	–	–	2.3	TC	[763]
Cs(100)	–	–	–	–	–	2.3	TC	[1088]
Cs(100)	–	–	–	–	–	2.30	TC	[475]
Cs(100)	–	–	–	–	–	2.31	TC	[476,711]
Cs(100)	–	–	–	–	–	2.36	TC	[555]
Cs(100)	–	–	–	–	–	2.39	TC	[476]
Cs(100)	–	–	–	–	–	2.40	TC	[1030]
Recommended	–	–	–	–	–	**2.24 ± 0.06**	–	–
Cs(110)	–	–	–	–	–	1.929	TC	[2947]
Cs(110)	–	–	–	–	–	2.0	TC	[1723]
Cs(110)	–	–	–	–	–	2.073	TC	[4091]
Cs(110)	–	–	–	–	–	2.09	TC	[334,3179]
Cs(110)	–	–	–	–	–	2.1	TC	[3137]
Cs(110)	–	–	–	–	–	2.1	TC	[1086]
Cs(110)	–	–	–	–	–	2.17	TC	[231]
Cs(110)	–	–	–	–	–	2.19	TC	[553,2427]
Cs(110)	–	–	–	–	–	2.21	TC	[3467]
Cs(110)	–	–	–	–	–	2.23	TC	[1159,3067]
Cs(110)	–	–	–	–	–	2.25	TC	[475]
Cs(110)	–	–	–	–	–	2.30	TC	[593]
Cs(110)	–	–	–	–	–	2.34	TC	[711]
Cs(110)	–	–	–	–	–	2.35	TC	[1030]
Cs(110)	–	–	–	–	–	2.37	TC	[1086]
Cs(110)	–	–	–	–	–	2.44	TC	[2402]
Cs(110)	–	–	–	–	–	2.44	TC	[3814]
Cs(110)	–	–	–	–	–	2.49	TC	[1086]
Cs(110)	–	–	–	–	–	2.5	TC	[763]
Cs(110)	–	–	–	–	–	2.5	TC	[1088]
Cs(110)	–	–	–	–	–	2.51	TC	[476,711]
Cs(110)	–	–	–	–	–	2.56	TC	[1030,1089]
Cs(110)	–	–	–	–	–	2.57	TC	[476]
Cs(110)	–	–	–	–	–	2.58	TC	[2835]
Cs(110)	–	–	–	–	–	2.59	TC	[1095]
Cs(110)	–	–	–	–	–	2.60	TC	[321]
Cs(110)	–	–	–	–	–	2.60	TC	[475]
Cs(110)	–	–	–	–	–	2.62	TC	[555]
Cs(110)	–	–	–	–	–	2.64	TC	[2835]
Cs(110)	–	–	–	–	–	2.66	TC	[1089]
Cs(110)	–	–	–	–	–	2.666	TC	[4069]
Cs(110)	–	–	–	–	–	2.68	TC	[1089]
Cs(110)	–	–	–	–	–	2.72	TC	[1086]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs(110)	–	–	–	–	–	2.73	TC	[1086]
Cs(110)	–	–	–	–	–	2.74	TC	[1086]
Cs(110)	–	–	–	–	–	2.74	TC	[1086]
Cs(110)	–	–	–	–	–	2.74	TC	[3693]
Cs(110)	–	–	–	–	–	2.75	TC	[3731]
Cs(110)	–	–	–	–	–	2.78	TC	[1086]
Cs(110)	–	–	–	–	–	2.8	TC	[1086,1088]
Cs(110)	–	–	–	–	–	2.81	TC	[3693]
Cs(110)	–	–	–	–	–	2.82	TC	[3712]
Cs(110)	–	–	–	–	–	2.82	TC	[3713]
Cs(110)	–	–	–	–	–	2.87	TC	[3692]
Cs(110)	–	–	–	–	–	2.90	TC	[3692]
Recommended	–	–	–	–	–	**2.54 ± 0.07**	–	–
Cs(111)	–	–	–	–	–	1.80	TC	[475]
Cs(111)	–	–	–	–	–	1.85	TC	[593]
Cs(111)	–	–	–	–	–	1.93	TC	[711]
Cs(111)	–	–	–	–	–	1.97	TC	[231]
Cs(111)	–	–	–	–	–	1.971	TC	[4091]
Cs(111)	–	–	–	–	–	1.98	TC	[3467]
Cs(111)	–	–	–	–	–	2.01	TC	[553]
Cs(111)	–	–	–	–	–	2.10	TC	[476,711]
Cs(111)	–	–	–	–	–	2.14	TC	[1159,3067]
Cs(111)	–	–	–	–	–	2.14	TC	[321]
Cs(111)	–	–	–	–	–	2.14	TC	[3814]
Cs(111)	–	–	–	–	–	2.14	TC	[1030]
Cs(111)	–	–	–	–	–	2.14	TC	[1095]
Cs(111)	–	–	–	–	–	2.19	TC	[476]
Cs(111)	–	–	–	–	–	2.2	TC	[1088]
Cs(111)	–	–	–	–	–	2.20	TC	[475]
Cs(111)	–	–	–	–	–	2.24	TC	[555]
Recommended	–	–	–	–	–	**2.09 ± 0.08**	–	–
Cs(112)	–	–	–	–	–	2.39	TC	[321]
Cs	–	–	–	–	–	1.3	TC	[3737]
Cs/GaP(111)	Cs^+	–	$\sim 10^{-10}$	80	–	1.3 ± 0.2	CPD	[1794]
Cs/GaP(111)	Cs^+	–	$\sim 10^{-10}$	~300	–	1.3 ± 0.2	CPD	[1794]
Cs/W	Cs	–	$\sim 10^{-7}$	~300	–	1.43	FE	[2335]
Cs/Os	Cs	–	? (Cs)	~500–800	–	1.44	TE	[650,3414]
Cs/Ti	Cs	–	? (Cs)	?	–	1.44	TE	[650,3413]
Cs/GaP	Cs	–	?	~300	–	1.45	PE	[3070]
Cs/Si(100)	Cs	–	$<6 \times 10^{-11}$	~300	–	1.45*	CPD	[2433]
Cs/MO$_2$C	Cs	–	? (Cs)	~500–650	–	1.48	TE	[650]
Cs/W(110)	–	–	–	–	–	1.5*	TC	[514]
Cs/Si(111)	Cs	–	$<4 \times 10^{-11}$	~300	–	1.5*	PE	[2659]
Cs/GaAs	Cs	–	?	~300	–	1.52	PE	[3070]
Cs/Si(100)	–	–	–	–	–	1.53*	TC	[2399]
Cs/Ta	Cs	–	? (Cs)	~500–650	–	1.55	TE	[650]
Cs/Fe	Cs	–	$<10^{-9}$	~300	–	1.55	PE	[307]
Cs/Ge(111)	Cs	–	$\sim 10^{-10}$	~300	–	1.55	CPD	[1396]
Cs/Cu	Cs	–	?	~300	–	1.55	PE	[1473]
Cs/W(110)	Cs	–	$(\sim 10^{-12})$	~300	–	1.55 ± 0.02	CPD	[1795]
Cs/Re	Cs	–	? (Cs)	~500–700	–	1.56	TE	[650,3414]
Cs/Ge(100)	Cs^+	–	1×10^{-10}	~300	–	1.6	CPD	[3423]
Cs/Si(111)[221]	Cs	–	$\sim 10^{-9}$	~300	–	1.6*	PE	[1823]
Cs/W(111)	–	–	–	–	–	1.6*	TC	[514]
Cs/Mo(110)	Cs	–	1×10^{-3} (Cs)	~700–850	–	1.6	TE	[976]
Cs/Si(111)	Cs	–	$\sim 10^{-10}$	~300	–	1.6	CPD	[3579]
Cs/W–Re(25%)	Cs	–	? (Cs)	690–740	–	1.60	TE	[393]
Cs/steel	Cs	–	? (Cs)	~450–700	–	1.60	TE	[650,3410,3413]
Cs/Si(111)	Cs	–	$\sim 10^{-10}$	~300	–	1.62	CPD	[1396]
Cs/Nb	Cs	–	? (Cs)	~500–700	–	1.63	TE	[650,3414]
Cs/Cu	Cs	–	? (Cs)	~450–650	–	1.64	TE	[650,3413]
Cs/W	Cs	–	? (Cs)	~500–750	–	1.64	TE	[650,3414]
Cs/Re[222]	Cs	–	?	?	–	1.64	TE	[3582]
Cs/Ag	Cs	–	?	~300	–	1.65	PE	[1473]
Cs/Pt(111)	Cs	–	$<2 \times 10^{-10}$	~300	–	1.65*	CPD	[2434]
Cs/W(100)	Cs	–	$\leq 10^{-10}$	77	–	1.65 ± 0.1	FE	[1978]
Cs/W(110)	Cs	–	6×10^{-6} (Cs)	770	–	1.654 ± 0.055	TE	[151]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs/Pt(210)	Cs	–	? (Cs)	~500–750	–	1.66	TE	[650,3413,3414]
Cs/ZrC	Cs	–	? (Cs)	~450	–	1.68	TE	[650]
Cs/Re	Cs	–	$\geq 10^{-4}$ (Cs)	~800–850	–	1.7	TE	[1774]
Cs/Cu(100)	–	–	–	–	–	1.7	TC	[389]
Cs/Ni(100)	–	–	–	–	–	1.7	TC	[389]
Cs/Ta(100)	–	–	–	–	–	1.7	TC	[389]
Cs/W	Cs	–	? (Cs)	~800–1000	–	1.7	TE	[3808]
Cs/Pt(100)	–	–	–	–	–	1.7	TC	[389]
Cs/MoS$_2$(0001)	Cs	–	$<1 \times 10^{-10}$	140	–	1.7	CPD	[2390]
Cs/Si(100)	Cs	–	5×10^{-11}	~300 (?)	–	1.7	PE	[1869]
Cs/Se/Si(100)[226]	Cs	–	$\sim 10^{-10}$	~300	–	1.7	CPD	[3811]
Cs/W(111)	Cs	–	?	77 (≤325)	–	1.7	FE	[3079]
Cs/W(112)	Cs	–	?	77 (≤325)	–	~1.7	FE	[3079]
Cs/W	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.7	CPD	[3289]
Cs/W(103)	Cs	–	?	77	–	1.7	FE	[3079]
Cs/W(103)	Cs	–	?	77 (≤325)	–	1.7	FE	[3079]
Cs/W(115)	Cs	–	?	77	–	1.7	FE	[3079]
Cs/W(115)	Cs	–	?	77 (≤325)	–	1.7	FE	[3079]
Cs/Mo	Cs	–	4×10^{-8}	~300 (900)	–	1.7 ± 0.2	CPD	[3754]
Cs/Ni	Cs	–	? (Cs)	~550–800	–	1.7–2.0	TE	[650]
Cs/Ta	Cs	–	? (Cs)	~500–650	–	1.70	TE	[3414]
Cs/Mo	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.71 ± 0.08	CPD	[3289]
Cs/Li	Cs	–	1×10^{-8}	~300	–	1.73	PE	[1433]
Cs/W(110)	Cs	–	$\leq 1 \times 10^{-9}$	~550	–	1.73	TE	[255]
Cs/W	Cs	–	? (Cs)	500	–	1.74*	TE	[3786]
Cs/W(100)	Cs	–	?	~300	–	1.74 ± 0.06*	CPD	[3612]
Cs/W	Cs	–	? (Cs)	~600–800	–	1.74 ± 0.26	TE	[2462]
Cs/Re	Cs	–	$\sim 10^{-10}$	~300	–	1.75	FE	[2319,3864]
Cs/Mo(110)	Cs	–	$\leq 10^{-10}$	~300	–	1.76*	CPD	[3805]
Cs/W(100)	Cs	–	?	77 (?)	–	1.76 ± 0.05	FE	[340]
Cs/W(112)	Cs	–	6×10^{-6} (Cs)	780	–	1.769 ± 0.063	TE	[151]
Cs/Mo	Cs	–	? (Cs)	~500–750	–	1.77	TE	[650,3414]
Cs/W(100)	Cs	–	$<5 \times 10^{-11}$	~300	–	1.77	CPD	[1672]
Cs/Re	Cs	–	?	77 (?)	–	1.77 ± 0.05	FE	[340]
Cs/Mo	Cs	–	$\sim 10^{-10}$	~300	–	1.78	FE	[3864]
Cs/W(112)	Cs	–	$\leq 1 \times 10^{-9}$	~550	–	1.78	TE	[255]
Cs/W(100)[231]	Cs	–	$<5 \times 10^{-11}$	~300	–	1.78	CPD	[360,361,1667]
Cs/W	Cs	–	?	77	–	1.78	FE	[396]
Cs/Mo(110)	Cs	–	$(\sim 10^{-12})$	?	–	1.78 ± 0.02	CPD	[1795]
Cs/Nb(111)	Cs	–	?	?	–	1.78 ± 0.03	TE	[2329]
Cs/Ta(110)	Cs	–	$\sim 10^{-11}$	~300	–	1.79	CPD	[683,1886]
Cs/W	Cs	–	2×10^{-8}	~300	–	1.79	FE	[2335]
Cs/W(100)	Cs	–	$\leq 1 \times 10^{-9}$	~550	–	1.79	TE	[255]
Cs/W(100)	Cs	–	$<5 \times 10^{-11}$	~300	–	1.8	CPD	[3510]
Cs/Si(111)	Cs	–	3×10^{-11}	~300	–	1.8*	CPD	[3470]
Cs/Mo(111)	Cs	–	5×10^{-9}	~300	–	1.8	CPD	[2786]
Cs/TiO$_2$(110)	Cs	–	?	~300	–	1.8	PE	[1610]
Cs/TiO$_2$(110)	Cs	–	8×10^{-11}	~300	–	1.8	PE	[3188]
Cs/Pt(111)	Cs	–	$<4 \times 10^{-11}$	295	–	1.8	PE	[423]
Cs/Ir	Cs	–	?	20	–	1.8	FE	[2320]
Cs/W	–	–	–	–	–	1.8	TC	[913]
Cs/Ag(110)[224]	Cs	–	?	~300	–	1.8	PE	[2144]
Cs/Ta(110)	–	–	–	–	–	1.8	TC	[509]
Cs/Si(111)	Cs	–	?	~300	–	1.8*	CPD	[1589]
Cs	–	–	–	–	–	1.8	TC	[3030]
Cs/W(100)	Cs	–	5×10^{-11}	~300	–	1.8	CPD	[3418]
Cs/W(112)	Cs$^+$	–	$<10^{-10}$	~300	–	1.8	CPD	[2829]
Cs/W	Cs	–	8×10^{-9}	~300	–	1.8	FE	[2335]
Cs/Ni(110)	Cs	–	$\sim 10^{-11}$	20	–	1.8	PE	[2977]
Cs/NiO/Ni(100)	Cs$^+$	–	$<5 \times 10^{-11}$	~300	–	1.8	CPD	[1005]
Cs/Re(2111)	Cs	–	$\sim 10^{-9}$	~300	–	1.8	FE	[838]
Cs/W	Cs	–	$\sim 10^{-9}$	77	–	1.8	FE	[810]
Cs/W(111)	Cs	–	$\sim 10^{-9}$	77	–	1.8	FE	[810]
Cs/Si(111)	Cs	–	?	303	–	1.8*	CPD	[3230]
Cs/W(100)	Cs	–	7×10^{-10}	77 (≤500)	–	1.8	FE	[3691]
Cs/Mo	Cs	–	? (Cs)	~600–1000	–	1.8	TE	[3798,3799]
Cs/W	Cs	–	? (Cs)	~850–950	–	1.8	TE	[3798,3799]
Cs/Mo	Cs	–	? (Cs)	~600–800	–	1.8	TE	[1390]
Cs/W	Cs$^+$	–	$\leq 1 \times 10^{-10}$	~300	–	1.8*	CPD	[3812]
Cs/W	Cs	–	$<2 \times 10^{-9}$	~300	–	1.8	FE	[2367]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs/W	Cs	–	$\sim 10^{-10}$	~ 300	–	1.8	FE	[2319,3864,3865]
Cs/W(111)	Cs	–	?	77	–	1.8	FE	[3079]
Cs/MoS$_2$(0001)	Cs	–	$< 1 \times 10^{-10}$	175	–	1.8	CPD	[2390]
Cs/W(100)	–	–	–	–	–	1.8	TC	[389]
Cs/Ir(100)	–	–	–	–	–	1.8	TC	[389]
Cs/W(100)	Cs	–	$\sim 10^{-10}$	~ 300	–	1.8	FE	[2324]
Cs/Al$_2$O$_3$/Al	Cs	–	? (Cs)	336	–	1.8 ± 0.1	CPD	[1649]
Cs/W	Cs	–	? (Cs)	620–650	–	1.80	TE	[393]
Cs(pool)	–	–	?	500	–	1.80*	TE	[3786]
Cs	–	–	–	–	–	1.80	TC	[1744]
Cs/W(100)	Cs	–	?	~ 300	–	1.80 ± 0.02	CPD	[1787,3600]
Cs/W^{228}	Cs	–	?	77 (?)	–	1.80 ± 0.05	FE	[340,3759]
Cs/Ni	Cs	–	?	77 (?)	–	1.80 ± 0.05	FE	[340]
Cs/W(100)^{225}	Cs	–	$\leq 2 \times 10^{-10}$	293	–	1.81	CPD	[1480]
Cs/Ge(111)	Cs$^+$	–	1×10^{-10}	~ 300	–	1.81	CPD	[3418,3423]
Cs/Re	Cs	–	$\sim 10^{-9}$	~ 300	–	1.81	FE	[838]
Cs/W(100)^{225}	Cs	–	$< 3 \times 10^{-11}$	~ 300	–	1.81	PE	[3435]
Cs/W	–	–	–	–	–	1.81	TC	[2465]
Cs/Mo	–	–	–	–	–	1.81	TC	[2465]
Cs	–	–	–	–	–	1.81	TC	[2949]
Cs	–	–	–	–	–	1.81	TC	[3728]
Cs/W(100)^{225}	Cs	–	?	98	–	1.81	FE	[644]
Cs/Cr	Cs	–	? (Cs)	~ 500–800	–	1.82	TE	[650,3413]
Cs/W(100)	Cs$^+$	–	$\sim 10^{-10}$	~ 300	–	1.82	CPD	[506]
Cs/W(100)	Cs	–	$< 5 \times 10^{-10}$	~ 300	–	1.82	CPD	[1887]
Cs/Ru(0001)	Cs	–	3×10^{-10}	~ 300	–	1.82	CPD	[1827]
Cs/W	Cs	–	$\leq 3 \times 10^{-10}$	~ 300	–	1.82 ± 0.01	CPD	[362]
Cs/W(100)	Cs	–	$\leq 3 \times 10^{-10}$	~ 300	–	1.82 ± 0.01	CPD	[362,1892,2481, 3830,3831]
Cs/Nb(112)	Cs	–	?	?	–	1.82 ± 0.03	TE	[2329]
Cs/W(100)	Cs$^+$	–	$\sim 10^{-10}$	~ 300	–	1.82 ± 0.04	CPD	[581]
Cs/W(100)	Cs	–	?	~ 300	–	1.82 ± 0.05	CPD	[3612]
Cs/Mo	Cs	–	?	77 (?)	–	1.82 ± 0.05	FE	[340]
Cs/Re(2112)	Cs	–	$\sim 10^{-9}$	~ 300	–	1.83	FE	[838]
Cs/W(111)	Cs	–	$\leq 1 \times 10^{-9}$	~ 550	–	1.83	TE	[255]
Cs/Fe	Cs	–	? (Cs)	~ 700–800	–	1.84	TE	[650,3413]
Cs/Al$_2$O$_3$	Cs	–	? (Cs)	?	–	1.84	TE	[650]
Cs/Mo$_2$Si$_3$	Cs	–	? (Cs)	?	–	1.84	TE	[650]
Cs/W	Cs	–	?	~ 300	–	1.84 ± 0.01	CPD	[1163]
Cs/Pt(111)	Cs	–	$< 2 \times 10^{-10}$	~ 300	–	1.85*	CPD	[2434]
Cs/W(112)	Cs	–	$\sim 10^{-9}$	77	–	1.85	FE	[810]
Cs/Fe	Cs	–	? (Cs)	?	–	1.85	TE	[650]
Cs/Ir	Cs	–	? (Cs)	~ 550–600	–	1.85	TE	[650]
Cs/Re	Cs	–	$\sim 10^{-10}$	290	–	1.85	FE	[2324]
Cs/W	Cs	–	$< 10^{-9}$	~ 300 (900)	–	1.85	FE	[2768]
Cs/Si(111)	Cs	–	$< 6 \times 10^{-11}$	~ 300	–	1.85*	CPD	[2433]
Cs/TaC	Cs	–	3×10^{-10}	~ 300	–	1.85 ± 0.05	CPD	[1504]
Cs/Ir	Cs	–	? (Cs)	~ 500–800	–	1.86	TE	[3414]
Cs/W	Cs	–	2×10^{-9}	~ 300	–	1.86	FE	[2335]
Cs/W^{232}	Cs$^+$	–	$< 3 \times 10^{-10}$	~ 300	–	1.86*	CPD	[3289,3815]
Cs/Cu	Cs	–	? (Cs)	?	–	1.86	PE	[3447]
Cs/?	Cs	–	?	?	–	1.87	?	[3785]
Cs/Ta	Cs	–	? (Cs)	~ 300	–	1.87	FE	[1972]
Cs/Si(100)^{223}	Cs	–	$< 1 \times 10^{-10}$	~ 300	–	1.87*	CPD	[2883]
Cs/W(100)	–	–	–	–	–	1.88	TC	[1539]
Cs	–	–	–	–	–	1.88	TC	[3318]
Cs/Au	Cs	–	$\sim 10^{-3}$ (Ar)	?	–	1.89	PE	[2789]
Cs/W(100)	Cs	–	$(< 10^{-11})$	~ 300	–	1.9	CPD	[776]
Cs/Mo(111)	Cs	–	?	~ 300	–	1.9	PE	[1527]
Cs/Si(100)^{226}	Cs	–	$\sim 10^{-10}$	~ 300	–	1.9*	CPD	[3811]
Cs/Si(100)	–	–	–	–	–	1.9	TC	[1223]
Cs/Au(100)	–	–	–	–	–	1.9	TC	[389]
Cs/Ta	Cs	–	$\sim 10^{-11}$	~ 300	–	1.9	CPD	[683]
Cs/Si(100)	Cs	–	7×10^{-11}	~ 300	–	1.9	CPD	[2531]
Cs/Si(100)	Cs$^+$	–	1×10^{-10}	~ 300	–	1.9	CPD	[3423]
Cs	–	–	–	–	–	1.9	TC	[1993]
Cs/W	Cs	–	$\sim 10^{-10}$	290	–	1.9	FE	[2324,3816]
Cs/Cu(111)	Cs	–	1×10^{-10}	~ 300	–	1.9*	CPD	[2491]
Cs/Ni(100)	Cs	–	$\leq 6 \times 10^{-10}$	~ 300	–	1.9	PE	[2366]
Cs/Ag(110)	Cs	–	?	80	–	1.9	PE	[2144]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs/Ag(110)	Cs	–	?	~300	–	1.9	PE	[2144]
Cs/Mo(111)	Cs	–	?	~300	–	1.9	PE	[1527]
Cs/Be	Cs	–	$\leq 8 \times 10^{-10}$	~300	–	1.9	CPD	[3286]
Cs/W	Cs	–	? (Cs)	~700	–	1.9*	TE	[1858]
Cs/W(110)	Cs	–	?	77	–	1.9	FE	[3079,3818]
Cs/W(110)	Cs	–	?	77 (≤325)	–	1.9	FE	[3079,3818]
Cs/W(100)	Cs	–	(~10^{-11})	~300	–	1.9	CPD	[3340]
Cs/Mo	Cs, H	H$^-$	~10^{-8}	188–293	1.9^N	–	NSI	[3677]
Cs/Mo	Cs	–	7×10^{-9}	~300	–	1.9	CPD	[3756]
Cs/O/Ni(100)	Cs	–	$<5 \times 10^{-11}$	~300	–	1.9	CPD	[1005]
Cs/Cu(111)[227]	Cs	–	1×10^{-10}	~300	–	1.9*	CPD	[2496]
Cs/Ni	Cs	–	$<10^{-9}$	77	–	1.9	CPD	[2139,3128,3698]
Cs/Si(nanowire)	Cs	–	$<5 \times 10^{-9}$	~300	–	1.9	FE	[2443]
Cs/GaAs(110)	Cs	–	$<10^{-10}$	~300	–	1.9	CPD	[2793]
Cs/MoS$_2$	Cs	–	?	200	–	1.9	CPD	[2843]
Cs/Mo[232]	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.9*	CPD	[3289,3815]
Cs/W[232]	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.9*	CPD	[3289,3815]
Cs/W	Cs	–	5×10^{-10}	~77	–	1.9 ± 0.1	FE	[2590]
Cs/Mo[229]	Cs$^+$	–	$\leq 1 \times 10^{-10}$	~300	–	1.9 ± 0.1*	CPD	[3283]
Cs/Si	Cs$^+$	–	–	–	–	1.90 ± 0.09*	TC	[4367]
Cs	–	–	–	–	–	1.92	TC	[3477]
Cs	–	–	–	–	–	1.92	TC	[339]
Cs	–	–	~10^{-10}	300	–	1.92	PE	[4297]
Cs	–	–	~10^{-9}	298	–	1.93 ± 0.03	PE	[2612,2613]
Cs	–	–	–	–	–	1.94	TC	[1066]
Cs/glass	Cs	–	~10^{-9}	82	–	1.94	PE	[2576]
Cs/Re(2110)	Cs	–	~10^{-9}	~300	–	1.94	FE	[838]
Cs	–	–	~10^{-9}	~300	–	1.94	PE	[4241]
Cs/Be	Cs	–	? (Cs)	~500–800	–	1.94	TE	[650,3410,3413]
Cs/Mo(100)	Cs	–	~10^{-11}	~300	–	1.94 ± 0.05	CPD	[3855]
Cs/quartz	Cs	–	$<4 \times 10^{-10}$	100	–	1.95	PE	[1862]
Cs/Cu(111)	Cs	–	$\sim 1 \times 10^{-11}$	~300	–	1.95	CPD	[2532]
Cs/?	Cs	–	?	~300	–	1.95	PE	[3111]
Cs/surface[230]	–	–	–	–	–	≤1.95	TC	[650,3412]
Cs/O/W(100)[231]	Cs	–	?	~300	–	1.95	CPD	[1667]
Cs	–	–	~10^{-9}	298	–	1.95 ± <0.05	PE	[2612,2613]
Cs/W(111)	Cs	–	$\leq 10^{-10}$	77	–	1.95 ± 0.1	FE	[1978]
Cs/Be[232]	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.96	PE	[3289]
Cs/Be[232]	Cs$^+$	–	$<3 \times 10^{-10}$	~300	–	1.96	CPD	[3289]
Cs/Ag/glass	Cs	–	~10^{-8}	~80	–	1.96	PE	[1452]
Cs/W(110)	Cs	–	5×10^{-7}	~300	–	≥1.96	PE	[3765]
Cs/Al(111)	Cs	–	1×10^{-11}	~300	–	1.98*	CPD	[2867]
Cs/Ag(100)	Cs	–	$<1 \times 10^{-10}$	80	–	1.98 ± 0.06	CPD	[3186]
Cs/Ru(0001)	Cs	–	~10^{-10}	220	–	2.0	PE	[4092–4094]
Cs/W(110)	Cs	–	~10^{-9}	77	–	2.0	FE	[810]
Cs/W(110)	–	–	–	–	–	2.0	TC	[4216]
Cs/Ag(111)	–	–	–	–	–	2.0	TC	[4216]
Cs/Pt(111)	–	–	–	–	–	2.0	TC	[4216]
Cs/Mo(110)	Cs	–	5×10^{-9}	~300	–	2.0	CPD	[2786]
Cs/Ag(111)	Cs	–	$<1 \times 10^{-10}$	~300	–	2.0*	CPD	[1426]
Cs/Mo	Cs	–	1×10^{-8}	~300	–	2.0	PE	[1433]
Cs/Mo	Cs	–	7×10^{-9}	~300	–	2.0	PE	[3756]
Cs/Cu(100)	Cs	–	$<4 \times 10^{-11}$	~300	–	2.0	PE	[3809]
Cs/W(110)	–	–	–	–	–	2.0	TC	[3300]
Cs/Mo(110)	Cs	–	?	~300	–	2.0	CPD	[1420]
Cs/Au	Cs	–	1×10^{-8}	~300	–	2.0	PE	[1433]
Cs/quartz	Cs	–	~10^{-10}	90	–	2.0	PE	[2605]
Cs/Si(100)	Cs	–	~10^{-10}	200	–	2.0	CPD	[302]
Cs/W(112)	Cs	–	(≤10^{-11})	~300	–	2.0	CPD	[977]
Cs/Si(111)	Cs	–	~10^{-10}	130	–	2.0	PE	[1817]
Cs/Ru(001)	Cs	–	?	~300	–	2.0*	CPD	[2984]
Cs	–	–	–	–	–	2.0*	TC	[1955]
Cs/W	Cs	–	~10^{-10}	800	–	2.0	FE	[2324,3816]
Cs/Re	Cs	–	~10^{-10}	850	–	2.0	FE	[2324]
Cs/Ba/W(100)	Cs	–	(<10^{-11})	210	–	2.0	CPD	[776]
Cs/W(110)	Cs	–	~10^{-8}	~300	–	2.0	PE	[3218]
Cs/HfN	Cs	–	? (Cs)	~700	–	2.0*	TE	[1858]
Cs/Ag(110)	Cs	–	?	~300	–	2.0*	CPD	[1816]
Cs/Se/Si(100)[226]	Cs	–	~10^{-10}	~300	–	2.0*	CPD	[3811]
Cs/cnt	Cs	–	2×10^{-9}	~300	–	2.0	PE	[1165]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs/TaC	Cs⁺	–	3×10^{-10}	~300	–	2.0 ± 0.02	CPD	[1504]
Cs/Cu	Cs	–	?	~300	–	2.0 ± 0.1	PE	[3091]
Cs/Ag	Cs	–	?	~300	–	2.0 ± 0.1	PE	[3091]
Cs/W(112)	Cs	–	$\leq 10^{-10}$	77	–	2.0 ± 0.1	FE	[1978]
Cs/W(110)	Cs	–	$\leq 10^{-10}$	77	–	$2.0 \pm 0.1^*$	FE	[1978]
Cs/Cu(110)	Cs	–	5×10^{-11}	140	–	2.0 ± 0.1	PE	[3453,3454]
Cs/Cu	Cs	–	3×10^{-9}	100–140	–	2.0 ± 0.1	PE	[2015]
Cs/Ni(100)	Cs⁺	–	$<5 \times 10^{-11}$	~300	–	2.00	CPD	[1005,3674]
Cs/Ta(110)	Cs⁺	–	$\sim 10^{-10}$	~300	–	2.00	CPD	[506]
Cs/Si(100)ⁿ	Cs⁺	–	4×10^{-11}	200	–	2.00 ± 0.05	CPD	[880]
Cs/GaN(0001)	–	–	–	–	–	$2.02 - 2.34$	TC	[4187]
Cs	–	–	–	–	–	2.03	TC	[4150]
Cs	–	–	$\sim 10^{-9}$	183	–	2.03 ± 0.02	PE	[2612,2613]
Cs/ss	Cs	–	(D₂-plasma)	?	–	2.03 ± 0.16	PE	[4452]
Cs/O/W(100)²³¹	Cs	–	?	~300	–	2.05	CPD	[1667]
Cs	–	–	–	–	–	2.05^*	TC	[1955]
Cs	–	–	–	–	–	2.05	TC	[1951]
Cs/graphene	–	–	–	–	–	2.05	TC	[4075]
Cs/glass	Cs	–	$\leq 3 \times 10^{-11}$	195	–	2.05 ± 0.01	PE	[2615]
Cs/W(100)	Cs	–	$\sim 10^{-9}$	77	–	2.06	FE	[810]
Cs	–	–	–	–	–	2.06	TC	[3477]
Cs(cluster)	–	–	–	–	–	2.06	TC	[3477,3479]
Cs/Mo(100)	Cs	–	7×10^{-10}	77	–	2.06	FE	[3691]
Cs/Mo(112)	Cs	–	7×10^{-10}	77	–	2.06	FE	[3691]
Cs/W(110)	Cs	–	$\leq 3 \times 10^{-10}$	~300	–	2.06 ± 0.01	CPD	[362]
Cs/W	Cs	–	$\leq 10^{-9}$	~300	–	2.07	CPD	[3857]
Cs/Cu(100)	Cs	–	$<5 \times 10^{-11}$	~300	–	2.07	CPD	[2842,2850]
Cs/W(110)	Cs	–	($\leq 10^{-11}$)	77	–	2.07^*	CPD	[3341]
Cs	–	–	–	–	–	2.07	TC	[3467]
Cs/W(110)	Cs	–	$<2 \times 10^{-10}$	~300	–	2.07 ± 0.01	CPD	[2481]
Cs/Si(100)	–	–	–	–	–	$2.08 \pm 0.10^*$	TC	[3498]
Cs/Ag(111)	–	–	–	–	–	2.09	TC	[3995]
Cs/glass	Cs	–	$\leq 3 \times 10^{-11}$	77	–	2.09 ± 0.01	PE	[2615]
Cs/Ru(001)	Cs	–	$<5 \times 10^{-10}$	80 (≫80)	–	2.1^*	CPD	[2152]
Cs/Ni(111)	Cs	–	8×10^{-11}	100	–	2.1	PE	[772]
Cs/Mo	Cs	–	2×10^{-8}	~300	–	2.1	CPD	[3770]
Cs/W(112)	Cs	–	$\sim 10^{-10}$	~300	–	2.1	FE	[2324]
Cs/Nb(110)	Cs	–	$\sim 10^{-10}$	~300	–	2.1	CPD	[2381]
Cs/HOPG	Cs	–	?	90	–	2.1	PE	[1620]
Cs/W(100)	Cs	–	($<10^{-11}$)	210	–	2.1	CPD	[776]
Cs/Cu(110)	Cs	–	?	140	–	2.1	PE	[3450]
Cs/Pt	Cs	–	4×10^{-10}	20	–	2.1^*	AI³⁸	[3496]
Cs/Ru(0001)	Cs	–	$<10^{-10}$	~300	–	2.1	PE	[3782]
Cs/W(110)	Cs	–	$<2 \times 10^{-11}$	~300	–	2.1	CPD	[2685]
Cs/Ni(100)	Cs	–	$\sim 10^{-10}$	~300	–	2.1^*	CPD	[2895]
Cs/W(111)	Cs	–	($\leq 10^{-11}$)	77	–	2.1	CPD	[2619]
Cs/Cu(110)	Cs	–	?	100, 260	–	2.1	?	[3159,3172]
Cs/W(110)	Cs	–	($<10^{-12}$)	77	–	2.1	CPD	[1085]
Cs/W(110)	Cs	–	($\leq 10^{-11}$)	~300	–	2.1	CPD	[977]
Cs/Ag(110)²²⁴	Cs	–	?	80	–	2.1	PE	[2144]
Cs/Mo(110)	Cs	–	($\leq 10^{-11}$)	~300	–	2.1	CPD	[977]
Cs	–	–	–	–	–	2.1	TC	[706]
Cs/W(110)	Cs	–	$\leq 10^{-10}$	77	–	2.1 ± 0.1	FE	[1978]
Cs/Ba/Nb(100)	Cs	–	($<10^{-11}$)	220	–	2.10 ± 0.05	CPD	[776]
Cs/Ba/Nb(110)	Cs	–	4×10^{-10}	~300	–	2.11	CPD	[2672]
Cs/W(110)	Cs	–	($<10^{-12}$)	77	–	2.11	CPD	[1085]
Cs/glass	Cs	–	$\leq 3 \times 10^{-11}$	195	–	2.11 ± 0.01	PE	[2615]
Cs	–	–	–	–	–	2.14	TC	[1711]
Cs	–	–	–	–	–	2.14	TC	[3637]
Cs/GaAs(110)	Cs	–	?	190	–	2.14	PE	[2168]
Cs/glass	Cs	–	$\leq 10^{-10}$	77	–	2.14 ± 0.02	PE	[1489]
Cs/glass	Cs	–	$<2 \times 10^{-10}$	77	–	2.14 ± 0.05	PE	[1474]
Cs/Mo(100)	Cs	–	$\sim 10^{-11}$	~300	–	$2.14 \pm 0.06^*$	CPD	[3855]
Cs/Si(100)	Cs	–	$\sim 10^{-10}$	200	–	2.15	CPD	[302]
Cs	–	–	–	–	–	2.15	TC	[1711]
Cs/W(110)	Cs	–	$<2 \times 10^{-10}$	250	–	2.15	CPD	[1807]
Cs	–	–	–	–	–	2.15	TC	[298]
Cs/W(110)	Cs	–	1×10^{-9}	~300	–	2.15	CPD	[3721–3723,3774]
Cs/Mo(110)	Cs	–	5×10^{-11}	77	–	2.15	CPD	[329]
Cs	–	–	–	–	–	2.15	TC	[3725]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs/W(110)	Cs	–	?	~300	–	2.15	CPD	[2881]
Cs/W(110)	Cs	–	(<10⁻¹¹)	210	–	2.15	CPD	[776]
Cs/Ba/W(110)	Cs	–	(<10⁻¹¹)	210	–	2.15	CPD	[776]
Cs/W(110)	Cs	–	<10⁻⁹	~300	–	2.15	CPD	[3857]
Cs	–	–	–	–	–	2.16	TC	[1711]
Cs/Re(1011)	Cs	–	~10⁻⁹	~300	–	2.16	FE	[838]
Cs/Mo(100)	Cs	–	<5 × 10⁻¹¹	~300	–	2.16 ± 0.09*	CPD	[3736]
Cs/Ir	–	–	–	–	–	2.18	TC	[416]
Cs/W(110)	Cs	–	?	77 (?)	–	2.18 ± 0.05	FE	[340]
Cs	–	–	–	–	–	2.19	TC	[3352]
Cs/ss	Cs	–	(H₂-plasma)	?	–	2.19 ± 0.08	PE	[4452]
Cs/Cu(111)²³³	–	–	–	–	–	2.2	TC	[3697]
Cs/Ru(001)	Cs	–	<5 × 10⁻¹⁰	80 (≫80)	–	2.2	CPD	[2152]
Cs/Mo(110)	Cs	–	?	~300	–	2.2	CPD	[2676]
Cs/Ba/Mo(110)	Cs	–	?	~300	–	2.2	CPD	[2676]
Cs/cnt/Si	Cs	–	≤8 × 10⁻¹⁰	~300	–	2.2	PE	[3225]
Cs/Cu(111)²³⁴	Cs	–	~10⁻¹⁰	200	–	2.2	PE	[2512]
Cs/Ni/ss	Cs	–	~10⁻¹⁰	4.2	–	2.2 ± 0.1	PE	[1410]
Cs/W(110)	–	–	–	–	–	2.20	TC	[1539]
Cs/W(110)	Cs	–	7 × 10⁻¹⁰	77 (500)	–	2.22	FE	[3691]
Cs/Nb(100)	Cs	–	(<10⁻¹¹)	220	–	2.22	CPD	[776]
Cs/W(100)	–	–	–	–	–	2.22*	TC	[1705]
Cs	–	–	–	–	–	2.23	TC	[477]
Cs/Cu(100)	–	–	–	–	–	2.23 ± 0.01	TC	[4135]
Cs	–	–	–	–	–	2.24	TC	[231]
Cs	–	–	–	–	–	2.24	TC	[477,1924,4035]
Cs	–	–	–	150.5	–	2.241	TC	[2419]
Cs	–	–	–	–	–	2.25	TC	[3312]
Cs	–	–	–	–	–	2.25	TC	[2427]
Cs	–	–	–	–	–	2.26	TC	[3477]
Cs	–	–	–	–	–	2.26	TC	[553]
Cs/Ru(0001)	Cs	–	?	~300	–	2.26	PE	[4020]
Cs/C(0001)	Cs	–	5 × 10⁻¹⁰	80	–	2.26*	CPD	[2156]
Cs/C(0001)²³⁵	–	–	–	–	–	2.26*	TC	[2782]
Cs/C(0001)²³⁵	Cs	–	<2 × 10⁻¹⁰	~300	–	2.26*	CPD	[2782]
Cs	–	–	–	0	–	2.264	TC	[2419]
Cs/W(100)	–	–	–	–	–	2.28	TC	[385]
Cs	–	–	–	–	–	2.28	TC	[3467]
Cs/Cu(111)²³⁴	–	–	~10⁻¹⁰	200	–	2.3	PE	[2512]
Cs/Mo(112)	Cs	–	(<10⁻¹¹)	77 (300)	–	2.3	CPD	[2032]
Cs/W(100)	Cs	–	~10⁻¹⁰	~300	–	2.3	CPD	[2477,2599,2600]
Cs/Si(111)	Cs	–	<1 × 10⁻¹⁰	~300	–	2.3*	PE	[2663]
Cs/Ag(100)	Cs	–	<2 × 10⁻¹⁰	80	–	2.3 ± 0.1*	CPD	[2179]
Cs/Si(100)	Cs⁺	–	?	~300 (≤833)	–	2.3 ± 0.15	CPD	[768]
Cs	–	–	–	–	–	2.30	TC	[477]
Cs	–	–	–	–	–	2.31	TC	[767]
Cs	–	–	–	–	–	2.33	TC	[231]
Cs/graphite	–	–	–	–	–	2.33*	TC	[1843]
Cs/Al(111)	–	–	–	–	–	2.34	TC	[3158]
Cs	–	–	–	–	–	2.35	TC	[2427]
Cs	–	–	–	–	–	2.35	TC	[4101]
Cs	–	–	–	–	–	2.35	TC	[477,1924,4035, 4036]
Cs	–	–	–	–	–	2.37	TC	[1613]
Cs	–	–	–	–	–	2.37	TC	[383]
Cs/Mo(100)	–	–	–	–	–	2.39*	TC	[1705]
Cs/Cu(111)²³³	–	–	–	–	–	2.4	TC	[3697]
Cs/Nb(110)	Cs	–	4 × 10⁻¹⁰	~300	–	2.4	CPD	[2672]
Cs/cnt/GaAs²³⁶	Cs	–	2 × 10⁻⁹	~300	–	2.4	PE	[291]
Cs/MoS₂(0001)	Cs	–	<1 × 10⁻¹⁰	~300	–	2.4	CPD	[2390]
Cs/Nb(110)	Cs	–	4 × 10⁻¹⁰	~300	–	2.40	FE	[2672]
Cs/graphite	–	–	–	–	–	2.41*	TC	[1843]
Cs/Al(111)	Cs	–	8 × 10⁻¹¹	140	–	2.44	CPD	[734,2154,2162]
Cs/W(100)	–	–	–	–	–	2.44	TC	[387]
Cs/Ta	Cs	–	~10⁻¹¹	~300	–	2.47	CPD	[683]
Cs	–	–	–	–	–	2.47	TC	[1711]
Cs	–	–	–	–	–	2.49	TC³	[475,519,2474]
Cs	–	–	–	–	–	2.5	TC	[2845]
Cs/C(0001)²³⁵	–	–	–	–	–	2.5*	TC	[2782]
Cs/C(0001)²³⁵	Cs	–	<2 × 10⁻¹⁰	~300	–	2.5*	CPD	[2782]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs	–	–	–	–	–	2.51	TC	[2629]
Cs	–	–	–	–	–	2.54	TC	[230]
Cs/W(100)	–	–	–	–	–	2.55	TC	[385]
Cs	–	–	–	–	–	2.56	TC	[2493]
Cs	–	–	–	–	–	2.60	TC	[2382]
Cs/Ru(001)	Cs	–	<5 × 10⁻¹⁰	80	–	2.62	PE	[3152]
Cs	–	–	–	–	–	2.64	TC	[521]
Cs	–	–	–	–	–	2.64	TC	[3628]
Cs	–	–	–	–	–	2.67	TC	[2493]
Cs	–	–	–	–	–	2.74	TC	[477]
Cs/W(100)	–	–	–	–	–	2.77	TC	[385]
Cs/Si(100)	–	–	–	–	–	2.8	TC	[3362]
Cs/MoS$_2$	Cs	–	<1 × 10⁻¹⁰	~300	–	2.9	CPD	[2843]
Cs/cnt	Cs	–	6 × 10⁻⁹	~300	–	3.0 ± 0.1	FE	[2436]
Cs	–	–	–	–	–	3.10	TC	[2629]
Recommended	–	–	–	–	–	**2.05 ± 0.05**	–	–

Liquid (T > 301 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Cs	–	–	~10⁻¹⁰	302	–	1.91*	PE	[4297]
Cs	–	–	~10⁻⁹	302	–	1.94	PE	[4241]
Cs	–	–	~10⁻⁸	302	–	1.95	PE	[4208]
Cs	–	–	–	301	–	2.212	TC	[2419]

56. Barium Ba

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ba(100)/BaO	–	–	–	–	–	2.22	TC	[357]
Ba(100)	–	–	–	–	–	2.31	TC	[4091]
Ba(100)	–	–	–	–	–	2.48	TC	[1254]
Ba(100)	–	–	–	–	–	2.50	TC	[1159,3067]
Ba(100)	–	–	–	–	–	2.6	TC	[1714]
Ba(100)	–	–	–	–	–	2.62	TC	[357]
Ba(100)	–	–	–	–	–	2.67	TC	[231]
Ba(100)	–	–	–	–	–	2.68	TC	[3467]
Ba(100)	–	–	–	–	–	3.00	TC	[321]
Ba(100)	–	–	–	–	–	3.06	TC	[1030]
Ba(100)	–	–	–	–	–	3.15	TC	[476]
Ba(100)	–	–	–	–	–	3.26	TC	[476]
Ba(100)	–	–	–	–	–	3.42	TC	[1030]
Recommended	–	–	–	–	–	**3.07 ± 0.06**	–	–
Ba(110)	–	–	–	–	–	2.1	TC	[1723]
Ba(110)	–	–	–	–	–	2.19	TC	[1434]
Ba(110)	–	–	–	–	–	2.28	TC	[334,3179]
Ba(110)	–	–	–	–	–	2.384	TC	[4091]
Ba(110)	–	–	–	–	–	2.71	TC	[1159,3067]
Ba(110)	–	–	–	–	–	2.83	TC	[231]
Ba(110)	–	–	–	–	–	2.88	TC	[3467]
Ba(110)	–	–	–	–	–	2.95	TC	[2427]
Ba(110)	–	–	–	–	–	3.21	TC	[476]
Ba(110)	–	–	–	–	–	3.32	TC	[476]
Ba(110)	–	–	–	–	–	3.49	TC	[321]
Ba(110)	–	–	–	–	–	3.56	TC	[1030]
Ba(110)	–	–	–	–	–	3.58	TC	[1030]
Ba(110)	–	–	–	–	–	3.59	TC	[1089]
Ba(110)	–	–	–	–	–	3.70	TC	[1089]
Ba(110)	–	–	–	–	–	3.81	TC	[1089]
Recommended	–	–	–	–	–	**3.46 ± 0.14**	–	–
Ba(111)	–	–	–	–	–	2.293	TC	[4091]
Ba(111)	–	–	–	–	–	2.48	TC	[1159,3067]
Ba(111)	–	–	–	–	–	2.72	TC	[3467]
Ba(111)	–	–	–	–	–	2.73	TC	[231]
Ba(111)	–	–	–	–	–	2.85	TC	[476]
Ba(111)	–	–	–	–	–	2.85	TC	[1030]
Ba(111)	–	–	–	–	–	2.86	TC	[1030]
Ba(111)	–	–	–	–	–	2.87	TC	[321]
Ba(111)	–	–	–	–	–	2.96	TC	[476]
Recommended	–	–	–	–	–	**2.81 ± 0.06**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ba(112)	–	–	–	–	–	3.20	TC	[321]
Ba	–	–	?	~300	–	1.73	CPD	[2297]
Ba/W	Ba	–	(<10⁻¹⁴)	770–910	–	1.96	TE	[2572]
Ba/W	Ba	–	~10⁻¹¹	1000	–	2.0	TE	[3781]
Ba/W(221)	Ba	–	(<10⁻¹¹)	78 (≤800)	–	2.0	FE	[809]
Ba	–	–	?	~300	–	2.02	PE	[3694]
Ba/Nb(100)	Ba	–	(<10⁻¹¹)	~300 (1000)	–	2.04	CPD	[776]
Ba/W(111)	Ba	–	~10⁻⁸	~1000	–	2.1	TE	[2351]
Ba/W	Ba	–	≤3 × 10⁻⁹	~300	–	2.1	FE	[218,3739]
Ba/Re	Ba	–	~10⁻⁹	~300 (800)	–	2.1	FE	[3535]
Ba/W	Ba	–	≤1 × 10⁻⁹	~300 (870)	–	2.1	FE	[2587]
Ba/W	Ba	–	(<10⁻¹¹)	78 (≤800)	–	2.1	FE	[809]
Ba/W	Ba	–	?	880–990	–	2.15 ± 0.05	TE	[2928]
Ba/W(110)	Ba	–	(<10⁻¹¹)	~300 (1000)	–	2.18	CPD	[776]
Ba/W(110)	Ba	–	~10⁻⁸	~1000	–	2.2	TE	[2351]
Ba/W(111)	Ba	–	≤1 × 10⁻¹⁰	77	–	2.2	FE	[2372]
Ba/Rh	Ba	–	≤1 × 10⁻⁹	~300 (870)	–	2.2	FE	[2587]
Ba/W(111)	Ba	–	(<10⁻¹¹)	78 (≤800)	–	2.2	FE	[809]
Ba/W	Ba	–	3 × 10⁻⁹	~300	–	2.2	CPD	[1064]
Ba/Nb(100)	Ba	–	(<10⁻¹¹)	~300 (600)	–	2.23	CPD	[776]
Ba/W	Ba	–	≤5 × 10⁻⁹	~300–800	–	2.23 ± 0.04	CPD	[3320]
Ba/W(100)	Ba	–	(<10⁻¹¹)	~300 (700)	–	2.25	CPD	[776]
Ba/W₂C	Ba	–	?	~300 (800)	–	2.25	FE	[3531]
Ba/Ni(110)	Ba	–	≤10⁻¹⁰	~300	–	2.26*	CPD	[3376]
Ba/Re	Ba	–	~10⁻⁹	~300 (600)	–	2.3	FE	[3535]
Ba/W(211)	Ba	–	(<10⁻¹¹)	78 (≤800)	–	2.3	FE	[809]
Ba/Si(001)²³⁷	Ba	–	<6 × 10⁻¹⁰	~300	–	2.3	PE	[2170]
Ba/glass	Ba	–	<3 × 10⁻⁸	~300	–	2.3	PE	[3576]
Ba/quartz	Ba	–	5 × 10⁻¹⁰	~300	–	2.3	PE	[2024]
Ba/Nb	Ba	–	≤5 × 10⁻⁹	~300	–	2.3*	CPD	[3261]
Ba/W(100)	Ba	–	(<10⁻¹¹)	210 (730)	–	2.3	CPD	[776]
Ba/Nb(100)	Ba	–	(<10⁻¹¹)	220 (850)	–	2.3	CPD	[776]
Ba/Ti/W(111)	Ba	–	≤1 × 10⁻¹⁰	77	–	2.3	FE	[2372]
Ba/W(111)	Ba	–	(<10⁻¹¹)	77	–	2.3	CPD	[2507]
Ba/Ta(112)	Ba	–	(≤10⁻¹¹)	~300 (600)	–	2.3	CPD	[347]
Ba/Nb(110)	Ba	–	≤10⁻⁸	~1000–1150	–	2.3 ± 0.03	TE	[2359]
Ba/Nb,Ta	Ba	–	≤10⁻⁸	~1000–1150	–	2.3 ± 0.03	TE	[2359]
Ba/W	Ba	–	~10⁻⁸	745–910	–	2.3 ± 0.1	TE	[3064]
Ba/W(100)	Ba	–	~10⁻⁹	~950–1100	–	2.3 ± 0.1	TE	[143]
Ba/W(110)	Ba	–	~10⁻⁹	~950–1100	–	2.3 ± 0.1	TE	[143]
Ba/W(111)	Ba	–	~10⁻⁹	~950–1100	–	2.3 ± 0.1	TE	[143]
Ba/W(112)	Ba	–	~10⁻⁹	~950–1100	–	2.3 ± 0.1	TE	[143]
Ba/Ta(112)	Ba	–	(≤10⁻¹¹)	77 (600)	–	2.30	CPD	[347]
Ba	–	–	–	–	–	2.30	TC	[1066]
Ba/Ni(110)	Ba	–	≤10⁻¹⁰	~300	–	2.30	CPD	[3376]
Ba/Mo(111)	Ba	–	≤10⁻⁹	860–980	–	2.30 ± 0.1	TE	[323]
Ba/W(100)	Ba	–	≤10⁻¹⁰	500	–	2.34	CPD	[1891]
Ba/W	Ba	–	≤1 × 10⁻⁹	~300 (?)	–	2.35	FE	[2037]
Ba/glass²³⁸	Ba	–	?	~300	–	2.35 ± 0.03	CPD	[1157]
Ba/Ru,Os,Ir	Ba	–	≤10⁻⁸	~1000–1150	–	2.36 ± 0.03	TE	[2359]
Ba/Nb(100)	Ba	–	(≤10⁻¹¹)	~300 (700)	–	2.38	CPD	[776]
Ba/W²³⁸	Ba	–	?	90	–	2.39 ± 0.05	CPD	[1365]
Ba/Ta	Ba	–	~10⁻⁸	~300	–	2.39 ± 0.06*	CPD	[1385]
Ba/Ir	Ba	–	≤1 × 10⁻⁹	300 (970)	–	2.4	FE	[2587]
Ba/W(100)	–	–	–	–	–	2.4	TC	[4258]
Ba/Pt	Ba	–	?	~1200	–	2.4	TE	[4266]
Ba/W(100)	Ba	–	(<10⁻¹¹)	78 (≤800)	–	2.4	FE	[809]
Ba/Ge	Ba	–	~10⁻⁹	~300	–	2.4	CPD	[1954]
Ba/Au	Ba	–	~10⁻⁹	~300	–	2.4	CPD	[1954]
Ba/W	Ba	–	?	77 (?)	–	2.4	FE	[3777]
Ba/W	Ba	–	?	600, 730	–	2.4	FE	[3555]
Ba/Ge/W	Ba	–	?	600, 730	–	2.4	FE	[3555]
Ba/Ir(111)	Ba	–	≤8 × 10⁻¹⁰	770–940	–	2.4	TE	[3546,3547]
Ba/C/Ir(111)	Ba	–	~10⁻¹⁰	850–980	–	2.4	TE	[3986]
Ba/?	Ba	–	?	?	–	2.4	TE	[3402]
Ba	–	–	–	–	–	2.4	TC	[1993]
Ba/Nb(100)	Ba	–	≤10⁻⁸	~1000–1150	–	2.4 ± 0.03	TE	[2359]
Ba/Zr,Hf	Ba	–	≤10⁻⁸	~1000–1150	–	2.4 ± 0.03	TE	[2359]
Ba/Mo,W	Ba	–	≤10⁻⁸	~1000–1150	–	2.4 ± 0.03	TE	[2359]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ba/W(100)	Ba	–	($<10^{-11}$)	~300 (500)	–	2.40	CPD	[776]
Ba/W(100)	Ba	–	($<10^{-11}$)	~300 (1000)	–	2.40	CPD	[776]
Ba/glass[238]	Ba	–	?	~300	–	2.41 ± 0.05*	CPD	[1157]
Ba/W(100)	Ba	–	($<10^{-11}$)	~300	–	2.42	CPD	[776]
Ba/W	Ba	–	$<10^{-10}$	77	–	2.42	FE	[2960]
Ba/W[238]	Ba	–	?	90	–	2.42 ± 0.05	CPD	[1365]
Ba/W(113)	Ba	–	$<5 \times 10^{-9}$	~300	–	2.44	CPD	[1138]
Ba/W	Ba	–	$<10^{-10}$	~300	–	2.44	FE	[1464]
Ba	–	–	–	–	–	2.45	TC	[3476]
Ba/Si(100)	Ba	–	$<10^{-10}$	~300	–	2.45*	CPD	[3370]
Ba/W(113)	Ba	–	$\leq 5 \times 10^{-9}$	~300	–	2.45	CPD	[1963]
Ba/Au	Ba	–	5×10^{-9}	300	–	2.45	PE	[2710]
Ba/W(110)	Ba	–	$\leq 10^{-8}$	~1000–1150	–	2.45 ± 0.03	TE	[2359]
Ba/quartz	Ba	–	$<5 \times 10^{-9}$	~330 (~470)	–	2.45 ± 0.05	PE	[3090]
Ba/W[244]	Ba	–	$\leq 2 \times 10^{-9}$	~900	–	2.46	CPD	[3530]
Ba	–	–	–	–	–	2.47	TC	[339]
Ba	–	–	–	–	–	2.47	TC	[3476]
Ba	–	–	–	–	–	2.48	TC	[3637]
Ba/glass	Ba	–	~2×10^{-8}	~300	–	2.48	PE	[2564]
Ba	–	–	–	–	–	2.48	TC	[1254]
Ba/W	Ba	–	$\leq 2 \times 10^{-9}$	~300	–	2.48	CPD	[3530]
Ba/Mo(110)	Ba	–	($\leq 10^{-11}$)	77	–	2.48	CPD	[1209,1895]
Ba/Ni	Ba	–	?	~300	–	2.49	PE	[1641]
Ba/Fe(110)/W(110)	Ba	–	?	77	–	2.5	CPD	[4231]
Ba/Mo(110)/W(110)	Ba	–	?	77	–	2.5	CPD	[4231]
Ba/Ag(111)/W(110)	Ba	–	?	77	–	2.5	CPD	[4231]
Ba/W(112)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.5	FE	[2372]
Ba/Ti/W(112)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.5	FE	[2372]
Ba/Ta(112)	Ba	–	($\leq 10^{-11}$)	77	–	2.5	CPD	[347]
Ba	–	–	–	–	–	2.5	TC	[3030]
Ba/Ta(112)	Ba	–	($\leq 10^{-11}$)	~300	–	2.5	CPD	[347]
Ba/W(111)	Ba	–	($<10^{-11}$)	~300	–	2.5	CPD	[2507]
Ba/Si(100)[239]	Ba	–	$<2 \times 10^{-11}$	~300	–	2.5*	PE	[1732]
Ba/Nb	Ba	–	$\leq 3 \times 10^{-9}$	~300	–	2.5*	CPD	[3263]
Ba/Ag(111)	Ba	–	~1×10^{-10}	~300	–	2.5	CPD	[3303]
Ba/Cu/W(110)	Ba	–	$\leq 1 \times 10^{-10}$	~300	–	2.5	FE	[2371]
Ba/Re(1010)	Ba	–	($\leq 10^{-11}$)	77	–	2.5	CPD	[2501]
Ba/Re(1010)	Ba	–	($\leq 10^{-11}$)	~300	–	2.5	CPD	[599,2501]
Ba/W(110)	Ba	–	~10^{-8}	~300	–	2.5	PE	[3218]
Ba/W	Ba	–	?	~300	–	2.5	CPD	[2577]
Ba/W	Ba	–	~10^{-10}	~300	–	2.5	CPD	[3532]
Ba/W(100)	Ba	–	$\leq 10^{-8}$	~1000–1150	–	2.5 ± 0.03	TE	[2359]
Ba/Ir(111)	Ba	–	$\leq 5 \times 10^{-9}$	<800	–	2.50	TE	[649]
Ba/Ag(111)	Ba	–	$<1 \times 10^{-10}$	~300 (≤450)	–	2.50	CPD	[990]
Ba/Ta(112)	Ba	–	($\leq 10^{-11}$)	77	–	2.50	CPD	[347]
Ba/Ta(112)	Ba	–	($\leq 10^{-11}$)	~300	–	2.50	CPD	[347]
Ba/W(100)	Ba	–	$\leq 10^{-10}$	~300	–	2.50	FE	[1891]
Ba/glass	Ba	–	?	~300–400	–	2.511 ± 0.002	PE	[1637,1638,2232]
Ba/Re[222]	Ba	–	?	?	–	2.52	TE	[3582]
Ba/Ag/Ta[242]	Ba	–	?	~300	–	2.52 ± 0.03*	CPD	[1050]
Ba/glass[373]	Ba	–	?	~300	–	2.520	PE	[2232]
Ba/W(112)	Ba	–	($\leq 10^{-11}$)	77	–	2.53	CPD	[379]
Ba/W(112)	Ba	–	($\leq 10^{-11}$)	~300	–	2.53	CPD	[379]
Ba/Nb(100)	Ba	–	($\leq 10^{-11}$)	~300	–	2.53	CPD	[776]
Ba/Ag/Ta[242]	Ba	–	?	~300	–	2.53 ± 0.03*	CPD	[1050]
Ba/W(110)	Ba	–	($\leq 10^{-11}$)	77	–	2.54	CPD	[1895]
Ba/Al(111)	Ba	–	3×10^{-11}	20 (120)	–	2.55	PE	[1427]
Ba/Ag(111)	Ba	–	$\leq 1 \times 10^{-10}$	~300	–	2.56	CPD	[990]
Ba/W(100)[241]	Ba	–	$\leq 6 \times 10^{-10}$	~300	–	2.560 ± 0.005	CPD	[2104,2108]
Ba/glass[240]	Ba	–	?	~300	–	2.57*	CPD	[1367]
Ba/W	Ba	–	$\leq 2 \times 10^{-9}$	760–775	–	2.57 ± 0.06*	CPD	[3528]
Ba/W(110)	Ba	–	($<10^{-11}$)	~300 (900)	–	2.59	CPD	[776]
Ba//W(110)	Ba	–	?	77	–	2.6	CPD	[4231]
Ba/Cu(111)/W(110)	Ba	–	?	77	–	2.6	CPD	[4231]
Ba/Ag(111)/W(110)	Ba	–	?	~300	–	2.6	CPD	[4231]
Ba/W(110)	Ba	–	?	~300	–	2.6	CPD	[2145]
Ba/W	Ba	–	?	~300	–	2.6	CPD	[3689]
Ba/Mo(110)	Ba	–	?	~300	–	2.6	FE	[2676]
Ba/W(110)	Ba	–	~10^{-10}	77 (~300)	–	2.6	CPD	[2022]
Ba/Mo(112)	Ba	–	($<10^{-11}$)	~300	–	2.6	CPD	[2637]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ba/W(110)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.6*	FE	[2372]
Ba/Ti/W(110)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.6*	FE	[2372]
Ba/Re(1010)	Ba	–	($<10^{-11}$)	~300	–	2.6	CPD	[2637]
Ba/W(100)	Ba	–	?	~300	–	2.6	CPD	[2145]
Ba/W	Ba	–	$<10^{-9}$	~300	–	2.6	FE	[3269]
Ba/Cu(111)	Ba	–	?	~300	–	2.6*	PE	[2515]
Ba/W[243]	Ba	–	2×10^{-9}	~300	–	2.6	CPD	[3259]
Ba	–	–	–	–	–	2.6	TC	[706]
Ba/Lu/W	Ba	–	$\leq 1 \times 10^{-9}$	~300 (?)	–	2.60	FE	[2037]
Ba/W(100)	Ba	–	$\leq 10^{-10}$	~300	–	2.60	CPD	[1891]
Ba/W(100)	–	–	–	–	–	2.62	TC	[357]
Ba/Mo(110)	Ba	–	($\leq 10^{-11}$)	~300	–	2.63	CPD	[1209,1895]
Ba/Mo(110)	Ba	–	($\leq 10^{-11}$)	77 ($\leq$500)	–	2.63	CPD	[1209,1895]
Ba/Mo(110)	Ba	–	$\leq 2 \times 10^{-10}$	77	–	2.63	CPD	[327]
Ba/W(110)	Ba	–	2×10^{-10}	77	–	2.63	CPD	[3985]
Ba/Re(0001)	Ba	–	$\leq 2 \times 10^{-9}$	77, ~300	–	2.64*	CPD	[3750]
Ba/W[244]	Ba	–	$\leq 2 \times 10^{-9}$	~300	–	2.65	CPD	[3530]
Ba	–	–	–	–	–	2.65	TC	[298]
Ba/W(110)	Ba	–	($<10^{-11}$)	~300 (1200)	–	2.65	CPD	[776]
Ba/Ir(100)	Ba	–	?	~300	–	2.65 ± 0.05	CPD	[3135,3701]
Ba/W	Ba	–	$\leq 2 \times 10^{-9}$	~300	–	2.65 ± 0.06*	CPD	[3528]
Ba	–	–	–	–	–	2.66	TC	[3729]
Ba/Ag/Ta[238]	Ba	–	?	~300	–	2.66 ± 0.01	CPD	[1050]
Ba/W(110)	Ba	–	($<10^{-11}$)	210	–	2.67	CPD	[776]
Ba/W(110)	Ba	–	2×10^{-10}	77	–	2.67	CPD	[3985]
Ba/W	Ba	–	$\leq 6 \times 10^{-10}$	~300	–	2.67 ± 0.02	CPD	[2108]
Ba/W(100)[241]	Ba	–	$\leq 3 \times 10^{-10}$	~300	–	2.69 ± 0.02	CPD	[2104]
Ba/W[243]	Ba	–	3×10^{-7}	~300	–	2.7	CPD	[3259]
Ba/Si(100)[239]	Ba	–	$<2 \times 10^{-11}$	~300	–	2.7	PE	[1732]
Ba/Nb(110)	Ba	–	4×10^{-10}	~300	–	2.7	CPD	[2672]
Ba/Cu(111)	Ba	–	$\sim 10^{-10}$	~300	–	2.7	PE	[2509]
Ba/Mo(110)	Ba	–	$\leq 3 \times 10^{-10}$	~300	–	2.7	CPD	[330]
Ba/Fe(110)/W(110)	Ba	–	?	~300	–	2.7	CPD	[4231]
Ba/Mo(110)/W(110)	Ba	–	?	~300	–	2.7	CPD	[4231]
Ba/Si(111)	–	–	–	–	–	2.7*	TC	[4075]
Ba/W(100)	Ba	–	$<10^{-10}$	~300	–	2.7*	CPD	[2055]
Ba/O/W(100)	Ba	–	$<10^{-10}$	~300	–	2.7*	CPD	[2055]
Ba/W(100)[245]	Ba	–	?	~300	–	2.7	CPD	[2149]
Ba/Ir(100)[245]	Ba	–	?	~300	–	2.7	CPD	[2149]
Ba/Pt	Ba	–	$\leq 2 \times 10^{-9}$	~300 (1400)	–	2.7 ± 0.1	FE	[3543]
Ba/W(100)	–	–	–	–	–	2.70	TC	[386]
Ba/O/W(100)	–	–	–	–	–	2.70	TC	[386]
Ba/Ni	Ba	–	?	0^E	–	2.70	PE	[3026]
Ba/W(110)	Ba	–	($\leq 10^{-11}$)	~300	–	2.70	CPD	[1895,2738]
Ba/Mo(110)	Ba	–	$\leq 2 \times 10^{-10}$	~300	–	2.73	CPD	[327]
Ba	–	–	–	–	–	2.73	TC	[550]
Ba/W(110)	Ba	–	($\leq 10^{-11}$)	~300	–	2.74	CPD	[776]
Ba	–	–	–	–	–	2.76	TC	[3467]
Ba/W(110)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.8	FE	[2372]
Ba/W(110)	Ba	–	?	~300	–	2.8	CPD	[4231]
Ba/Cu(111)/W(110)	Ba	–	?	~300	–	2.8	CPD	[4231]
Ba/Ti/W(110)	Ba	–	$\leq 1 \times 10^{-10}$	77	–	2.8	FE	[2372]
Ba/W	Ba	–	2×10^{-11}	~300	–	2.8	CPD	[1867]
Ba/Ni	Ba	–	$<1 \times 10^{-9}$	~300	–	2.8	CPD	[3463]
Ba	–	–	–	–	–	2.80	TC	[1744]
Ba/W(100)	Ba	–	($\leq 10^{-11}$)	~300 (1200)	–	2.84	CPD	[776]
Ba/W(110)	Ba	–	1×10^{-9}	~300	–	2.9	CPD	[2017]
Ba	–	–	–	–	–	2.91	TC	[231]
Ba/W(110)[241]	Ba	–	$\leq 6 \times 10^{-10}$	~300	–	2.955 ± 0.005	CPD	[2104,2108]
Ba	–	–	–	–	–	2.96	TC	[231]
Ba/W(110)	Ba	–	($\leq 10^{-10}$)	~300	–	2.97 ± 0.02	CPD	[2595]
Ba/W(100)	Ba	–	$\sim 10^{-11}$	~300 (1100)	–	3.0	PE	[2518]
Ba/Si(111)	Ba	–	?	~300	–	3.0 ± 0.9	CPD	[2160]
Ba	–	–	–	–	–	3.01	TC	[1924]
Ba	–	–	–	–	–	3.02	TC	[1924]
Ba	–	–	–	–	–	3.02	TC	[3467]
Ba/W(110)	Ba	–	($<10^{-11}$)	~300 (600)	–	3.06	CPD	[776]
Ba	–	–	–	–	–	3.06	TC	[1613]
Ba/Pt	Ba	–	$\leq 2 \times 10^{-9}$	~300 (1720)	–	3.7 ± 0.1	FE	[3543]
Ba/W(110)[241]	Ba	–	$\leq 3 \times 10^{-10}$	~300	–	3.10 ± 0.02	CPD	[2104]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ba/W	Ba	–	2×10^{-9}	~300 (1000)	–	3.3	FE	[1966]
Ba	–	–	–	–	–	3.61	TC	[3476]
Recommended	–	–	–	–	–	**2.50 ± 0.02**	–	–

57. Lanthanum La[399]

hcp (α, $T < 583$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La(0001)/Mo(110)	La	–	$\leq 3 \times 10^{-10}$	~300	–	3.0	CPD	[640]
La(0001)	–	–	–	–	–	3.06	TC	[1434]
La(0001)	–	–	–	–	–	3.21	TC	[334]

fcc (β, $T = 583–1141$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La(100)	–	–	–	–	–	3.74	TC	[321]
La(100)	–	–	–	–	–	4.83	TC	[485,1703]
La(110)	–	–	–	–	–	3.53	TC	[321]
La(110)	–	–	–	–	–	4.84	TC	[485,1703]
La(111)	–	–	–	–	–	2.9	TC	[1723]
La(111)	–	–	–	–	–	3.30	TC	[334,3179]
La(111)	–	–	–	–	–	4.04	TC	[321]

bcc (γ, $T > 1141$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La(100)	–	–	–	–	–	3.23	TC	[321]
La(100)	–	–	–	–	–	4.83	TC	[1703]
La(110)	–	–	–	–	–	3.76	TC	[321]
La(110)	–	–	–	–	–	5.93	TC	[1703]
La(111)	–	–	–	–	–	3.09	TC	[321]
La(112)	–	–	–	–	–	3.44	TC	[321]

hcp (α, $T < 583$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La/W(111)	La	–	~10^{-9}	~300	–	2.4	FE	[2011]
La/W	La	–	4×10^{-10}	~300 (1050)	–	2.4	FE	[1583]
La	–	–	–	–	–	2.49	TC	[3476]
La/W	La	–	~10^{-10}	~300	–	2.49	FE	[378]
La/W(011)	La	–	4×10^{-10}	~300 (1050)	–	2.5	FE	[1583]
La/?	La	–	?	~300	–	2.50	CPD	[2634]
La	–	–	? (N_2)	~300	–	2.50 ± 0.02	CPD	[4066]
La	–	–	–	–	–	2.57	TC	[3476]
La/B/Mo(110)[252]	La	–	2×10^{-10}	~300	–	2.6	CPD	[3963]
La/W(111)	La	–	~10^{-10}	~300	–	2.63	FE	[378]
La/W	La	–	~10^{-10}	~300	–	2.7	FE	[2827]
La/W(111)	La	–	?	77	–	2.7	CPD	[2507]
La	–	–	–	–	–	2.71	TC	[1066]
La/W(111)	La	–	?	~300	–	2.75	CPD	[2507]
La/W(100)	La	–	~10^{-10}	~300	–	2.78	FE	[378]
La	–	–	–	–	–	2.8*	TC	[1955]
La/W	La	–	~10^{-10}	~300	–	2.8	FE	[2827]
La/B/Mo(110)[252]	La	–	2×10^{-10}	~300	–	2.8	CPD	[2700]
La	–	–	–	–	–	2.84	TC	[3476]
La/W	La	–	~10^{-10}	77	–	2.86	FE	[2827]
La/Pt(111)[246]	La	–	?	77	–	2.86	PE	[3009]
La/W(112)	La	–	~10^{-10}	~300	–	2.90	FE	[378]
La	–	–	–	–	–	3.0	TC	[1993]
La/Ta(112)	La	–	$\leq 10^{-11}$	~300 (800)	–	3.02	CPD	[801]
La/W(100)	La	–	$\leq 10^{-11}$	~300	–	3.04	CPD	[2020]
La/W(100)	La	–	$\leq 1 \times 10^{-9}$	~300	–	3.05	CPD	[1996]
La/Ta(112)	La	–	$\leq 10^{-11}$	~300 (1000)	–	3.09	CPD	[801]
La/Ta(112)	La	–	$\leq 10^{-11}$	~300 (400)	–	3.11	CPD	[801]
La/Mo(112)	La	–	($\leq 10^{-11}$)	77	–	3.12	CPD	[2502]
La/Ta(112)	La	–	$\leq 10^{-11}$	~300 (600)	–	3.13	CPD	[801]
La/W(110)	La	–	$\leq 1 \times 10^{-9}$	~300	–	3.17	CPD	[1996]
La/Mo(110)	La	–	2×10^{-10}	~300	–	3.2	CPD	[2700]
La	–	–	–	–	–	3.21	TC	[3318]
La	–	–	–	–	–	3.25	TC	[550]
La	–	–	–	0	–	3.28	TC	[4419]

Table 1 (continued)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La	–	–	–	–	–	3.28	TC	[3318]
La	–	–	–	–	–	3.3	TC	[706]
La/W	La	–	?	0^E	–	3.3	TE	[3022]
La/Re(1010)	La	–	($<10^{-11}$)	77	–	3.3	CPD	[2506]
La/Mo(110)[252]	La	–	2×10^{-10}	~300	–	3.3	CPD	[3963,4276]
La/W(110)	La	–	~10^{-10}	~300	–	3.30	FE	[378]
La	–	–	–	–	–	3.30	TC	[3352]
La	–	–	–	–	–	3.30	TC	[521]
La/Cr(110)	La	–	~10^{-11}	~300	–	3.31*	CPD	[4276]
La/Nb(110)	La	–	~10^{-11}	~300	–	3.34*	CPD	[4276]
La/W(110)	La	–	($\leq10^{-10}$)	~300	–	3.4	CPD	[3350,3351,3365]
La/Mo(110)	La	–	($\leq10^{-10}$)	~300	–	3.4	CPD	[3350]
La/Mo(110)[252]	La	–	2×10^{-10}	~300	–	3.4	CPD	[2700]
La/quartz	La	–	~10^{-10}	~300	–	3.5 ± 0.2	PE	[304]
La/W(110)	La	–	~10^{-11}	~300	–	3.52	CPD	[4276]
La	–	–	–	–	–	3.58	TC	[298]
La	–	–	–	–	–	3.62	TC	[2629]
La	–	–	–	–	–	3.85	TC	[1744]
La/W	La	–	2×10^{-11}	~300	–	4.33	FE	[2397]
La	–	–	–	–	–	4.47	TC	[2629]
Recommended	–	–	–	–	–	**3.27 ± 0.04**	–	–

fcc (β, T = 583–1141 K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
La/Nb(110)	La	–	$\leq10^{-8}$	~1000–1150	–	2.6 ± 0.03	TE	[2359]
La/Ta(110)	La	–	$\leq10^{-8}$	~1000–1150	–	2.6 ± 0.03	TE	[2359]
La/W	La	–	?	?	–	2.71	TE	[1750]
La	–	–	–	–	–	2.72	TC	[1066]
La/W(116)	La	–	1×10^{-9}	?	–	2.8	TE	[1975]
La/Nb(100)	La	–	$\leq10^{-8}$	~1000–1150	–	2.8 ± 0.03	TE	[2359]
La/W(111)	La	–	1×10^{-9}	?	–	2.9	TE	[1975]
La/W(100)	La	–	$\leq10^{-8}$	~1000–1150	–	2.9 ± 0.03	TE	[2359]
La/Zr,Hf	La	–	$\leq10^{-8}$	~1000–1150	–	2.9 ± 0.03	TE	[2359]
La/Nb,Ta	La	–	$\leq10^{-8}$	~1000–1150	–	2.9 ± 0.03	TE	[2359]
La/Ru,Os,Ir	La	–	$\leq10^{-8}$	~1000–1150	–	2.9 ± 0.03	TE	[2359]
La/Mo,W	La	–	$\leq10^{-8}$	~1000–1150	–	2.96 ± 0.03	TE	[2359]
La/Re	La	–	$\leq10^{-8}$	~1000–1150	–	2.96 ± 0.03	TE	[2359]
La/W(100)	La	–	$\leq10^{-11}$	650	–	2.97	TE	[2020]
La/W(100)	La	–	$\leq10^{-11}$	900	–	3.00	TE	[2020]
La/W(100)	La	–	1×10^{-9}	?	–	3.1	TE	[1975]
La/W(110)	La	–	$\leq10^{-8}$	~1000–1150	–	3.1 ± 0.03	TE	[2359]
La/W(110)	La	–	1×10^{-9}	?	–	3.2	TE	[1975]
Recommended	–	–	–	–	–	**2.98 ± 0.10**	–	–

58. Cerium Ce[399]

fcc (β, T = 263–1003 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ce(100)	–	–	$<5 \times 10^{-11}$	~300	–	4.05 ± 0.1	PE	[4147]
Ce(100)	–	–	–	–	–	4.62	TC	[321]
Ce(110)	–	–	–	–	–	4.35	TC	[321]
Ce(111)	–	–	–	–	–	3.26	TC	[1434]
Ce(111)	–	–	–	–	–	4.98	TC	[321]

bcc (γ, T > 1003 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ce(100)	–	–	–	–	–	3.98	TC	[321]
Ce(110)	–	–	–	–	–	4.63	TC	[321]
Ce(111)	–	–	–	–	–	3.81	TC	[321]
Ce(112)	–	–	–	–	–	4.24	TC	[321]

fcc (β, T = 263–1003 K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ce/W(111)	Ce	–	~10^{-9}	~300	–	2.2	FE	[2011]
Ce	–	–	–	–	–	2.23	TC	[1744]
$Ce_n (n \rightarrow \infty)$	–	–	~10^{-6}	70	–	2.40	IP	[4263]
Ce/W[247]	Ce	–	–	~300^E	–	2.5*	TE	[3022]
Ce/W(111)	Ce	–	1×10^{-9}	?	–	2.5	TE	[1975]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ce/Pd/Ru(0001)[248]	Ce	–	~10^{-10}	~300	–	2.5 ± 0.1*	PE	[3718]
Ce/Ir–Ce(9%)	–	–	~10^{-8}	1300	–	2.57	TE	[4239]
Ce/W(116)	Ce	–	1×10^{-9}	?	–	2.6	TE	[1975]
Ce/Rh(110)	Ce	–	8×10^{-11}	~300	–	2.6*	PE	[2287]
Ce/?	Ce	–	?	~300	–	2.60	CPD	[3596]
Ce/?	Ce	–	?	~300	–	2.62	CPD	[2634]
Ce	–	–	? (N_2)	~300	–	2.62 ± 0.02	CPD	[2634,4066,4251]
Ce/quartz	–	–	~10^{-6} (Ar)	293	–	2.65 ± 0.02	CPD	[3977]
Ce	–	–	–	–	–	2.66	TC	[2750]
Ce/W	Ce	–	?	?	–	2.71	TE	[1750]
Ce/Rh(110)	Ce	–	8×10^{-11}	~300 (770)	–	2.8*	PE	[2287]
Ce/W	Ce	–	~10^{-10}	520	–	2.8	FE	[2826]
Ce	–	–	–	–	–	2.8	TC	[1955]
Ce/Pd/Ru(0001)[248]	Ce	–	~10^{-10}	~300	–	2.8 ± 0.1*	PE	[3718]
Ce/Ni	Ce	–	?	~300	–	2.84	PE	[2922]
Ce	–	–	–	–	–	2.84	TC	[3352]
Ce/W	Ce	–	~10^{-10}	~300	–	2.85	FE	[2826]
Ce/W(110)	Ce	–	1×10^{-9}	?	–	2.9	TE	[1975]
Ce/Pt(111)	Ce	–	<1×10^{-10}	~300	–	2.9*	CPD	[1601]
Ce/?	Ce	–	?	~300	–	2.9	PE	[2115]
Ce/quartz	Ce	–	~10^{-10}	~300	–	2.9 ± 0.2	PE	[304]
Ce/Ru(0001)	Ce	–	~10^{-10}	~300	–	2.90	PE	[4199]
Ce	–	–	–	–	–	2.98	TC	[1066]
Ce/Ir-0.4%Ce	–	–	?	~300 (2000)	–	3.0	FE	[3613]
Ce/Pd(110)[249]	Ce	–	~10^{-10}	~300	–	3.02*	PE	[3306]
Ce[174]	–	–	–	0^E	–	3.07	TC	[1747]
Ce/Pd(111)[249]	Ce	–	~10^{-10}	~300	–	3.10*	PE	[3306]
Ce	–	–	–	–	–	3.24	TC	[550]
Ce$_n$(n → ∞)	–	–	–	–	–	3.27 ± 0.35	TC	[4261]
Ce/W(100)	Ce	–	1×10^{-9}	?	–	3.3	TE	[1975]
Ce/Pd(110)[249]	Ce	–	~10^{-10}	~300	–	3.36	PE	[3306]
Ce/Pd(110)[249]	Ce	–	~10^{-10}	~300	–	3.55	PE	[3306]
Recommended	–	–	–	–	–	**2.89 ± 0.07**	–	–
bcc (γ, T = 1003–1068 K for bulk)								
Ce/?	Ce	–	?	1050	–	2.67	TE	[3022]
Ce/W	Ce	–	~10^{-10}	1060	–	2.96	FE	[2826]
Ce/?	Ce	–	?	~1000	–	3.18*	TE	[1747]
Ce/Re(0001)	Ce	–	≤5×10^{-8}	≥1000	–	3.20	TE	[96]

59. Praseodymium Pr[399]

hcp (α, T < 1071 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pr(0001)	–	–	–	–	–	3.11	TC	[1434]
bcc (β, T > 1071 K)								
Pr(100)	–	–	–	–	–	3.32	–	[321]
Pr(110)	–	–	–	–	–	3.86	–	[321]
Pr(111)	–	–	–	–	–	3.17	–	[321]
Pr(112)	–	–	–	–	–	3.54	–	[321]
hcp (α, T < 1071 K for bulk)								
Pr$_n$(n → ∞)	–	–	~10^{-6}	70	–	2.50	IP	[4263]
Pr/W(111)	Pr	–	~10^{-9}	~300	–	2.6	FE	[2011]
Pr	–	–	? (N_2)	~300	–	2.63 ± 0.02	CPD	[4251]
Pr	–	–	? (N_2)	~300	–	2.67	CPD	[2634,4066,4253]
Pr	–	–	–	–	–	2.70	TC	[3352]
Pr	–	–	–	–	–	2.8	TC	[1955]
Pr	–	–	–	–	–	2.80	TC	[2750]
Pr	–	–	–	–	–	2.81	TC	[1066]
Pr	–	–	–	–	–	3.04	TC	[550]
Pr	–	–	–	–	–	3.25	TC	[550]
Pr$_n$(n → ∞)	–	–	–	–	–	3.54 ± 0.13	TC	[4261]
Recommended	–	–	–	–	–	**2.83 ± 0.11**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc (β, T = 1071–1208 K for bulk)								
Pr/?	Pr	–	?	1120	–	2.74	TE	[3022]

60. Neodymium Nd[399]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, T < 1141 K)								
Nd(0001)	–	–	–	–	–	3.09	TC	[1434]
Nd(0001)/W(100)	Nd	–	1×10^{-9}	~300	–	3.30	CPD	[1543,4145]
bcc (β, T > 1141 K)								
Nd(100)	–	–	–	–	–	3.63	TC	[321]
Nd(110)	–	–	–	–	–	4.23	TC	[321]
Nd(111)	–	–	–	–	–	3.48	TC	[321]
Nd(112)	–	–	–	–	–	3.87	TC	[321]
hcp (α, T < 1141 K for bulk)								
Nd/Cu(100)	Nd	–	1×10^{-10}	~300	–	2.63	CPD	[2734]
Nd	–	–	–	–	–	2.7	TC	[1744]
Nd/Cu(100)	Nd	–	?	~300	–	2.7	CPD	[2739]
Nd/W(111)	Nd	–	~10^{-9}	~300	–	2.8	FE	[2011]
Nd	–	–	? (N_2)	~300	–	2.80 ± 0.02	CPD	[4066]
Nd/Cu(100)	Nd	–	1×10^{-10}	550	–	2.88*	CPD	[2734]
Nd	–	–	–	–	–	2.92	TC	[1066]
Nd	–	–	–	–	–	2.94	TC	[2750]
Nd/W(111)	Nd	–	<10^{-10}	170	–	2.95	FE	[3793]
Nd/W	Nd	–	<10^{-10}	170	–	3.0	FE	[3793]
Nd	–	–	–	–	–	3.04	TC	[550]
Nd	–	–	–	–	–	3.1	TC	[1955]
Nd/W	Nd	–	≤1×10^{-9}	~300	–	3.1 ± 0.05	FE	[2602]
Nd/Cu(100)	Nd	–	1×10^{-10}	800	–	3.13	CPD	[2734]
Nd/W(100)	Nd	–	<10^{-10}	170	–	3.2	FE	[3793]
Nd/Cu(111)	Nd	–	<1×10^{-10}	~300	–	3.2*	CPD	[2735]
Nd/quartz	Nd	–	~10^{-10}	~300	–	3.2 ± 0.25	PE	[304]
Nd	–	–	–	–	–	3.25	TC	[550]
Nd/Mo(112)	Nd	–	~10^{-11}	~300	–	3.36	CPD	[2535]
Recommended	–	–	–	–	–	**3.14 ± 0.08**	–	–
bcc (β, T = 1141–1297 K for bulk)								
Nd/?	Nd	–	?	1150–1450	–	2.95	TE	[3022]

61. Prometium Pm

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, T < ?)								
Pm(0001)	–	–	–	–	–	3.09	TC	[1434]
fcc (β, T > ?)								
Pm(100)	–	–	–	–	–	3.73	TC	[321]
Pm(110)	–	–	–	–	–	3.52	TC	[321]
Pm(111)	–	–	–	–	–	4.03	TC	[321]
hcp (α, T < ?)								
Pm[379]	–	–	–	–	–	3.0	TC	[1955]
Pm	–	–	–	–	–	3.07	TC	[1956]
Pm	–	–	–	–	–	3.08	TC	[2750]
Pm	–	–	–	–	–	3.21	TC	[550]

62. Samarium Sm[399]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc (β, T > 1200 K)								
Sm(100)	–	–	–	–	–	3.23	TC	[321]
Sm(110)	–	–	–	–	–	3.76	TC	[321]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Sm(111)	–	–	–	–	–	3.09	TC	[321]
Sm(112)	–	–	–	–	–	3.44	TC	[321]
Rhombohedral (α, $T < 1200$ K for bulk)								
Sm	–	–	–	–	–	1.8	TC	[1744]
Sm	–	–	? (N_2)	~300	–	2.52 ± 0.02	CPD	[4066]
Sm/Mo(110)	Sm	–	<8 × 10⁻¹¹	~300	–	2.56*	CPD	[3147]
Sm/?	Sm	–	~10⁻¹⁰	~300	–	2.6	PE	[1514]
Sm/Mo(110)	Sm	–	<5 × 10⁻¹¹	~300	–	2.64	CPD	[3148]
Sm/W(111)	Sm	–	~10⁻⁹	~300	–	2.7	FE	[2011]
Sm/Mo(111)	Sm	–	<1 × 10⁻¹⁰	300	–	2.7	CPD	[2449]
Sm/Au/SiO₂	Sm	–	8 × 10⁻¹¹	~300	–	2.7	PE	[4204]
Sm/quartz	Sm	–	~10⁻¹⁰	~300	–	2.7 ± 0.3	PE	[304]
Sm/Mo(112)	Sm	–	<5 × 10⁻¹¹	~300	–	2.71	CPD	[2450]
Sm/Si	Sm	–	?	~300	–	2.75	PE	[4217]
Sm/Ni(111)²⁵⁰	Sm	–	1 × 10⁻¹⁰	293	–	2.8*	PE	[3000]
Sm/Ir(111)	Sm	–	≤1 × 10⁻⁸	~1100–1200	–	2.8	TE	[3583]
Sm/Cu(111)	Sm	–	~1 × 10⁻¹⁰	~300	–	2.84	CPD	[2272]
Sm/W	Sm	–	?	?	–	2.85	?	[1360]
Sm/Si(111)	Sm	–	6 × 10⁻¹¹	~300	–	2.9	CPD	[3758]
Sm/W	Sm	–	?	750	–	2.98	TE	[2489]
Sm/Cu(111)	Sm	–	~1 × 10⁻¹⁰	680–870	–	2.99	CPD	[2272]
Sm	–	–	–	–	–	3.06	TC	[550]
Sm	–	–	–	–	–	3.1	TC	[1955]
Sm/W(112)	Sm	–	≤10⁻¹¹	~300	–	3.10	CPD	[4274]
Sm/Si(111)	Sm	–	?	~300	–	3.11*	CPD	[3755,3758]
Sm/?	Sm	–	?	~1150–1600	–	3.15	TE	[3022]
Sm/W(112)	Sm	–	(≤10⁻¹¹)	77	–	3.16	CPD	[2671]
Sm/Si(111)	–	–	–	–	–	3.2*	TC	[4076]
Sm/?	Sm	–	?	0ᴱ (≤1600)	–	3.2	TE	[3022]
Sm/Si(100)	Sm	–	<3 × 10⁻⁶	~300	–	3.20	PE	[2435]
Sm	–	–	–	–	–	3.22	TC	[2750]
Sm	–	–	–	–	–	3.27	TC	[550]
Sm/Pd(100)	Sm	–	~10⁻¹⁰	~300	–	3.3*	CPD	[1917]
Sm/W(110)	Sm	–	?	~300	–	4.38	CPD	[2542]
Recommended	–	–	–	–	–	**2.81 ± 0.10**	–	–

63. Europium Eu

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc								
Eu(100)	–	–	–	–	–	3.26	TC	[321]
Eu(110)	–	–	–	–	–	2.35	TC	[1434]
Eu(110)	–	–	–	–	–	2.42	TC	[334]
Eu(110)	–	–	–	–	–	3.80	TC	[321]
Eu(111)	–	–	–	–	–	3.12	TC	[321]
Eu(112)	–	–	–	–	–	3.48	TC	[321]
bcc								
Eu/W	Eu	–	3 × 10⁻¹⁰	78	–	2.2	FE	[2643]
Eu/W(112)	Eu	–	7 × 10⁻¹¹	300	–	2.25 ± 0.20*	CPD	[2389]
Eu/W(112)	Eu	–	7 × 10⁻¹¹	300 (<700)	–	2.25 ± 0.20*	CPD	[2389]
Eu/W(111)	Eu	–	~10⁻⁹	~300	–	2.4	FE	[2011]
Eu/W(116)	Eu	–	1 × 10⁻⁹	?	–	2.5	TE	[1975]
Eu/quartz	Eu	–	~10⁻¹⁰	~300	–	2.5 ± 0.3	PE	[304]
Eu	–	–	–	–	–	2.54	TC	[1956]
Eu	–	–	–	–	–	2.54	TC	[3352]
Eu	–	–	–	–	–	2.56	TC	[4432]
Eu/W(111)	Eu	–	1 × 10⁻⁹	?	–	2.6	TE	[1975]
Eu/W	Eu	–	?	?	–	2.7	TE	[2494]
Eu	–	–	4 × 10⁻¹⁰	~300	–	2.7 ± 0.05	CPD	[3120]
Eu	–	–	? (N_2)	~300	–	2.78 ± 0.02	CPD	[4066]
Eu/W(110)	Eu	–	1 × 10⁻⁹	?	–	2.8	TE	[1975]
Eu	–	–	–	–	–	2.8	TC	[1955]
Eu/W(110)	Eu	–	<7 × 10⁻¹¹	~300	–	2.8*	CPD	[2393]
Eu/Si(111)	–	–	–	–	–	2.8*	TC	[4076]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Eu/Si(111)[445]	Eu	–	$\leq 5 \times 10^{-10}$	~300	–	2.8*	CPD	[3757,4111]
Eu	–	–	–	–	–	2.87	TC	[550]
Eu/Si(111)[445]	Eu	–	$\leq 5 \times 10^{-10}$	~300	–	2.9*	CPD	[4112]
Eu/Si(111)[445]	Eu	–	$\leq 5 \times 10^{-10}$	500	–	2.9*	CPD	[3757,4111]
Recommended	–	–	–	–	–	**2.74 ± 0.12**	–	–

64. Gadolinium Gd[399]

hcp (α, T < 1533 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Gd(0001)	–	–	–	–	–	3.22	TC	[1434]
Gd(0001)/W(110)	Gd	–	$<2 \times 10^{-10}$	~300	–	3.25	PE	[3567]
Gd(0001)	–	–	$\sim 10^{-11}$	~300	–	3.3 ± 0.1	PE	[2148,2498,2504]
Gd(0001)/W(110)	Gd	–	$\sim 10^{-11}$	~300	–	3.3 ± 0.1	PE	[2522]
Gd(0001)[251]	–	–	–	–	–	3.67	TC	[3462]
Gd(0001)[251]	–	–	–	–	–	3.84	TC	[3462]
Gd(0001)	–	–	–	–	–	4.52	TC	[321]
Recommended	–	–	–	–	–	**3.27 ± 0.03**	–	–
Gd(1010)	–	–	–	–	–	4.31	TC	[321]
Gd(1124)	–	–	–	–	–	3.78	TC	[321]

bcc (β, T > 1533 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Gd(100)	–	–	–	–	–	2.9	TC	[4218]
Gd(100)	–	–	–	–	–	3.55	TC	[321]
Gd(110)	–	–	–	–	–	4.13	TC	[321]
Gd(111)	–	–	–	–	–	3.40	TC	[321]
Gd(112)	–	–	–	–	–	3.78	TC	[321]

hcp (α, T < 1533 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Gd	–	–	–	–	–	2.18 ± 0.05	TC	[2358]
Gd/W	Gd	–	?	~300	–	2.4 ± 0.3	FE	[1856]
Gd	–	–	–	–	–	2.41	TC	[1744]
Gd	–	–	–	–	–	2.45 ± 0.07	TC	[2358]
Gd	–	–	? (N_2)	~300	–	2.57 ± 0.02	CPD	[4251]
Gd/W(111)	Gd	–	1×10^{-9}	?	–	2.6	TE	[1975]
Gd/W(111)	Gd	–	1×10^{-9}	~300	–	2.6	FE	[2011]
Gd/W(111)	Gd	–	$\sim 10^{-10}$	~300	–	2.6	FE	[818]
Gd	–	–	? (N_2)	~300	–	2.65 ± 0.02	CPD	[4066]
Gd/W(111)	Gd	–	$\leq 10^{-9}$	~300	–	2.7	FE	[1987]
Gd/W(111)	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	2.7	FE	[1987]
Gd/W(111)	Gd	–	1×10^{-9}	~300	–	2.7	FE	[1975]
Gd/W(116)	Gd	–	1×10^{-9}	?	–	2.7	TE	[1975]
Gd/W	Gd	–	?	~300	–	2.7 ± 0.3	FE	[1856]
Gd/W(116)	Gd	–	$\leq 10^{-9}$	~300	–	2.8	FE	[1987]
Gd/W(111)	Gd	–	($\leq 10^{-11}$)	~300 (≤ 1000)	–	2.80 ± 0.01	CPD	[2046]
Gd/W(111)	Gd	–	$\leq 10^{-9}$	77	–	2.85	FE	[3704]
Gd(slab)	–	–	5×10^{-9}	~300	–	2.9 ± 0.1	PE	[2716]
Gd/Re–Gd(4.4%)	–	–	$\sim 10^{-8}$	1300	–	2.90	TE	[4240]
Gd	–	–	?	295	–	2.90 ± 0.06	CPD	[2943]
Gd/W(111)	Gd	–	($\leq 10^{-11}$)	~300	–	2.93	CPD	[2046]
Gd/W(116)	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	3.0	FE	[1975,1987]
Gd/B/Mo(110)[253]	Gd	–	2×10^{-10}	~300	–	3.0	CPD	[2700]
Gd	–	–	–	–	–	3.05	TC	[2750]
Gd	–	–	–	–	–	3.07	TC	[1956]
Gd	–	–	–	–	–	3.07	TC	[2943]
Gd(foil)	–	–	$<8 \times 10^{-11}$	~300	–	3.075 ± 0.050	PE	[342,3866,3868]
Gd/W(100)	Gd	–	$\leq 10^{-9}$	~300	–	3.1	FE	[1987]
Gd/W(112)	Gd	–	$\leq 10^{-9}$	~300	–	3.1	FE	[1987]
Gd	–	–	$\leq 10^{-9}$	~300	–	3.1	PE	[1483]
Gd/W(112)	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	3.1	FE	[1987]
Gd/W	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	3.1	FE	[1987]
Gd	–	–	–	–	–	3.1	TC	[1955]
Gd/Mo(111)	Gd	–	$<1 \times 10^{-10}$	~300	–	3.1	CPD	[2449]
Gd/quartz	Gd	–	$\sim 10^{-10}$	~300	–	3.1 ± 0.15	PE	[304]
Gd/W(110)	Gd	–	$\leq 10^{-9}$	77	–	3.12*	FE	[3704]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Gd/W	Gd	–	?	~300 (1070)	–	3.2 ± 0.3	FE	[1856]
Gd/Mo(112)	Gd	–	1×10^{-10}	~300	–	3.23	CPD	[2452]
Gd	–	–	–	–	–	3.27	TC	[550]
Gd/W(110)	Gd	–	$\leq 10^{-9}$	~300	–	3.3	FE	[1987]
Gd/W(100)	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	3.3	FE	[1975,1987]
Gd/W(110)	Gd	–	$\leq 10^{-9}$	77	–	3.31	FE	[3704]
Gd/Mo(110)	Gd	–	$\leq 3 \times 10^{-10}$	~300	–	3.4	CPD	[331]
Gd/Mo(110)	Gd	–	$\sim 10^{-10}$	~300	–	3.4	CPD	[4272]
Gd/Mo(112)	Gd	–	$\leq 10^{-11}$	~300 (1100)	–	3.40	CPD	[2533]
Gd	–	–	–	–	–	3.45	TC	[2358]
Gd/W(100)	Gd	–	$(\leq 10^{-11})$	~300 (≤800)	–	3.45 ± 0.02	CPD	[2664]
Gd/W(100)	Gd	–	$(\leq 10^{-11})$	~300 (1200)	–	3.48	CPD	[2664]
Gd/Mo(110)[253]	Gd	–	2×10^{-10}	~300	–	3.5	CPD	[2700]
Gd/W(100)	Gd	–	1×10^{-9}	?	–	3.5	TE	[1975]
Gd/W(110)	Gd	–	1×10^{-9}	?	–	3.5	TE	[1975]
Gd/W(110)	Gd	–	$<7 \times 10^{-11}$	~300 (1200)	–	3.51*	CPD	[2393]
Gd[446]	–	–	?	290.85	–	3.55 ± 0.15	PE	[3899]
Gd/W(110)	Gd	–	$\leq 10^{-9}$	~300 (>400)	–	3.6	FE	[1975,1987]
Gd/W(112)	Gd	–	$(\leq 10^{-11})$	77	–	3.6	CPD	[2043]
Gd/W(100)	Gd	–	$(\leq 10^{-11})$	~300 (1000)	–	3.60	CPD	[2664]
Gd/W(112)	Gd	–	$\leq 10^{-11}$	~300	–	3.62	CPD	[2533]
Gd/W(100)	Gd	–	$(\leq 10^{-11})$	~300	–	3.68	CPD	[2664]
Gd	–	–	–	–	–	3.70 ± 0.06	TC	[2358]
Gd/Mo(110)	Gd	–	$<5 \times 10^{-10}$	~300	–	3.75	CPD	[4238]
Gd[254]	–	–	–	–	–	3.76	TC	[2358]
Gd[254]	–	–	–	–	–	3.77	TC	[2358]
Recommended	–	–	–	–	–	**3.09 ± 0.04**	–	–

65. Terbium Tb[399]

hcp (α, $T < 1500$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tb(0001)	–	–	–	–	–	3.29	TC	[1434]
Tb(0001)[450]	–	–	?	300[E]	–	4.8*	TE	[3920]
Tb(0001)	–	–	–	–	–	4.95	TC	[321]
Tb(1010)	–	–	–	–	–	4.72	TC	[321]
Tb(1124)	–	–	–	–	–	4.13	TC	[321]

bcc (β, $T > 1500$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tb(100)	–	–	–	–	–	3.88	TC	[321]
Tb(110)	–	–	–	–	–	4.52	TC	[321]
Tb(111)	–	–	–	–	–	3.72	TC	[321]
Tb(112)	–	–	–	–	–	4.13	TC	[321]

hcp (α, $T < 1500$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tb/W(111)	Tb	–	$(\leq 10^{-11})$	~300 (1000)	–	2.81	CPD	[2046]
Tb/W(111)	Tb	–	$(\leq 10^{-11})$	~300 (800)	–	2.83	CPD	[2046]
Tb/W(111)	Tb	–	$(\leq 10^{-11})$	~300	–	2.92	CPD	[2046]
Tb/W(023)	Tb	–	$(\leq 10^{-11})$	77	–	2.92	FE	[3157]
Tb/W(112)	Tb	–	7×10^{-11}	~300 (1000)	–	2.92*	CPD	[2389]
Tb/W(111)	Tb	–	$(\leq 10^{-11})$	77	–	2.94	FE	[3157]
Tb/W(112)	Tb	–	$(\leq 10^{-11})$	77	–	2.94	FE	[3157]
Tb/Re–Tb(5%)	–	–	$\sim 10^{-8}$	1300	–	2.95	TE	[4240]
Tb/W(113)	Tb	–	$(\leq 10^{-11})$	77	–	2.97	FE	[3157]
Tb/W(111)	Tb	–	$\leq 10^{-9}$	77	–	2.97	FE	[3704]
Tb(slab)	–	–	5×10^{-9}	~300	–	3.0 ± 0.1	PE	[2716]
Tb	–	–	–	–	–	3.06	TC	[2750]
Tb	–	–	–	–	–	3.09	TC	[1956]
Tb	–	–	–	–	–	3.1	TC	[1955]
Tb/W(110)	Tb	–	$\leq 10^{-9}$	77	–	3.11*	FE	[3704]
Tb/W(111)	Tb	–	$(<10^{-11})$	~300	–	3.14*	CPD	[4235]
Tb	–	–	$\sim 10^{-9}$	1490	–	3.19	TE	[4356]
Tb	–	–	–	–	–	3.2	TC	[1744]
Tb/W(112)	Tb	–	$(\leq 10^{-11})$	77	–	3.24	CPD	[2671]
Tb	–	–	–	–	–	3.29	TC	[550]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tb/W(110)	Tb	–	($\leq 10^{-11}$)	77	–	3.3	FE	[3157]
Tb/W(110)	Tb	–	$\leq 10^{-9}$	77	–	3.30	FE	[3704]
Tb/W(110)	Tb	–	$< 7 \times 10^{-11}$	~300	–	3.36*	CPD	[2393]
Tb/W(100)	Tb	–	($\leq 10^{-11}$)	~300 (≤ 700)	–	3.40 ± 0.01	CPD	[2664]
Tb/W(100)	Tb	–	($\leq 10^{-11}$)	~300 (1200)	–	3.44	CPD	[2664]
Tb/Mo(110)	Tb	–	1×10^{-10}	~300	–	3.46	CPD	[3181,4273]
Tb/W(100)	Tb	–	($\leq 10^{-11}$)	~300 (≤ 1000)	–	3.48 ± 0.01	CPD	[2664]
Tb/W(100)	Tb	–	($\leq 10^{-11}$)	~300	–	3.60	CPD	[2664,3201]
Tb/Mo(110)	Tb	–	1×10^{-10}	~300 (800)	–	3.63	CPD	[3181,4273]
Recommended	–	–	–	–	–	**3.14 ± 0.09**	–	–

66. Dysprosium Dy[399]

hcp (α, $T < 1657$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Dy(0001)	–	–	–	–	–	3.31	TC	[1434]
Dy(0001)	–	–	–	–	–	5.00	TC	[321]
Dy(1010)	–	–	–	–	–	4.77	TC	[321]
Dy(1124)	–	–	–	–	–	4.18	TC	[321]

hcp (α, $T < 1657$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Dy/W	Dy	–	$\leq 3 \times 10^{-9}$	300 (?)	–	2.75	FE	[2969]
Dy/W(111)	Dy	–	$\leq 10^{-9}$	77	–	2.79	FE	[3704]
Dy/W	Dy	–	?	~300 (700)	–	2.9	FE	[532,1622]
Dy/W(111)	Dy	–	?	~300	–	2.9	FE	[532]
Dy/Re–Dy(4%)	–	–	~10^{-8}	1300	–	2.90	TE	[4240]
Dy/W(100)	Dy	–	~10^{-11}	~300	–	3.0*	PE	[2900]
Dy/Ta(112)	Dy	–	$\leq 10^{-11}$	~300 (600)	–	3.06	CPD	[801]
Dy	–	–	–	–	–	3.08	TC	[2750]
Dy	–	–	–	–	–	3.09	TC	[1956]
Dy	–	–	–	–	–	3.1	TC	[1955]
Dy/Ta(112)	Dy	–	$\leq 10^{-11}$	~300 (500)	–	3.11	CPD	[801]
Dy/Mo(112)	Dy	–	$\leq 1 \times 10^{-11}$	100 (~1000)	–	3.15*	CPD	[1937]
Dy/Mo(112)	Dy	–	($\leq 10^{-11}$)	77	–	3.15	CPD	[2052]
Dy/Mo(112)	Dy	–	$\leq 1 \times 10^{-11}$	90 (≥ 600)	–	3.16 ± 0.05*	CPD	[3616]
Dy/Ta(112)	Dy	–	$\leq 10^{-11}$	~300 (400)	–	3.25	CPD	[801]
Dy/Mo(112)	Dy	–	$\leq 1 \times 10^{-11}$	100 (≤ 400)	–	3.3*	CPD	[1937]
Dy/W(112)	Dy	–	($\leq 10^{-11}$)	77	–	3.3	CPD	[2043]
Dy	–	–	–	–	–	3.30	TC	[550]
Dy/Ta(112)	Dy	–	$\leq 10^{-11}$	77	–	3.41	CPD	[801]
Dy/Ta(112)	Dy	–	$\leq 10^{-11}$	~300	–	3.41	CPD	[801]
Dy/Mo(112)	Dy	–	~10^{-11}	~300	–	3.43	CPD	[2535]
Dy/Mo(112)	Dy	–	$\leq 1 \times 10^{-11}$	90 (~550)	–	3.43 ± 0.05*	CPD	[3616]
Dy/Mo(110)	Dy	–	1×10^{-10}	~300	–	3.58	CPD	[3181]
Dy/Mo(110)	Dy	–	$\leq 2 \times 10^{-10}$	~300	–	3.60	CPD	[2655,4272]
Dy/Al$_2$O$_3$/Mo(110)	Dy	–	$\leq 2 \times 10^{-10}$	~300	–	3.60	CPD	[2655]
Recommended	–	–	–	–	–	**3.18 ± 0.08**	–	–

67. Holmium Ho[399]

hcp (α, $T < 1701$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ho(0001)	–	–	–	–	–	3.37	TC	[1434]
Ho(0001)	–	–	–	–	–	4.37	TC	[321]
Ho(1010)	–	–	–	–	–	4.23	TC	[321]
Ho(1124)	–	–	–	–	–	3.71	TC	[321]

hcp (α, $T < 1701$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ho/W(111)	Ho	–	$\leq 10^{-11}$	~300 (640)	–	2.73 ± 0.03	FE	[3162]
Ho/W(023)	Ho	–	$\leq 10^{-11}$	77	–	2.84	FE	[3162]
Ho/W(113)	Ho	–	$\leq 10^{-11}$	~300{77}	–	2.84	FE	[3162]
Ho/W(113)	Ho	–	$\leq 10^{-11}$	~300	–	2.93 ± 0.05	FE	[3162]
Ho/Re–Ho(3%)	–	–	~10^{-8}	1300	–	2.95	TE	[4240]
Ho/W	Ho	–	$\leq 3 \times 10^{-9}$	~300 (?)	–	3.02	FE	[2969]
Ho/W(111)	Ho	–	$\leq 10^{-9}$	77	–	3.02	FE	[3704]
Ho/W(111)	Ho	–	$\leq 10^{-11}$	~300{77}	–	3.03 ± 0.03	FE	[3162]
Ho/W(113)	Ho	–	$\leq 10^{-11}$	~300{77}	–	3.03 ± 0.05	FE	[3162]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ho/W(111)	Ho	–	≤10⁻¹¹	77	–	3.06	FE	[3162]
Ho/W(113)	Ho	–	≤10⁻¹¹	77	–	3.06	FE	[3162]
Ho/W	Ho	–	≤10⁻¹¹	~300{77}	–	3.06 ± 0.05	FE	[3162]
Ho/W(113)	Ho	–	≤10⁻¹¹	~300 (800)	–	3.07	FE	[3162]
Ho	–	–	–	–	–	3.09	TC	[1956]
Ho	–	–	–	–	–	3.09	TC	[2750]
Ho	–	–	–	–	–	3.1	TC	[1955]
Ho	–	–	–	–	–	3.30	TC	[550]
Ho/W(112)	Ho	–	≤10⁻¹¹	77	–	3.31	FE	[3162]
Ho/W(112)	Ho	–	≤10⁻¹¹	77	–	3.55	CPD	[2049]
Recommended	–	–	–	–	–	**3.05 ± 0.05**	–	–

68. Erbium Er

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp								
Er(0001)	–	–	–	–	–	3.41	TC	[1434]
Er(0001)/Mo(110)	Er	–	~10⁻¹⁰	~300	–	3.53	CPD	[3163]
Er(0001)/Mo(110)	Er	–	~10⁻¹⁰	800	–	3.68	CPD	[3163]
Er(0001)	–	–	–	–	–	4.43	TC	[321]
Er(1010)	–	–	–	–	–	4.29	TC	[321]
Er(1124)	–	–	–	–	–	3.77	TC	[321]
hcp								
Er/6H-SiC(0001)	Er	–	4 × 10⁻¹⁰	~300	–	2.9 ± 0.1	CPD	[1832,3644]
Er/W	Er	–	<3 × 10⁻⁹	300 (?)	–	2.95	FE	[2969]
Er/Si(111)	Er	–	7 × 10⁻¹¹	~300	–	3.00	PE	[3461]
Er/Re–Er(2.5%)	–	–	~10⁻⁸	1300	–	3.00	TE	[4240]
Er(foil)²⁵⁵	–	–	~10⁻⁶	1300	–	3.06	TE	[3071]
Er/W(111)	Er	–	≤10⁻⁹	77	–	3.07	FE	[3704]
Er/6H-SiC(0001)	Er	–	4 × 10⁻¹⁰	~300 (1000)	–	3.1	CPD	[1832]
Er	–	–	–	–	–	3.1	TC	[1955]
Er	–	–	–	–	–	3.11	TC	[2750]
Er	–	–	–	–	–	3.12	TC	[1956]
Er	–	–	–	–	–	3.31	TC	[550]
Er/Si(100)	Er	–	≤4 × 10⁻¹⁰	230	–	3.5	CPD	[3199]
Er/Si(100)	Er	–	≤4 × 10⁻¹⁰	370	–	3.5	CPD	[3199]
Er/Mo(110)	Er	–	1 × 10⁻¹⁰	~300	–	3.53	CPD	[3181]
Recommended	–	–	–	–	–	**3.14 ± 0.08**	–	–

69. Thulium Tm³⁹⁹

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, T < 1277 K)								
Tm(0001)	–	–	–	–	–	3.46	TC	[1434]
Tm(0001)	–	–	–	–	–	4.48	TC	[321]
Tm(1010)	–	–	–	–	–	4.34	TC	[321]
Tm(1124)	–	–	–	–	–	3.81	TC	[321]
hcp (α, T < 1277 K for bulk)								
Tm/W(111)	Tm	–	≤10⁻⁹	77	–	2.94	FE	[3704]
Tm/Mo(110)	Tm	–	<4 × 10⁻¹¹	~300	–	3.0*	CPD	[2744]
Tm	–	–	–	–	–	3.1	TC	[1955]
Tm	–	–	–	–	–	3.11	TC	[550]
Tm	–	–	–	–	–	3.12	TC	[2750]
Tm	–	–	–	–	–	3.12	TC	[1956]
Tm/Re(0001)	Tm	–	≤5 × 10⁻⁸	1060–1460	–	3.15	TE	[96]
Tm/W(100)	Tm	–	<1 × 10⁻⁹	950–1300	–	3.23	TE	[1558]
Tm	–	–	–	–	–	3.32	TC	[550]
Recommended	–	–	–	–	–	**3.12 ± 0.07**	–	–

70. Ytterbium Yb³⁹⁹

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
fcc (α, T < 1071 K)								
Yb(100)	–	–	–	–	–	4.15	TC	[321]
Yb(110)	–	–	–	–	–	3.90	TC	[321]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Yb(111)	–	–	–	–	–	2.51	TC	[334,1434]
Yb(111)	–	–	–	–	–	4.47	TC	[321]
bcc (β, $T > 1071$ K)								
Yb(100)	–	–	–	–	–	3.57	TC	[321]
Yb(110)	–	–	–	–	–	2.45	TC	[334]
Yb(110)	–	–	–	–	–	4.16	TC	[321]
Yb(111)	–	–	–	–	–	3.42	TC	[321]
Yb(112)	–	–	–	–	–	3.81	TC	[321]
fcc (α, $T < 1071$ K for bulk)								
Yb	–	–	–	–	–	2.59	TC	[1956]
Yb	–	–	–	–	–	2.59	TC	[3352]
Yb/W$_2$C(111)	Yb	–	$<10^{-10}$	170	–	2.6	FE	[3792]
Yb/W(111)	Yb	–	$<10^{-10}$	170	–	2.6	FE	[3793]
Yb/W	Yb	–	$\leq 1 \times 10^{-9}$	?	–	2.6 ± 0.05	FE	[2602]
Yb	–	–	? (N_2)	~300	–	2.67	CPD	[2634,4066]
Yb/W	Yb	–	$<10^{-10}$	170	–	2.7	FE	[3793]
Yb	–	–	? (N_2)	~300	–	2.74 ± 0.02	CPD	[4251]
Yb	–	–	–	–	–	2.8	TC	[1955]
Yb/W(111)	Yb	–	$\sim 10^{-9}$	~300	–	2.8	FE	[2011]
Yb/H-Si(111)	Yb	–	1×10^{-10}	~300	–	2.80 ± 0.05	PE	[1195,2545]
Yb/Sm/Si(111)	Yb	–	$\leq 5 \times 10^{-10}$	~300	–	2.9*	CPD	[4110]
Yb/Si(111)^p	Yb	–	$<6 \times 10^{-10}$	~300	–	2.92 ± 0.02*	CPD	[4013]
Yb	–	–	–	–	–	2.95	TC	[550]
Yb/W(100)	Yb	–	$<10^{-10}$	170	–	3.0	FE	[3793]
Yb/Mo(110)	Yb	–	4×10^{-11}	~300	–	3.0*	CPD	[3146,3148]
Yb/Ta(112)	Yb	–	$\sim 10^{-11}$	~300 (600)	–	3.0*	CPD	[3316]
Yb/Si(111)	–	–	–	–	–	3.0*	TC	[4076]
Yb/Si(111)^{440}	Yb	–	$\leq 5 \times 10^{-10}$	~300	–	3.00 ± 0.03	CPD	[4109]
Yb/Si(111)^n	Yb	–	$<6 \times 10^{-10}$	~300	–	3.05*	CPD	[4012]
Yb/Ta(112)	Yb	–	$\sim 10^{-11}$	~300	–	3.1*	CPD	[3316]
Yb/Mo(112)	Yb	–	$\sim 10^{-11}$	~300 (700)	–	3.1*	CPD	[3316]
Yb/Mo(112)	Yb	–	$\sim 10^{-11}$	~300 (900)	–	3.1*	CPD	[3316]
Yb/Si(111)^n	Yb	–	$<6 \times 10^{-10}$	~300	–	3.1 ± 0.2*	CPD	[4013]
Yb/Si(111)	Yb	–	?	~300	–	3.16*	CPD	[3755]
Yb/Ir(111)	Yb	–	$\leq 5 \times 10^{-8}$	1025–1085	–	3.2	TE	[104]
Yb/Si(111)^n	Yb	–	$<6 \times 10^{-10}$	~300	–	3.27*	CPD	[4012]
Yb/Mo(112)	Yb	–	$\sim 10^{-11}$	~300	–	3.3*	CPD	[3316]
Recommended	–	–	–	–	–	**2.91 ± 0.09**	–	–

71. Lutetium Lu

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp (α, $T < $?)								
Lu(0001)	–	–	–	–	–	3.53	TC	[1434]
Lu(0001)	–	–	–	–	–	3.57	TC	[334]
Lu(0001)	–	–	–	–	–	4.45	TC	[321]
Lu(1010)	–	–	–	–	–	4.30	TC	[321]
Lu(1124)	–	–	–	–	–	3.78	TC	[321]
bcc (β, $T > $?)								
Lu(100)	–	–	–	–	–	3.54	TC	[321]
Lu(110)	–	–	–	–	–	4.13	TC	[321]
Lu(111)	–	–	–	–	–	3.39	TC	[321]
Lu(112)	–	–	–	–	–	3.77	TC	[321]
hcp (α, $T < $?)								
Lu	–	–	–	–	–	2.8	TC	[1744]
Lu/W(113)	Lu	–	($\leq 10^{-11}$)	77	–	3.05	FE	[3157]
Lu	–	–	–	–	–	3.1	TC	[1955]
Lu/W(111)	Lu	–	$\leq 10^{-9}$	77	–	3.11	FE	[3704]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Lu/W(111)	Lu	–	($\leq 10^{-11}$)	77	–	3.12	FE	[3157]
Lu	–	–	–	–	–	3.14	TC	[1956]
Lu/W	Lu	–	$\leq 1 \times 10^{-9}$	~300 (?)	–	3.14	FE	[2037]
Lu/Re–Lu(4%)	–	–	~10^{-8}	1300	–	3.20	TE	[4240]
Lu/W(112)	Lu	–	($\leq 10^{-11}$)	77	–	3.28	FE	[3157]
Lu/Mo(110)	Lu	–	$\leq 5 \times 10^{-9}$	~300	–	3.3	CPD	[2603]
Lu	–	–	–	–	–	3.33	TC	[550]
Lu/Mo(110)	Lu	–	$\leq 5 \times 10^{-9}$	~300 (800)	–	3.5	CPD	[2603]
Recommended	–	–	–	–	–	**3.17 ± 0.09**	–	–

72. Hafnium Hf

hcp (α, $T < 2050$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hf(0001)	–	–	5×10^{-8}	~1800–2000	–	4.10 ± 0.05	TE	[3921]
Hf(0001)	–	–	?	~1700–1900	–	4.11 ± 0.05	TE	[2967]
Hf(0001)	–	–	–	–	–	4.26	TC	[334]
Hf(0001)	–	–	–	–	–	4.51	TC	[4005]
Hf(0001)	–	–	–	–	–	5.50	TC	[321]
Hf(1010)	–	–	–	–	–	3.63	TC	[4005]
Hf(1010)	–	–	–	–	–	5.25	TC	[321]
Hf(1124)	–	–	–	–	–	4.60	TC	[321]

bcc (β, $T > 2050$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hf(100)	–	–	–	–	–	4.1	TC	[3171]
Hf(100)	–	–	–	–	–	4.2	TC	[1714,3167,3171]
Hf(100)	–	–	–	–	–	4.3	TC	[321]
Hf(110)	–	–	–	–	–	5.03	TC	[321]
Hf(111)	–	–	–	–	–	4.13	TC	[321]
Hf(112)	–	–	–	–	–	4.60	TC	[321]

hcp (α, $T < 2050$ K for bulk)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hf	–	–	$<2 \times 10^{-7}$	~1700–1900	–	3.17 ± 0.02	TE	[3066]
Hf[256]	–	–	?	<1700	–	3.20	TE	[1756,3524,3527]
Hf/W[257]	Hf	–	?	1100	–	3.20	TE	[1479]
Hf/W(100)	Hf	–	~10^{-10}	965	–	3.27	FE	[501][487]
Hf/W(100)	Hf	–	~10^{-10}	852	–	3.33	FE	[501]
Hf/W(100)	Hf	–	~10^{-10}	1100	–	3.36	FE	[501]
Hf/W(100)	Hf	–	~10^{-10}	747	–	3.39	FE	[501]
Hf/W(100)	Hf	–	~10^{-10}	642	–	3.46	FE	[501]
Hf	–	–	?	?	–	3.5	TE	[3402]
Hf/W(100)	Hf	–	4×10^{-11}	600	–	3.5*	CPD	[1737]
Hf/W(100)	Hf	–	~10^{-10}	551	–	3.51	FE	[501]
Hf	–	–	–	–	–	3.52	TC	[3318]
Hf	–	–	–	–	–	3.53	TC	[2949]
Hf[256]	–	–	?	>1900	–	3.53	TE	[3524,3527]
Hf	–	–	–	–	–	3.54	TC	[3318]
Hf	–	–	–	–	–	3.56	TC	[1744]
Hf/W	Hf	–	$<10^{-10}$	~300 (1300)	–	3.56 ± 0.01	FE	[3195]
Hf	–	–	~6×10^{-10}	~1300–1900	–	3.60	TE	[2092]
Hf	–	–	~3×10^{-9}	~1000–1600	–	3.65	TE	[159]
Hf/W	Hf	–	$<8 \times 10^{-11}$	~300 (1355)	–	3.65	FE	[3222]
Hf/W(100)	Hf	–	~10^{-10}	~300	–	3.68	FE	[501]
Hf	–	–	–	–	–	3.7	TC	[1993]
Hf/1%Hf–Nb	–	–	$\leq 10^{-8}$	1550 (1800)	–	3.72	TE	[1778]
Hf	–	–	$\leq 1 \times 10^{-6}$	~1600–1800	–	3.75 ± 0.1	TE	[216]
Hf	–	–	$\leq 10^{-8}$	~1300 (1900)	–	3.82	TE	[1778]
Hf	–	–	–	–	–	3.85	TC	[3637]
Hf	–	–	–	–	–	3.89	TC	[298]
Hf/quartz	Hf	–	~10^{-10}	~300	–	3.9 ± 0.1	PE	[304]
Hf	–	–	~10^{-9}	~1500	–	3.9 ± 0.1	CPD	[1588]
Hf	–	–	2×10^{-10}	~300	–	3.90	PE	[1814]
Hf	–	–	$\leq 10^{-8}$	~1500–2100	–	3.91	TE	[1778]
Hf	–	–	~6×10^{-10}	~1400–2000	–	3.91	TE	[2092]
Hf/W[257]	Hf	–	?	2000	–	3.92	TE	[1479]
Hf	–	–	?	?	–	3.97	TE	[2105]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hf/SiO$_2$	Hf	–	?	?	–	4.0	CPD	[2689]
Hf/W	Hf	–	<8 × 10^{-11}	~300 (≥730)	–	4.0	FE	[3222]
Hf/W[257]	HfI$_4$	–	?	1900{500}	–	4.00 ± 0.01	TE	[1479]
Hf	–	–	~10^{-6}	~1600	–	4.06 ± 0.06	TE	[1780]
Hf	–	–	–	–	–	4.1	TC	[706]
Hf	–	–	–	–	–	4.20	TC	[3476]
Hf	–	–	–	–	–	4.31	TC	[3476]
Hf	–	–	–	–	–	4.66	TC	[3476]
Recommended	–	–	–	–	–	**3.64 ± 0.06**	–	–

73. Tantalum Ta

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ta(100)	–	–	–	–	–	3.8 ± 0.1	TC	[470]
Ta(100)	–	–	–	–	–	3.83	TC	[1200]
Ta(100)	–	–	–	–	–	3.96	TC	[4316,4412]
Ta(100)	–	–	–	–	–	4.0 ± 0.1	TC	[470]
Ta(100)	–	–	–	–	–	4.04	TC	[1200]
Ta(100)	–	–	–	–	–	4.07	TC	[2548]
Ta(100)	–	–	–	–	–	4.08	TC	[1159,1980,3067]
Ta(100)	–	–	–	–	–	4.096	TC	[4091]
Ta(100)	–	–	<10^{-10}	?	–	4.1	TE	[694]
Ta(100)	–	–	–	–	–	4.1 ± 0.1	TC	[470]
Ta(100)	–	–	?	?	–	4.10	FE	[796]
Ta(100)	–	–	–	–	–	4.11	TC	[1200]
Ta(100)	–	–	5 × 10^{-9}	~1800–2100	–	4.12 ± 0.05	TE	[739,798,1406]
Ta(100)	–	–	–	–	–	4.14	TC	[3224]
Ta(100)	–	–	≤2 × 10^{-9}	~1700–2000	–	4.15 ± 0.02	TE	[127,144]
Ta(100)	–	–	<5 × 10^{-11}	~1500–1700	–	4.16 ± 0.05	TE	[1896]
Ta(100)	–	–	≤2 × 10^{-9}	?	(4.20 ± 0.04)	4.17 ± 0.04	TE	[797,799,2331]
Ta(100)	Na	Na$^+$	≤2 × 10^{-9}	1050–1750	4.20 ± 0.04	(4.17 ± 0.04)	PSI	[797]
Ta(100)	–	–	<5 × 10^{-11}	?	–	4.2	TE	[3776]
Ta(100)	–	–	<5 × 10^{-11}	~300	–	4.24 ± 0.05	CPD	[1896]
Ta(100)	–	–	<1 × 10^{-11}	78	–	4.25	FE	[648]
Ta(100)	–	–	–	–	–	4.3	TC	[469]
Ta(100)	–	–	–	–	–	4.3 ± 0.1	TC	[470]
Ta(100)	–	–	–	–	–	4.44	TC	[321]
Ta(100)	–	–	–	–	–	4.5	TC	[3171]
Ta(100)	F$^+$	F$^-$	2 × 10^{-10}	1965	4.51 ± 0.1^N	–	NSI	[604]
Ta(100)	Cl$^+$	Cl$^-$	2 × 10^{-10}	1985	4.55 ± 0.1^N	–	NSI	[604]
Ta(100)	Br$^+$	Br$^-$	2 × 10^{-10}	1938	4.55 ± 0.1^N	–	NSI	[604]
Ta(100)	–	–	–	–	–	4.6	TC	[389]
Ta(100)	–	–	–	–	–	4.6	TC	[3171]
Ta(100)	–	–	–	–	–	4.87	TC	[485,2791]
Recommended	–	–	–	–	–	**4.15 ± 0.05**	–	–
Ta(110)	–	–	≤2 × 10^{-9}	?	–	4.43 ± 0.05	TE	[1406]
Ta(110)	–	–	~10^{-10}	~300	–	4.47 ± 0.02	CPD	[777]
Ta(110)	–	–	–	–	–	4.6	TC	[1723]
Ta(110)	–	–	?	? (2300)	–	4.62 ± 0.04	TE	[3347]
Ta(110)	–	–	4 × 10^{-9}	?	–	4.63 ± 0.01	TE	[1477]
Ta(110)	–	–	~10^{-11}	1560–2360	–	4.73	TE	[683,1886,3846]
Ta(110)	–	–	–	–	–	4.74	TC	[2548]
Ta(110)	–	–	≤4 × 10^{-10}	~300	–	4.74 ± 0.02	PE	[680,1268]
Ta(110)	–	–	–	–	–	4.75	TC	[1159,1980,3067]
Ta(110)	–	–	?	~1200–1600	–	4.75 ± 0.06	TE	[681]
Ta(110)	–	–	?	?	–	4.76 ± 0.04	TE	[3347]
Ta(110)	–	–	–	–	–	4.77	TC	[1200]
Ta(110)	–	–	–	–	–	4.78	TC	[1200]
Ta(110)	–	–	?	? (2300)	–	4.78 ± 0.04	TE	[3347]
Ta(110)	–	–	?	80	–	4.79	FE	[1052]
Ta(110)	–	–	?	~300	–	4.8	PE	[460]
Ta(110)	–	–	≤2 × 10^{-9}	~1700–2000	–	4.80 ± 0.02	TE	[127,144]
Ta(110)	–	–	~10^{-9}	~1200–1900	(4.8)	4.80 ± 0.03	TE	[786]
Ta(110)	Li	Li$^+$	~10^{-9}	?	4.8	(4.80 ± 0.03)	PSI	[786]
Ta(110)	–	–	1 × 10^{-9}	~1000–1700	(4.85 ± 0.05)	4.81	TE	[726]
Ta(110)	–	–	≤2 × 10^{-9}	?	–	4.82 ± 0.04	TE	[797,799,2331]
Ta(110)	–	–	–	–	–	4.83	TC	[3224]
Ta(110)	–	–	5 × 10^{-9}	~1800–2100	–	4.83 ± 0.05	TE	[739,798]
Ta(110)	Na	Na$^+$	≤2 × 10^{-9}	~1000–1650	4.84 ± 0.04	(4.82 ± 0.04)	PSI	[797]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ta(110)	Na	Na$^+$	1×10^{-9}	1010–1680	4.85 ± 0.05	(4.81)	PSI	[726]
Ta(110)	–	–	$<5 \times 10^{-8}$	~1300–2000	(4.85 ± 0.06)	4.85	TE	[279]
Ta(110)	L[466]	L$^+$	$<5 \times 10^{-8}$	~1300–2000	4.85 ± 0.06	(4.85)	PSI	[279]
Ta(110)	–	–	–	–	–	4.86	TC	[1200]
Ta(110)	F$^+$	F$^-$	2×10^{-10}	2186	4.86 ± 0.1^N	–	NSI	[604]
Ta(110)	–	–	–	–	–	4.87	TC	[1200]
Ta(110)	–	–	~10^{-11}	~300	–	4.9	CPD	[1888]
Ta(110)	–	–	~10^{-9}	?	–	4.9	TE	[3909]
Ta(110)	–	–	–	–	–	4.9 ± 0.1	TC	[470]
Ta(110)	–	–	?	?	–	4.91	TE	[3407]
Ta(110)	Cl$^+$	Cl$^-$	2×10^{-10}	2183	4.92 ± 0.1^N	–	NSI	[604]
Ta(110)	–	–	~10^{-10}	~300	–	4.94 ± 0.05	PE	[506]
Ta(110)	–	–	?	?	–	4.95	FE	[796]
Ta(110)	–	–	–	–	–	4.964	TC	[4091]
Ta(110)	–	–	–	–	–	5.03	TC	[3474]
Ta(110)	–	–	–	–	–	5.08	TC	[334]
Ta(110)	–	–	–	–	–	5.08	TC	[3473]
Ta(110)	–	–	–	–	–	5.15	TC	[3179]
Ta(110)	–	–	–	–	–	5.16	TC	[321]
Ta(110)	–	–	~10^{-7} (O$_2$)	2200	–	5.2	TE	[3909]
Ta(110)	–	–	–	–	–	5.58	TC	[485,2791]
Ta(110)	–	–	–	–	–	6.06	TC	[485,2791]
Recommended	–	–	–	–	**4.84 ± 0.02**	**4.82 ± 0.06**	–	–
Ta(111)	–	–	–	–	–	3.50	TC	[1200]
Ta(111)	–	–	–	–	–	3.51	TC	[1200]
Ta(111)	–	–	$<1 \times 10^{-11}$	78	–	3.55	FE	[648]
Ta(111)	–	–	–	–	–	3.93	TC	[2548]
Ta(111)	–	–	–	–	–	3.93	TC	[1200]
Ta(111)	–	–	–	–	–	3.94	TC	[1159,1980,3067]
Ta(111)	–	–	?	?	–	3.95	FE	[796]
Ta(111)	–	–	–	–	–	3.96	TC	[1200]
Ta(111)	–	–	5×10^{-9}	~1800–2100	(4.00 ± 0.05)	3.98 ± 0.05	TE	[726,739,798,1406]
Ta(111)	–	–	?	80	–	3.99	FE	[1052]
Ta(111)	–	–	~10^{-7}	2200	–	4.00	TE	[3360]
Ta(111)	–	–	$\leq 2 \times 10^{-9}$	~1700–2000	–	4.00 ± 0.02	TE	[127,144]
Ta(111)	Na	Na$^+$	$\leq 2 \times 10^{-9}$	~1600–1800	4.00 ± 0.04	(4.02 ± 0.04)	PSI	[797]
Ta(111)	Na	Na$^+$	1×10^{-9}	~1700–2200	4.00 ± 0.05	(3.98 ± 0.05)	PSI	[726]
Ta(111)	–	–	~10^{-9}	~1500–1900	–	4.02 ± 0.02	TE	[800]
Ta(111)	–	–	$\leq 2 \times 10^{-9}$	?	(4.00 ± 0.04)	4.02 ± 0.04	TE	[797,799,2331]
Ta(111)	–	–	$<2 \times 10^{-9}$	~1700–2300	–	4.04	TE	[662]
Ta(111)	–	–	–	–	–	4.08	TC	[3224]
Ta(111)[258]	–	–	?	? (2100)	–	4.08 ± 0.03	TE	[729]
Ta(111)[258]	–	–	?	? (2100)	–	4.14 ± 0.03	TE	[729]
Ta(111)	–	–	~10^{-9}	2200	–	4.20	TE	[3360]
Ta(111)	–	–	–	–	–	4.201	TC	[4091]
Ta(111)	–	–	–	–	–	4.25	TC	[321]
Ta(111)[258]	–	–	?	? (2100)	–	4.28 ± 0.03	TE	[729]
Ta(111)	–	–	~10^{-5}	2200	–	4.40	TE	[3360]
Ta(111)[258]	–	–	?	? (2100)	–	4.46 ± 0.03	TE	[729]
Recommended	–	–	–	–	–	**4.01 ± 0.04**	–	–
Ta(112)	–	–	–	–	–	3.77	TC	[1200]
Ta(112)	–	–	–	–	–	3.80	TC	[1200]
Ta(112)	–	–	–	–	–	4.03	TC	[1200]
Ta(112)	–	–	–	–	–	4.05	TC	[1200]
Ta(112)	–	–	$<1 \times 10^{-11}$	78	–	4.05	FE	[648]
Ta(112)	–	–	–	–	–	4.25	TC	[3224]
Ta(112){70%}[267]	–	–	$\leq 10^{-9}$	~1100–2200	–	4.25 ± 0.05	TE	[124,650]
Ta(112)	–	–	?	?	–	4.30	FE	[796]
Ta(112)	–	–	–	–	–	4.31	TC	[1159,1980,3067]
Ta(112){82%}	–	–	–	–	(4.49 ± 0.04)	4.34 ± 0.03	TC	[803]
Ta(112)	–	–	$\leq 2 \times 10^{-9}$	~1700–2000	–	4.35 ± 0.05	TE	[127,144]
Ta(112)	–	–	1×10^{-10}	~1300–1900	–	4.352 ± 0.01	TE	[192]
Ta(112)	–	–	?	80	–	4.37	FE	[1052]
Ta(112)	–	–	($\leq 10^{-11}$)	77	–	4.40	CPD	[347,2662]
Ta(112)	–	–	($\leq 10^{-11}$)	~300	–	4.40	CPD	[347,801,2662]
Ta(112)	–	–	5×10^{-9}	~1800–2100	–	4.40 ± 0.05	TE	[798,1406]
Ta(112){82%}	–	–	–	–	4.49 ± 0.04	(4.34 ± 0.03)	TC	[803]
Ta(112)	–	–	1×10^{-10}	~1300–1900	–	4.58 ± 0.02	TE	[192]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ta(112)	–	–	–	–	–	4.73	TC	[321]
Ta(112)	–	–	1×10^{-10}	~1300–1900	–	4.74 ± 0.02	TE	[192]
Ta(112)	–	–	$<2 \times 10^{-9}$	1250–1650	–	4.8	TE	[802]
Ta(112)	K	K$^+$	2×10^{-9}	~1000–1500	4.8*	(4.8 ± 0.05)	PSI	[79]
Ta(112)	–	–	2×10^{-9}	~1200–2300	(4.8)	4.8 ± 0.05	TE	[79]
Recommended	–	–	–	–	–	**4.36 ± 0.04**	–	–
Ta(114)	–	–	–	–	–	3.98	TC	[3224]
Ta(116)	–	–	$\leq 2 \times 10^{-9}$	~1700–2000	–	~3.90	TE	[127,144]
Ta(116)	–	–	–	–	–	3.92	TC	[3224]
Ta(116)	–	–	–	–	–	3.94	TC	[1980,3067]
Ta(123)	–	–	–	–	–	4.04	TC	[3224]
Ta(130)[259]	–	–	$\leq 4 \times 10^{-10}$	~300	–	3.96 ± 0.04	PE	[680]
Ta(130)	–	–	–	–	–	4.03	TC	[3224]
Ta(130)	–	–	?	80	–	4.22	FE	[1052]
Ta(130)[259]	–	–	$\leq 4 \times 10^{-10}$	~300 (1670)	–	4.57 ± 0.02	PE	[680]
Ta(233)	–	–	–	–	–	3.99	TC	[3224]
Ta	^{91}Rb	^{91}Rb$^+$	~10^{-6}	~2100	>3*	–	PSI	[3861]
Ta	–	–	?	?	–	3.14	TE	[3019]
Ta/quartz[260]	Ta	–	$\leq 10^{-8}$	35	–	3.5 ± 0.2	CPD	[1686]
Ta[261]	–	(Ta$^-$)	$<2 \times 10^{-8}$	~2000–2100	3.7 ± 0.4*^{N}	–	NSI	[804]
Ta/quartz[260]	Ta	–	$\leq 10^{-8}$	4.2	–	3.8 ± 0.2	CPD	[1686]
Ta/quartz[260]	Ta	–	$\leq 10^{-8}$	293	–	3.8 ± 0.2	CPD	[1686]
Ta	–	–	–	–	–	3.80	TC	[521]
Ta	–	–	–	–	–	3.80	TC	[1901]
Ta	–	–	–	–	–	3.85	TC	[1744]
Ta[261]	–	(Ta$^-$)	$<2 \times 10^{-8}$	~2000–2100	3.9 ± 0.3^N	–	NSI	[804]
Ta	–	–	~10^{-7}	~1500–1950	–	3.90 ± 0.04	TE	[2769]
Ta	–	–	$<10^{-6}$	~300	–	3.93	PE	[2919]
Ta	–	–	?	~300	–	3.96	CPD	[2297]
Ta	–	–	2×10^{-8}	1650–2100	–	3.96	TE	[3643]
Ta	I$_2$	I$^-$	$\leq 10^{-2}$ (I$_2$)	~1900–2200	3.96 ± 0.03^N	(4.30 ± 0.02)	NSI	[81]
Ta	–	–	–	–	–	4.0	TC	[1993]
Ta	–	–	2×10^{-8}	~1200–1500	–	4.03 ± 0.04	TE	[2566]
Ta	–	–	–	–	–	4.05	TC	[2949]
Ta	–	–	?	~300	–	4.05 ± 0.03	PE	[1635]
Ta	–	–	–	–	–	4.07	TC	[2949]
Ta	–	–	?	~1400–1600	–	4.07	TE	[1949]
Ta	–	–	~10^{-9}	~1200–1800	–	4.08 ± 0.04	TE	[975]
Ta[266]	–	–	–	293^E	–	4.09	TC	[3586]
Ta	–	–	~10^{-3} (Cs)	?	–	4.09	CPD	[1642]
Ta	–	–	?	?	–	4.1	TE	[3402]
Ta(porous)	–	–	?	>1600	(4.2)	4.1	TE	[3762]
Ta/W(100)	Ta	–	1×10^{-11}	77	–	4.10	FE	[2965]
Ta/W(100)	Ta	–	1×10^{-11}	20–830	–	4.10	FE	[2965]
Ta	KCl	K$^+$	?	?	4.10 ± 0.02	–	PSI	[2306]
Ta	RbCl	Rb$^+$	?	?	4.10 ± 0.02	–	PSI	[2306]
Ta[265]	–	–	$\leq 8 \times 10^{-8}$	293	–	4.12	PE	[1633]
Ta/quartz	Ta	–	$<10^{-8}$	77, ~300	–	4.12	PE	[3036]
Ta/Ni	Ta	–	?	~300	–	4.12	PE	[2922]
Ta[265]	–	–	–	293	–	4.12 ± 0.02	TC	[1135]
Ta[266]	–	–	?	~1450–2050	–	4.12 ± 0.04	TE	[792]
Ta	–	–	?	~300	–	4.12 ± 0.07	PE	[974]
Ta[265]	–	–	$\leq 8 \times 10^{-8}$	293	–	4.13	PE	[1633,1636]
Ta[266]	–	–	–	973^E	–	4.13	TC	[3586]
Ta	–	–	–	–	–	4.13	TC	[3318]
Ta	–	–	–	–	–	4.13	TC	[3224]
Ta	–	–	$\leq 8 \times 10^{-8}$	293^E	–	4.13	TE	[1636]
Ta	–	–	$<5 \times 10^{-10}$	293	–	4.13	PE	[348]
Ta	–	–	~700 (Ar)	?	–	4.13 ± 0.013	TE	[2007]
Ta	–	–	4×10^{-11}	~300	–	4.14	PE	[1430,2733]
Ta	–	–	?	1370–1670	–	4.14	TE	[2567]
Ta	–	–	~10^{-8}	~1600–2300	–	4.14 ± 0.02	TE	[1164]
Ta/glass	Ta	–	~10^{-11}	77	–	4.14 ± 0.1	PE	[1528]
Ta/glass	Ta	–	~10^{-11}	~300	–	4.14 ± 0.1	PE	[1528]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ta	–	–	$\sim 10^{-11}$	1560–2360	–	4.15	TE	[683]
Ta	–	–	$\sim 10^{-9}$	?	–	4.15	TE	[979]
Ta	–	–	?	~ 300	–	4.15	PE	[1371]
Ta	–	–	?	?	–	4.15	TE	[2455]
Ta/Si(111)[166]	Ta	–	4×10^{-11}	~ 300	–	4.15	PE	[1430,2733]
Ta{70% (112)}[267]	–	–	–	–	–	4.15	TC	[1254]
Ta	–	–	?	~ 1500–2000	–	4.15	TE	[1306]
Ta	–	–	$\leq 5 \times 10^{-9}$	?	–	4.15 ± 0.05	TE	[806]
Ta[260]	–	–	$\leq 10^{-8}$	4.2–35	–	4.16	FE	[1686]
Ta	–	–	$<5 \times 10^{-10}$	293	–	4.16	PE	[348]
Ta	–	–	?	90	–	4.16	CPD	[2294]
Ta[265]	–	–	–	973	–	4.16 ± 0.02	TC	[1135]
Ta	–	–	4×10^{-9}	~ 300	–	4.17	PE	[1269]
Ta/Nb	Ta	–	$\sim 10^{-9}$	~ 1200–1800	–	4.17	TE	[975]
Ta	Sr	Sr⁺	$<1 \times 10^{-7}$	2450–2800	4.17	(4.21)	PSI	[80]
Ta[265]	–	–	$\leq 8 \times 10^{-8}$	973	–	4.18	PE	[1633,1636]
Ta	–	–	$\sim 10^{-6}$	?	–	4.18	TE	[3272]
Ta[265]	–	–	$\leq 8 \times 10^{-8}$	973	–	4.19	PE	[1633]
Ta	–	–	–	–	–	4.19	TC	[2005]
Ta	–	–	$<3 \times 10^{-8}$	1420–1700	(5.9 ± 0.3*)	4.19 ± 0.02	TE	[137]
Ta(porous)	Cs	Cs⁺	?	~ 1100–1400	4.2	(4.1)	PSI	[3762]
Ta	–	–	–	–	–	4.2	TC	[3318]
Ta	–	–	–	–	–	4.2	TC	[2583]
Ta	–	–	?	~ 1400–2000	–	4.2	TE	[3020]
Ta	–	–	$\leq 8 \times 10^{-8}$	973[E]	–	4.20	TE	[1636]
Ta	–	–	$<1 \times 10^{-7}$	?	(4.17, 4.23)	4.21	TE	[80]
Ta	–	–	$\leq 3 \times 10^{-9}$	~ 300	–	4.21 ± 0.06	CPD	[3106]
Ta	–	–	9×10^{-7}	2138–2440	–	4.218 ± 0.016	TE	[2296]
Ta	–	–	$\sim 1 \times 10^{-6}$	2088–2430	–	4.218 ± 0.028	TE	[2296]
Ta	–	–	–	–	–	4.22	TC	[3264,3265,3267]
Ta[269]	Br⁺	Br⁻	?	2125	4.22*[N]	(4.37 ± 0.1)	NSI	[600,641]
Ta	–	–	$<10^{-8}$	~ 300	–	4.22 ± 0.02	CPD	[349]
Ta$_n$(n → ∞)	–	–	–	–	–	4.22 ± 0.08	TC	[4261]
Ta	–	–	$\sim 1 \times 10^{-6}$	2050–2580	–	4.229 ± 0.014	TE	[2296]
Ta[269]	I⁺	I⁻	?	2125	4.23*[N]	(4.37 ± 0.1)	NSI	[600,641]
Ta	Ba	Ba⁺	$<1 \times 10^{-7}$	~ 2500–2800	4.23 ± 0.03	(4.21)	PSI	[80]
Ta	–	–	$\leq 10^{-9}$	~ 1800–2200	–	4.25	TE	[66]
Ta	–	–	?	~ 300	–	4.25	CPD	[2084]
Ta{82% (112)}[268]	–	–	? (Cs)	~ 1100–1700	–	4.25	TE	[650,3414]
Ta	–	–	$\leq 10^{-8}$	~ 1400–2100	–	4.25 ± 0.05	TE	[1775,1777,1778]
Ta{70% (112)}[267]	–	–	$\leq 10^{-9}$	~ 1100–2200	–	4.25 ± 0.05	TE	[124,650]
Ta	–	–	2×10^{-7}	~ 1800–2100	(5.10–5.19)	4.27 ± 0.04	TE	[23,67]
Ta[269]	Cl⁺	Cl⁻	?	2125	4.28*[N]	(4.37 ± 0.1)	NSI	[600,641]
Ta	–	–	?	?	–	4.3	TE	[2459]
Ta	–	–	?	1640–1890	–	4.3	TE	[2078]
Ta	–	–	$\sim 10^{-10}$	~ 300	–	4.3 ± 0.1	PE	[350]
Ta	–	–	$<10^{-9}$	~ 1900–2200	(4.64 ± 0.03)	4.30 ± 0.02	TE	[81]
Ta	–	–	$<10^{-9}$	~ 1900–2200	(3.96 ± 0.03[N])	4.30 ± 0.02	TE	[81]
Ta[174]	–	–	–	O[E]	–	4.31	TC	[1747]
Ta	–	–	1×10^{-7}	~ 1700–2200	(4.88 ± 0.05)	4.33 ± 0.03	TE	[76,77]
Ta{82% (112)}[268]	–	–	–	–	(4.49 ± 0.04)	4.34 ± 0.03	TC	[803]
Ta	–	–	$\sim 10^{-5}$	≤ 1200	–	4.35	TE	[2216]
Ta	–	–	–	–	–	4.35	TC	[3476]
Ta	–	–	?	~ 1900–2100	–	4.35 ± 0.05	TE	[1779]
Ta	–	–	–	–	–	4.37	TC	[298]
Ta	–	–	?	~ 1850–2300	(4.22–4.28)*[N]	4.37 ± 0.1	TE	[600,641]
Ta	–	–	? (K)	~ 1300–1700	–	4.38	TE	[2559]
Ta	–	–	$\sim 10^{-11}$	~ 300	–	4.38	CPD	[3338]
Ta	–	–	–	–	–	4.39	TC	[3476]
Ta	–	–	$<10^{-7}$	2200	–	4.4	TE	[2582]
Ta	–	–	–	0	–	4.41	TC	[4419]
Ta	–	–	–	–	–	4.45	TC	[2629]
Ta	–	–	~ 700 (Ar)	~ 3000	–	4.46	TE	[2007]
Ta{82% (112)}[268]	–	–	–	–	4.49 ± 0.04	(4.34 ± 0.03)	TC	[803]
Ta	–	–	~ 700 (Ar)	~ 3000	–	4.50	TE	[2007]
Ta	–	–	–	–	–	4.6	TC	[706]
Ta[270]	Na	Na⁺	$\sim 10^{-5}$ (Na)	~ 1900–2200	4.64 ± 0.03	(4.30 ± 0.02)	PSI	[81]
Ta[170,271]	–	(Ta⁺)	$<2 \times 10^{-8}$	~ 2000–2550	4.64 ± 0.14	–	PSI	[804]
Ta{mainly (110)}	–	–	0.1–6 (Cs)	~ 1700–1900	–	4.67 ± 0.07*	TE	[2609]
Ta	–	–	?	~ 300	–	4.70 ± 0.05	CPD	[3399]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ta	–	–	–	–	–	4.81	TC	[3476]
Ta	In	In$^+$	1×10^{-7}	~1700–2200	4.88 ± 0.05	(4.33 ± 0.03)	PSI	[76,77]
Ta	^{87}Br	^{87}Br$^-$	~10^{-6}	~2100	<5^{*N}	–	NSI	[3861]
Ta[170,271]	–	(Ta$^+$)	~10^{-7}	~2400–2660	5.0 ± 0.5	(4.33 ± 0.03)	PSI	[77]
Ta[271]	–	(Ta$^+$)	<7 × 10^{-7}	2550–2770	5.02 ± 0.11	–	PSI	[805,3083]
Ta	KCl	K$^+$	2×10^{-7}	~1800–2100	5.10 ± 0.01	(4.27 ± 0.04)	PSI	[23,2422]
Ta	RbBr	Rb$^+$	2×10^{-7}	~1800–2100	5.13 ± 0.03	(4.27 ± 0.04)	PSI	[23,67,2422]
Ta	RbCl	Rb$^+$	2×10^{-7}	~1800–2100	5.19 ± 0.03	(4.27 ± 0.04)	PSI	[23,67]
Ta	–	–	–	–	–	5.50	TC	[2629]
Ta[272]	–	(Ta$^+$)	<3 × 10^{-8}	~2700–2900	5.85 ± 0.3*	(4.19 ± 0.02)	PSI	[137]
Recommended	–	–	–	–	**4.95 ± 0.20**	**4.20 ± 0.03**	–	–
Recommended	–	–	–	–	**417 ± 0.13^N**	–	–	–

74. Tungsten W

bcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(100)	–	–	–	–	–	3.7	TC	[2979]
W(100)	–	–	–	–	–	3.8	TC	[351]
W(100)	–	–	–	–	–	4.090	TC	[4091]
W(100)	–	–	–	–	–	4.10	TC	[1270]
W(100)–Re(5%)	–	–	?	~1900–2100	–	4.10 ± 0.05	TE	[438]
W(100)	–	–	–	–	–	4.13	TC	[1270]
W(100)	–	–	?	~2000–2400	–	4.15 ± 0.02	TE	[2356]
W(100)	–	–	(≤10^{-10})	77	–	4.2	FE	[1974]
W(100)	–	–	?	~300 (2200)	–	4.2	FE	[3952]
W(100)	–	–	–	–	–	4.3	TC	[2265]
W(100)	–	–	?	~2200–2450	–	4.32 ± 0.01	TE	[2340,2343]
W(100)	–	–	–	–	–	4.34	TC	[2691]
W(100)	–	–	–	–	–	4.35 ± 0.01	TC	[4188]
W(100)	–	–	–	–	–	4.37	TC	[4189]
W(100)	–	–	–	–	–	4.4	TC	[351]
W(100)	–	–	–	–	–	4.4	TC	[3615]
W(100)	–	–	2×10^{-9}	~1700–2000	–	4.40	TE	[141]
W(100)	–	–	–	–	–	4.44	TC	[1270]
W(100)	–	–	1×10^{-8}	~1900–2100	–	4.45 ± 0.05	TE	[2012]
W(100)	–	–	–	–	–	4.46	TC	[3224]
W(100)	–	–	~10^{-10}	~300	–	4.47	FE	[378]
W(100)	–	–	5×10^{-9}	~2000–2400	–	4.48	TE	[352]
W(100)	–	–	–	–	–	4.49	TC	[4405]
W(100)	–	–	(≤10^{-11})	~300	–	4.5	CPD	[259]
W(100){95%}[302]	–	–	? (Cs)	~1600–2400	–	4.5	TE	[3414]
W(100)	–	–	–	–	–	4.5 ± 0.2	TC	[381]
W(100)	–	–	~10^{-11}	~300	–	4.50	CPD	[3338]
W(100)	–	–	–	–	–	4.50	TC	[4117]
W(100)	–	–	–	–	–	4.50	TC	[4405]
W(100){almost}[277]	–	–	≤10^{-9}	~1300–2200	–	4.50 ± 0.07	TE	[650]
W(100)/W(100)[309]	WF$_6$, H$_2$	–	~10^{-7}	~1850–2450	–	4.51 ± 0.01	TE	[1053]
W(100)	Sr	Sr$^+$	~10^{-9}	~2500–2850	4.52	–	PSI	[138]
W(100)	–	–	2×10^{-9}	~1400–2000	–	4.52	TE	[150]
W(100)	–	–	2×10^{-10}	90	–	4.52	FE	[3101,3102]
W(100){95%}[302]	–	–	~10^{-9}	?	–	4.52	TE	[3414]
W(100)–Re(5%)[274]	–	–	?	~2200	–	4.52 ± 0.04	TE	[438]
W(100){probably}	–	–	2×10^{-8}	1920–2300	(4.55 ± 0.03)	4.52 ± 0.07	TE	[92]
W(100){95%}[300]	–	–	~10^{-9}	1150–2200	–	4.52 ± 0.07	TE	[124]
W(100){96%}[300]	–	–	~10^{-9}	1150–2200	–	4.52 ± 0.07	TE	[124]
W(100)	–	–	–	–	–	4.53	TC	[3356,3452]
W(100)[273]	–	–	3×10^{-8}	–1900–	–	4.53	TE	[651]
W(100)	–	–	?	~1400–2000	–	4.53	TE	[149]
W(100)	–	–	≤8 × 10^{-9}	~2200–2450	–	4.53 ± 0.05	TE	[2340,2343]
W(100)	–	–	≤10^{-5} (I$_2$)	~1500–2300	(4.55 ± 0.05)^N	4.53 ± 0.05	TE	[571]
W(100)	Br$_2$	Br$^-$	? (Br$_2$)	~1500–2300	4.53 ± 0.05^N	–	NSI	[1658]
W(100)	–	–	~10^{-10}	77	–	4.54	FE	[2714]
W(100)	–	–	~2 × 10^{-9}	~2000–2400	–	4.54	TE	[4343]
W(100)	–	–	–	–	–	4.54	TC	[2701]
W(100)	–	–	–	–	–	4.54	TC	[3224]
W(100)–Re(1%)[274]	–	–	?	1850–2270	–	4.54	TE	[3086]
W(100)–Ir(2%)[275]	–	–	?	~1800–2030	–	4.54	TE	[3086]
W(100)[310]	–	–	~10^{-7}	~1850–2450	–	4.54 ± 0.01	TE	[1053]
W(100)	–	–	?	2100–2200	–	4.54 ± 0.01	TE	[3349]

(*continued on next page*)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(100)	K	K$^+$	≤3 × 10^{-10}	1574	4.54 ± 0.02	(4.59 ± 0.03)	PSI	[82,261]
W(100)	–	–	≤2 × 10^{-8}	1670–2040	(4.60)	4.55	TE	[83]
W(100)	–	–	≤3 × 10^{-11}	1670–1820	–	4.55	TE	[353]
W(100)	–	–	–	–	–	4.55	TC	[1136]
W(100)	–	–	2 × 10^{-10}	~300	–	4.55	PE	[1859]
W(100)	–	–	<3 × 10^{-11}	~300	–	4.55	PE	[3435]
W(100){probably}	Ba	Ba$^+$	2 × 10^{-8}	2050–2550	4.55 ± 0.03	(4.52 ± 0.07)	PSI	[92]
W(100)	I$_2$	I$^-$	≤10^{-5} (I$_2$)	~1500–2300	4.55 ± 0.05^N	(4.53 ± 0.05)	NSI	[571]
W(100)	–	–	~10^{-9}	~1940–2340	–	4.55 ± 0.05	TE	[143]
W(100)	–	–	1 × 10^{-8}	~1900–2100	–	4.55 ± 0.05	TE	[1663,2012]
W(100)	–	–	~10^{-8}	1170	–	4.56	TE	[3015]
W(100)	–	–	–	–	–	4.56	TC	[1271]
W(100)	–	–	–	–	–	4.56	TC	[3224]
W(100)–Re(2%)[274]	–	–	?	1640–1840	–	4.56	TE	[353]
W(100)	–	–	?	~1400–2000	–	4.56 ± 0.02	TE	[149]
W(100)	Sr	Sr$^+$	~10^{-9}	~2500–2850	4.56 ± 0.04	–	PSI	[138]
W(100)–Os(1%)[276]	–	–	?	~1700–2030	–	4.57 ± 0.04	TE	[3086]
W(100)	–	–	~10^{-10}	77	–	4.57	FE	[340]
W(100){95%}[301]	–	–	–	–	(4.69 ± 0.05)	4.57 ± 0.00	TC	[803]
W(100)	–	–	3 × 10^{-11}	78, 295	–	4.57 ± 0.14	FE	[354]
W(100)	–	–	–	–	–	4.58	TC	[531]
W(100)–Re(6%)[274]	–	–	?	1630–1770	–	4.59	TE	[353]
W(100)	–	–	~10^{-10}	77	–	4.59 ± 0.02	FE	[502]
W(100)	–	–	≤4 × 10^{-8}	~1650–2050	–	4.59 ± 0.02	TE	[140]
W(100)	–	–	≤3 × 10^{-10}	~1150–1650	(4.54 ± 0.02)	4.59 ± 0.03	TE	[82]
W(100){96%}[300]	–	–	–	–	(4.60 ± 0.04)	4.59 ± 0.04	TC	[630,2453]
W(100)	–	–	1 × 10^{-9}	?	(4.62 ± 0.06)	4.59 ± 0.05	TE	[84]
W(100)	–	–	?	~300	–	4.6	PE	[1603]
W(100)	–	–	≤5 × 10^{-8}	~1600–2100	(4.6)	4.6	TE	[271]
W(100)	Sm	Sm$^+$	≤5 × 10^{-8}	~1650–2000	4.6	(4.6)	PSI	[271]
W(100)	–	–	<10^{-10}	170	–	4.6	FE	[3793]
W(100)	Li	Li$^+$	<10^{-9}	~1000–1300	4.6	–	PSI	[318]
W(100)	–	–	–	–	–	4.6	TC	[382,1908]
W(100)	–	–	?	?	–	4.6	FE	[1463]
W(100)	–	–	1 × 10^{-8}	~300	–	4.6	CPD	[1511]
W(100)	–	–	–	–	–	4.6	TC	[3615]
W(100)	–	–	?	~1800–2300	–	4.6	TE	[1958]
W(100)	–	–	?	?	–	4.6	FE	[1964]
W(100)	–	–	≤7 × 10^{-11}	~300	–	4.6	CPD	[2385]
W(100)	–	–	?	77	–	4.6	FE	[3079]
W(100)	–	–	?	20, 100	–	4.6	FE	[3508]
W(100)	–	–	?	?	(4.6 ± 0.1)	4.6 ± 0.1	TE	[15,649]
W(100)	Ba	Ba$^+$	?	?	4.6 ± 0.1	(4.6 ± 0.1)	PSI	[15,649]
W(100)	–	–	~10^{-10}	–1600–	–	4.6 ± 0.1	TE	[335,1650,1651, 1967]
W(100)	La	La$^+$	3 × 10^{-8}	~2000–2750	4.6 ± 0.1	–	PSI	[153]
W(100)	Nd	Nd$^+$	<10^{-8}	~1900–2550	4.6 ± 0.1	–	PSI	[153]
W(100)	K	K$^+$	≤1 × 10^{-6}	?	4.6 ± 0.1	–	PSI	[216]
W(100)	–	–	?	?	(4.6 ± 0.1)	4.6 ± 0.1	TE	[1659]
W(100)	K	K$^+$	?	?	4.6 ± 0.1	(4.6 ± 0.1)	PSI	[1659]
W(100)	–	–	?	?	–	4.6 ± 0.1	FE	[3033]
W(100)	In	In$^+$	≤2 × 10^{-8}	1630–2040	4.60	(4.55)	PSI	[83]
W(100)	–	–	≤5 × 10^{-10}	298, 613	–	4.60	CPD	[355]
W(100)	–	–	?	~1700–2200	–	4.60	TE	[2187,3664]
W(100)	–	–	~10^{-9}	?	–	4.60	TE	[3096]
W(100)	La	La$^+$	~10^{-9}	~2500–2850	4.60 ± 0.03	–	PSI	[138]
W(100)	–	–	~10^{-9}	?	(4.66 ± 0.03)	4.60 ± 0.03	TE	[3103]
W(100){96%}[300]	–	–	–	–	4.60 ± 0.04	(4.59 ± 0.04)	TC	[630,2453]
W(100)	–	–	<2 × 10^{-10}	?	–	4.60 ± 0.05	TE	[142]
W(100)	–	–	≤2 × 10^{-9}	~1700–2000	–	4.60 ± 0.05	TE	[127,144]
W(100)	–	–	–	–	–	4.60 ± 0.05	TC	[384]
W(100)	–	–	~10^{-10}	~300	–	4.60 ± 0.05	CPD	[820]
W(100)[278]	–	–	8 × 10^{-9}	?	(4.66 ± 0.11*)	4.60 ± 0.06	TE	[280]
W(100)	–	–	≤3 × 10^{-10}	~1150–1650	–	4.61 ± 0.03	TE	[652]
W(100){95%}[301]	–	–	–	–	(4.70 ± 0.04)	4.61 ± 0.04	TC	[2453]
W(100)[273]	–	–	3 × 10^{-8}	–1900–	–	4.61 ± 0.05	TE	[651]
W(100)	–	–	3 × 10^{-9}	~1500–2000	–	4.61 ± 0.05	TE	[2214,2217]
W(100)[170,278]	Cs	Cs$^+$	2 × 10^{-9}	~1000–1500	4.61 ± 0.07	(4.65 ± 0.02)	PSI	[266,2314–2316]
W(100){probably}	–	–	~10^{-10}	~300	–	4.62	CPD	[1516]
W(100)	–	–	<10^{-8}(Sr)	~2000	–	4.62	TE	[1792]

(continued on next page)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(100)	–	–	?	~300	–	4.62	CPD	[3600]
W(100)	–	–	≤10⁻⁸	~1700–2300	–	4.62 ± 0.03	TE	[1793]
W(100)	–	–	<1 × 10⁻¹⁰	~300	–	4.62 ± 0.05	PE	[2669]
W(100)	Bi	Bi⁺	1 × 10⁻⁹	?	4.62 ± 0.06	(4.59 ± 0.05)	PSI	[84]
W(100)	–	–	<5 × 10⁻¹¹	~300	–	4.63	CPD	[1672]
W(100)	–	–	≤10⁻¹⁰	78	–	4.63	FE	[356]
W(100)	–	–	–	–	–	4.63	TC	[357]
W(100)	–	–	–	–	–	4.63	TC	[383,385]
W(100)/Mo	WX₆	–	6 × 10⁻⁷	?	–	4.63	TE	[1521]
W(100)	–	–	~10⁻¹⁰	~300	–	4.63	CPD	[2110]
W(100)	–	–	–	–	–	4.63	TC	[3452]
W(100)	–	–	~10⁻¹⁰	77, 300	–	4.63 ± 0.02	FE	[358,3092]
W(100)	–	–	~10⁻⁸ (O₂)	2200	–	4.64	TE	[212]
W(100)	–	–	≤6 × 10⁻¹¹	78	–	4.64	FE	[807]
W(100)	–	–	1 × 10⁻⁹	~300	–	4.64	FE	[2220]
W(100)	–	–	2 × 10⁻¹⁰	~300	–	4.64	PE	[3436]
W(100)	–	–	<5 × 10⁻¹⁰	~300	–	4.64 ± 0.01	CPD	[2471]
W(100)	–	–	≤3 × 10⁻¹⁰	~300	–	4.64 ± 0.02	CPD	[1054]
W(100)	–	–	?	~300	–	4.645 ± 0.005	CPD	[1490]
W(100)	–	–	≤6 × 10⁻¹⁰	120, 300	–	4.65	CPD	[359,2124,2721]
W(100)	–	–	<5 × 10⁻¹¹	~300	–	4.65	CPD	[360,361]
W(100)	–	–	–	–	–	4.65	TC	[386]
W(100)	–	–	<2 × 10⁻¹⁰	~300	–	4.65	FE	[489]
W(100)	–	–	<10⁻¹⁰	295	–	4.65	FE	[1276]
W(100){99.5%}	–	–	<10⁻¹⁰	~300	–	4.65	CPD	[2058]
W(100)	–	–	–	–	–	4.65	TC	[2548]
W(100)	–	–	~10⁻¹⁰	~300	–	4.65	CPD	[3076]
W(100)	–	–	≤3 × 10⁻¹⁰	~300	–	4.65 ± 0.01	CPD	[194]
W(100)	–	–	≤3 × 10⁻¹⁰	~300	–	4.65 ± 0.01	CPD	[362,2481]
W(100)[278]	–	–	2 × 10⁻⁹	~1400–2200	(4.61 ± 0.07)	4.65 ± 0.02	TE	[266,2314–2316]
W(100)	–	–	?	~2000–2400	–	4.65 ± 0.02	TE	[2356]
W(100)	–	–	≤4 × 10⁻¹⁰	~300	–	4.65 ± 0.02	CPD	[582,2102,3088]
W(100)	–	–	≤10⁻¹⁰	~300	–	4.65 ± 0.03	PE	[3432]
W(100)	–	–	<5 × 10⁻¹⁰	~300	–	4.65 ± 0.04	CPD	[1055,1056]
W(100)	–	–	≤3 × 10⁻¹⁰	~300	–	4.655 ± 0.005	CPD	[2104]
W(100)	–	–	–	–	–	4.66	TC	[1159,1980,2129, 3067]
W(100)	Na	Na⁺	~10⁻⁹	?	4.66 ± 0.03	(4.60 ± 0.03)	PSI	[3103]
W(100)	–	–	<10⁻⁸	~1900–2400	–	4.66 ± 0.06	TE	[87]
W(100)[170,278]	Cs	Cs⁺	8 × 10⁻⁹	?	4.66 ± 0.11*	(4.60 ± 0.06)	PSI	[280]
W(100)	–	–	?	~2100–2200	–	4.66 ± 0.13	TE	[3349]
W(100)	–	–	≤4 × 10⁻¹⁰	~300	–	4.660 ± 0.005	CPD	[2108]
W(100)	–	–	–	–	–	4.67	TC	[3224]
W(100)	–	–	2 × 10⁻¹⁰	90	–	4.68	FE	[3102]
W(100)	La	La⁺	~10⁻⁹	~2500–2900	4.69	–	PSI	[138]
W(100)	–	–	?	1920	–	4.69	TE	[2187,3664]
W(100){95%}[301]	–	–	–	–	4.69 ± 0.05	(4.57 ± 0.00)	TC	[803]
W(100)	–	–	?	~300 (2200)	–	4.7	FE	[3847,3952,3953]
W(100)	–	–	<10⁻¹⁰	~300	–	4.7	CPD	[808]
W(100)	–	–	7 × 10⁻¹⁰	77	–	4.7	FE	[3691]
W(100)	–	–	≤1 × 10⁻⁹	300, 1000	–	4.7	FE	[1965]
W(100)	–	–	(<10⁻¹¹)	78	–	4.70	FE	[809]
W(100)	–	–	?	20, 100	–	4.70	FE	[812]
W(100){95%}[301]	–	–	–	–	4.70 ± 0.04	(4.61 ± 0.04)	TC	[2453]
W(100)	–	–	~10⁻¹⁰	77–600	–	4.70 ± 0.05*	FE	[502]
W(100)	–	–	?	?	–	4.71	FE	[1284]
W(100)[170,278]	Cs	Cs⁺	~10⁻¹⁰	~800–1050	4.72*	–	PSI	[265]
W(100)	–	–	≤3 × 10⁻¹⁰	1000	–	4.72 ± 0.02	CPD	[194]
W(100)	–	–	<2 × 10⁻¹⁰	78	–	4.72 ± 0.04	FE	[1674,2254–2256]
W(100)	–	–	~10⁻¹⁰	77	–	4.75	FE	[340]
W(100)	–	–	~10⁻⁸	~2050–2350	–	4.76 ± 0.05	TE	[3064]
W(100)	–	–	~10⁻⁹	77	–	4.77	FE	[363,810,811,2766]
W(100)	–	–	–	–	–	4.77	TC	[383,385]
W(100)	–	–	<1 × 10⁻¹¹	78	–	4.78	FE	[373]
W(100){95%}[277]	–	–	–	–	–	4.78	TC	[1254]
W(100)	–	–	<5 × 10⁻¹⁰	77	–	4.8	FE	[3114]
W(100)	–	–	<1 × 10⁻¹¹	77	–	4.80	FE	[1549]
W(100)	La	La⁺	~10⁻⁹	~2500–2850	4.80 ± 0.03	–	PSI	[138]
W(100)	–	–	<8 × 10⁻¹¹	~300	–	4.80 ± <0.05	FE	[364,530]
W(100)	–	–	3 × 10⁻⁹	~1500–2000	–	4.80 ± 0.05	TE	[2214,2217]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(100)	–	–	$\sim10^{-10}$	~300	–	4.82	FE	[2324]
W(100)	–	–	$<10^{-11}$	77	–	4.82	FE	[267]
W(100)	–	–	–	–	–	4.82	TC	[384]
W(100)	–	–	2×10^{-10}	~300	–	4.83 ± 0.02	FE	[999]
W(100)	–	–	$(\sim10^{-11})$	~300	–	4.86	FE	[3237]
W(100)	–	–	–	–	–	4.88	TC	[387]
W(100)	–	–	$<1\times10^{-10}$	~300	–	4.88 ± 0.02	FE	[2616]
W(100)	–	–	–	–	–	4.89	TC	[387]
W(100)	–	–	?	15	–	4.89	FE	[653]
W(100)	–	–	$<5\times10^{-10}$	77	–	4.9	FE	[3114]
W(100)	–	–	$\sim1\times10^{-10}$	~300	–	4.9	FE	[3438]
W(100)	–	–	$\sim10^{-10}$	79	–	4.90	FE	[1275]
W(100)	–	–	$<10^{-8}$	20	–	4.90 ± 0.03	FE	[813]
W(100)	–	–	$\sim10^{-10}$	78	–	4.93 ± 0.06	FE	[819]
W(100)	–	–	–	–	–	4.963	TC	[365]
W(100)	–	–	?	~300	–	4.97	FE	[1730]
W(100)	–	–	–	–	–	4.979	TC	[365]
W(100)	–	–	?	80	–	4.98	FE	[1057]
W(100)	–	–	–	–	–	5.00	TC	[2701]
W(100)	–	–	–	–	–	5.009	TC	[365]
W(100)	–	–	–	–	–	5.03	TC	[387]
W(100)	Sr	Sr^+	$\sim10^{-9}$	~1700–2200	5.07	–	PSI	[138]
W(100)	–	–	–	–	–	5.08	TC	[387]
W(100)	–	–	–	–	–	5.10	TC	[387]
W(100)–Os(1%)[276]	–	–	?	2080–2300	–	5.12 ± 0.06	TE	[3086]
W(100)	–	–	–	–	–	5.16	TC	[387]
W(100)	–	–	5×10^{-10}	~300	–	5.2	FE	[376]
W(100)–Ir(2%)[275]	–	–	?	2030–2200	–	5.28 ± 0.06	TE	[3086]
W(100)–Ir(2%)[275]	–	–	?	2030–2200	–	5.30 ± 0.06	TE	[3086]
W(100)	–	–	–	–	–	5.4	TC	[388,389,511]
W(100)	–	–	–	–	–	5.47	TC	[384]
W(100)	–	–	–	–	–	7.8	TC	[2528]
Recommended	–	–	–	–	**4.62 ± 0.05**	**4.65 ± 0.02**	–	–
W(110)[289]	–	–	1×10^{-9}	~1400–2000	–	4.58	TE	[150]
W(110)	–	–	$\sim10^{-10}$	77	–	4.6	FE	[2714]
W(110)	–	–	?	?	–	4.60 ± 0.08	FE	[1377,1378]
W(110)[279]	NaCl	Na^+, Cl^-	$<10^{-10}$	1845–2136	4.609 ± 0.014	(5.18 ± 0.08)	PSI, NSI	[89]
W(110)[279]	NaCl	Cl^-, Na^+	$<10^{-10}$	1845–2136	4.609 ± 0.014^N	(5.18 ± 0.08)	NSI, PSI	[89]
W(110)	–	–	$<10^{-8}$	~1900–2250	–	4.61	TE	[85]
W(110)	–	–	1×10^{-8}	~1900–2100	–	4.63 ± 0.05	TE	[1663,2012]
W(110)	–	–	?	~1400–2000	–	4.65 ± 0.02	TE	[149,2706]
W(110)[289]	–	–	1×10^{-9}	~1400–2000	–	4.66	TE	[150]
W(110)[279]	NaCl	Na^+, Cl^-	$<10^{-10}$	1800–2200	4.66 ± 0.09	–	PSI, NSI	[3690]
W(110)[279]	NaCl	Cl^-, Na^+	$<10^{-10}$	1800–2200	4.66 ± 0.09^N	–	NSI, PSI	[3690]
W(110)	–	–	1×10^{-8}	~1900–2100	–	4.67 ± 0.05	TE	[1663,2012]
W(110)	–	–	$\sim10^{-12}$	~300	–	4.68	FE	[3406]
W(110)	–	–	–	–	–	4.7	TC	[1723]
W(110)	–	–	?	?	–	4.7 ± 0.1	TE	[3578]
W(110)	–	–	–	–	–	4.758	TC	[4091]
W(110)	–	–	–	–	–	4.79	TC	[1270]
W(110)	–	–	–	–	–	4.8	TC	[1723]
W(110)	–	–	$<10^{-8}$	~1800–2200	(5.14)	4.8 ± 0.1	TE	[85]
W(110)	–	–	?	?	–	4.8 ± 0.1	TE	[3578]
W(110)	Gd	Gd^+	$\sim10^{-10}$	~2000–2700	$4.80\pm0.09*$	–	PSI	[416]
W(110)	–	–	$\sim10^{-10}$	79	–	4.82	FE	[1275]
W(110){80%}[311]	–	–	$<10^{-9}$	~1700–2600	–	4.82 ± 0.02	TE	[162]
W(110)[280]	Ba	Ba^+	$<10^{-8}$	~1800–2140	4.82 ± 0.06	(5.04, 5.30)	PSI	[87]
W(110)	–	–	–	–	–	4.84	TC	[1270]
W(110)	–	–	–	–	–	4.84	TC	[4309]
W(110)	–	–	$<8\times10^{-9}$	~2200–2450	–	4.87 ± 0.04	TE	[2340]
W(110){80%}[311]	–	–	–	–	(5.26 ± 0.00)	4.87 ± 0.06	TC	[2453]
W(110)/Nb(110)	–	–	–	–	–	4.9	TC	[2073]
W(110)	–	–	1×10^{-8}	~1500–1850	–	4.9	TE	[1499]
W(110)	–	–	?	?	–	>4.9	FE	[1463]
W(110)	–	–	$\leq2\times10^{-9}$	~1600–2200	(5.28 ± 0.03)	4.90 ± 0.02	TE	[88,814]
W(110){80%}[311]	–	–	–	–	(5.25 ± 0.02)	4.90 ± 0.02	TC	[630]
W(110)	–	–	5×10^{-9}	~2000–2400	–	4.92	TE	[352]
W(110)/?	WCl_6	–	?	?	–	5.0	FE	[3735]
W(110)	–	–	$\leq6\times10^{-8}$	~1800–2150	–	5.0	TE	[2247]

(continued on next page)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(110){80%}[311]	–	–	<10⁻⁹	~700–2600	–	5.0 ± 0.2	TE	[162]
W(110)	–	–	~10⁻¹⁰	–1600–	–	5.0 ± 0.2	TE	[335,1650,1651, 1967]
W(110)	–	–	~10⁻⁸	?	–	5.00	TE	[3353]
W(110)	–	–	~10⁻¹⁰	77–700	–	5.02 ± 0.03	FE	[502]
W(110)	–	–	–	–	–	5.025	TC	[4189]
W(110)	–	–	–	–	–	5.03	TC	[471]
W(110)	–	–	≤2 × 10⁻⁹	~1600–2200	(5.30 ± 0.03)	5.03 ± 0.02	TE	[3542]
W(110)[280]	–	–	<10⁻⁸	~1900–2300	(4.82, 5.14)	5.04 ± 0.06	TE	[87]
W(110)	–	–	–	–	–	5.05	TC	[367]
W(110)	–	–	–	–	–	5.05	TC	[151,2936]
W(110)[281]	–	–	<2 × 10⁻¹⁰	~300	–	5.05 ± 0.02	CPD	[815]
W(110)/W(110)[310]	W	–	~10⁻⁷	~1850–2450	–	5.06 ± 0.01	TE	[1053]
W(110)	–	–	7 × 10⁻¹¹	200	–	5.06 ± 0.05	PE	[3566]
W(110)	–	–	–	–	–	5.07	TC	[1270]
W(110)	–	–	<8 × 10⁻¹¹	~300	–	5.07 ± <0.05	FE	[364,530,3213]
W(110)	–	–	–	–	–	5.08	TC	[3115]
W(110)	–	–	≤3 × 10⁻⁹	~1200	–	5.08	FE	[2072]
W(110)	–	–	2 × 10⁻⁹	~2000	–	5.09	TE	[141]
W(110)	Li	Li⁺	<10⁻⁹	~1000–1200	5.1	–	PSI	[318,319,366]
W(110)	–	–	2 × 10⁻¹¹	~300	–	5.1	PE	[1940]
W(110)[283]	–	–	~10⁻¹⁰	~300	(5.2)	5.1	PE	[2774,3768]
W(110)	–	–	≤1 × 10⁻¹⁰	~300	–	5.1	PE	[3177,3191]
W(110)[282]	–	–	–	–	–	5.10	TC	[2073,2074]
W(110)	–	–	?	?	–	5.10	FE	[3618]
W(110)/Mo(110)[282]	–	–	–	–	–	5.10+0.01	TC	[2074]
W(110)	–	–	~10⁻¹⁰	~300	–	5.10 ± 0.01	CPD	[2106,2110]
W(110)	–	–	–	–	–	5.11	TC	[3224]
W(110)[284]	Cs	Cs⁺	2 × 10⁻⁹	~1000–1500	5.11	(5.33 ± 0.04)	PSI	[2314]
W(110)	–	–	<5 × 10⁻¹⁰	~300	–	5.11 ± 0.01	CPD	[2471]
W(110)	–	–	<5 × 10⁻¹⁰	~300	–	5.11 ± 0.02	CPD	[1055,1056,2102]
W(110)	–	–	≤3 × 10⁻¹⁰	~300	–	5.120 ± 0.005	CPD	[2104]
W(110)	–	–	≤4 × 10⁻¹⁰	~300	–	5.125 ± 0.005	CPD	[2108]
W(110)	–	–	–	–	–	5.13	TC	[4405]
W(110)[310]	–	–	~10⁻⁷	~1850–2450	–	5.13 ± 0.01	TE	[1053]
W(110)	–	–	≤4 × 10⁻¹⁰	~300	–	5.13 ± 0.02	CPD	[582]
W(110)[280]	Na[270]	Na⁺	? (Na)	~1900–2000	5.14	(5.04, 5.30)	PSI	[87]
W(110)[270]	Na	Na⁺	? (Na)	~1500–2000	5.14	(4.8 ± 0.1)	PSI	[85,3037]
W(110)	–	–	≤3 × 10⁻¹⁰	~300	–	5.14 ± 0.01	CPD	[362,2481]
W(110)	Na	Na⁺	~10⁻⁹	~1450–2000	5.14 ± 0.03	(5.30 ± 0.03)	PSI	[3103]
W(110)	–	–	?	~300	–	5.141 ± 0.007	CPD	[1490]
W(110)[281]	–	–	<2 × 10⁻¹⁰	~300 (2500)	–	5.15	CPD	[815]
W(110)	–	–	–	–	–	5.15	TC	[3224]
W(110)	KCl	K⁺	1 × 10⁻¹⁰	~1000–1500	5.15	–	PSI	[1548]
W(110)	–	–	?	80, 300	–	5.15	CPD	[2112]
W(110)	–	–	<3 × 10⁻¹⁰	~300	–	5.15 ± 0.01	CPD	[194]
W(110)[310]	–	–	~10⁻⁷	~1850–2450	–	5.15 ± 0.01	TE	[1053]
W(110)	–	–	?	~300	–	5.15 ± 0.01	CPD	[3420]
W(110)	–	–	~10⁻¹⁰	~300	–	5.15 ± 0.02	CPD	[3076,3088]
W(110)	–	–	?	77	–	5.15 ± 0.05	FE	[502]
W(110)/W(100)[309]	WF₆, H₂	–	~10⁻⁷	1850–2450	–	5.16 ± 0.01	TE	[1053]
W(110)/W(110)[309]	WCl₆, H₂	–	~10⁻⁷	1850–2450	–	5.16 ± 0.01	TE	[1053]
W(110)	–	–	?	77	–	5.16 ± 0.02	FE	[502]
W(110)[285]	Na	Na⁺	~10⁻¹⁰	1180	5.17 ± 0.01	–	PSI	[154,260]
W(110)	–	–	?	2100–2200	–	5.17 ± 0.02	TE	[3349]
W(110)	–	–	5 × 10⁻⁹ (O₂)	2050	–	5.18	TE	[212]
W(110)	–	–	–	–	–	5.18	TC	[531]
W(110)[279]	–	–	<10⁻¹⁰	~1850–2250	(4.609 ± 0.014)	5.18 ± 0.08	TE	[89]
W(110)[279]	–	–	<10⁻¹⁰	~1850–2250	(4.609 ± 0.014)ᴺ	5.18 ± 0.08	TE	[89]
W(110)[285]	Na	Na⁺	~10⁻¹⁰	1180	5.19 ± 0.01	–	PSI	[3768]
W(110)	–	–	≤3 × 10⁻¹⁰	1000	–	5.19 ± 0.01	CPD	[194]
W(110)	Tb	Tb⁺	~10⁻¹⁰	~2200–2500	5.19 ± 0.07*	–	PSI	[416]
W(110)	–	–	?	~300	–	5.2	FE	[1767]
W(110)	–	–	~10⁻⁹ (O₂)	2050	–	5.2	TE	[212]
W(110)	–	–	(≤10⁻¹⁰)	77	–	5.2	FE	[1974]
W(110)	–	–	?	~300 (2200)	–	5.2	FE	[3952]
W(110)	–	–	~10⁻¹¹	20–200	–	5.2	FE	[2218]
W(110)	–	–	7 × 10⁻¹⁰	77	–	5.2	FE	[3691]
W(110)	–	–	?	~1800–2300	–	5.2	TE	[1958]
W(110)[283]	Na	Na⁺	~10⁻¹⁰	~300	5.2	(5.1)	PSI	[2773,2774]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(110)	–	–	$<10^{-9}$	$\sim$300	–	5.20	PE	[3857]
W(110)	–	–	–	–	–	5.20	TC	[365]
W(110)	–	–	–	–	–	5.20	TC	[3224]
W(110)	Ho	Ho$^+$	$\sim$10^{-10}	$\sim$1900–2500	5.20 ± 0.05*	–	PSI	[416]
W(110)	–	–	$<10^{-10}$	$\sim$300	–	5.20 ± 0.05	FE	[2262]
W(110)	–	–	–	–	–	5.21	TC	[3473]
W(110)	–	–	3×10^{-7}	–2300–	–	5.21 ± 0.04	TE	[1402]
W(110)^{310}	–	–	$\sim$10^{-7}	$\sim$1850–2450	–	5.22 ± 0.01	TE	[1053]
W(110)	–	–	$\leq 8 \times 10^{-9}$	$\sim$1700–2160	–	5.22 ± 0.01	TE	[1183]
W(110)	–	–	$<8 \times 10^{-9}$	2300	–	5.22 ± 0.02	TE	[147,1037,2357, 3802]
W(110)	–	–	?	?	–	5.22 ± 0.05	FE	[816]
W(110)	Dy	Dy$^+$	$\sim$10^{-10}	$\sim$1850–2500	5.22 ± 0.07*	–	PSI	[416]
W(110)	–	–	$\leq 10^{-8}$	$\sim$1800–2250	–	5.24 ± 0.03	TE	[1793]
W(110){>90%}	Na^{270}	Na$^+$	1×10^{-8} (Na)	$\sim$1200–2000	5.25	(5.27)	PSI	[90]
W(110)	–	–	?	?	–	5.25	TE	[368]
W(110)	–	–	$<2 \times 10^{-10}$	$\sim$300	–	5.25	FE	[489]
W(110)	–	–	$\sim$10^{-9}	$\sim$300	–	5.25	CPD	[1272]
W(110)	–	–	2×10^{-10}	$\sim$300	–	5.25	CPD	[2592]
W(110)	–	–	?	$\sim$300	–	5.25	PE	[3443]
W(110)	–	–	$\sim$10^{-10}	77, 300	–	5.25 ± 0.02	FE	[358,3092]
W(110){80%}^{311}	–	–	–	–	5.25 ± 0.02	(4.90 ± 0.05)	TC	[630,2453]
W(110)	–	–	?	100	–	5.25 ± 0.02	PE	[1273]
W(110){>90%}	–	–	5×10^{-9}	$\sim$1500–1900	(5.25 ± 0.05)	5.25 ± 0.05	TE	[86,90,2094]
W(110){>90%}	Na	Na$^+$	5×10^{-9}	$\sim$1200–2000	5.25 ± 0.05	(5.25 ± 0.05)	PSI	[86,90,2094]
W(110)	–	–	?	$\sim$300	–	5.25 ± 0.25	FE	[1767]
W(110)	–	–	–	–	–	5.26	TC	[1271]
W(110)^{289}	–	–	–	–	–	5.26	TC	[150]
W(110)	–	–	?	1920	–	5.26	TE	[2187,3664]
W(110)	–	–	?	$\sim$300	–	5.26	PE	[3448]
W(110){80%}^{311}	–	–	–	–	5.26 ± 0.02	(4.87 ± 0.06)	TC	[2453]
W(110)	–	–	–	–	–	5.269	TC	[365]
W(110)	–	–	5×10^{-10}	$\sim$1500–1900	(5.25)	5.27	TE	[90]
W(110)^{142}	–	–	$\leq 2 \times 10^{-10}$	$\sim$300	–	5.28*	CPD	[2598]
W(110)	–	–	$\sim$10^{-8}	?	–	5.29	TE	[3353]
W(110)	Li	Li$^+$	$\leq 2 \times 10^{-9}$	$\sim$1250–1800	5.28 ± 0.03	(4.90, 5.30)	PSI	[88,814]
W(110)	–	–	?	$\sim$300 (2200)	–	5.3	FE	[3847,3952]
W(110)	–	–	($\leq 10^{-11}$)	$\sim$300	–	5.3	CPD	[259]
W(110)	Tm	Tm$^+$	?	$\sim$2000	5.3	–	PSI	[3559]
W(110)	–	–	1×10^{-11}	300, 700	–	5.3	CPD	[370]
W(110)	–	–	–	–	–	5.3	TC	[1723]
W(110)	–	–	($\leq 10^{-11}$)	$\sim$300	–	5.3	CPD	[2380]
W(110)	–	–	$<2 \times 10^{-10}$	90	–	5.3	PE	[2778]
W(110)	–	–	2×10^{-10}	$\sim$300	–	5.3	PE	[2834]
W(110)	–	–	$\sim$10^{-9}	?	–	5.3	TE	[3096]
W(110)	–	–	($\sim$10^{-12})	$\sim$300	–	5.3 ± 0.02	CPD	[1795]
W(110)	–	–	$\sim$10^{-9}	$\sim$1700–2000	–	5.3 ± 0.07	TE	[1277]
W(110)	–	–	($<1 \times 10^{-11}$)	$\sim$300	–	5.30	FE	[2251]
W(110)	–	–	$<2 \times 10^{-10}$	27, 90	–	5.30	CPD	[4107]
W(110)	–	–	?	20	–	5.30	FE	[2956,3472,3508, 3563]
W(110)	–	–	$<2 \times 10^{-10}$	78	–	5.30	FE	[1674,2251,2253, 2254]
W(110)	–	–	$<1 \times 10^{-10}$	$\sim$300	–	5.30 ± 0.02	FE	[2054]
W(110)	–	–	$\leq 2 \times 10^{-9}$	$\sim$1600–2000	(5.30 ± 0.03)	5.30 ± 0.03	TE	[88,814,3541]
W(110)	Li	Li$^+$	$\leq 2 \times 10^{-9}$	1250–1800	5.30 ± 0.03	(5.30, 5.03)	PSI	[814,3542]
W(110)	–	–	$\sim$10^{-9}	$\sim$1600–2000	(5.14 ± 0.03)	5.30 ± 0.03	TE	[3103]
W(110)	–	–	3×10^{-9}	$\sim$1500–2000	–	5.30 ± 0.05	TE	[2214,2217]
W(110)^{280}	–	–	$<10^{-8}$	$\sim$1900–2300	(4.82, 5.14)	5.30 ± 0.06	TE	[87]
W(110)	–	–	$<10^{-8}$	$\sim$1900–2400	–	5.30 ± 0.06	TE	[148]
W(110)	–	–	$<5 \times 10^{-11}$	$\sim$300	–	5.32	CPD	[1274]
W(110)	–	–	$\sim$10^{-10}	78	–	5.32 ± 0.10	FE	[819]
W(110)	–	–	2×10^{-9}	1450–2000	–	5.33 ± 0.03	TE	[817]
W(110)	–	–	$\sim$10^{-8}	$\sim$2050–2350	–	5.33 ± 0.03	TE	[372,3064]
W(110)^{284}	–	–	2×10^{-9}	$\sim$1400–2200	(5.11)	5.33 ± 0.04	TE	[266,2314–2316]
W(110)	–	–	$\sim$10^{-11}	$\sim$300	–	5.34 ± 0.03*	CPD	[2647]
W(110)	–	–	$<10^{-10}$	$\sim$300	–	5.34 ± 0.05	FE	[2044]
W(110)	–	–	–	–	–	5.345	TC	[365]
W(110)	–	–	$<2 \times 10^{-11}$	78	–	5.35	FE	[262]
W(110)	–	–	$\sim$10^{-9}	77	–	5.35	FE	[1137]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(110)	–	–	2×10^{-11}	>1200	–	5.35	TE	[1940]
W(110)	–	–	$\leq 7 \times 10^{-11}$	~300	–	5.35	CPD	[2385]
W(110)	–	–	$\leq 2 \times 10^{-9}$	~1700–2000	–	5.35 ± 0.05	TE	[127,144]
W(110)	–	–	$\leq 8 \times 10^{-10}$	~300	–	5.35 ± 0.05	FE	[1689]
W(110)	–	–	$\sim 10^{-10}$	~300	–	5.35 ± 0.05	CPD	[2381]
W(110)	–	–	$\sim 10^{-11}$	78	–	5.35 ± 0.09	FE	[654]
W(110)	–	–	6×10^{-6} (Cs)	1950–2150	–	5.37	TE	[151]
W(110)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	5.37	FE	[2072]
W(110)	Sr	Sr$^+$	8×10^{-9}	~2300–2800	5.38 ± 0.03	–	PSI	[145]
W(110)	Ca	Ca$^+$	8×10^{-9}	~2300–2800	5.39 ± 0.04	–	PSI	[145]
W(110)	–	–	$\sim 10^{-10}$	80–550	–	5.40	FE	[2499]
W(110)	–	–	$\sim 10^{-9}$	~2050–2350	–	5.40 ± 0.05	TE	[143]
W(110)	–	–	$< 10^{-10}$	38, 80	–	5.42 ± 0.02	FE	[1010]
W(110)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	5.43	FE	[2072]
W(110)	–	–	?	40–298	–	5.43 ± 0.03	CPD	[2832]
W(110)	–	–	–	–	–	5.44	TC	[357]
W(110)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	5.44	FE	[2072]
W(110)	La	La$^+$	$\sim 10^{-9}$	~1700–2700	5.44 ± 0.05	–	PSI	[138]
W(110)	Sr	Sr$^+$	8×10^{-9}	~2300–2800	5.44 ± 0.05	–	PSI	[145]
W(110)	Ca	Ca$^+$	8×10^{-9}	~2300–2800	5.45 ± 0.05	–	PSI	[145]
W(110)[170,286]	–	(W$^+$)	$< 5 \times 10^{-8}$	~2500	5.46 ± 0.11	–	PSI	[146]
W(110)	–	–	?	80	–	5.47	FE	[1058]
W(110)	Sr	Sr$^+$	8×10^{-9}	~2300–2800	5.47 ± 0.10	–	PSI	[145]
W(110)	–	–	$< 10^{-9}$	~300	–	5.5	FE	[2354]
W(110)	–	–	?	?	–	5.5 ± 0.2	FE	[3033]
W(110)	–	–	–	–	–	5.50	TC	[2548]
W(110)	–	–	–	–	–	5.50	TC	[1159,1980,2129, 3067]
W(110)	Sr	Sr$^+$	$\sim 10^{-9}$	~1700–2700	5.52 ± 0.05	–	PSI	[138]
W(110)	–	–	?	~1700–2200	–	5.54	TE	[2187,3664]
W(110)	–	–	–	–	–	5.54	TC	[4117]
W(110)	–	–	(1×10^{-10})	~300	–	5.54 ± <0.06	FE	[1529]
W(110)	–	–	–	–	–	5.55	TC	[3179]
W(110)	–	–	?	?	–	5.6	FE	[1964]
W(110)	–	–	$\leq 5 \times 10^{-10}$	~300	–	5.6 ± 0.1	FE	[2013]
W(110)	–	–	–	–	–	5.62	TC	[334]
W(110)	–	–	2×10^{-10}	~300	–	5.66 ± 0.03	FE	[999]
W(110)	–	–	?	~300	–	5.69	FE	[3581]
W(110)	–	–	$< 10^{-7}$	2100	–	5.7	TE	[371]
W(110)	–	–	$\sim 10^{-10}$	77	–	5.70	FE	[340]
W(110)	–	–	?	20, 100	–	5.70	FE	[812]
W(110)	–	–	$(< 10^{-12})$	~300 (~2500)	(6.0)	5.70	FE	[152]
W(110)	–	–	?	~300	–	5.70 ± 0.15	FE	[1766]
W(110)	–	–	–	–	–	5.73	TC	[3224]
W(110)	–	–	$\sim 10^{-10}$	79	–	5.74	FE	[1275]
W(110)	–	–	–	–	–	5.75	TC	[4405]
W(110)	–	–	2×10^{-10}	~300	–	5.75 ± 0.03	FE	[999]
W(110)	–	–	?	77	–	5.75 ± 0.15	FE	[3079]
W(110)	–	–	?	15	–	5.76	FE	[653]
W(110)	–	–	$< 1 \times 10^{-11}$	78	–	5.79	FE	[373]
W(110)	–	–	$\sim 10^{-10}$	~300	–	5.79	FE	[378]
W(110)	–	–	$\sim 10^{-10}$	77	–	5.79 ± 0.04	FE	[502]
W(110)	–	–	$\sim 1 \times 10^{-10}$	~300	–	5.8	FE	[3438]
W(110)	–	–	$\sim 10^{-10}$	78	–	5.8 ± 0.5	FE	[819]
W(110)	–	–	$< 10^{-10}$	90	–	5.80	FE	[656,926]
W(110)	–	–	$< 10^{-8}$	20	–	5.80 ± 0.05	FE	[813]
W(110)	–	–	?	15	–	5.83	FE	[653]
W(110)	–	–	$(< 10^{-11})$	78	–	5.85	FE	[267]
W(110)	–	–	$< 10^{-10}$	~300	–	5.9	CPD	[808]
W(110)	–	–	$\sim 10^{-10}$	~300	–	5.9	FE	[2324]
W(110)	–	–	$\sim 2 \times 10^{-9}$	~300	–	5.93	FE	[2766]
W(110)	–	–	$\leq 10^{-12}$	77	–	5.96	FE	[657]
W(110)	–	–	$\sim 10^{-10}$	79	–	5.98	FE	[1275]
W(110)	–	–	$(< 10^{-12})$	~300 (~1800)	(6.0)	5.99	FE	[152]
W(110)	–	–	$< 10^{-10}$	298	–	5.99	FE	[1010]
W(110)	–	–	?	?	–	6.0	FE	[2565,2574]
W(110)	–	–	$(< 10^{-11})$	78	–	6.0	FE	[809]
W(110)	–	–	$< 10^{-10}$	79	–	6.00	FE	[1276]
W(110)	–	–	?	77	–	6.02 ± 0.06	FE	[502]
W(110)	–	–	$< 10^{-10}$	144	–	6.03 ± 0.02	FE	[1010]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(110)	–	–	(<10⁻¹²)	~300 (~1500)	–	6.10	FE	[152]
W(110)	–	–	~10⁻¹⁰	79	–	6.10	FE	[1275]
W(110)	–	–	~10⁻¹⁰	77	–	6.20 ± 0.06	FE	[502]
W(110)	–	–	~10⁻¹⁰	78	–	6.28 ± 0.08	FE	[819]
W(110)	–	–	~10⁻¹⁰	77	–	6.30	FE	[340]
W(110)	–	–	~10⁻¹⁰	79	–	6.30	FE	[1275]
W(110)	–	–	?	80	–	6.35	FE	[1057]
W(110)	–	–	?	77	–	6.40 ± 0.09	FE	[502]
W(110)	–	–	~10⁻¹⁰	77	–	6.5	FE	[2714]
W(110)	–	–	–	–	–	6.70	TC	[1059]
W(110)	–	–	~10⁻¹²	77	–	7.1	FE	[1281]
W(110)	–	–	–	–	–	7.15	TC	[1059]
W(110)	–	–	~10⁻¹²	77	–	7.2	FE	[1281]
W(110)	–	–	~10⁻¹²	77 (~1000)	–	8.78	FE	[1281]
Recommended	–	–	–	–	**5.28 ± 0.11**	**5.32 ± 0.02**	–	–
W(111)	–	–	?	~1400	–	3.25 ± 0.02	TE	[2356]
W(111)	–	–	?	?	–	3.9	FE	[1964]
W(111)	–	–	–	~2300	–	4.07 ± 0.02	TE	[2356]
W(111)	–	–	?	~1800–2300	–	4.2	TE	[1958]
W(111)	–	–	?	?	–	4.2 ± 0.1	FE	[3033]
W(111)	–	–	–	–	–	4.20	TC	[1270]
W(111)	–	–	?	~300	–	4.21	FE	[1730]
W(111)	–	–	≤3 × 10⁻⁹	~1200	–	4.24	FE	[2072]
W(111)	–	–	1 × 10⁻⁸	~1900–2100	–	4.24 ± 0.05	TE	[2012]
W(111)	–	–	–	–	–	4.240	TC	[4091]
W(111)	–	–	?	?	–	4.25	TE	[368]
W(111)	–	–	–	–	–	4.25	TC	[1270]
W(111)	–	–	1 × 10⁻⁸	~1900–2100	–	4.26 ± 0.05	TE	[1663,2012]
W(111)/W	WF₆	–	~10⁻⁸	~1800	–	4.3	TE	[2050]
W(111)	–	–	~10⁻¹⁰	~300	–	4.3	FE	[374,818]
W(111)	–	–	?	?	–	4.3 ± 0.1	FE	[1377,1378]
W(111)	–	–	<10⁻⁹	~300	–	4.32	PE	[375]
W(111)	–	–	?	~300	–	4.33	FE	[3581]
W(111)	–	–	<1 × 10⁻¹¹	78	–	4.35	FE	[373]
W(111)	–	–	?	~2000–2400	–	4.35 ± 0.02	TE	[2356]
W(111)	–	–	?	~1400–2000	–	4.35 ± 0.02	TE	[149]
W(111)	–	–	<8 × 10⁻¹¹	~300	–	4.35 ± <0.05	FE	[364,530,3213]
W(111)	–	–	2 × 10⁻⁹	~1700–2000	–	4.36	TE	[141]
W(111)	–	–	<2 × 10⁻¹⁰	78	–	4.37	FE	[1674,2253]
W(111)	KCl	K⁺	1 × 10⁻¹⁰	~1000–1300	4.37	–	PSI	[1548]
W(111)	–	–	?	~1400–2000	–	4.37 ± 0.02	TE	[149,2706]
W(111)[287]	–	–	<1 × 10⁻¹⁰	~800–1300	–	4.38	FE	[3440]
W(111)	–	–	–	–	–	4.38	TC	[4405]
W(111)	–	–	≤2 × 10⁻⁹	~1600–2200	(4.50 ± 0.03)	4.38 ± 0.02	TE	[88]
W(111)	–	–	1 × 10⁻⁹	~1400–2000	–	4.38 ± 0.02	TE	[150]
W(111)	–	–	–	–	–	4.381	TC	[4189]
W(111)	–	–	(<10⁻¹²)	~300	–	4.39	FE	[152]
W(111)	–	–	~10⁻⁸	?	–	4.39	TE	[3353]
W(111)	–	–	?	~1900	–	4.39	TE	[1581]
W(111)	–	–	<10⁻¹⁰	170	–	4.4	FE	[3793]
W(111)	–	–	?	~300 (2200)	–	4.4	FE	[3847,3952,3953]
W(111)	–	–	(≤10⁻¹¹)	~300	–	4.4	CPD	[259]
W(111)	–	–	<10⁻¹⁰	~300	–	4.4	CPD	[808]
W(111)	–	–	~10⁻⁹	77	–	4.4	FE	[363,810,811,2766]
W(111)	–	–	~10⁻⁹	?	–	4.4	TE	[3686]
W(111)	–	–	~10⁻¹⁰	–1600–	–	4.4 ± 0.1	TE	[335,1650,1651, 1967]
W(111)	–	–	5 × 10⁻¹⁰	~300	–	4.40	FE	[376]
W(111)	–	–	<10⁻¹⁰	78, 295	–	4.40	FE	[679,1276]
W(111)	–	–	?	?	–	4.40	FE	[1463]
W(111)	–	–	~10⁻¹⁰	300–1500	–	4.40	FE	[1783]
W(111)	–	–	~10⁻⁹	?	–	4.40	TE	[3096]
W(111)	–	–	≤2 × 10⁻⁹	~1600–2200	(4.50 ± 0.03)	4.40 ± 0.02	TE	[88,814,3541,3542]
W(111)	–	–	<10⁻⁸	~1900–2400	–	4.40 ± 0.02	TE	[127,144,148]
W(111)	–	–	~10⁻⁸	~2050–2350	–	4.40 ± 0.03	TE	[372,3064]
W(111)	–	–	2 × 10⁻⁹	1450–1750	(4.42, 4.44)	4.40 ± 0.03	TE	[817,3103]
W(111)	–	–	3 × 10⁻⁹	~1500–2000	–	4.40 ± 0.05	TE	[2214,2217]
W(111)	–	–	(1 × 10⁻¹⁰)	~300	–	4.40 ± <0.06	FE	[1529]
W(111)	–	–	–	695	–	4.404	TC	[377]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(111)	–	–	(<10⁻¹¹)	78	–	4.41	FE	[267]
W(111)	–	–	~10⁻¹⁰	~300	–	4.41	FE	[4237]
W(111)	–	–	–	–	–	4.41	TC	[3224]
W(111)	–	–	<10⁻¹⁰	90	–	4.41	FE	[656,926]
W(111)	–	–	?	~1500–2000	–	4.41	TE	[1581]
W(111)	–	–	~10⁻¹⁰	~300	–	4.41	FE	[2324]
W(111)	–	–	?	~300–1100	–	4.41	FE	[3426]
W(111)	–	–	–	418	–	4.415	TC	[377]
W(111)	–	–	?	?	–	4.42	FE	[1283]
W(111)	–	–	~10⁻⁹	~1900–2300	–	4.42 ± 0.03	TE	[143]
W(111)	Na	Na⁺	?	1450–1750	4.42 ± 0.03	(4.40 ± 0.03)	PSI	[3103]
W(111)	–	–	(<10⁻¹¹)	78	–	4.43	FE	[809]
W(111)	–	–	?	1920	–	4.43	TE	[2187,3664]
W(111)[287]	–	–	<1 × 10⁻¹⁰	80–500	–	4.43	FE	[3440]
W(111)	–	–	5 × 10⁻¹⁰	~1400–2150	–	4.43 ± 0.05	TE	[151]
W(111)	–	–	–	–	–	4.44	TC	[1271]
W(111)	–	–	–	–	–	4.44	TC	[4405]
W(111)	–	–	≤3 × 10⁻⁹	~1200	–	4.44	FE	[2072]
W(111)	–	–	?	2100–2200	–	4.44 ± 0.02	TE	[3349]
W(111)	Na	Na⁺	2 × 10⁻⁹	1360–1630	4.44 ± 0.03	(4.40 ± 0.03)	PSI	[817]
W(111)	Li	Li⁺	~10⁻⁹	~1400–1700	4.44 ± 0.03	(4.40 ± 0.03)	PSI	[3103]
W(111)	–	–	5 × 10⁻⁹	~2000–2400	–	4.45	TE	[352]
W(111)	–	–	≤2 × 10⁻¹⁰	~300	–	4.45	CPD	[1056]
W(111)	–	–	~10⁻¹⁰	77	–	4.45	FE	[3092]
W(111)	–	–	<8 × 10⁻¹⁰	78	–	4.45	FE	[1731]
W(111)	–	–	?	20, 100	–	4.45	FE	[3508]
W(111)	–	–	~10⁻¹⁰	~300	–	4.45 ± 0.02	CPD	[1056,3088]
W(111)	–	–	~10⁻¹⁰	77	–	4.45 ± 0.03	FE	[358,502]
W(111)	–	–	~10⁻¹⁰	78	–	4.45 ± 0.05	FE	[819]
W(111)	–	–	5 × 10⁻¹⁰	~300	–	4.46	FE	[3670]
W(111)	–	–	–	–	–	4.46	TC	[2548]
W(111)	–	–	<2 × 10⁻¹⁰	~300	–	4.47	FE	[489]
W(111)	–	–	–	–	–	4.47	TC	[1159,1980,2129, 3067]
W(111)	–	–	~10⁻¹⁰	77, 300	–	4.47 ± 0.02	FE	[358]
W(111)	–	–	2 × 10⁻¹⁰	~300	–	4.47 ± 0.03	FE	[999]
W(111)	–	–	–	–	–	4.48	TC	[1270]
W(111)	–	–	2 × 10⁻⁹	~1900–2400	–	4.48	TE	[4343]
W(111)	–	–	–	–	–	4.49	TC	[3224]
W(111)	–	–	~10⁻¹⁰	~300	–	4.49	FE	[378]
W(111)	–	–	~10⁻¹⁰	77	–	4.49 ± 0.02	FE	[502]
W(111)	–	–	~10⁻¹¹	78	–	4.49 ± 0.03	FE	[654]
W(111)	Ca	Ca⁺	8 × 10⁻⁹	~2300–2800	4.49 ± 0.04	–	PSI	[145]
W(111)	Sr	Sr⁺	8 × 10⁻⁹	~2300–2800	4.49 ± 0.04	–	PSI	[145]
W(111)	–	–	~10⁻¹⁰	79	–	4.5	FE	[1275]
W(111)	–	–	1 × 10⁻⁸	~1500–1850	–	4.5	TE	[1499]
W(111)	–	–	3 × 10⁻⁹	~300	–	4.5 ± 0.1	FE	[2215]
W(111)	–	–	?	77	–	4.50	FE	[2956,3079,3509]
W(111)	–	–	≤2 × 10⁻¹¹	78	–	4.50	FE	[262]
W(111)	–	–	–	–	–	4.50	TC	[3224]
W(111)	Li	Li⁺	≤2 × 10⁻⁹	~1400–1800	4.50 ± 0.03	(4.40 ± 0.02)	PSI	[88,3542]
W(111)	–	–	–	–	–	4.500	TC	[365]
W(111)	–	–	<5 × 10⁻¹¹	~300	–	4.51	CPD	[1274]
W(111)	–	–	?	~300–1100	–	4.51	FE	[3427]
W(111)	–	–	~10⁻¹¹	~300	–	4.53 ± 0.03*	CPD	[2647]
W(111)	–	–	?	20, 100	–	4.54	FE	[812]
W(111)	–	–	?	~1700–2200	–	4.54	TE	[2187,3664]
W(111)[310]	–	–	~10⁻⁷	~1850–2450	–	4.54 ± 0.01	TE	[1053]
W(111)	–	–	–	–	–	4.55	TC	[357]
W(111)	–	–	<10⁻¹⁰	~300	–	4.55 ± 0.01	FE	[2044]
W(111)	–	–	≤8 × 10⁻¹⁰	~300	–	4.55 ± 0.05	FE	[1689]
W(111)	–	–	~10⁻¹⁰	79	–	4.56	FE	[1275]
W(111)	–	–	≤3 × 10⁻⁹	~1200	–	4.56	FE	[2072]
W(111)	–	–	–	–	–	4.562	TC	[365]
W(111)	–	–	?	80	–	4.57	FE	[1057]
W(111)	–	–	<10⁻¹⁰	~300	–	4.57 ± 0.09	FE	[2044]
W(111)	–	–	<5 × 10⁻¹¹	~300	–	4.58	CPD	[3309]
W(111)	–	–	–	–	–	4.59	TC	[3224]
W(111)	–	–	≤10⁻⁸	~1700–2300	–	4.59 ± 0.03	TE	[1793]
W(111)	–	–	3 × 10⁻⁹ (O₂)	2050	–	4.6	TE	[212]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(111)	–	–	$\sim1 \times 10^{-10}$	~300	–	4.6	FE	[3438]
W(111)	–	–	–	–	–	4.60	TC	[531]
W(111)	–	–	$\leq4 \times 10^{-10}$	~300	–	4.60 ± 0.02	CPD	[582]
W(111)	–	–	$<10^{-8}$	20	–	4.60 ± 0.05	FE	[813]
W(111)	–	–	5×10^{-10} (O_2)	1900	–	4.61	TE	[212]
W(111)	–	–	?	~2100–2200	–	4.61 ± 0.17	TE	[3349]
W(111)	–	–	$<1 \times 10^{-10}$	~300	–	4.62 ± 0.02	FE	[2616]
W(111)	–	–	$\sim10^{-12}$	~300	–	4.64	FE	[3406]
W(111)	–	–	5×10^{-8} (O_2)	2200	–	4.67	TE	[212]
W(111)	–	–	?	15	–	4.68	FE	[653]
W(111)	–	–	$\sim10^{-8}$	?	–	4.73	TE	[3353]
W(111)	–	–	$\leq8 \times 10^{-9}$	~2000–2200	–	4.74 ± 0.15	TE	[1183]
W(111)	–	–	?	15	–	4.78	FE	[653]
W(111)	–	–	$\sim10^{-10}$	79	–	4.8	FE	[1275]
W(111)	–	–	$\sim10^{-11}$	78	–	4.8	FE	[2823]
W(111)	–	–	?	77	–	4.80 ± 0.03	FE	[502]
W(111)	–	–	3×10^{-11}	78, 295	–	4.83 ± 0.38	FE	[354]
W(111)	–	–	$\sim10^{-11}$	20–200	–	4.9	FE	[2218]
W(111)	–	–	$\leq3 \times 10^{-9}$	~1200	–	5.27	FE	[2072]
W(111)	–	–	$\sim10^{-10}$	77	–	5.3	FE	[2714]
W(111)	–	–	–	–	–	5.60	TC	[4117]
Recommended	–	–	–	–	**4.45 ± 0.04**	**4.45 ± 0.03**	–	–
W(112)	Gd	Gd$^+$	$\sim10^{-9}$	~2100–3000	$4.28 \pm 0.02*$	(4.85 ± 0.07)	PSI	[91]
W(112)	–	–	$\leq3 \times 10^{-9}$	~1200	–	4.36	FE	[2072]
W(112)	Yb	Yb$^+$	$\sim10^{-9}$	~1550–2900	$4.38 \pm 0.01*$	(4.85 ± 0.07)	PSI	[91]
W(112)	–	–	2×10^{-9}	~1700–2000	–	4.48	TE	[141]
W(112)	–	–	1×10^{-8}	~1900–2100	–	4.5 ± 0.05	TE	[1663,2012]
W(112)	–	–	2×10^{-8}	~300	–	4.50	PE	[821]
W(112)	–	–	2×10^{-9}	~1700–2000	–	4.51	TE	[141]
W(112)	–	–	$\sim10^{-8}$	~2050–2350	–	4.53 ± 0.05	TE	[3064]
W(112)	–	–	–	–	–	4.57	TC	[3224]
W(112)	–	–	$\leq10^{-10}$	77	–	4.6	FE	[1974]
W(112)	–	–	$\sim10^{-11}$	78	–	4.6 ± 0.4	FE	[2823]
W(112)	–	–	–	–	–	4.60	TC	[4405]
W(112)	–	–	$<5 \times 10^{-11}$	~300	–	4.61	CPD	[1672]
W(112)	–	–	–	–	–	4.64	TC	[3224]
W(112)	–	–	$(<10^{-12})$	~300 (~2500)	–	4.65	FE	[152]
W(112)	–	–	–	–	–	4.66	TC	[3224]
W(112)	–	–	?	~1400–2000	–	4.66 ± 0.02	TE	[149,2706]
W(112)	–	–	1×10^{-9}	~1400–2000	–	4.66 ± 0.02	TE	[150]
W(112)	–	–	$<10^{-8}$	~1800–2200	–	4.67 ± 0.02	TE	[85]
W(112)	–	–	$\sim10^{-10}$	~300	–	4.68	CPD	[2110]
W(112)	–	–	–	–	–	4.69	TC	[4405]
W(112)	–	–	$\sim10^{-11}$	~300	–	$4.69 \pm 0.03*$	CPD	[2647]
W(112)	–	–	3×10^{-8} (O_2)	2200	–	4.7	TE	[212]
W(112)	–	–	$\sim10^{-11}$	78	–	4.7	FE	[2823]
W(112)	–	–	$\sim10^{-10}$	–1600–	–	4.7 ± 0.1	TE	[335,1650,1651, 1967]
W(112)	Gd	Gd$^+$	$\sim10^{-9}$	~2100–2900	$4.70 \pm 0.02*$	(4.85 ± 0.07)	PSI	[91]
W(112)	Er	Er$^+$	$\sim10^{-9}$	~1900–2900	$4.70 \pm 0.02*$	(4.85 ± 0.07)	PSI	[91]
W(112)	–	–	?	2100	–	4.70 ± 0.02	TE	[3349]
W(112)	–	–	6×10^{-6} (Cs)	~1800–2200	–	4.71	TE	[151]
W(112)	–	–	$\sim10^{-10}$	~300	–	4.71 ± 0.05	CPD	[820]
W(112)	–	–	–	–	–	4.72	TC	[1271]
W(112)	–	–	$<5 \times 10^{-11}$	~300	–	4.72	CPD	[1274]
W(112)	Er	Er$^+$	$\sim10^{-9}$	~1800–3300	$4.72 \pm 0.06*$	(4.85 ± 0.07)	PSI	[91]
W(112)	–	–	$\leq3 \times 10^{-10}$	~300	–	4.73 ± 0.02	CPD	[1054]
W(112)	–	–	$\leq8 \times 10^{-10}$	~300	–	4.74 ± 0.05	FE	[1689]
W(112)	–	–	–	–	–	4.75	TC	[531]
W(112)	–	–	$\leq7 \times 10^{-11}$	~300	–	4.75	CPD	[2385]
W(112)	–	–	$<10^{-7}$	~1800–2300	–	4.75 ± 0.03	TE	[371]
W(112)	–	–	$\leq3 \times 10^{-10}$	~300	–	4.75 ± 0.05	FE	[530,3213]
W(112)	–	–	$<2 \times 10^{-10}$	~300	–	4.76	FE	[489]
W(112)	–	–	$\sim10^{-10}$	~300	–	4.77 ± 0.02	CPD	[2106,3088]
W(112)	–	–	$(<10^{-11})$	~300	–	$4.79 \pm 0.05*$	CPD	[2637]
W(112)	–	–	?	?	–	4.8	FE	[1463]
W(112)	–	–	$\sim10^{-11}$	20–200	–	4.8	FE	[2218]
W(112)	–	–	$(\leq10^{-11})$	77	–	4.8	CPD	[2671]
W(112)	–	–	$(\leq10^{-11})$	~300	–	4.80	CPD	[259,379,380,658]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(112)	–	–	$\leq 2 \times 10^{-11}$	78	–	4.80	FE	[262]
W(112)	–	–	$<10^{-10}$	90	–	4.80	FE	[656,926]
W(112)	–	–	$\leq 2 \times 10^{-9}$	~1700–2000	–	4.80 ± 0.05	TE	[127,143,144]
W(112)	–	–	$\sim 10^{-11}$	78	–	4.80 ± 0.05	FE	[654]
W(112)	–	–	–	–	–	4.800	TC	[365]
W(112)	–	–	–	–	–	4.811	TC	[365]
W(112)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	4.82	FE	[2072]
W(112)	–	–	(1×10^{-10})	~300	–	4.82 ± <0.06	FE	[1529,4237]
W(112)	–	–	$\sim 10^{-10}$	77	–	4.84 ± 0.06	FE	[502]
W(112)	–	–	$(<10^{-11})$	78	–	4.85	FE	[267]
W(112)	–	–	–	–	–	4.85	TC	[3224]
W(112)	–	–	3×10^{-11}	78	–	4.85	FE	[822]
W(112)	–	–	$\sim 10^{-10}$	~300	–	4.85	FE	[2324]
W(112)	–	–	$\sim 10^{-9}$	~1700–2450	(4.28–4.72)	4.85 ± 0.07	TE	[91]
W(112)	–	–	$(<10^{-11})$	78	–	4.87	FE	[809]
W(112)	–	–	$(<10^{-12})$	~300 (~1700)	–	4.88	FE	[152]
W(112)	–	–	$<1 \times 10^{-11}$	78	–	4.88	FE	[373]
W(112)	–	–	3×10^{-11}	78, 295	–	4.89 ± 0.15	FE	[354]
W(112)	–	–	?	?	–	4.9 ± 0.2	FE	[3033]
W(112)	–	–	$\sim 10^{-10}$	77	–	4.90	FE	[3092]
W(112)	–	–	$(<1 \times 10^{-11})$	~300	–	4.90 ± 0.02	FE	[2254]
W(112)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	4.91	FE	[2072]
W(112)	–	–	?	77	–	4.91	FE	[2956,3079]
W(112)	–	–	$\leq 3 \times 10^{-9}$	~1200	–	4.93	FE	[2072]
W(112)	–	–	$\sim 10^{-10}$	77	–	4.93 ± 0.01	FE	[502]
W(112)	–	–	–	–	–	4.94	TC	[1159,1980,2129, 3067]
W(112)	–	–	$\sim 10^{-9}$	77	–	4.95	FE	[363,810,811,2766]
W(112)	–	–	$\sim 10^{-10}$	~300	–	4.95	FE	[378]
W(112)	–	–	3×10^{-10}	~300	–	4.97 ± 0.05	FE	[999]
W(112)	–	–	?	20, 100	–	4.98	FE	[812]
W(112)	–	–	$<2 \times 10^{-10}$	78	–	5.0 ± 0.1	FE	[1674,2253]
W(112)	–	–	$\sim 10^{-10}$	77	–	5.00	FE	[502]
W(112)	–	–	?	~300–1100	–	5.01	FE	[3426]
W(112)	–	–	?	15	–	5.02	FE	[653]
W(112)	–	–	3×10^{-10}	~300	–	5.03 ± 0.02	FE	[999]
W(112)	–	–	?	15	–	5.04	FE	[653]
W(112)	–	–	$\sim 10^{-10}$	77	–	5.05 ± 0.05	FE	[502]
W(112)	–	–	$<10^{-8}$	20	–	5.05 ± 0.05	FE	[813]
W(112)	–	–	?	80	–	5.08	FE	[1057]
W(112)	–	–	$\sim 10^{-10}$	77	–	5.1	FE	[2714]
W(112)	–	–	$\sim 10^{-10}$	78	–	5.12 ± 0.07	FE	[819]
W(112)	–	–	3×10^{-10}	~300	–	5.14 ± 0.05	FE	[999]
W(112)	–	–	$\sim 10^{-10}$	79	–	5.18	FE	[1275]
W(112)	–	–	5×10^{-10}	~1500–1900	–	5.20	TE	[90]
W(112)	–	–	?	~1800–2300	–	5.3	TE	[1958]
Recommended	–	–	–	–	**4.70 ± 0.01**	**4.78 ± 0.03**	–	–
W(113)	–	–	2×10^{-9}	~1500–2000	–	4.15 ± 0.07	TE	[2468]
W(113)	–	–	$\leq 4 \times 10^{-10}$	~1450–2000	–	4.18 ± 0.04	CPD	[195]
W(113)	–	–	$\leq 4 \times 10^{-10}$	~1450–2000	–	4.235 ± 0.04	TE	[195]
W(113)	–	–	–	–	–	4.27	TC	[3224]
W(113)	–	–	–	–	–	4.35	TC	[3224]
W(113)	–	–	–	–	–	4.36	TC	[3224]
W(113)	–	–	–	–	–	4.37	TC	[3224]
W(113)	–	–	$\sim 10^{-10}$	78	–	4.46 ± 0.05	FE	[819]
W(113)	–	–	5×10^{-10}	~300	–	4.50	TE	[376]
W(113){nearly}	Sr	Sr$^+$	$\sim 10^{-9}$	~2400–2800	4.52 ± 0.03	–	PSI	[138]
W(113)	–	–	$\sim 10^{-10}$	~300	–	4.54	PE	[1060,1848,1849]
W(113)	–	–	$\sim 10^{-10}$	~300	–	4.55 ± 0.05	CPD	[820]
W(113)	–	–	$<5 \times 10^{-9}$	~300	–	4.57	CPD	[138]
W(113)	–	–	$\leq 10^{-9}$	~1600–2400	–	4.58	TE	[1225,1282]
W(113)	–	–	$<5 \times 10^{-10}$	~300	–	4.59 ± 0.01	CPD	[2471]
W(113)	–	–	$<2 \times 10^{-10}$	~300	–	4.65	CPD	[1056]
W(113)	La	La$^+$	$\sim 10^{-9}$	~2400–2800	4.79 ± 0.05	–	PSI	[138]
W(113)	–	–	1×10^{-10}	~300	–	4.82	PE	[1226]
Recommended	–	–	–	–	–	**4.43 ± 0.09**	–	–
W(114)	–	–	?	?	–	4.31	FE	[1283]
W(114)	–	–	–	–	–	4.32	TC	[3224]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(114)	–	–	$\sim 10^{-10}$	79	–	4.40	FE	[1275]
W(114)	–	–	–	–	–	4.40	TC	[3224]
W(114)	–	–	$\sim 10^{-10}$	$\sim 1800–2200$	–	4.40 ± 0.05	TE	[820,2134]
W(114)	–	–	–	–	–	4.42	TC	[3224]
W(114)	–	–	$\sim 10^{-10}$	$\sim 1100–1360$	–	4.42 ± 0.02	TE	[1394,1854]
W(114)	–	–	$\sim 10^{-10}$	78	–	4.42 ± 0.05	FE	[819]
W(114)[288]	–	–	$<5 \times 10^{-10}$	77	–	4.42 ± 0.05	CPD	[920]
W(114)	–	–	–	–	–	4.44	TC	[3224]
W(114)	–	–	$\sim 10^{-10}$	79	–	4.48	FE	[1275]
W(114)	–	–	$\sim 10^{-11}$	20–200	–	4.8	FE	[2218]
Recommended	–	–	–	–	–	**4.40 ± 0.03**	–	–
W(115)	–	–	?	77	–	4.3	FE	[3079]
W(115)	–	–	$\sim 10^{-10}$	~ 300	–	4.35 ± 0.05	CPD	[820]
W(115)	–	–	$<5 \times 10^{-11}$	~ 300	–	4.43	CPD	[1274]
W(115)	–	–	$\sim 10^{-11}$	~ 300	–	4.46 ± 0.03*	CPD	[2647]
W(116)	–	–	–	–	–	4.10	TC	[4405]
W(116)	–	–	–	–	–	4.121	TC	[365]
W(116)	–	–	–	–	–	4.152	TC	[365]
W(116)	–	–	?	?	–	4.2	FE	[1463]
W(116)	–	–	?	78	–	4.20	FE	[679]
W(116)	–	–	3×10^{-10}	~ 300	–	4.21 ± 0.05	FE	[530]
W(116)	–	–	–	–	–	4.250	TC	[365]
W(116)	–	–	2×10^{-9}	$\sim 1700–2000$	–	4.26	TE	[141]
W(116)	–	–	$\sim 10^{-10}$	79	–	4.26	FE	[1275]
W(116)	–	–	?	?	–	4.26	FE	[1284]
W(116)	–	–	–	–	–	4.27	TC	[3224]
W(116)	–	–	?	?	–	4.3	FE	[1964]
W(116)	–	–	$\sim 10^{-10}$	77	–	4.3	FE	[2714]
W(116)	–	–	1×10^{-8}	$\sim 1900–2100$	–	4.3 ± 0.05	TE	[1663,2012]
W(116)	–	–	$\sim 10^{-10}$	–1600–	–	4.3 ± 0.1	TE	[335,1650,1651, 1967]
W(116)	–	–	5×10^{-10}	~ 300	–	4.30	FE	[376]
W(116)	–	–	–	–	–	4.30	TC	[4405]
W(116)	–	–	$(<10^{-12})$	~ 300	–	4.30	FE	[152]
W(116)	–	–	$\sim 1 \times 10^{-9}$	$\sim 1350–2050$	–	4.30 ± 0.01	TE	[150]
W(116)	–	–	$\sim 10^{-8}$	$\sim 2050–2350$	–	4.30 ± 0.03	TE	[372,3064]
W(116)	–	–	$\leq 2 \times 10^{-9}$	$\sim 1700–2000$	–	4.32 ± 0.02	TE	[127,144]
W(116)	–	–	$\sim 10^{-10}$	77	–	4.32 ± 0.04	FE	[502]
W(116)	–	–	1×10^{-8}	$\sim 1900–2100$	–	4.32 ± 0.05	TE	[1663,2012]
W(116)	–	–	$\sim 10^{-10}$	78	–	4.32 ± 0.06	FE	[819]
W(116)	–	–	$\sim 10^{-10}$	~ 300	–	4.34	FE	[4237]
W(116)	–	–	–	–	–	4.35	TC	[3224]
W(116)	–	–	?	$\sim 1400–2000$	–	4.35 ± 0.02	TE	[149,2706]
W(116)	–	–	–	–	–	4.36	TC	[3224]
W(116)	–	–	$\sim 10^{-10}$	~ 300	–	4.36 ± 0.05	CPD	[820]
W(116)	–	–	2×10^{-9}	$\sim 1700–2000$	–	4.37	TE	[141]
W(116)	–	–	?	77	–	4.41 ± 0.04	FE	[502]
W(116)	–	–	–	–	–	4.47	TC	[1159,1980,2129, 3067]
Recommended	–	–	–	–	–	**4.30 ± 0.04**	–	–
W(119)	–	–	$\sim 10^{-10}$	~ 300	–	4.56 ± 0.05	CPD	[820]
W(120)	–	–	–	–	–	4.308	TC	[365]
W(120)	–	–	–	–	–	4.31	TC	[3224]
W(120)	–	–	$\leq 1 \times 10^{-10}$	78	–	4.32	FE	[1278]
W(120)	–	–	–	–	–	4.320	TC	[365]
W(120)	–	–	?	?	–	4.33	FE	[1283]
W(120)	–	–	?	~ 300	–	4.33	FE	[3581]
W(120)	–	–	$(<10^{-12})$	~ 300	–	4.34	FE	[152]
W(120)	–	–	(1×10^{-10})	~ 300	–	4.35 ± <0.06	FE	[1529]
W(120)	–	–	$\leq 1 \times 10^{-10}$	~ 300	–	4.36 ± 0.01	FE	[1278]
W(120)	–	–	$\sim 10^{-10}$	78	–	4.36 ± 0.04	FE	[819]
W(120)	–	–	?	~ 300	–	<4.39	FE	[1766]
W(120)	–	–	–	–	–	4.39	TC	[3224]
W(120)	–	–	?	20, 100	–	4.40	FE	[812]
W(120)	–	–	–	–	–	4.40	TC	[3224]
W(120)	–	–	–	–	–	4.404	TC	[365]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(120)	–	–	–	–	–	4.42	TC	[3224]
W(120)	–	–	?	20, 100	–	4.45	FE	[3508]
W(120)	–	–	?	~300–1100	–	4.46	FE	[3426]
W(120)	–	–	<10⁻⁸	20	–	4.46 ± 0.05	FE	[813]
W(120)	–	–	≤8 × 10⁻⁹	~2200–2450	–	4.47 ± 0.01	TE	[2340]
W(120)	–	–	≤8 × 10⁻⁹	~2200–2450	–	4.54 ± 0.05	TE	[2340]
W(120)	–	–	?	?	–	5.76	FE	[1964]
Recommended	–	–	–	–	–	**4.38 ± 0.05**	–	–
W(122)	–	–	–	–	–	4.133	TC	[365]
W(122)	–	–	–	–	–	4.162	TC	[365]
W(122)	–	–	–	–	–	4.259	TC	[365]
W(122)	–	–	–	–	–	4.29	TC	[3224]
W(122)	–	–	~10⁻¹⁰	78	–	4.30 ± 0.04	FE	[819]
W(122)	–	–	(<10⁻¹²)	~300	–	4.35	FE	[152]
W(122)	–	–	–	–	–	4.37	TC	[3224]
W(122)	–	–	(<10⁻¹¹)	78	–	4.37	FE	[809]
W(122)	–	–	–	–	–	4.38	TC	[3224]
W(122)	–	–	–	–	–	4.39	TC	[3224]
W(122)	–	–	?	~300–1100	–	4.40	FE	[3427]
W(122)	–	–	?	~300–1100	–	4.47	FE	[3426]
W(122)	–	–	<10⁻⁹	~300	–	4.5	FE	[2354]
Recommended	–	–	–	–	–	**4.34 ± 0.05**	–	–
W(123)	–	–	–	–	–	4.31	TC	[4405]
W(123)	–	–	–	–	–	4.37	TC	[3224]
W(123)	–	–	–	–	–	4.41	TC	[4405]
W(123)	–	–	–	–	–	4.433	TC	[365]
W(123)	–	–	–	–	–	4.442	TC	[365]
W(123)	–	–	–	–	–	4.45	TC	[3224]
W(123)	–	–	–	–	–	4.47	TC	[3224]
W(123)[290]	–	–	≤4 × 10⁻¹¹	~1200	–	4.50	FE	[2045]
W(123)	–	–	~10⁻¹⁰	78	–	4.50 ± 0.06	FE	[819]
W(123)	–	–	–	–	–	4.511	TC	[365]
W(123)	–	–	(<10⁻¹²)	~300	–	4.52	FE	[152]
W(123)	–	–	–	–	–	4.53	TC	[3224]
W(123)	–	–	~10⁻¹⁰	79	–	4.56	FE	[1275]
W(123)	–	–	?	~300–1100	–	4.58	FE	[3426]
W(123)	–	–	~10⁻¹⁰	79	–	4.61	FE	[1275]
W(123)	–	–	–	–	–	4.77	TC	[1271]
W(123)[290]	–	–	≤4 × 10⁻¹¹	80–400	–	4.90 ± 0.03	FE	[2045]
Recommended	–	–	–	–	–	**4.50 ± 0.05**	–	–
W(124)	–	–	–	–	–	4.25	TC	[3224]
W(124)	–	–	–	–	–	4.33	TC	[3224]
W(124)	–	–	?	~300–1100	–	4.33	FE	[3426]
W(124)	–	–	–	–	–	4.34	TC	[3224]
W(124)	–	–	~10⁻¹⁰	78	–	4.35 ± 0.05	FE	[819]
W(124)	–	–	–	–	–	4.35	TC	[3224]
Recommended	–	–	–	–	–	**4.33 ± 0.03**	–	–
W(130)	–	–	~10⁻¹⁰	77	–	4.16 ± 0.03	FE	[502]
W(130)	–	–	~10⁻¹⁰	77	–	4.21 ± 0.01	FE	[502]
W(130)	–	–	≤8 × 10⁻⁹	~2200–2450	–	4.24 ± 0.05	TE	[2340]
W(130)	–	–	3 × 10⁻¹¹	78, 295	–	4.25	FE	[354]
W(130)	–	–	<2 × 10⁻¹⁰	~300	–	4.25	FE	[489]
W(130)	–	–	?	?	–	4.27	FE	[1283]
W(130)	–	–	≤8 × 10⁻⁹	~2200–2450	–	4.28 ± 0.01	TE	[2340]
W(130)	–	–	~10⁻¹⁰	77	–	4.28 ± 0.01	FE	[502]
W(130)	–	–	~1 × 10⁻¹⁰	~300	–	4.3	FE	[3438]
W(130)	–	–	~10⁻¹⁰	~300–1500	–	4.30	FE	[1783]
W(130)	–	–	–	–	–	4.30	TC	[4405]
W(130)	–	–	<10⁻¹⁰	90	–	4.30	FE	[656,926]
W(130)	–	–	(<10⁻¹²)	~300	–	4.31	FE	[152]
W(130)	–	–	2 × 10⁻⁹	~300	–	4.31 ± 0.07	CPD	[2468]
W(130)	–	–	~10⁻¹⁰	77	–	4.32 ± 0.05	FE	[502]
W(130)	–	–	~10⁻¹⁰	77	–	4.34 ± 0.02	FE	[502]
W(130)	–	–	~10⁻¹⁰	78	–	4.34 ± 0.04	FE	[819]
W(130)	–	–	5 × 10⁻¹⁰	~300	–	4.35	FE	[376]
W(130)	–	–	2 × 10⁻¹⁰	~300	–	4.35	FE	[3992]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(130)	–	–	2×10^{-8}	~300	–	4.35	PE	[821]
W(130)	–	–	?	?	–	4.35	FE	[1284]
W(130)	–	–	~10^{-11}	78	–	4.35	FE	[2823]
W(130)	–	–	?	~300	–	4.35 ± 0.05	FE	[2484]
W(130)	–	–	–	–	–	4.37	TC	[3224]
W(130)	–	–	<5×10^{-10}	77	–	4.4	FE	[3114]
W(130)	–	–	~10^{-10}	77	–	4.40 ± 0.13	FE	[502]
W(130)	–	–	2×10^{-10}	~300	–	4.45	FE	[4296]
W(130)	–	–	–	–	–	4.45	TC	[3224]
W(130)	–	–	–	–	–	4.46	TC	[1271]
W(130)	–	–	–	–	–	4.46	TC	[3224]
W(130)	–	–	<2×10^{-10}	78	–	4.48	FE	[1674,2253]
W(130)	–	–	?	77	–	4.5	FE	[3079]
W(130)	–	–	–	–	–	4.52	TC	[3224]
W(130)	–	–	3×10^{-11}	78, 295	–	5.19 ± 0.16	FE	[354]
Recommended	–	–	–	–	–	**4.32 ± 0.04**	–	–
W(133)	–	–	~10^{-10}	78	–	4.68 ± 0.07	FE	[819]
W(134)	–	–	~10^{-10}	78	–	4.74 ± 0.07	FE	[819]
W(144)	–	–	<10^{-10}	295	–	5.15	FE	[1276]
W(144)	–	–	<10^{-10}	79	–	5.25	FE	[1276]
W(150)	–	–	<10^{-10}	~300	–	4.43 ± 0.01	FE	[2044]
W(160)	–	–	5×10^{-10}	~300	–	4.31	FE	[3670]
W(160)	–	–	~10^{-10}	78	–	4.43 ± 0.04	FE	[819]
W(160)	–	–	<8×10^{-10}	78	–	4.45	FE	[1731]
W(223)	–	–	~10^{-10}	78	–	4.70 ± 0.05	FE	[819]
W(227)	–	–	~10^{-10}	~300	–	4.43 ± 0.05	CPD	[820]
W(229)	–	–	~10^{-10}	~300	–	4.34 ± 0.05	CPD	[820]
W(230)	–	–	–	–	–	4.26	TC	[3224]
W(230)	–	–	(1×10^{-10})	~300	–	4.29 ± <0.06	FE	[1529]
W(230)	–	–	~10^{-10}	~300	–	4.31	FE	[4237]
W(230)	–	–	–	–	–	4.34	TC	[3224]
W(230)	–	–	–	–	–	4.35	TC	[3224]
W(230)	–	–	–	–	–	4.36	TC	[3224]
W(230)	–	–	~10^{-10}	77	–	4.4	FE	[2714]
W(230)	–	–	~10^{-10}	78	–	4.58 ± 0.06	FE	[819]
Recommended	–	–	–	–	–	**4.33 ± 0.05**	–	–
W(233)	–	–	–	–	–	4.277	TC	[365]
W(233)	–	–	–	–	–	4.291	TC	[365]
W(233)	–	–	–	–	–	4.33	TC	[3224]
W(233)	–	–	–	–	–	4.36	TC	[4405]
W(233)	–	–	–	–	–	4.378	TC	[365]
W(233)	–	–	–	–	–	4.41	TC	[3224]
W(233)	–	–	~10^{-10}	78	–	4.41 ± 0.05	FE	[819]
W(233)	–	–	–	–	–	4.42	TC	[3224]
W(233)	–	–	–	–	–	4.45	TC	[3224]
W(233)	–	–	$(<10^{-12})$	~300	–	4.46	FE	[152]
Recommended	–	–	–	–	–	**4.38 ± 0.06**	–	–
W(235)[290]	–	–	≤4×10^{-11}	~1200	–	4.30	FE	[2045]
W(235)[290]	–	–	≤4×10^{-11}	~80–400	–	4.72 ± 0.05	FE	[2045]
W(250)	–	–	~10^{-10}	~300	–	4.55 ± 0.05	CPD	[820]
W(257)[290]	–	–	≤4×10^{-11}	~1200	–	4.80	FE	[2045]
W(257)[290]	–	–	≤4×10^{-11}	~80–900	–	5.00 ± 0.01	FE	[2045]
W(334)	–	–	<10^{-10}	295	–	4.20	FE	[1276]
W(334)	–	–	~10^{-10}	78	–	4.62 ± 0.04	FE	[819]
W(650)	–	–	–	–	–	4.24	TC	[3224]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W(650)	–	–	–	–	–	4.30	TC	[3224]
W(650)	–	–	–	–	–	4.32	TC	[3224]
W(650)	–	–	–	–	–	4.33	TC	[3224]
W(650)	–	–	$<8 \times 10^{-9}$	~2200–2450	–	4.67 ± 0.03	TE	[2340]
W	–	(W$^+$)	6×10^{-9}	~2900–3000	2.6 ± 0.2	–	PSI	[924]
W	–	–	–	–	–	2.80	TC	[2493]
W	–	–	–	–	–	2.85	TC	[2493]
W(fp)[291]	–	–	–	–	–	3.65	TC	[2973]
W	–	–	$<10^{-10}$	78	–	3.8*	FE	[2695]
W(fp)[291]	–	–	–	–	–	3.80	TC	[2973]
W	–	–	–	–	–	3.91	TC	[521]
W	–	–	$<4 \times 10^{-11}$	~300	–	4.0	FE	[3809]
W	–	–	$<10^{-8}$	~2200–2400	–	4.10 ± 0.20	TE	[1062]
W(porous)	Cs	Cs$^+$	?	~1150–1250	4.2	–	PSI	[3764]
W	–	–	–	–	–	4.2	TC	[1993]
W[292]	–	–	$\sim10^{-9}$	~300	–	4.2	FE	[1493]
W[292]	–	–	$\sim10^{-9}$	~300	–	4.25	FE	[1493]
W	–	–	?	?	–	4.31	TE	[2455]
W/glass[293]	W	–	$\sim10^{-10}$	77–90	–	4.33	PE	[3049]
W{46.3%(310)}[411]	–	–	–	–	(4.96 ± 0.03)	4.34 ± 0.05	TC	[630]
W[292]	–	–	$\sim10^{-9}$	~300	–	4.35	FE	[1493]
W	–	–	$\leq10^{-6}$	~1600–1800	–	4.35	TE	[2301]
W/glass	W	–	$\sim10^{-10}$	77–90	–	4.35	PE	[3052]
W	–	–	–	–	–	4.36	TC	[2005]
W/glass[293]	W	–	$<10^{-9}$	77–90	–	4.36	PE	[2095]
W	–	–	?	~300	–	4.38	CPD	[2297]
W{46.3%(310)}[411]	–	–	–	–	(4.99 ± 0.06)	4.38 ± 0.05	TC	[2453]
W	–	–	$(<10^{-13})$	21	–	4.4	CPD	[3504]
W	–	–	?	~300	–	4.4	FE	[3987]
W	–	–	–	–	–	4.40	TC	[3637]
W	–	–	–	–	–	4.40	TC	[2707]
W	–	–	–	–	–	4.40	TC	[2949]
W(fp)[291]	–	–	–	–	–	4.40	TC	[2973]
W	–	–	–	–	–	4.40	TC	[4441]
W	–	–	?	~1400–2000	–	4.40	TE	[3020]
W	–	–	$<10^{-8}$	~1900–2400	–	4.40 ± 0.05	TE	[1858]
W	–	–	$\sim10^{-8}$	~300	–	4.41	PE	[4340]
W	–	–	–	–	–	4.41	TC	[298]
W	U	U$^+$	$<1 \times 10^{-7}$	~2800–2950	4.41 ± 0.08	–	PSI	[80]
W	–	–	–	–	–	4.42	TC	[1066]
W[294]	–	–	12 (Ar)	~300	–	4.42 ± 0.02	PE	[621]
W	–	–	2×10^{-7}	~2000–2200	(5.09, 5.23)	4.42 ± 0.02	TE	[36]
W	–	–	$\leq10^{-10}$	~300	–	4.44	FE	[392]
W	–	–	$<5 \times 10^{-10}$	77, ~300	–	4.45	FE	[3822]
W	–	–	$\sim10^{-9}$	?	–	4.45 ± 0.05	TE	[1775]
W(1% oxides)	–	–	?	~1350–2200	–	4.456 ± 0.006	TE	[660]
W	–	–	–	–	–	4.46	TC	[3224]
W{25%(110)}[295]	–	–	–	2000	(5.12*)	4.46*	TC	[3844]
W	–	–	$\sim6 \times 10^{-10}$	~1400–1700	–	4.46	TE	[2089,2092]
W	CsCl	Cl$^-$	?	~2300–2600	4.46*[N]	–	NSI	[574]
W	–	–	$\sim10^{-8}$	~1600–2100	–	4.46 ± 0.09	TE	[1880,1882]
W	–	–	$\sim10^{-10}$	–1600–	–	4.47	TE	[335,1650,1651, 1967]
W	–	–	? (Cs)	~1200–2000	–	4.47	TE	[650]
W	–	–	$<6 \times 10^{-10}$	1080–1400	–	4.47 ± 0.01	TE	[161]
W/W(110)[309]	WCl$_6$, H$_2$	–	$\sim10^{-7}$	~1850–2450	–	4.47 ± 0.01	TE	[1053]
W	–	–	2×10^{-7}	~2000–2200	(5.23 ± 0.03)	4.47 ± 0.04	TE	[37]
W	–	–	?	~1400–1900	–	4.48	TE	[393]
W	–	–	5×10^{-7}	2270	–	4.48	TE	[1746]
W	–	–	2×10^{-7}	~2000–2100	(5.20 ± 0.05)	4.48 ± 0.06	TE	[23]
W/glass	W	–	?	293 (351)	–	4.49 ± 0.03	CPD	[2573]
W/glass	W	–	?	351 (428)	–	4.49 ± 0.03	CPD	[2573]
W	KCl	Cl$^-$	?	~2300–2600	4.49*[N]	–	NSI	[574]
W	KI	I$^-$	?	~2300–2550	4.49*[N]	–	NSI	[574]
W[299]	I	I$^-$	$\sim10^{-7}$	1980	4.49*[N]	(4.51)	NSI	[827]
W	–	–	2×10^{-8}	~300–1040	–	4.49 ± 0.02	PE	[826]
W[170,296]	–	(W$^+$)	$<10^{-6}$	~2800–3000	4.49 ± 0.14	(4.59 ± 0.04)	PSI	[823]
W	–	–	$\sim10^{-9}$	~1800–2600	–	4.5	TE	[394]
W[297]	–	(W$^-$)	?	~2200–2300	4.5*[N]	–	NSI	[966]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W	–	–	–	–	–	4.5	TC	[1561]
W{95%(100)}[302]	–	–	? (Cs)	~1600–2400	–	4.5	TE	[3414]
W	–	–	–	–	–	4.5	TC	[1645]
W	–	–	~700 (Ar)	~3500	–	4.5	TE	[2007]
W	–	–	~10^{-10}	~2000–2800	–	4.5	TE	[2098]
W	–	–	?	~1400–2000	–	4.5	TE	[3020]
W	–	–	? (Cs)	~1200–1800	–	4.5	TE	[3414]
W[298]	–	–	≤2 × 10^{-9}	~1500–2500	–	4.5 ± 0.07	TE	[3533]
W	–	–	~10^{-6}	~1800	–	4.5 ± 0.1	TE	[1779]
W	–	–	5 × 10^{-10}	~300	–	4.50	FE	[3670]
W	–	–	<10^{-11}	78	–	4.50	FE	[267]
W/Mo	WF$_6$	–	5 × 10^{-9}	~2000–2200	–	4.50	TE	[352,4343]
W	–	–	–	–	–	4.50	TC	[3224]
W	–	–	–	–	–	4.50	TC	[2583]
W	–	–	~10^{-9}	?	–	4.50	TE	[3096]
W	–	–	?	?	–	4.50	TE	[3402]
W	–	–	~10^{-7}	?	–	4.50	TE	[3523]
W	–	–	≤5 × 10^{-10}	20	–	4.50 ± <0.02	FE	[3862]
W/glass	W	–	?	77 (293)	–	4.50 ± 0.04	CPD	[2573]
W	–	–	≤10^{-9}	1150–2200	–	4.50 ± 0.05	TE	[650]
W	–	–	5 × 10^{-8}	~1000–1500	–	4.51	TE	[395]
W{25%(110)}[295]	Cs	Cs$^+$	–	2000	4.51	–	TC	[3843]
W	RbCl	Cl$^-$	?	~2300–2600	4.51*N	–	NSI	[574]
W[299]	–	–	~10^{-7}	~1300–2000	(4.51*N)	4.51	TE	[827]
W[299]	I$_2$	I$^-$	~10^{-7}	1940	4.51*N	(4.51)	NSI	[827]
W/W(100)[309]	WF$_6$, H$_2$	–	~10^{-7}	1850–2450	–	4.51 ± 0.01	TE	[1053]
W	K	K$^+$	?	1350–2170	4.514 ± 0.002	–	PSI	[158]
W	–	–	?	~1200–2000	–	4.515	TE	[2705]
W	–	–	?	1350–2200	–	4.519	TE	[660]
W	–	–	–	–	–	4.52	TC	[3224]
W	–	–	~10^{-9}	~300	–	4.52	PE	[1609]
W	–	–	?	~1500–1900	–	4.52	TE	[1372]
W	–	–	?	?	–	4.52	TE	[1450]
W	–	–	5 × 10^{-7}	2270	–	4.52	TE	[1746]
W	–	–	3 × 10^{-9}	?	–	4.52	TE	[159]
W	–	–	5 × 10^{-10}	~300	–	4.52	FE	[1853]
W	–	–	–	–	–	4.52	TC	[2456]
W	–	–	<10^{-6}	~300	–	4.52	PE	[2919]
W	–	–	? (Cs)	~1200–1400	–	4.52	TE	[3752]
W	–	–	?	~1600–2000	–	4.52	TE	[2925,2926]
W{95%(100)}[302]	–	–	~10^{-9}	?	–	4.52	TE	[3414]
W	–	–	<10^{-6}	?	–	4.52 ± 0.01	TE	[2919]
W	–	–	<8 × 10^{-10}	77	–	4.52 ± 0.04	CPD	[920]
W	Rb	Rb$^+$	?	1150–1450	4.52 ± 0.05	–	PSI	[2107]
W{95%(100)}[300]	–	–	~10^{-9}	1150–2200	–	4.52 ± 0.07	TE	[124]
W{96%(100)}[300]	–	–	~10^{-9}	1150–2200	–	4.52 ± 0.07	TE	[124]
W	–	–	<2 × 10^{-9}	~1050–1250	–	4.52 ± 0.09	TE	[2241]
W{<35%(110)}	–	–	–	–	(5.09 ± 0.10)	4.52 ± 0.12	TC	[283,630]
W	–	–	?	~1350–2200	–	4.529	TE	[660]
W	–	–	6 × 10^{-9}	~300	–	4.53	PE	[1139]
W	–	–	?	?	–	4.53	TE	[1486]
W	–	–	≤10^{-7}	O^E (~1850)	–	4.53	TE	[1878]
W[174]	–	–	–	O^E	–	4.53	TC	[1747]
W	–	–	≤10^{-6}	~1600–1800	–	4.53	TE	[2305]
W	–	–	? (Cs)	2300	–	4.53	TE	[2341]
W/glass	–	–	~10^{-10}	90 (403)	–	4.53	PE	[3049]
W	–	–	?	~2400–2500	–	4.53 ± 0.01	TE	[2204]
W	–	–	?	~1500–2200	–	4.53 ± 0.02	TE	[792]
W	–	–	?	?	–	4.53 ± 0.05	TE	[2209]
W	–	–	~10^{-7}	O^E (~1700)	–	4.53 ± 0.07	TE	[3326]
W	–	–	?	1577	–	4.539	TE	[661]
W	–	–	–	–	–	4.54	TC	[3224]
W	–	–	~10^{-9}	?	–	4.54	TE	[979]
W	SF$_6$	SF$_6^-$	2 × 10^{-6}	~1400–1700	4.54N	–	NSI	[586]
W	–	–	~10^{-9}	>1200	–	4.54	TE	[1203]
W	–	–	?	~1100–1700	–	4.54	TE	[1949]
W	Cs	Cs$^+$	?	~1400–1800	4.54	–	PSI	[2109]
W	–	–	?	1970	–	4.54	TE	[2121]
W/glass	–	–	?	O^E (295)	–	4.54	PE	[3392]
W	–	–	?	2300–2450	–	4.54	TE	[3842]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W[303]	–	–	–	~300	–	4.54$_5$	TC	[828]
W	–	–	5×10^{-9}	~2000–2400	–	4.55	TE	[352]
W	–	–	–	1800	–	4.55	TC	[471]
W	–	–	? (Cs, Ba)	~1600–2000	–	4.55	TE	[1485]
W	–	–	$\sim10^{-8}$	~1600–2300	–	4.55	TE	[1776]
W(foil)	–	–	$\leq 2 \times 10^{-10}$	~300	–	4.55	CPD	[1781]
W/glass	W	–	$\leq 2 \times 10^{-10}$	~300	–	4.55	CPD	[1781]
W	–	–	?	?	–	4.55	TE	[2233]
W	RbCl	Rb$^+$	?	?	4.55	–	PSI	[2306]
W	–	–	?	~1200–1500	–	4.55	TE	[2928]
W/glass[293]	W	–	$\sim10^{-10}$	293 (403)	–	4.55	PE	[3049]
W	–	–	–	–	–	4.55	TC	[3264,3265,3267]
W	–	–	$<6 \times 10^{-10}$	~1100–1400	–	4.55 ± 0.01	TE	[161]
W	–	–	$\leq 3 \times 10^{-10}$	~300	–	4.55 ± 0.01	CPD	[194]
W	–	–	$<5 \times 10^{-10}$	~1800–2500	–	4.55 ± 0.01	TE	[232]
W/glass	W	–	$\sim10^{-8}$	~300	–	4.55 ± 0.02	CPD	[133,349]
W	Ag	Ag$^+$	3×10^{-6}(O$_2$)	~2500–2800	4.55 ± 0.1	–	PSI	[3408,3409]
W	Ag	Ag$^+$	$<10^{-7}$(O$_2$)	~2300–2600	4.55 ± 0.1	–	PSI	[3408,3409]
W	Cu	Cu$^+$	3×10^{-6}(O$_2$)	~2500–2800	4.55 ± 0.1	–	PSI	[3408,3409]
W	Cu	Cu$^+$	$<10^{-7}$(O$_2$)	~2300–2600	4.55 ± 0.1	–	PSI	[3408,3409]
W	–	–	?	1577	–	4.556	TE	[661]
W	–	–	?	~1350–2200	–	4.557	TE	[660]
W	–	–	?	~1700–2200	–	4.56	TE	[2187,3664]
W	–	–	–	–	–	4.56	TC	[3318]
W	–	–	–	–	–	4.56	TC	[3224]
W	–	–	$<2 \times 10^{-9}$	~1700–2300	–	4.56	TE	[662]
W	–	–	$<10^{-8}$	~300	–	4.56	CPD	[829]
W	–	–	$\leq 10^{-7}$	~1500–1600	–	4.56	TE	[1777]
W	–	–	1×10^{-9}	~300 (~2100)	–	4.56	CPD	[3617]
W{46%(100)}	–	–	–	–	(4.98 ± 0.05)	4.56 ± 0.01	TC	[803]
W{46%(100)}	–	–	–	–	(5.00 ± 0.05)	4.56 ± 0.01	TC	[2453]
W	–	–	?	~2100–2200	–	4.56 ± 0.01	TE	[3349]
W	–	–	$<10^{-9}$	~1700–2300	–	4.56 ± 0.02	TE	[162]
W	–	–	$\leq 5 \times 10^{-7}$	?	–	4.56 ± 0.03	TE	[160]
W	–	–	5×10^{-10}	~300	–	4.56 ± 0.03	FE	[2492]
W	–	–	$\leq 10^{-4}$ (Na)	~1450–2450	–	4.56 ± 0.04	TE	[1063]
W	–	–	?	?	(4.65*)	4.56 ± 0.06	TE	[3834]
W	–	–	?	1577	–	4.567	TE	[661]
W	K	K$^+$	4×10^{-9}	~1000–1600	4.57	–	PSI	[188]
W	–	–	2×10^{-9}	~1900–2400	–	4.57	TE	[4343]
W{95%(100)}[301]	–	–	–	–	(4.69 ± 0.05)	4.57 ± 0.00	TC	[803]
W	–	–	$\leq 9 \times 10^{-7}$	2160–2520	–	4.57 ± 0.01	TE	[2296]
W	–	–	1×10^{-7}	~1900–2200	(5.18 ± 0.03)	4.57 ± 0.04	TE	[281]
W	–	–	1×10^{-10}	~300	(4.67 ± 0.09)	4.57 ± 0.1	PE	[3055]
W	–	–	$<10^{-8}$	~2200–2400	–	4.57 ± 0.21	TE	[1062]
W	–	–	$\leq 2 \times 10^{-6}$	~2100–2700	–	4.575 ± 0.015	TE	[2296]
W	–	–	$\leq 10^{-9}$	~1900–2200	–	4.58	TE	[66]
W	–	–	$\leq 2 \times 10^{-8}$	~1350–2050	–	4.58	TE	[130,1363]
W	KBr	Br$^-$	?	~2300–2600	4.58^N	–	NSI	[574]
W	–	–	? (Ba)	~1600–2000	–	4.58	TE	[1485]
W	–	–	?	?	–	4.58	TE	[3524,3525]
W	Ba	Ba$^+$	$<1 \times 10^{-7}$	~2400–2800	4.58 ± 0.01	–	PSI	[80]
W	–	–	1×10^{-7}	~2100–2600	(5.14 ± 0.03)	4.58 ± 0.03	TE	[76,77]
W[304]	–	–	5×10^{-7}	2300	(5.05, 5.10)	4.58 ± 0.05	TE	[94]
W	–	–	$\leq 1 \times 10^{-6}$	~2100–2700	–	4.588 ± 0.011	TE	[2296]
W	–	–	–	–	–	4.59	TC	[1744]
W/W(100)[309]	WF$_6$, H$_2$	–	$\sim10^{-7}$	~1850–2450	–	4.59 ± 0.01	TE	[1053]
W{96%(100)}[300]	–	–	–	–	(4.60 ± 0.04)	4.59 ± 0.01	TC	[630,2453]
W[296]	–	–	$<10^{-6}$	?	(4.49 ± 0.14)	4.59 ± 0.04	TE	[823]
W	–	–	$\sim10^{-7}$	~1700–2050	–	4.59 ± 0.04	TE	[2820]
W[292]	–	–	$\sim10^{-9}$	~300	–	4.6	FE	[1493]
W	–	–	$<10^{-4}$ (Cs)	~2500–3000	–	4.6	TE	[111]
W[294]	–	–	2×10^{-7}	~300 (2300)	–	4.6	PE	[621]
W	–	–	?	~300	–	4.6	PE	[1243]
W	–	–	?	?	–	4.6	TE	[1792]
W	KCl	K$^+$	?	?	4.6	–	PSI	[2306]
W/Mo(100)[305]	W	–	1×10^{-11}	77	–	4.6	FE	[2965]
W	–	–	–	–	–	4.6	TC	[3318]
W{46.3%(310)}[411]	–	–	–	–	–	4.6	TC	[489]
W	–	–	? (Cs)	~2000–2500	–	4.6	TE	[3798,3799]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W	–	–	$\leq 1 \times 10^{-6}$	?	(4.75 ± 0.02)	4.6 ± 0.1	TE	[216]
W[306]	NaCl	Na⁺	$\leq 5 \times 10^{-8}$	~1550–1770	4.6 ± 0.1	–	PSI	[3113]
W{46%(100)}	Li	Li⁺	~10⁻⁹	~1800–2800	4.60	–	PSI	[534]
W/Ni	W	–	?	~300	–	4.60	PE	[2922]
W	–	–	~10⁻¹⁰	~300	–	4.60	CPD	[3532]
W	–	–	? (CsI)	~2100–2400	–	4.60 ± 0.01	TE	[1321]
W	Sr	Sr⁺	~10⁻⁹	~2400–2800	4.60 ± 0.02	–	PSI	[138]
W	La	La⁺	~10⁻⁹	~2400–2800	4.60 ± 0.02	–	PSI	[138]
W	–	–	$\leq 5 \times 10^{-8}$	?	(5.14 ± 0.05)	4.60 ± 0.04	TE	[84,93,824]
W{96%(100)}[300]	–	–	–	–	4.60 ± 0.04	(4.59 ± 0.01)	TC	[630,2453]
W	–	–	$\leq 10^{-4}$ (Na)	~1450–2450	–	4.60 ± 0.04	TE	[1063]
W	–	–	$\leq 8 \times 10^{-8}$	~1600–2500	(4.75 ± 0.05)	4.60 ± 0.05	TE	[95]
W	In	In⁺	4×10^{-10} (O₂)	~2100–2850	4.60 ± 0.05	–	PSI	[139]
W	In	In⁺	1×10^{-6} (O₂)	~2500–2850	4.60 ± 0.05	–	PSI	[139]
W	–	–	1×10^{-7}	~1900–2200	(5.19, 5.20)	4.60 ± 0.05	TE	[281]
W	–	–	<10⁻⁸	~1900–2250	(4.95 ± 0.05)	4.61	TE	[85]
W	–	–	? (NaI)	~2500–3000	–	4.61 ± 0.01	TE	[1321]
W	–	–	5×10^{-10}	~300	–	4.61 ± 0.01	PE	[2492]
W	Sr	Sr⁺	8×10^{-9}	~2300–2800	4.61 ± 0.03	–	PSI	[145]
W{35%(110)}	–	–	–	–	(5.18 ± 0.03)	4.61 ± 0.03	TC	[630,2453]
W	–	–	1×10^{-7}	~2000–2200	(5.16 ± 0.05)	4.61 ± 0.03	TE	[281]
W{95%(100)}[301]	–	–	–	–	(4.70 ± 0.04)	4.61 ± 0.04	TC	[2453]
W{46%(100)}[475]	Eu	Eu⁺	~10⁻⁹	~1800–2800	4.61 ± 0.05	–	PSI	[390,825]
W{46%(100)}	Ce	Ce⁺	~10⁻⁹	~1800–2800	4.61 ± 0.05	–	PSI	[390]
W{46%(100)}	Li	Li⁺	~10⁻⁹	~1800–2300	4.61 ± 0.05	–	PSI	[391,535,825]
W{46%(100)}	Na	Na⁺	~10⁻⁹	~1700–1950	4.61 ± 0.05	–	PSI	[535,659,825]
W{46%(100)}	K	K⁺	~10⁻⁹	~1250–1650	4.61 ± 0.05	–	PSI	[535,825]
W{46%(100)}	Rb	Rb⁺	~10⁻⁹	~1300–1650	4.61 ± 0.05	–	PSI	[535,825]
W{46%(100)}	Cs	Cs⁺	~10⁻⁹	~1150–1500	4.61 ± 0.05	–	PSI	[535,825]
W[294]	–	–	12 (Ar)	~300	–	4.62	PE	[621]
W	–	–	? (Cs)	~2000–2400	–	4.62	TE	[3808]
W	–	–	?	~1200–1500	–	4.62	TE	[3248]
W	–	–	~10⁻⁷	~1450–2250	–	4.62	TE	[1878]
W	–	–	$\leq 3 \times 10^{-10}$	1000	–	4.62 ± 0.01	CPD	[194]
W{33.6%(112)}	–	–	–	–	(5.13 ± 0.04)	4.62 ± 0.02	TC	[630,2453]
W{46%(100)}	Eu	Eu⁺	~10⁻⁹	~1800–2800	4.62 ± 0.05	–	PSI	[533,534]
W/glass[293]	W	–	~10⁻¹⁰	77 (438)	–	4.63	PE	[2095]
W{35.2%(110)}	–	–	–	–	(5.15 ± 0.03)	4.63 ± 0.01	TC	[281]
W	–	–	<10⁻⁸	~1900–2400	–	4.63 ± 0.05	TE	[1858]
W	–	–	$\leq 10^{-7}$	~1450–2250	–	4.64	TE	[1878]
W	K	K⁺	?	~1300–1400	4.64 ± 0.03*	–	PSI	[1373]
W	Ag	Ag⁺	$\leq 10^{-5}$ (O₂)	~2500–2800	4.65	–	PSI	[55]
W	Ba	Ba⁺	$\leq 10^{-4}$ (Ba)	~2600–2900	4.65*	(4.56 ± 0.06)	PSI	[3834]
W	–	–	?	1500	–	4.65	TE	[3534]
W	–	–	6×10^{-9}	1800	–	4.65	TE	[4060]
W[312]	KCl	K⁺	?	~1700–2400	4.65 ± 0.05	–	PSI	[46]
W[312]	KBr	K⁺	?	~1700–2400	4.65 ± 0.05	–	PSI	[46]
W[312]	KI	K⁺	?	~1700–2400	4.65 ± 0.05	–	PSI	[46]
W/SiO₂	W	–	?	?	–	4.65 ± 0.05	FE	[1605]
W	–	–	~10⁻⁷	~2000	–	4.65 ± 0.05	TE	[1649]
W	Ti	Ti⁺	$\leq 10^{-6}$ (O₂)	~2300–2900	4.65 ± 0.1	–	PSI	[3408]
W[307]	–	(W⁺, W⁻)	?	~2262–2353	4.65 ± 0.4*	–	PSI, NSI	[965]
W	–	–	$<8 \times 10^{-11}$	~300	–	4.650 ± 0.100	CPD	[342,3868]
W	Cu	Cu⁺	$\leq 10^{-5}$ (O₂)	~2500–2800	4.66	–	PSI	[55]
W/Mo[308]	WF₆, H₂	–	~10⁻⁷	–2000–	–	4.66	TE	[1398]
W/W(110)[309]	WCl₆, H₂	–	~10⁻⁷	~1850–2450	–	4.66 ± 0.01	TE	[1053]
W	Na	Na⁺	$\leq 5 \times 10^{-9}$	~1500–1700	4.66 ± 0.01*	–	PSI	[2594]
W/Mo[308]	WCl₆, H₂	–	~10⁻⁷	–2000–	–	4.67	TE	[1398]
W	–	–	?	1900	–	4.67	TE	[2762]
W	–	–	–	–	–	4.67	TC	[3224]
W	K	K⁺	$\leq 3 \times 10^{-9}$	1150–2000	4.67 ± 0.09	(4.57 ± 0.1)	PSI	[3055]
W	–	–	6×10^{-7} (O₂)	~2100–2500	–	4.68	CPD	[200]
W[308]	–	–	~10⁻⁷	–2000–	–	4.68	TE	[1398]
W	–	–	–	–	–	4.68	TC	[2629]
W	K	K⁺	2×10^{-7}	~1400–2200	4.68 ± 0.01*	–	PSI	[50]
W	–	–	?	~2100–2700	–	4.68 ± 0.07	TE	[228]
W	–	–	$\leq 10^{-7}$	1450–2150	–	4.69	TE	[1878]
W	–	–	?	?	–	4.69	TE	[2105]
W/W(100)[309]	WF₆, H₂	–	~10⁻⁷	~1850–2450	–	4.69 ± 0.01	TE	[1053]
W	KI	K⁺	2×10^{-7}	~1500–2200	4.69 ± 0.02*	–	PSI	[51]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W	–	–	?	0^E (≤1100)	–	4.69 ± 0.03	PE	[3392]
W{95%(100)}[301]	–	–	–	–	4.69 ± 0.05	(4.57 ± 0.00)	TC	[803]
W(porous)	–	–	?	>1600	–	4.7	TE	[3762]
W(porous)	K	K$^+$	<10^{-7}	~1400–1600	4.7	–	PSI	[3763]
W	Na	Na$^+$	~10^{-4} (Na)	2000	4.7*	–	PSI	[3839]
W	–	–	<10^{-7}	2200	–	4.7	TE	[2582]
W/Mo(100)[305]	W	–	1×10^{-11}	77 (1300)	–	4.7	FE	[2965]
W/W(110)	–	–	–	–	–	4.7	TC	[2975]
W	–	–	5×10^{-8}	~300	–	4.7	PE	[3301]
W	Na	Na$^+$	?	~1600–2200	4.7 ± 0.1	–	PSI	[1061]
W	Mg	Mg$^+$	?	~1600–2200	4.7 ± 0.1	–	PSI	[1061]
W	Ca	Ca$^+$	?	~1600–2200	4.7 ± 0.1	–	PSI	[1061]
W	Sr	Sr$^+$	?	~1600–2200	4.7 ± 0.1	–	PSI	[1061]
W	Ba	Ba$^+$	?	~1600–2200	4.7 ± 0.1	–	PSI	[1061]
W	–	–	0.08 (Cs)	~2000–2350	–	4.70	TE	[2937]
W	Li	Li$^+$	2×10^{-7}	~2100–2800	4.70	–	PSI	[50]
W	Na	Na$^+$	2×10^{-7}	~2100–2800	4.70	–	PSI	[50]
W	Rb	Rb$^+$	2×10^{-7}	~1600–2600	4.70 ± 0.02*	–	PSI	[50]
W	KCl	K$^+$	2×10^{-7}	~1600–2300	4.70 ± 0.03*	–	PSI	[51]
W	KBr	K$^+$	2×10^{-7}	~1600–2300	4.70 ± 0.03*	–	PSI	[51]
W{95%(100)}[301]	–	–	–	–	4.70 ± 0.04	(4.61 ± 0.04)	TC	[2453]
W	–	–	<2×10^{-7}	~2000–2200	–	4.70 ± 0.40	TE	[3066]
W	Na	Na$^+$	≤3×10^{-7}	~1500–2900	4.71	–	PSI	[136]
W	NaI	Na$^+$	≤3×10^{-7}	~1500–2900	4.71	–	PSI	[136]
W	K	K$^+$	?	~1000	4.71*	–	PSI	[3794]
W	–	–	~10^{-9}	~300	–	4.71	CPD	[2473]
W	–	–	?	?	–	4.71	TE	[3386]
W	–	–	?	1100	–	4.71	TE	[3392]
W/W(100)[309]	WF$_6$, H$_2$	–	~10^{-7}	1850–2450	–	4.71 ± 0.01	TE	[1053]
W/Mo[308]	WF$_6$, H$_2$	–	~10^{-7}	–2000–	–	4.72	TE	[1398]
W	Li	Li$^+$	2×10^{-7}	~2100–2800	4.72 ± 0.01*	–	PSI	[50]
W	Na	Na$^+$	2×10^{-7}	~2200–2900	4.72 ± 0.01*	–	PSI	[50]
W	KF	K$^+$	2×10^{-7}	~1400–2200	4.72 ± 0.02*	–	PSI	[51]
W	KBr	K$^+$	2×10^{-7}	~1600–2400	4.72 ± 0.03*	–	PSI	[1285]
W	K	K$^+$	2×10^{-7}	~1300–2200	4.72 ± 0.04*	–	PSI	[1285]
W	–	–	6×10^{-3}	~300	–	4.72 ± 0.05	PE	[2079,2080]
W	–	–	–	–	–	4.73	TC	[3476]
W	–	–	–	1500–1900	–	4.73 ± 0.01	TC	[1372]
W	–	–	? (Cs)	~2000–2350	–	4.74	TE	[2937]
W	LiI	Li$^+$	≤3×10^{-7}	~1500–1900	4.74	–	PSI	[136]
W	KBr	K$^+$	?	~1900–2100	4.74*	–	PSI	[2208]
W	KI	K$^+$	?	~1900–2100	4.74*	–	PSI	[2208]
W	–	–	?	~2100–2200	–	4.74 ± 0.01	TE	[3349]
W(fp)[291]	–	–	–	–	–	4.75	TC	[2973]
W	–	–	~10^{-8}	?	–	4.75	TE	[196]
W[308]	–	–	~10^{-7}	–2000–	–	4.75	TE	[1398]
W	K	K$^+$	≤1×10^{-6}	~1300–1800	4.75 ± 0.02	(4.6 ± 0.1)	PSI	[216]
W	Li	Li$^+$	≤8×10^{-8}	~1800–2500	4.75 ± 0.05	(4.60 ± 0.05)	PSI	[95]
W	–	–	–	–	–	4.77	TC	[3476]
W	–	–	–	0	–	4.77	TC	[4419]
W{95%(100)}[277]	–	–	–	–	–	4.78	TC	[1254]
W	K	K$^+$	?	~1200–2100	4.78*	–	PSI	[2208]
W	–	–	?	?	–	4.79	TE	[3386]
W	–	–	7×10^{-5}	~2000–2150	–	4.79 ± 0.01	TE	[2454]
W{46.3%(310)}[411]	–	–	<2×10^{-10}	~300	–	4.8	FE	[489]
W/Si^{n}[482]	W	–	?	~300	–	4.8	CPD	[4375]
W	K	K$^+$	<10^{-9}	~1100–1200	4.8 ± 0.1*	–	PSI	[2579,3055]
W[170,297]	–	(W$^+$)	?	~2200–2600	4.8 ± 0.2*	–	PSI	[966]
W[170]	–	(W$^+$)	~10^{-7}	~2600–2900	4.8 ± 0.6	(4.58 ± 0.03)	PSI	[77]
W	Na	Na$^+$	≤10^{-4} (Na)	2300	4.80 ± 0.03*	–	PSI	[1364]
W	–	–	?	~300–1100	–	4.80 ± 0.09	PE	[3390]
W[313]	NaCl	Na$^+$	?	~1800–2600	4.82	–	PSI	[47]
W[315]	Li	Li$^+$	≤3×10^{-7}	~1800–2000	4.82 ± 0.02	–	PSI	[155]
W[315]	NaCl	Na$^+$	≤3×10^{-7}	~1550–2450	4.83 ± 0.05	–	PSI	[156]
W	NaBr	Na$^+$	?	~1700–2600	4.84	–	PSI	[47]
W/Si(111)[166]	W	–	4×10^{-11}	~300	–	4.87	PE	[1429,1430]
W{80%(110)}[311]	–	–	–	–	(5.26 ± 0.02)	4.87 ± 0.06	TC	[2453]
W/W(110)[309]	WCl$_6$, H$_2$	–	~10^{-7}	~1850–2450	–	4.88 ± 0.01	TE	[1053]
W	–	–	–	–	–	4.9	TC	[706]
W	–	–	?	~1400–2500	–	4.90	TE	[3856]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
W	–	–	–	–	–	4.90	TC	[339]
W	–	–	1×10^{-10}	~300	–	4.90	CPD	[2632]
W{80%(110)}[311]	–	–	–	–	(5.25 ± 0.02)	4.90 ± 0.05	TC	[630]
W	–	–	?	?	–	4.90 ± 0.05	TE	[2209]
W	–	–	? (K)	~1400–1800	–	4.95	TE	[2559]
W[312]	KCl	K⁺	?	1450	4.95	–	TC	[3747]
W[270]	Na	Na⁺	? (Na)	~1500–2000	4.95 ± 0.05	(4.61)	PSI	[85]
W[314]	KI	I⁻	$<1 \times 10^{-6}$	~1800–2300	4.95 ± 0.05[N]	–	NSI	[183]
W{46.3%(310)}	–	–	–	–	4.96 ± 0.03	(4.34 ± 0.05)	TC	[630]
W/W(100)[309]	WF₆, H₂	–	~10^{-7}	~1850–2450	–	4.98 ± 0.01	TE	[1053]
W{46%(100)}	–	–	–	–	4.98 ± 0.05	(4.56 ± 0.01)	TC	[803]
W{46.3%(310)}	–	–	–	–	4.99 ± 0.06	(4.38 ± 0.05)	TC	[2453]
W	–	–	$<10^{-9}$	~1700–2300	–	5.0	TE	[162]
W	–	–	?	~1400–1750	–	5.0	TE	[2078]
W	Nd	Nd⁺	$<1 \times 10^{-7}$	~2700–2900	5.00 ± 0.04*	–	PSI	[80]
W{46%(100)}	–	–	–	–	5.00 ± 0.05	(4.56 ± 0.01)	TC	[2453]
W/W(110)[309]	WCl₆, H₂	–	~10^{-7}	~1850–2450	–	5.03 ± 0.01	TE	[1053]
W	–	(W⁺)	$<7 \times 10^{-7}$	~2850–3000	5.04 ± 0.29	–	PSI	[805,3083]
W[313]	NaCl	Na⁺	?	1450	5.05	–	TC	[3747]
W[304]	In	In⁺	5×10^{-7}	~2300–2700	5.05 ± 0.05	(4.58 ± 0.05)	PSI	[94]
W	KCl	K⁺	2×10^{-7}	~2000–2300	5.09 ± 0.02	(4.42 ± 0.02)	PSI	[36]
W	KCl	K⁺	2×10^{-7}	~2000–2200	5.09 ± 0.06	(4.48 ± 0.06)	PSI	[23]
W{<35%(110)}	–	–	–	–	5.09 ± 0.10	(4.52 ± 0.12)	TC	[283,630]
W	Na	Na⁺	$\leq 10^{-7}$ (Na)	2400	5.1*	–	PSI	[3839]
W[304]	In	In⁺	5×10^{-7}	2350	5.10	(4.58 ± 0.05)	PSI	[94]
W[315]	LiCl	Li⁺	$\leq 3 \times 10^{-7}$	~2250–2700	5.11 ± 0.02	–	PSI	[156]
W{25%(110)}[295]	–	–	–	2000	5.12*	(4.46*)	TC	[3844]
W	KF	K⁺	2×10^{-7}	~2000–2200	5.12 ± 0.02	(4.48 ± 0.06)	PSI	[23]
W[315]	Li	Li⁺	$\leq 3 \times 10^{-7}$	~2200–2500	5.12 ± 0.02	–	PSI	[155]
W[315]	Tl	Tl⁺	$\leq 3 \times 10^{-7}$	~1900–2500	5.12 ± 0.03	–	PSI	[157]
W{33.6%(112)}	–	–	–	–	5.13 ± 0.04	(4.62 ± 0.02)	TC	[630,2453]
W	In	In⁺	1×10^{-7}	~2100–2600	5.14 ± 0.03	(4.58 ± 0.03)	PSI	[76,77]
W	Bi	Bi⁺	$\leq 5 \times 10^{-8}$	~2050–2300	5.14 ± 0.05	(4.60 ± 0.04)	PSI	[84,93,824]
W[315]	In	In⁺	$\leq 3 \times 10^{-7}$	~1900–2500	5.15 ± 0.01	–	PSI	[157,3538]
W{35.2%(110)}	–	–	–	–	5.15 ± 0.03	(4.63 ± 0.01)	TC	[281]
W/W(100)[309]	W	–	~10^{-7}	~1850–2450	–	5.16 ± 0.01	TE	[1053]
W/W(110)[309]	W	–	~10^{-7}	~1850–2450	–	5.16 ± 0.01	TE	[1053]
W	LiI	Li⁺	2×10^{-7}	~2000–2200	5.16 ± 0.05	(4.61 ± 0.03)	PSI	[281]
W[306]	Ag	Ag⁺	$\leq 5 \times 10^{-8}$	?	5.16 ± 0.1	–	PSI	[3113]
W	LiCl	Li⁺	2×10^{-7}	~2000–2200	5.18 ± 0.03	(4.57 ± 0.04)	PSI	[281]
W{35%(110)}	–	–	–	–	5.18 ± 0.03	(4.61 ± 0.03)	TC	[630,2453]
W	NaCl	Na⁺	2×10^{-7}	~1900–2200	5.19 ± 0.01	–	PSI	[208]
W	LiCl	Li⁺	2×10^{-7}	~2000–2200	5.19 ± 0.03	(4.48 ± 0.06)	PSI	[23]
W	LiF	Li⁺	2×10^{-7}	~2000–2200	5.19 ± 0.05	(4.60 ± 0.05)	PSI	[281]
W{mainly(110)}	–	–	0.1–6 (Cs)	~1700–1900	–	5.2 ± 0.1*	TE	[2609]
W	NaBr	Na⁺	2×10^{-7}	~2000–2200	5.20 ± 0.02	(4.48 ± 0.06)	PSI	[23,2422]
W	LiCl	Li⁺	2×10^{-7}	~2000–2200	5.20 ± 0.02	(4.47 ± 0.04)	PSI	[37]
W	LiBr	Li⁺	2×10^{-7}	~2000–2200	5.20 ± 0.04	(4.60 ± 0.05)	PSI	[281,2411]
W	LiBr	Li⁺	2×10^{-6}	~2100–2200	5.20 ± 0.05	–	PSI	[2411]
W	–	–	–	–	–	5.21	TC	[3476]
W	NaCl	Na⁺	2×10^{-7}	~2000–2200	5.21 ± 0.02	(4.48 ± 0.06)	PSI	[23,2411]
W	RbCl	Rb⁺	2×10^{-7}	~2000–2200	5.21 ± 0.06	(4.48 ± 0.06)	PSI	[23]
W	NaCl	Na⁺	2×10^{-7}	~2000–2200	5.22 ± 0.02	(4.47 ± 0.04)	PSI	[37,2422]
W	LiF	Li⁺	2×10^{-7}	~2000–2200	5.22 ± 0.07	(4.48 ± 0.06)	PSI	[23]
W	NaCl	Na⁺	2×10^{-7}	~2000–2300	5.23 ± 0.01	(4.42 ± 0.02)	PSI	[36]
W	NaI	Na⁺	2×10^{-7}	~2000–2200	5.23 ± 0.02	(4.48 ± 0.06)	PSI	[23,2422]
W	LiBr	Li⁺	2×10^{-7}	~2000–2200	5.23 ± 0.02	(4.48 ± 0.06)	PSI	[23,37,57,2422]
W	NaCl	Na⁺	2×10^{-7}	~2000–2200	5.24 ± 0.05	–	PSI	[57]
W{80%(110)}[311]	–	–	–	–	5.25 ± 0.02	(4.90 ± 0.05)	TC	[630]
W[314]	Cu	Cu⁺	$<1 \times 10^{-6}$	~1800–2300	5.25 ± 0.05	(4.95 ± 0.05[N])	PSI	[183]
W[314]	Ag	Ag⁺	$<1 \times 10^{-6}$	~1800–2300	5.25 ± 0.05	(4.95 ± 0.05[N])	PSI	[183]
W{80%(110)}[311]	–	–	–	–	5.26 ± 0.02	(4.87 ± 0.06)	TC	[2453]
W	LiI	Li⁺	2×10^{-7}	~2000–2200	5.26 ± 0.02	(4.48 ± 0.06)	PSI	[23]
W[170]	LiI	Li⁺	2×10^{-7}	~2000–2200	5.27 ± 0.01	(4.47 ± 0.04)	PSI	[37]
W[170]	Cs	Cs⁺	$<5 \times 10^{-8}$	770–800	5.3 ± 0.1	–	PSI	[263]
W	K	K⁺	$<5 \times 10^{-8}$	780–820	5.3 ± 0.2	–	PSI	[263,269]
W	–	–	–	–	–	5.67	TC	[3931]
W	–	–	–	–	–	5.78	TC	[2629]
W	Na	Na⁺	?	1370	5.45 ± 0.06*	–	PSI	[3766]
Recommended	–	–	–	–	**5.17 ± 0.05**	**4.56 ± 0.03**	–	–
Recommended	–	–	–	–	**4.51 ± 0.03[N]**	–	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				75. Rhenium Re[416]				
hcp								
Re(0001)	–	–	–	–	–	4.88	TC	[4004]
Re(0001)/Mo	Re	–	?	–1800–	–	4.9	TE	[2416]
Re(0001)/Mo	ReCl$_3$	–	~10^{-9}	~1800–2000	–	5.01 ± 0.05	TE	[398]
Re(0001)/Mo	ReCl$_3$	–	~10^{-7}	~2300–2500	–	5.02 ± 0.02	TE	[398]
Re(0001)/Mo	ReCl$_3$	–	~10^{-8}	~2100–2200	–	5.02 ± 0.04	TE	[398]
Re(0001)	–	–	–	–	–	5.09	TC	[3473]
Re(0001)	–	–	≤5 × 10^{-8}	?	(5.15 ± 0.26)	5.15 ± 0.10	TE	[96]
Re(0001)	La	La$^+$	≤5 × 10^{-8}	~2000–2100	5.15 ± 0.21	(5.15 ± 0.10)	PSI	[96]
Re(0001)	Ce	Ce$^+$	≤5 × 10^{-8}	~2300–2400	5.15 ± 0.21	(5.15 ± 0.10)	PSI	[96]
Re(0001)	Er	Er$^+$	≤5 × 10^{-8}	~1900–2000	5.15 ± 0.21	(5.15 ± 0.10)	PSI	[96]
Re(0001)	Gd	Gd$^+$	≤5 × 10^{-8}	~2100–2200	5.15 ± 0.34	(5.15 ± 0.10)	PSI	[96]
Re(0001)	Tm	Tm$^+$	≤5 × 10^{-8}	~1600–1750	5.15 ± 0.34	(5.15 ± 0.10)	PSI	[96]
Re(0001)	–	–	–	–	–	5.17	TC	[4004]
Re(0001){80%}	–	–	?	~300	–	5.20 ± 0.1	PE	[401]
Re(0001)	–	–	~10^{-10}	120	–	5.24	PE	[399]
Re(0001)	–	–	2 × 10^{-10}	100	–	5.26 ± 0.05	CPD	[3378]
Re(0001)	–	–	–	–	–	5.35	TC	[4005]
Re(0001){mainly}	–	–	~10^{-5} (air)	~2400–2600	–	5.4	TE	[56,206]
Re(0001)	–	–	~10^{-10}	~300	–	5.4	PE	[400]
Re(0001)	–	–	6 × 10^{-11}	~300	–	5.4	CPD	[836]
Re(0001)	–	–	–	–	–	5.46	TC	[3224]
Re(0001)	–	–	~10^{-10}	80	–	5.5	PE	[664]
Re(0001)	–	–	≤6 × 10^{-8}	~1800–2150	–	5.51	TE	[2247]
Re(0001)	–	–	–	–	–	5.53	TC	[1159,1980,3067]
Re(0001)	–	–	~10^{-9}	?	–	5.53 ± 0.03	TE	[1065,2593]
Re(0001)	–	–	–	–	–	5.57	TC	[3224]
Re(0001)	–	–	≤7 × 10^{-9}	~1700–2300	–	5.59 ± 0.05	TE	[402,3415,3416]
Re(0001)	–	–	–	–	–	5.71	TC	[334]
Re(0001)	–	–	–	–	–	5.77	TC	[321]
Re(0001)	–	–	≤10^{-10}	50–300	–	6.40 ± 0.02	FE	[2488,2499]
Recommended	–	–	–	–	**5.15 ± <0.34**	**5.30 ± 0.21**	–	–
Re(1010)	–	–	–	–	–	4.62	TC	[4004]
Re(1010)	–	–	–	–	–	4.93	TC	[4004]
Re(1010)	–	–	(<8 × 10^{-12})	~300	–	5.05	CPD	[599,2490]
Re(1010)	–	–	≤1 × 10^{-8}	~1900–2250	–	5.05 ± 0.04	TE	[837,2325,2326]
Re(1010)	–	–	<10^{-11}	77	–	5.1	CPD	[2506]
Re(1010)	–	–	≤7 × 10^{-9}	~1700–2300	–	5.15 ± 0.02	TE	[402,3415,3416]
Re(1010)	–	–	~10^{-9}	?	–	5.15 ± 0.03	TE	[1065,2593]
Re(1010)	–	–	≤5 × 10^{-10}	–1800–	–	5.15 ± 0.05	TE	[286,412,537,665, 839,2051,4458]
Re(1010)	–	–	–	–	–	5.20	TC	[1159,1980,3067]
Re(1010)	–	–	–	–	–	5.51	TC	[321]
Re(1010)	–	–	~10^{-10}	~300	–	5.52 ± 0.03	PE	[403]
Re(1010)	–	–	–	–	–	5.67	TC	[4005]
Re(1010)[211]	–	–	<5 × 10^{-9}	~300	–	5.95 ± 0.15	FE	[730]
Recommended	–	–	–	–	–	**5.12 ± 0.05**	–	–
Re(1011)	–	–	–	–	–	4.94	TC	[4004]
Re(1011)	–	–	≤1 × 10^{-8}	~1900–2250	–	5.04 ± 0.04	TE	[837,2325,2326]
Re(1011)	–	–	–	–	–	5.25	TC	[4004]
Re(1011)	–	–	<5 × 10^{-9}	~300 (<800)	–	5.25 ± 0.04	FE	[730]
Re(1011)	–	–	<5 × 10^{-9}	~300 (<800)	–	5.36 ± 0.04	FE	[730]
Re(1011)	–	–	≤7 × 10^{-9}	~1700–2300	–	5.37 ± 0.03	TE	[402,3415,3416]
Re(1011)	–	–	<5 × 10^{-9}	~300 (>800)	–	5.55 ± 0.03	FE	[730]
Re(1011)	–	–	~10^{-10}	~300	–	5.69 ± 0.06	PE	[403]
Re(1011)	–	–	~10^{-9}	77	–	5.75	FE	[363,811,838]
Re(1011)	–	–	~10^{-10}	~300	–	5.82 ± 0.07	PE	[403]
Re(1011)	–	–	~10^{-10}	~300	–	5.88 ± 0.10	PE	[403]
Recommended	–	–	–	–	–	**5.26 ± 0.13**	–	–
Re(1120)	–	–	–	–	–	4.55	TC	[4004]
Re(1120)	–	–	≤1 × 10^{-8}	~1900–2250	–	4.80 ± 0.04	TE	[837,2325,2326]
Re(1120)	–	–	–	–	–	4.86	TC	[4004]
Re(1120)	–	–	~10^{-10}	~300	–	4.94 ± 0.06	PE	[403]
Re(1120)	–	–	~10^{-9}	77	–	5.07	FE	[363,811,838]

(*continued on next page*)

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Re(1120)	–	–	$<5 \times 10^{-9}$	~300	–	5.08 ± 0.02	FE	[730]
Recommended	–	–	–	–	–	**4.95 ± 0.11**	–	–
Re(1121)	–	–	–	–	–	4.33	TC	[4004]
Re(1121)	–	–	–	–	–	4.62	TC	[4004]
Re(1121)	–	–	$\leq 1 \times 10^{-8}$	~1900–2250	–	4.70 ± 0.04	TE	[837,2325,2326]
Re(1121)	–	–	$\sim 10^{-9}$	77	–	4.82	FE	[363,811,838]
Re(1121)	–	–	$\sim 10^{-10}$	~300	–	4.93 ± 0.09	PE	[403]
Re(1121)	–	–	$\sim 10^{-10}$	~300	–	5.02 ± 0.05	PE	[403]
Recommended	–	–	–	–	–	**4.82 ± 0.14**	–	–
Re(1122)	–	–	–	–	–	4.48	TC	[4004]
Re(1122)	–	–	–	–	–	4.79	TC	[4004]
Re(1122)	–	–	$<5 \times 10^{-9}$	~300	–	4.95 ± 0.02	FE	[730]
Re(1122)	–	–	$\sim 10^{-10}$	~300	–	5.10 ± 0.02	PE	[403]
Re(1122)	–	–	$\sim 10^{-9}$	77	–	5.27	FE	[363,811,838]
Re(1122)	–	–	$\sim 10^{-10}$	~300	–	5.36 ± 0.05	PE	[403]
Recommended	–	–	–	–	–	**5.03 ± 0.18**	–	–
Re(1123)	–	–	–	–	–	4.41	TC	[4004]
Re(1123)	–	–	–	–	–	4.72	TC	[4004]
Re(1123)	–	–	$\sim 10^{-9}$	?	–	4.84 ± 0.03	TE	[1065,2593]
Re(1124)	–	–	$\leq 1 \times 10^{-8}$	~1900–2250	–	4.72 ± 0.04	TE	[837,2325,2326]
Re(1124)	–	–	–	–	–	4.83	TC	[321]
Re(1130)	–	–	–	–	–	4.44	TC	[4004]
Re(1130)	–	–	–	–	–	4.73	TC	[4004]
Re(2130)	–	–	–	–	–	4.49	TC	[4004]
Re(2130)	–	–	–	–	–	4.77	TC	[4004]
Re(3140)	–	–	–	–	–	4.55	TC	[4004]
Re(3140)	–	–	–	–	–	4.80	TC	[4004]
Re	–	–	–	–	–	3.98	TC	[521]
Re	–	–	$\sim 10^{-6}$	1620	–	4.15	TE	[1780]
Re	KI	I^-	$\leq 1 \times 10^{-6}$	1600	$>4.30^N$	(5.0 ± 0.1)	NSI	[216]
Re	–	–	$\sim 10^{-6}$	~1600	–	4.35	TE	[1780]
Re	–	–	$\sim 10^{-6}$	~1900–2100	–	4.45–5.2	TE	[1779]
Re	KI	I^-	$\leq 1 \times 10^{-6}$	1800	$>4.46^N$	(5.0 ± 0.1)	NSI	[216]
Re	–	–	–	–	–	4.53	TC	[2949]
Re	KBr	Br^-	$\leq 1 \times 10^{-6}$	1600	$>4.60^N$	(5.0 ± 0.1)	NSI	[216]
Re	–	–	–	–	–	4.62	TC	[298]
Re	–	–	–	–	–	4.67	TC	[3476]
Re	–	–	?	?	–	4.7	TE	[3402]
Re	–	–	–	–	–	4.7	TC	[706]
Re	–	–	–	–	–	4.72	TC	[3318]
Re	–	–	2×10^{-8}	~1700–2150	–	4.72	TE	[832]
Re	K	K^+	?	1660	$4.73 \pm 0.10^*$	–	PSI	[737]
Re/W[316]	–	–	5×10^{-7}	~1950–2700	–	4.74 ± 0.02^{486}	TE	[666]
Re	–	–	$\sim 10^{-9}$	~1300–2200	–	4.75	TE	[1775]
Re/W	Re	–	?	?	–	4.75	TE	[2575]
Re	Rb	Rb^+	?	1660	$4.75 \pm 0.10^*$	–	PSI	[737]
Re	KBr	Br^-	$\leq 1 \times 10^{-6}$	1800	$>4.76^N$	(5.0 ± 0.1)	NSI	[216]
Re/Cr/W	–	–	$<10^{-5}$	?	–	4.77	TE	[3041]
Re	–	–	–	–	–	4.78	TC	[3476]
Re	Sm	Sm^+	$<10^{-7}$	2100	4.78	–	PSI	[2970]
Re	–	–	$\sim 10^{-9}$	77	–	4.8	FE	[363,811,838]
Re	–	–	$\sim 10^{-6}$ (Cs)	~2000–2200	–	4.8	TE	[1774]
Re[320]	–	–	? (Cs)	~1300–2000	–	4.8	TE	[3414]
Re/SiC[323]	–	–	4×10^{-10}	~300 (700)	–	4.8 ± 0.1	CPD	[3646]
Re	–	–	–	–	–	4.81	TC	[3318]
Re/Mo[319]	$ReCl_3$, H_2	–	$\sim 10^{-7}$	~2000	–	4.82	TE	[1398]
Re	K	K^+	$\leq 1 \times 10^{-6}$	1800	4.85	(5.0 ± 0.1)	PSI	[216]
Re	–	–	$\leq 10^{-8}$	~1500	–	4.85	TE	[1778]
Re	–	–	5×10^{-8}	~1700–2500	(5.35 ± 0.05)	4.85 ± 0.05	TE	[100]
Re	–	–	$\sim 10^{-10}$	~1500–2100	–	4.85 ± 0.05	TE	[165]
Re	–	–	$\sim 10^{-9}$	~1200–1800	–	4.86	TE	[975]
Re	K	K^+	$\leq 1 \times 10^{-6}$	1600	4.87	(5.0 ± 0.1)	PSI	[216]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Re	–	–	–	–	–	4.87	TC	[2629]
Re	–	–	? (Cs)	2300	–	4.87	TE	[2341]
Re	–	–	~10^{-9}	>1200	–	4.88	TE	[1203]
Re/W	Re	–	?	?	–	4.89	TE	[3257]
Re	–	–	?	1900	–	4.9	TE	[3093]
Re(porous)	–	–	?	>1600	–	4.9	TE	[3762]
Re	K	K^+	≤2×10^{-7}	~1050–1950	4.9	(4.93 ± 0.04)	PSI	[53]
Re	KCl	K^+	≤2×10^{-7}	~1150–1950	4.9	(4.93 ± 0.04)	PSI	[53]
Re[317]	Li	Li^+	<10^{-7}	?	4.9	–	PSI	[2944]
Re	–	–	~10^{-9}	?	–	4.9	TE	[979]
Re	–	–	4×10^{-9}	~1600–1950	–	4.9 ± 0.05	TE	[341]
Re[318]	–	(Re^-)	?	~2250–2500	4.9 ± 0.2*N	–	NSI	[966]
Re	–	–	–	–	–	4.90	TC	[3224]
Re	LiCl	Li^+	5×10^{-7}	2600	4.90	(5.0 ± 0.1)	PSI	[99]
Re	KBr	K^+	≤1×10^{-6}	1800	4.90	(5.0 ± 0.1)	PSI	[216]
Re	KI	K^+	≤1×10^{-6}	1800	4.90	(5.0 ± 0.1)	PSI	[216]
Re	–	–	≤7×10^{-9}	~1700–2300	–	4.93 ± 0.02	TE	[402,3415,3416]
Re	–	–	1×10^{-9}	~1750–2400	(5.43 ± 0.03)	4.93 ± 0.04	TE	[76,77,97,190]
Re	–	–	≤2×10^{-7}	~1800–2300	(5.34)	4.93 ± 0.04	TE	[53]
Re	–	–	~10^{-7}–10^{-5} (air)	2010, 2080	(5.42 ± 0.02)	4.93 ± 0.05	TE	[23]
Re	–	–	~10^{-7}–10^{-5} (air)	1830	(5.42–5.58)	4.93–5.18	TE	[23]
Re	KCl	K^+	≤1×10^{-6}	1800	4.94	(5.0 ± 0.1)	PSI	[216]
Re	–	–	3×10^{-9}	~1250–2250	–	4.94	TE	[159]
Re/Mo[319]	$ReCl_3$, H_2	–	~10^{-7}	~2000	–	4.94	TE	[1398]
Re	–	–	~10^{-7}–10^{-5} (O_2)	1715	(5.45–5.81)	4.94–5.41	TE	[23]
Re/W	$ReCl_3$, H_2	–	~10^{-7}	~2000	–	4.95	TE	[1398]
Re	–	–	–	–	–	4.95	TC	[3264,3265,3267]
Re	–	–	?	?	–	4.95	TE	[1772]
Re	–	–	~10^{-7}–10^{-5} (O_2)	2080	(5.43 ± 0.01)	4.95 ± 0.01	TE	[23]
Re	–	–	2×10^{-7}	~1800–2000	(5.48 ± 0.02)	4.95 ± 0.05	TE	[23]
Re	–	–	5×10^{-10}	~1300–2500	–	4.95 ± 0.10	TE	[404,840]
Re	–	–	~10^{-7}–10^{-5} (air)	1930	(5.43 ± 0.04)	4.96 ± 0.05	TE	[23]
Re[320]	–	–	~10^{-9}	1325–2250	–	4.96 ± 0.05	TE	[124,650,3414]
Re	–	–	≤10^{-9}	~1800–2200	–	4.97	TE	[66]
Re	KCl	K^+	≤1×10^{-6}	1600	4.97	(5.0 ± 0.1)	PSI	[216]
Re	KBr	K^+	≤1×10^{-6}	1600	4.97	(5.0 ± 0.1)	PSI	[216]
Re	KI	K^+	≤1×10^{-6}	1600	4.97	(5.0 ± 0.1)	PSI	[216]
Re	La	La^+	≤10^{-7}	~2100	4.97	–	PSI	[2970]
Re	–	–	?	~300	–	4.97	PE	[1846]
Re	–	–	≤5×10^{-7}	?	–	4.97 ± 0.03	TE	[160]
Re	–	–	~10^{-7}–10^{-5} (air)	1710	(5.42–5.70)	4.97–5.36	TE	[23]
Re	–	–	<1×10^{-8}	~1650–2400	(5.21 ± 0.01)	4.98 ± 0.03	TE	[54,3078]
Re	In	In^+	<10^{-7}	~2100	4.99	–	PSI	[2970]
Re	KCl	Cl^-	≤1×10^{-6}	2000	4.99N	(5.0 ± 0.1)	NSI	[216]
Re	–	–	5×10^{-7}	2300	(5.39 ± 0.05)	4.99 ± 0.05	TE	[94]
Re	Nd	Nd^+	<10^{-7}	~2100	5	–	PSI	[2970]
Re[317]	Li	Li^+	<10^{-7}	?	5	–	PSI	[2944]
Re/W[321]	–	–	?	?	–	5.0	FE	[1850]
Re[322]	–	–	5×10^{-7}	~1900–2500	(5.03 ± 0.07)	5.0 ± 0.1	TE	[99,216]
Re[318]	–	(Re^+)	?	~1900–2350	5.0 ± 0.1*	–	PSI	[966]
Re	–	–	2×10^{-7}	~1700–2200	(5.53 ± 0.02)	5.00 ± 0.01	TE	[101]
Re	Na	Na^+	≤10^{-3} (Na)	2300	5.00 ± 0.03*	–	PSI	[1364]
Re	NaI	Na^+	5×10^{-7}	~1900–2500	5.01	(5.0 ± 0.1)	PSI	[99]
Re	–	–	–	0	–	5.03	TC	[4419]
Re[322]	KCl	Cl^-	≤1×10^{-6}	1800	5.03 ± 0.1N	(5.0 ± 0.1)	NSI	[216]
Re	–	–	<2×10^{-7}	1870	–	5.05	TE	[1970]
Re	Li	Li^+	<10^{-7}	~2000	5.05	–	PSI	[2953,2970]
Re	Tl	Tl^+	5×10^{-9}	1700	5.05*	–	PSI	[1393]
Re	Na	Na^+	5×10^{-7}	1370	5.06	(5.0 ± 0.1)	PSI	[99]
Re	NaCl	Na^+	5×10^{-7}	1370	5.06	(5.0 ± 0.1)	PSI	[99]
Re[322]	$C_2(CN)_4$	CN^-	≤1×10^{-6}	2440	5.06 ± 0.2N	(5.0 ± 0.1)	NSI	[216]
Re	–	–	700 (Ar)	~3000	–	5.1	TE	[2007]
Re	–	–	<8×10^{-11}	~300	–	5.1 ± 0.1	CPD	[405]
Re	Ce	Ce^+	~10^{-9}	~1400–2400	5.10	–	PSI	[536]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Re[170]	Na	Na$^+$	5×10^{-7}	~1300–1500	5.10 ± 0.07	–	PSI	[166]
Re	–	–	$<8 \times 10^{-11}$	~300	–	5.100 ± 0.100	CPD	[342,405,3868]
Re	Eu	Eu$^+$	~10^{-9}	~1400–2400	5.11	–	PSI	[536]
Re	NaBr	Na$^+$	5×10^{-7}	1370	5.11	(5.0 ± 0.1)	PSI	[99]
Re/W	ReCl$_3$	–	?	~1900–2700	–	5.13	TE	[841,1361]
Re	Na	Na$^+$	$\leq 2 \times 10^{-7}$	~1500–2300	5.14	(4.93 ± 0.04)	PSI	[53]
Re	NaCl	Na$^+$	$\leq 2 \times 10^{-7}$	~1700–2300	5.14	(4.93 ± 0.04)	PSI	[53]
Re/Si(111)	Re	–	$<4 \times 10^{-10}$	400 ($\leq$1100)	–	5.14	PE	[3708]
Re	Pr	Pr$^+$	$<10^{-7}$	~2100	5.16	–	PSI	[2970]
Re	Na	Na$^+$	$\leq 3 \times 10^{-7}$	~1300–2600	5.17	–	PSI	[136]
Re	Sr	Sr$^+$	$<1 \times 10^{-7}$	~2100–2700	5.17 ± 0.02	–	PSI	[80]
Re[170]	Na	Na$^+$	?	~1250–1450	5.17 ± 0.09	–	PSI	[684]
Re	–	–	$<8 \times 10^{-11}$	~300	–	5.171 ± 0.050	PE	[3866]
Re	–	–	–	–	–	5.18	TC	[3476]
Re/W	Re	–	$\leq 7 \times 10^{-8}$	~300	–	5.2	FE	[1804]
Re/6H-SiC[323]	Re	–	4×10^{-10}	~300 (500)	–	5.2 ± 0.1	CPD	[3646]
Re	–	–	$<1 \times 10^{-8}$	?	–	5.2 ± 0.1	TE	[3753]
Re	Ag	Ag$^+$	6×10^{-8} (O$_2$)	~2000–2500	5.2 ± 0.1	–	PSI	[3408,3409]
Re	Ag	Ag$^+$	~10^{-7}	~1850–2200	5.20 ± 0.1	–	PSI	[163]
Re{80%(0001)}	–	–	?	~300	–	5.20 ± 0.1	PE	[401]
Re	–	–	?	1900	–	5.21	TE	[1287]
Re	Li	Li$^+$	$<10^{-7}$	~1900	5.21	–	PSI	[2970]
Re	Li	Li$^+$	$<1 \times 10^{-8}$	~1000–2600	5.21 ± 0.01	(4.98 ± 0.03)	PSI	[54,3078]
Re	Ba	Ba$^+$	$<1 \times 10^{-7}$	~2000–2600	5.21 ± 0.02	–	PSI	[80]
Re	–	–	?	1650	–	5.22	TE	[1287]
Re	Na	Na$^+$	$\leq 2 \times 10^{-7}$	~1550–2350	5.25	–	PSI	[53]
Re	NaCl	Na$^+$	$\leq 2 \times 10^{-7}$	~1800–2350	5.25	–	PSI	[53]
Re/Mo	ReCl$_5$	–	?	1800	–	5.25 ± 0.02	TE	[1287]
Re	In	In$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.31 ± 0.03	(4.93 ± 0.04)	PSI	[97]
Re[170]	UF$_4$	U$^+$	$<1 \times 10^{-8}$	~2400–2700	5.33 ± 0.13*	–	PSI	[276]
Re	Li	Li$^+$	$\leq 2 \times 10^{-7}$	~1700–2350	5.34	(4.93 ± 0.04)	PSI	[53]
Re	LiCl	Li$^+$	$\leq 2 \times 10^{-7}$	~1800–2350	5.34	(4.93 ± 0.04)	PSI	[53]
Re	Bi	Bi$^+$	5×10^{-8}	~1700–2500	5.35 ± 0.05	(4.85 ± 0.05)	PSI	[100]
Re[324]	–	–	1×10^{-7}	?	–	5.35 ± 0.05	TE	[166,3730]
Re	In	In$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.38 ± 0.03	(4.93 ± 0.04)	PSI	[97]
Re	Ca	Ca$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.38 ± 0.03	(4.93 ± 0.04)	PSI	[97]
Re	In	In$^+$	5×10^{-7}	~2300–2700	5.39 ± 0.05	(4.99 ± 0.05)	PSI	[94]
Re	Li	Li$^+$	4×10^{-9}	~1300–1600	5.4	–	PSI	[164]
Re[170]	–	(Re$^+$)	~10^{-7}	~2400–2750	5.4 ± 0.6	(4.93 ± 0.04)	PSI	[77]
Re	In	In$^+$	5×10^{-7}	2350	5.40	(4.99 ± 0.05)	PSI	[94]
Re	NaCl	Na$^+$	2×10^{-7}	~1700–2200	5.40 ± 0.05	–	PSI	[57]
Re	Mg	Mg$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.40 ± 0.05	(4.93 ± 0.04)	PSI	[97]
Re	NaI	Na$^+$	2×10^{-7}	~1800–2000	5.41 ± 0.05	(4.95 ± 0.05)	PSI	[23]
Re	NaCl	Na$^+$	2×10^{-7}	~1800–2000	5.42 ± 0.02	(4.95 ± 0.05)	PSI	[23]
Re	NaCl	Na$^+$	~10^{-7}–10^{-5} (air)	2010	5.42 ± 0.02	(4.95 ± 0.05)	PSI	[23]
Re	NaCl	Na$^+$	~10^{-7}–10^{-5} (air)	1830	5.42–5.58	(4.93–5.18)	PSI	[23]
Re	NaCl	Na$^+$	~10^{-7}–10^{-5} (air)	1710	5.42–5.70	(4.97–5.36)	PSI	[23]
Re	NaI	Na$^+$	~10^{-7}–10^{-5} (air)	2080	5.43 ± 0.01	(4.93 ± 0.02)	PSI	[23]
Re	NaI	Na$^+$	~10^{-7}–10^{-5} (O$_2$)	2080	5.43 ± 0.01	(4.95 ± 0.01)	PSI	[23]
Re	Ag	Ag$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.43 ± 0.02	(4.93 ± 0.04)	PSI	[97]
Re	NaCl	Na$^+$	2×10^{-7}	~1700–2000	5.43 ± 0.02	–	PSI	[208]
Re	Ca	Ca$^+$	1×10^{-7}	~1750–2400	5.43 ± 0.02	(4.93 ± 0.04)	PSI	[76,77]
Re	NaCl	Na$^+$	~10^{-7}–10^{-5} (air)	1930	5.43 ± 0.04	(4.96 ± 0.05)	PSI	[23]
Re	NaI	Na$^+$	2×10^{-6} (air)	~1900–2100	5.44 ± 0.02	–	PSI	[23]
Re	Ca	Ca$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.44 ± 0.03	(4.93 ± 0.04)	PSI	[97]
Re	NaI	Na$^+$	2×10^{-5} (air)	~2000–2100	5.45 ± 0.02	–	PSI	[23]
Re	NaI	Na$^+$	~10^{-7}–10^{-5} (air)	1715	5.45–5.76	(4.97–5.37)	PSI	[23]
Re	NaI	Na$^+$	~10^{-7}–10^{-5} (O$_2$)	1715	5.45–5.81	(4.94–5.41)	PSI	[23]
Re	Ca	Ca$^+$	$\leq 1 \times 10^{-7}$	~1900–2400	5.46 ± 0.02	(4.93 ± 0.04)	PSI	[97]
Re	LiBr	Li$^+$	2×10^{-7}	~1800–2000	5.48 ± 0.02	(4.95 ± 0.05)	PSI	[23,2422]
Re	NaBr	Na$^+$	2×10^{-7}	~1700–2150	5.48 ± 0.03	–	PSI	[24,35]
Re	LiI	Li$^+$	2×10^{-7}	~1800–2000	5.49 ± 0.02	(4.95 ± 0.05)	PSI	[23,38]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Re	$C_2(CN)_4$	CN^-	$\leq 1 \times 10^{-6}$	1800	$>5.49 \pm 0.2^N$	(5.0 ± 0.1)	NSI	[216]
Re/HfO$_2$/SiO$_x$/Si	Re	–	$<5 \times 10^{-10}$	~300	–	5.5	PE	[1296]
Re	LiI	Li^+	2×10^{-6} (air)	2000	5.53	–	PSI	[38]
Re	LiCl	Li^+	2×10^{-7}	~1800–2000	5.53 ± 0.02	(4.95 ± 0.05)	PSI	[23]
Re	LiI	Li^+	2×10^{-7}	~1750–2150	5.53 ± 0.02	(5.00 ± 0.01)	PSI	[101]
Re	–	(Re^+)	$<7 \times 10^{-7}$	2590–2780	5.62 ± 0.08	–	PSI	[805,3083]
Re	–	–	–	–	–	6.01	TC	[2629]
Recommended	–	–	–	–	**5.41 ± 0.04**	**4.96 ± 0.05**	–	–

76. Osmium Os

hcp

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Os(0001)	–	–	–	–	–	5.32	TC	[4004]
Os(0001)	–	–	–	–	–	5.59	TC	[1980]
Os(0001)	–	–	–	–	–	5.62	TC	[4005]
Os(0001)	–	–	–	–	–	5.64	TC	[4004]
Os(0001)	–	–	–	–	–	6.05	TC	[321]
Os(0001)	–	–	–	–	–	6.42	TC	[334]
Os(1010)	–	–	–	–	–	4.94	TC	[4005]
Os(1010)	–	–	–	–	–	5.17	TC	[4004]
Os(1010)	–	–	–	–	–	5.34	TC	[1980]
Os(1010)	–	–	–	–	–	5.45	TC	[4004]
Os(1010)	–	–	–	–	–	5.78	TC	[321]
Os(0111)	–	–	–	–	–	5.23	TC	[4004]
Os(0111)	–	–	–	–	–	5.53	TC	[4004]
Os(0112)	–	–	–	–	–	4.85	TC	[4004]
Os(0112)	–	–	–	–	–	5.15	TC	[4004]
Os(0113)	–	–	–	–	–	4.67	TC	[4004]
Os(0113)	–	–	–	–	–	4.98	TC	[4004]
Os(1121)	–	–	–	–	–	4.67	TC	[4004]
Os(1121)	–	–	–	–	–	4.98	TC	[4004]
Os(1122)	–	–	–	–	–	4.90	TC	[4004]
Os(1122)	–	–	–	–	–	5.22	TC	[4004]
Os(1123)	–	–	–	–	–	4.77	TC	[4004]
Os(1123)	–	–	–	–	–	5.09	TC	[4004]
Os(1124)	–	–	–	–	–	5.06	TC	[321]
Os(2130)	–	–	–	–	–	4.87	TC	[4004]
Os(2130)	–	–	–	–	–	5.20	TC	[4004]
Os(3140)	–	–	–	–	–	4.77	TC	[4004]
Os(3140)	–	–	–	–	–	5.09	TC	[4004]
Os	–	–	?	~300	–	4.55	CPD	[2297]
Os	–	–	? (Cs)	~1500–2000	–	4.6–5.0	TE	[3414]
Os	–	–	–	–	–	4.65	TC	[2005]
Os	–	–	–	–	–	4.66	TC	[2949]
Os	–	–	6×10^{-9}	1800	–	4.68 ± 0.04	TE	[978]
Os	–	–	$<10^{-9}$	1900	–	4.69	TE	[650]
Os	–	–	?	?	–	4.7	TE	[3402]
Os	–	–	?	2000	–	4.71 ± 0.01	TE	[1628,1629]
Os	–	–	–	–	–	4.73	TC	[298]
Os	–	–	? (Cs)	~1600–2000	–	4.8	TE	[650]
Os	–	–	–	–	–	4.83	TC	[3264,3265,3267]
Os	–	–	$\leq 3 \times 10^{-9}$	1480–1640	–	4.83 ± 0.01	TE	[171]
Os	–	–	7×10^{-9}	2200	–	4.83 ± 0.04	TE	[978]
Os	–	–	$\sim 10^{-9}$	~1400–1640	–	4.83 ± 0.05	TE	[124,3414]
Os	–	–	–	–	–	4.84	TC	[3476]
Os	–	–	$<10^{-9}$	1500	–	4.84	TE	[650]
Os	–	–	$\leq 3 \times 10^{-9}$	~600–700	–	4.84 ± 0.04	CPD	[171]
Os	–	–	–	–	–	4.9	TC	[3318]
Os	–	–	–	–	–	4.9*	TC	[1955]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Os	–	–	–	–	–	4.91	TC	[1066]
Os	–	–	–	–	–	4.95	TC	[3476]
Os	–	–	–	–	–	4.95 ± 0.05	TC	[1256]
Os	–	–	<10⁻⁹	1200	–	4.96	TE	[650]
Os	–	–	–	–	–	4.99	TC	[3318]
Os	–	–	–	0	–	5.10	TC	[4419]
Os/W(100)–Os(1%)[276]	–	–	<10⁻⁸	2080–2300	–	5.12 ± 0.06	TE	[2811,3086]
Os	–	–	?	?	–	5.16	TE	[2105]
Os/W	Os	–	?	~1500	–	5.17	TE	[2101]
Os	–	–	2 × 10⁻⁷	2600	–	5.21 ± 0.04	TE	[978]
Os	–	–	–	–	–	5.3	TC	[706]
Os	–	–	–	–	–	5.37	TC	[3476]
Os/W[325]	Os	–	?	~300	–	5.93 ± 0.05	PE	[3322]
Os	–	–	–	–	–	6.06	TC	[1744]
Recommended	–	–	–	–	–	**4.97 ± 0.17**	–	–

77. Iridium Ir

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ir(100)	–	–	?	4	–	4.65 ± 0.05	FE	[1391]
Ir(100)	–	–	–	–	–	4.92	TC	[1928]
Ir(100)[326]	–	–	3 × 10⁻¹¹	77	–	5.2	FE	[1810]
Ir(100)	–	–	?	~300	–	5.2	PE	[1532]
Ir(100)	–	–	–	–	–	5.20	TC	[2548]
Ir(100)	–	–	–	–	–	5.20	TC	[1980,3067]
Ir(100)	–	–	~10⁻⁹	1900	–	5.3	TE	[1288]
Ir(100)	–	–	~10⁻⁹	?	–	5.37	TE	[3096]
Ir(100)[326]	–	–	3 × 10⁻¹¹	77	–	5.4	FE	[1810]
Ir(100)[327]	–	–	2 × 10⁻¹⁰	~300 (>1200)	–	5.4	PE	[2961]
Ir(100)[327]	–	–	2 × 10⁻¹⁰	135–300	–	5.5	PE	[1533,1534,2961]
Ir(100)	–	–	–	–	–	5.52	TC	[3224]
Ir(100)	–	–	–	–	–	5.55	TC	[4091]
Ir(100)	–	–	–	–	–	5.55	TC	[4421]
Ir(100)	–	–	~10⁻¹⁰	~300	–	5.6	CPD	[669,2126]
Ir(100)	–	–	?	275	–	5.6	PE	[1534]
Ir(100)	–	–	–	–	–	5.60	TC	[3243]
Ir(100)	–	–	–	–	–	5.60	TC	[4258]
Ir(100)	–	–	–	–	–	5.61	TC	[2203]
Ir(100)	–	–	–	–	–	5.62	TC	[2696,4444]
Ir(100)	–	–	<1 × 10⁻¹⁰	78	–	5.67 ± 0.05	FE	[414,843,1140]
Ir(100)[326]	–	–	<3 × 10⁻¹¹	77	–	5.70 ± 0.05	FE	[1797,1802,1810]
Ir(100)	–	–	?	78	–	5.80 ± 0.02	FE	[2189]
Ir(100)	–	–	–	–	–	5.84	TC	[1718,1721]
Ir(100)	–	–	–	–	–	5.89	TC	[3243]
Ir(100)	–	–	–	–	–	5.92	TC	[1933]
Ir(100)	–	–	?	78	–	6.00 ± 0.02	FE	[2189]
Ir(100)	–	–	<1 × 10⁻¹⁰	100	–	6.00 ± <0.1	PE	[672,914,1289]
Ir(100)	–	–	–	–	–	6.03	TC	[321]
Ir(100)	–	–	?	~300	–	6.1 ± 0.1	CPD	[1067]
Ir(100)	–	–	1 × 10⁻¹⁰	100	–	6.15 ± <0.1	PE	[672,1289]
Recommended	–	–	–	–	–	**5.60 ± 0.06**	–	–
Ir(110)	–	–	~10⁻⁹	1900	–	4.83	TE	[1288]
Ir(110)	–	–	–	–	–	4.83	TC	[2548]
Ir(110)	–	–	–	–	–	4.84	TC	[1980,3067]
Ir(110)	–	–	~10⁻⁹	?	–	4.85	TE	[3096]
Ir(110)	–	–	–	–	–	4.958	TC	[4091]
Ir(110)	–	–	<10⁻¹⁰	80	–	5.0	FE	[414,843]
Ir(110)	–	–	<3 × 10⁻¹¹	77	–	5.0	FE	[1802]
Ir(110)	–	–	–	–	–	5.07	TC	[3243]
Ir(110)	–	–	–	–	–	5.36	TC	[3243]
Ir(110)	–	–	–	–	–	5.37	TC	[3224]
Ir(110)	–	–	~10⁻¹⁰	77, 300	–	5.42 ± 0.02	FE	[358]
Ir(110)	–	–	–	–	–	5.45	TC	[1933]
Ir(110)	–	–	–	–	–	5.67	TC	[321]
Recommended	–	–	–	–	–	**5.23 ± 0.19**	–	–
Ir(111){80%}[329]	–	–	–	–	–	4.68	TC	[1254]
Ir(111){81%}[330]	–	–	? (Cs)	~1500–2000	–	5.2	TE	[3414]
Ir(111){80%}[329]	–	–	~10⁻⁹	~1300–2100	–	5.27 ± 0.05	TE	[124]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ir(111){81%}[328]	–	–	~10^{-9}	~1300–2100	–	5.27 ± 0.05	TE	[650,3414]
Ir(111){81%}[330]	–	–	≤10^{-4}(Li)	~1400–2200	(5.4*)	5.35 ± 0.05	TE	[169]
Ir(111){81%}[328]	–	–	–	–	(5.73 ± 0.01)	5.36 ± 0.07	TC	[803]
Ir(111){81%}[330]	Li	Li$^+$	≤10^{-4}(Li)	~1100	5.4*	(5.35 ± 0.05)	PSI	[169]
Ir(111)	–	–	–	–	–	5.42	TC	[3243]
Ir(111)	–	–	–	–	–	5.497	TC	[4091]
Ir(111)	–	–	–	–	–	5.55	TC	[2548]
Ir(111)	–	–	–	–	–	5.56	TC	[1980,3067]
Ir(111)	–	–	–	–	–	5.58	TC	[2068]
Ir(111)	–	–	–	–	–	5.6	TC	[1723]
Ir(111)	–	–	–	–	–	5.60	TC	[4258]
Ir(111)	–	–	~10^{-10}	80	–	5.65 ± 0.02	FE	[2499]
Ir(111)[334]	Li	Li$^+$	2×10^{-10}	~1100–1300	5.68 ± 0.01	–	PSI	[167]
Ir(111)[334]	Li	Li$^+$	2×10^{-10}	~1150–1400	5.69 ± 0.03	–	PSI	[167]
Ir(111)[334]	Li	Li$^+$	2×10^{-10}	~1100–1400	5.70 ± 0.02	–	PSI	[167,319]
Ir(111)	–	–	–	–	–	5.72	TC	[3243]
Ir(111)[170,334]	Li	Li$^+$	2×10^{-10}	1160–1375	5.72 ± 0.03	–	PSI	[167]
Ir(111){81%}[328]	–	–	–	–	5.73 ± 0.01	(5.36 ± 0.07)	TC	[803]
Ir(111)	–	–	1×10^{-8}	1760–2150	(5.79 ± 0.03)	5.74 ± 0.06	TE	[102,410]
Ir(111)	Bi	Bi$^+$	≤8×10^{-10}	?	5.75 ± 0.05	(5.75 ± 0.05)	PSI	[105,409]
Ir(111)	–	–	≤8×10^{-10}	?	(5.75, 5.8)	5.75 ± 0.05	TE	[105,252]
Ir(111)	Yb	Yb$^+$	≤5×10^{-8}	~1800–2000	5.75 ± 0.10	(5.75 ± 0.10)	PSI	[104]
Ir(111)	–	–	≤5×10^{-8}	~1800–2000	(5.75 ± 0.10)	5.75 ± 0.10	TE	[104]
Ir(111)	–	–	~10^{-10}	77, 300	–	5.76 ± 0.04	FE	[358]
Ir(111)	–	–	3×10^{-9}	~1700–2000	–	5.78 ± 0.05	TE	[273]
Ir(111)	Bi	Bi$^+$	1×10^{-8}	1770–2150	5.79 ± 0.03	(5.74 ± 0.06)	PSI	[102,410]
Ir(111)	Tl	Tl$^+$	1×10^{-8}	1250–2200	5.79 ± 0.03	(5.74 ± 0.06)	PSI	[102,410]
Ir(111)	–	–	<10^{-10}	78	–	5.79 ± 0.05	FE	[414,843,1140]
Ir(111)	Al	Al$^+$	≤10^{-8}	~1700–2500	5.8	–	PSI	[3428]
Ir(111)	In	In$^+$	≤10^{-8}	~1400–1900	5.8	–	PSI	[3428]
Ir(111)	K	K$^+$	<1×10^{-9}	~800–2000	5.8	(5.75 ± 0.05)	PSI	[252,411]
Ir(111)	Ba	Ba$^+$	≤5×10^{-9}	?	5.8	(5.80 ± 0.05)	PSI	[649]
Ir(111)	Ba	Ba$^+$	<5×10^{-10}	?	5.8	–	PSI	[3778]
Ir(111)	Tm	Tm$^+$	?	2000	5.8	–	PSI	[3559]
Ir(111)	In	In$^+$	~10^{-8}	?	5.8 ± 0.05	–	PSI	[186]
Ir(111)	–	–	?	~300	–	5.8	CPD	[3858]
Ir(111)	–	–	~10^{-10}	~300	–	~5.8	FE	[4268]
Ir(111)	–	–	<1×10^{-10}	?	–	5.80	TE	[168,410–413,537]
Ir(111)	–	–	~10^{-9}	?	–	5.80	TE	[3096]
Ir(111)	In	In$^+$	7×10^{-9}	–1700–	5.80 ± 0.03	(5.80 ± 0.03)	PSI	[103]
Ir(111)	–	–	7×10^{-9}	–1700–	(5.80 ± 0.03)	5.80 ± 0.03	TE	[103]
Ir(111)	–	–	<3×10^{-11}	77	–	5.80 ± 0.05	FE	[1797,1802]
Ir(111)	–	–	≤5×10^{-9}	?	(5.8)	5.80 ± 0.05	TE	[649]
Ir(111)	–	–	~10^{-10}	~300	–	5.85 ± 0.04	CPD	[415,3266,3275]
Ir(111)	–	–	–	–	–	5.86	TC	[3224]
Ir(111)	–	–	–	–	–	5.87	TC	[3291]
Ir(111)	–	–	–	–	–	5.92	TC	[1933]
Ir(111)	–	–	–	–	–	6.1	TC	[1723]
Ir(111)	–	–	–	–	–	6.51	TC	[321]
Ir(111)	–	–	–	–	–	6.63	TC	[334]
Ir(111)	–	–	–	–	–	6.65	TC	[3179]
Recommended	–	–	–	–	**5.76 ± 0.04**	**5.75 ± 0.06**	–	–
Ir(210)	–	–	<1×10^{-10}	78	–	5.0 ± 0.05	FE	[414,843]
Ir(210)	–	–	–	–	–	5.10	TC	[3224]
Ir(211)	–	–	–	–	–	5.07	TC	[3224]
Ir(211)	–	–	–	–	–	5.284	TC	[4091]
Ir(311)	–	–	<3×10^{-11}	77	–	5.2	FE	[1802]
Ir(311)	–	–	–	–	–	5.20	TC	[3224]
Ir(321)	–	–	–	–	–	5.072	TC	[4091]
Ir(321)	–	–	<1×10^{-10}	78	–	5.4	FE	[414]
Ir(331)	–	–	–	–	–	5.12	TC	[3224]
Ir(331)	–	–	<1×10^{-10}	78	–	5.4	FE	[414]
Ir(731)	–	–	<10^{-10}	78	–	4.9	FE	[843]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Ir	–	–	–	–	–	2.20	TC	[2493]
Ir	–	–	–	–	–	2.42	TC	[2493]
Ir	–	–	–	–	–	4.02	TC	[521]
Ir	–	–	?	~300	–	4.57	CPD	[2297]
Ir	–	–	3×10^{-9}	~1150–1900	–	4.57	TE	[159]
Ir	–	–	–	–	–	4.57	TC	[1399]
Ir	–	–	~10^{-6}	≤1700	–	~4.6	TC	[3537]
Ir	–	–	?	4	–	4.6 ± 0.6	FE	[1391]
Ir{80%(111)}[329]	–	–	–	–	–	4.68	TC	[1254]
Ir	–	–	–	–	–	4.78	TC	[2005]
Ir	–	–	–	–	–	4.86	TC	[3318]
Ir	–	–	–	–	–	4.91	TC	[3318]
Ir	–	–	–	–	–	4.97	TC	[3264]
Ir	–	–	–	–	–	5.00	TC	[3476]
Ir	–	–	–	–	–	5.02	TC	[2629]
Ir	–	–	1×10^{-9}	~300	–	5.14 ± 0.04	CPD	[845]
Ir	–	–	2×10^{-7}	~1450–1800	(5.72 ± 0.03)	5.15 ± 0.03	TE	[68]
Ir/glass	Ir	–	<1×10^{-10}	78	–	5.17	PE	[414]
Ir	–	–	–	–	–	5.17	TC	[3476]
Ir{81%(111)}[330]	–	–	? (Cs)	~1500–2000	–	5.2	TE	[3414]
Ir	–	–	1×10^{-7}	~1500–2400	–	5.2	TE	[2320]
Ir	–	–	3×10^{-7}	~1400–1700	–	5.2 ± 0.2	TE	[1290]
Ir	–	–	≤3×10^{-9}	~1600–1800	–	5.24 ± 0.03	TE	[171]
Ir/W(porous)	–	–	≤10^{-9}	~1500	–	5.25	TE	[650]
Ir	–	–	–	–	–	5.25	TC	[3224]
Ir	–	–	~10^{-7}	~1300–2100	(5.25–5.34)	5.25 ± 0.05	TE	[107]
Ir	K	K$^+$	~10^{-7}	~1200–2000	>5.25	(5.25 ± 0.05)	PSI	[107]
Ir	–	–	?	2670–2730	–	5.26 ± 0.01	TE	[495,2205]
Ir{81%(111)}[330]	–	–	~10^{-9}	?	–	5.27	TE	[3414]
Ir{80%(111)}[329]	–	–	~10^{-9}	~1300–2100	–	5.27 ± 0.05	TE	[124,650]
Ir/W(100)–Ir(2%)[275]	–	–	?	2030–2200	–	5.28 ± 0.06	TE	[3086]
Ir	–	–	?	?	–	5.29	?	[416]
Ir	Li	Li$^+$	<10^{-9}	~1000–1200	5.3	–	PSI	[318,319,366]
Ir	–	–	–	–	–	5.3	TC	[2583]
Ir	–	–	?	~1700–2200	–	5.3	TE	[668]
Ir	–	–	~10^{-9}	~300	–	5.3	CPD	[417]
Ir/Pd	Ir	–	~10^{-9}	~300	–	5.3	CPD	[417]
Ir	Na	Na$^+$	~10^{-10}	~1300	5.3	–	PSI	[844]
Ir	–	–	2×10^{-10}	?	–	5.3	TE	[669]
Ir	–	–	≤5×10^{-8}	~1900–2400	–	5.30 ± 0.01	TE	[978]
Ir	–	–	?	~2500–2600	–	5.30 ± 0.01	TE	[495,2205]
Ir	–	–	≤5×10^{-7}	?	–	5.30 ± 0.04	TE	[160]
Ir	–	–	–	–	–	5.31	TC	[298]
Ir	–	–	?	?	–	5.31	TE	[2105]
Ir	–	–	–	–	–	5.33	TC	[4441]
Ir/glass	Ir	–	<1×10^{-10}	78 (293)	–	5.33	PE	[414]
Ir	–	–	≤3×10^{-9}	~600–700	–	5.33	CPD	[171]
Ir	Na	Na$^+$	~10^{-7}	~1350–2000	5.34 ± 0.07	(5.25 ± 0.05)	PSI	[107]
Ir/glass	–	–	<5×10^{-10}	77 (373)	–	5.35	PE	[1256]
Ir{81%(111)}[330]	–	–	≤10^{-4} (Li)	~1400–2200	(5.4*)	5.35 ± 0.05	TE	[169]
Ir	–	–	3×10^{-7}	~1400–1600	–	5.36	TE	[1290]
Ir{81%(111)}[328]	–	–	–	–	(5.73 ± 0.01)	5.36 ± 0.07	TC	[803]
Ir/glass	Ir	–	<1×10^{-10}	78 (473)	–	5.38	PE	[414]
Ir{81%(111)}[330]	Li	Li$^+$	≤10^{-4} (Li)	~1100	5.4*	(5.35 ± 0.05)	PSI	[169]
Ir	Na	Na$^+$	~10^{-10}	~1300	5.4*	–	PSI	[844]
Ir	–	–	~10^{-9}	>1200	–	5.4	TE	[1203]
Ir	–	–	?	~1600–2300	–	5.40	TE	[170]
Ir	–	–	~10^{-9}	?	–	5.40	TE	[3096]
Ir	–	–	5×10^{-8}	~1550–2250	(5.80 ± 0.05)	5.40 ± 0.05	TE	[106,667]
Ir[325]	–	–	?	~300	–	5.50 ± 0.05	PE	[3322]
Ir	–	–	–	–	–	5.59	TC	[3476]
Ir/W(100)	Ir	–	~1×10^{-11}	77	–	5.60	FE	[2965]
Ir	NaBr	Na$^+$	2×10^{-7}	~1600–1900	5.72 ± 0.03	(5.15 ± 0.03)	PSI	[68]
Ir{81%(111)}[328]	–	–	–	–	5.73 ± 0.01	(5.36 ± 0.07)	TC	[803]
Ir	NaCl	Na$^+$	2×10^{-7}	~1600–1850	5.73 ± 0.02	(5.15 ± 0.03)	PSI	[68]
Ir	Bi	Bi$^+$	5×10^{-8}	~1700–2250	5.80 ± 0.05	(5.40 ± 0.05)	PSI	[106,667]
Recommended	–	–	–	–	**5.75 ± 0.04**	**5.28 ± 0.04**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				78. Platinum Pt				
fcc								
Pt(100)/MgO	Pt	–	?	~300	–	4.78	PE	[2448]
Pt(100)	–	–	–	–	–	5.20	TC	[1980]
Pt(100)	–	–	–	–	–	5.20 ± 0.02	TC	[3244]
Pt(100)	–	–	–	–	–	5.32	TC	[3244]
Pt(100)	–	–	?	~300	–	5.5 ± 0.2	CPD	[1067]
Pt(100)	–	–	–	–	–	5.625	TC	[4091]
Pt(100)	–	–	–	–	–	5.63	TC	[4416]
Pt(100)	–	–	–	–	–	5.64	TC	[3244]
Pt(100)	–	–	–	–	–	5.66	TC	[4087]
Pt(100)	–	–	–	–	–	5.67	TC	[3224]
Pt(100)	–	–	–	–	–	5.7	TC	[1938]
Pt(100)	–	–	3×10^{-10}	~300	–	5.7 ± 0.1	PE	[846]
Pt(100)	–	–	–	–	–	5.71	TC	[4434]
Pt(100)	–	–	–	–	–	5.711	TC	[3245]
Pt(100)	–	–	4×10^{-11}	100	–	5.75 ± 0.05	PE	[847]
Pt(100)	–	–	–	–	–	5.78	TC	[705]
Pt(100)	–	–	1×10^{-10}	80	–	5.8	FE	[2163]
Pt(100)	–	–	$<1 \times 10^{-10}$	78	–	5.8	FE	[414,848]
Pt(100)	–	–	1×10^{-10}	~300	–	5.8	PE	[3587]
Pt(100)	–	–	$<1 \times 10^{-10}$	78	–	5.81	FE	[849]
Pt(100)	–	–	1×10^{-10}	~300	–	5.82 ± 0.15	PE	[174,3136]
Pt(100)	–	–	$<10^{-10}$	80	–	5.84	FE	[428]
Pt(100)	–	–	2×10^{-11}	~300	–	5.84	PE	[429]
Pt(100)	–	–	–	–	–	5.840	TC	[2229]
Pt(100)	–	–	–	–	–	5.85	TC	[4229]
Pt(100)	–	–	2×10^{-11}	~300	–	5.86	PE	[429,2987,2996]
Pt(100)	–	–	?	~300	–	5.9 ± 0.1	PE	[850]
Pt(100)	–	–	–	–	–	5.92 ± 0.09	TC	[851,852]
Pt(100)[331]	–	–	–	–	–	5.93	TC	[795]
Pt(100)	–	–	–	–	–	5.94	TC	[2530]
Pt(100)	–	–	–	–	–	5.96	TC	[3356]
Pt(100)	–	–	–	–	–	5.99	TC	[321]
Pt(100)	–	–	$\sim 10^{-11}$	~300	–	6.00 ± 0.06	FE	[853]
Pt(100)[331]	–	–	–	–	–	6.07	TC	[795]
Pt(100)	–	–	–	–	–	6.07	TC	[1237]
Pt(100)	–	–	–	–	–	6.08	TC	[2701]
Pt(100)	–	–	–	–	–	6.09	TC	[2701]
Pt(100)	–	–	–	–	–	6.1	TC	[1938]
Pt(100)	–	–	–	–	–	6.1	TC	[2905]
Pt(100)	–	–	–	–	–	6.11	TC	[1928]
Pt(100)	–	–	–	–	–	6.12	TC	[2846]
Pt(100)	–	–	–	–	–	6.2	TC	[854]
Pt(100)	–	–	–	–	–	6.2	TC	[3733]
Pt(100)	–	–	–	–	–	6.21	TC	[3635]
Pt(100)	–	–	–	–	–	6.23	TC	[3382]
Pt(100)	–	–	–	–	–	6.52	TC	[1201]
Pt(100)	–	–	–	–	–	6.57	TC	[3339]
Pt(100)	–	–	–	–	–	6.60	TC	[855]
Pt(100)	–	–	–	–	–	6.7	TC	[389]
Pt(100)	–	–	–	–	–	6.86	TC	[3194]
Pt(100)	–	–	–	–	–	6.93	TC	[3194]
Pt(100)	–	–	–	–	–	6.97	TC	[334]
Recommended	–	–	–	–	–	**5.75 ± 0.06**	–	–
Pt(110)	–	–	–	–	–	4.84	TC	[1980]
Pt(110)	–	–	–	–	–	4.93	TC	[3791]
Pt(110)	–	–	–	–	–	5.223	TC	[4091]
Pt(110)[332]	–	–	$\sim 10^{-11}$	~300	–	5.24 ± 0.05	FE	[853]
Pt(110)	–	–	–	–	–	5.26	TC	[4087,4410]
Pt(110)	–	–	–	–	–	5.297	TC	[3245]
Pt(110)[332]	–	–	$\sim 10^{-11}$	~300	–	5.35 ± 0.05	FE	[853]
Pt(110)	–	–	$<1 \times 10^{-10}$	78	–	5.4	FE	[849,2728]
Pt(110)	–	–	1×10^{-10}	80	–	5.4	FE	[2163]
Pt(110)	–	–	7×10^{-11}	100	–	5.4	PE	[1923]
Pt(110)	–	–	–	–	–	5.441	TC	[2229]
Pt(110)	–	–	?	77	–	5.49	FE	[1294]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt(110)	–	–	?	?	–	5.5	?	[2042]
Pt(110)[333]	–	–	–	–	–	5.52	TC	[2543]
Pt(110)	–	–	–	–	–	5.52	TC	[3224]
Pt(110)	–	–	–	–	–	5.54	TC	[1931]
Pt(110)	–	–	–	–	–	5.63	TC	[321]
Pt(110)	–	–	$\sim10^{-11}$	~300	–	5.67	PE	[1291]
Pt(110)	–	–	–	–	–	5.69	TC	[4416]
Pt(110)	–	–	–	–	–	5.7	TC	[2905]
Pt(110)	–	–	7×10^{-11}	150	–	5.7 ± 0.1	PE	[856]
Pt(110)[333]	–	–	–	–	–	5.71	TC	[2543]
Pt(110)	–	–	2×10^{-11}	~300	–	5.72	PE	[429]
Pt(110)	–	–	–	–	–	5.74	TC	[1237]
Pt(110)	–	–	–	–	–	6.10	TC	[3194]
Pt(110)	–	–	–	–	–	6.15	TC	[3194]
Pt(110)	–	–	–	–	–	6.19	TC	[1201]
Recommended	–	–	–	–	–	**5.54 ± 0.07**	–	–
Pt(111)	–	–	–	–	–	4.54	TC	[1254]
Pt(111)	Ca	Ca$^+$	? (Ca)	?	4.7 ± 0.2	–	PSI	[126]
Pt(111)	Na	Na$^+$	$\leq6 \times 10^{-3}$ (Na)	~1450–1700	4.77 ± 0.07	–	PSI	[126,173]
Pt(111)	K	K$^+$	$\leq2 \times 10^{-2}$ (K)	1600	4.8 ± 0.2	–	PSI	[172]
Pt(111)	Ca	Ca$^+$	? (Ca)	1580	4.82 ± 0.05	–	PSI	[126]
Pt(111)/quartz	Pt	–	?	~300	–	4.93	PE	[2448]
Pt(111)/garnet	Pt	–	?	~300	–	4.93	PE	[2448]
Pt(111)/sapphire	Pt	–	?	~300	–	4.93	PE	[2448]
Pt(111)	–	–	?	?	–	4.95 ± 0.05	TE	[857]
Pt(111)	–	–	1×10^{-10}	77	–	5.40	CPD	[2993]
Pt(111)	–	–	$\sim10^{-10}$	~300	–	5.5 ± 0.1	PE	[418,3138]
Pt(111)[178]	–	–	$\sim10^{-11}$	~300	–	5.53 ± 0.06	FE	[853]
Pt(111){mainly}[344]	–	–	$<1 \times 10^{-9}$	~1300–1800	–	5.55 ± 0.1	TE	[434]
Pt(111)	–	–	–	–	–	5.56	TC	[1980]
Pt(111)	–	–	$\sim10^{-10}$	~300	–	5.6 ± 0.1	PE	[858]
Pt(111)	–	–	–	–	–	5.67 ± 0.06	TC	[3244]
Pt(111)	–	–	–	–	–	5.67 ± 0.07	TC	[3244]
Pt(111)	–	–	–	–	–	5.69	TC	[1028,1179]
Pt(111)	–	–	–	–	–	5.69	TC	[4087,4410]
Pt(111)	–	–	1×10^{-10}	80–340	–	5.7	PE	[616,1805]
Pt(111)	–	–	2×10^{-10}	~300	–	5.7	PE	[3455]
Pt(111)	–	–	$<10^{-10}$	~300	–	5.7	PE	[3715]
Pt(111)	–	–	$\sim10^{-10}$	100	–	5.7 ± 0.2	PE	[671]
Pt(111)	–	–	–	–	–	5.70	TC	[419]
Pt(111)	–	–	–	–	–	5.702	TC	[4091]
Pt(111)	–	–	–	–	–	5.72	TC	[420]
Pt(111)	–	–	–	–	–	5.73	TC	[1179]
Pt(111)	–	–	–	–	–	5.74	TC	[4258]
Pt(111)	–	–	–	–	–	5.747	TC	[3245]
Pt(111)[170,334]	Li	Li$^+$	2×10^{-10}	1320–1475	5.75 ± 0.02	–	PSI	[167]
Pt(111)	–	–	–	–	–	5.76	TC	[3244]
Pt(111)	–	–	–	–	–	5.76	TC	[343]
Pt(111)[334]	Li	Li$^+$	2×10^{-10}	1300–1340	5.76 ± 0.02	–	PSI	[167]
Pt(111)[334]	Li	Li$^+$	2×10^{-10}	1240–1475	5.77 ± 0.02	–	PSI	[167,319]
Pt(111)	–	–	?	?	–	5.79	TE	[1852]
Pt(111)	–	–	1×10^{-10}	~300	–	5.8	PE	[3989]
Pt(111){rich}	–	–	$\sim10^{-10}$	~300	–	5.8	CPD	[437]
Pt(111)/Ni(111)	Pt	–	$\sim10^{-10}$	<85 (≤500)	–	5.8	PE	[773]
Pt(111)	–	–	?	~300	–	5.8	CPD	[3518]
Pt(111)	–	–	2×10^{-10}	50	–	5.8	PE	[1437,2273,2275]
Pt(111)	–	–	–	–	–	5.8	TC	[1723]
Pt(111)[334]	Li	Li$^+$	2×10^{-10}	1240–1440	5.80 ± 0.02	–	PSI	[167]
Pt(111)	–	–	–	–	–	5.817	TC	[2229]
Pt(111)	–	–	–	–	–	5.84	TC	[1197]
Pt(111)[335]	–	–	$<10^{-10}$	85–400	–	5.84 ± 0.05	PE	[421–423,773]
Pt(111)/Pt(111)[335]	Pt	–	$<10^{-10}$	400	–	5.84 ± 0.05	PE	[421]
Pt(111)/Nb(110)	Pt	–	7×10^{-11}	~300	–	5.85	PE	[2874]
Pt(111)	–	–	2×10^{-10}	~300	–	5.85	PE	[424]
Pt(111)	–	–	4×10^{-11}	135–370	–	5.85 ± 0.05	PE	[425]
Pt(111)	–	–	?	95	–	5.85 ± 0.1	PE	[426,859]
Pt(111)	–	–	–	–	–	5.89	TC	[2068]
Pt(111)	–	–	8×10^{-11}	~300	–	5.9	PE	[427,1565]
Pt(111)	–	–	–	–	–	5.9	TC	[1723]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt(111)	–	–	$<1 \times 10^{-10}$	78	–	5.9	FE	[848]
Pt(111)/Ni(111)	Pt	–	$\sim 10^{-10}$	≤85 (573)	–	5.9	PE	[773]
Pt(111)/Re(0001)	Pt	–	$\sim 10^{-10}$	~300	–	5.9	PE	[400]
Pt(111)	Li	Li$^+$	2×10^{-10}	400	5.91 ± 0.07	–	PSI	[167]
Pt(111)	–	–	$<10^{-10}$	80	–	5.93	FE	[428]
Pt(111)	–	–	2×10^{-11}	~300	–	5.94	PE	[429]
Pt(111)	–	–	?	77	–	5.95	FE	[1294]
Pt(111)	–	–	8×10^{-11}	50	–	5.95	PE	[898,3197]
Pt(111)	–	–	?	<85	–	5.95 ± 0.1	PE	[1033]
Pt(111)	–	–	–	–	–	5.97	TC	[430]
Pt(111)	–	–	$\sim 10^{-10}$	~300	–	5.97	PE	[2529]
Pt(111)	–	–	$<1 \times 10^{-10}$	78	–	5.99	FE	[849]
Pt(111)	–	–	1×10^{-10}	80	–	6.0	FE	[2163]
Pt(111)	–	–	–	–	–	6.01	TC	[795]
Pt(111)	–	–	–	–	–	6.01	TC	[3224]
Pt(111)	–	–	–	–	–	6.02	TC	[4024]
Pt(111)	–	–	–	–	–	6.04	TC	[3291]
Pt(111)	–	–	–	–	–	6.04	TC	[1179]
Pt(111)	–	–	–	–	–	6.06	TC	[1028,1179,1834]
Pt(111)	–	–	–	–	–	6.07	TC	[419]
Pt(111)	–	–	1×10^{-10}	~300	–	6.08 ± 0.15	PE	[174]
Pt(111)	–	–	–	–	–	6.1	TC	[1292]
Pt(111)	–	–	–	–	–	6.1	TC	[2905]
Pt(111)	–	–	–	–	–	6.10	TC	[431,1931]
Pt(111)	–	–	2×10^{-10}	~300	–	6.10 ± 0.06	PE	[175]
Pt(111)	–	–	–	–	–	6.11	TC	[1293]
Pt(111)	–	–	–	–	–	6.12	TC	[432]
Pt(111)	–	–	–	–	–	6.12	TC	[1237]
Pt(111)	–	–	–	–	–	6.13	TC	[4174,4284]
Pt(111)	–	–	–	–	–	6.14	TC	[1197]
Pt(111)	–	–	–	–	–	6.16	TC	[1593]
Pt(111)	–	–	$\leq 1 \times 10^{-10}$	~300	–	6.2	PE	[3177,3191]
Pt(111)	–	–	–	–	–	6.3	TC	[1723]
Pt(111)	–	–	1×10^{-10}	100	–	6.40 ± <0.1	PE	[672]
Pt(111)	–	–	–	–	–	6.47	TC	[321]
Pt(111)	–	–	–	–	–	6.53	TC	[1201]
Pt(111)	–	–	?	37, 95	–	6.6*	PE	[3630]
Pt(111)	–	–	–	–	–	6.60	TC	[3194]
Pt(111)	–	–	–	–	–	6.67	TC	[3194]
Pt(111)	–	–	–	–	–	6.73	TC	[3179]
Pt(111)	–	–	–	–	–	6.74	TC	[334]
Recommended	–	–	–	–	**5.80 ± 0.06**	**5.84 ± 0.05**	–	–
Pt(210){~80%}[336]	–	–	? (Cs)	~1500–1900	–	5.0	TE	[650]
Pt(210){~80%}[336]	–	–	? (Cs)	~1500–1900	–	5.1	TE	[3413,3414]
Pt(210)	–	–	$<1 \times 10^{-10}$	78	–	5.17	FE	[849]
Pt(210)	–	–	10^{-11}	~300	–	5.18	FE	[2511]
Pt(210)	–	–	?	77	–	5.18	FE	[1294]
Pt(210)	–	–	$<1 \times 10^{-10}$	78	–	5.2	FE	[414,848]
Pt(210)	–	–	–	–	–	5.25	TC	[3224]
Pt(210){~80%}[336]	–	–	$<1 \times 10^{-9}$	~1600–1950	–	5.79 ± 0.09	TE	[179,650]
Recommended	–	–	–	–	–	**5.18 ± 0.04**	–	–
Pt(211)	–	–	–	–	–	5.22	TC	[3224]
Pt(211)	–	–	–	–	–	5.555	TC	[4091]
Pt(211)	–	–	–	–	–	5.84	TC	[1293]
Pt(211)	–	–	–	–	–	5.88	TC	[1293]
Pt(221)[337]	–	–	–	–	–	5.74	TC	[1293]
Pt(221)[337]	–	–	–	–	–	5.76	TC	[1293]
Pt(221?)[337]	–	–	2×10^{-11}	~300	–	5.77	PE	[429]
Pt(310)	–	–	$\sim 10^{-11}$	~300	–	5.36 ± 0.05	FE	[853,2511]
Pt(310)	–	–	–	–	–	5.419	TC	[4091]
Pt(311)	–	–	–	–	–	5.35	TC	[3224]
Pt(311)	–	–	$<1 \times 10^{-10}$	78	–	5.5	FE	[414,848,2728]
Pt(320)	–	–	–	–	–	5.16	TC	[3224]
Pt(320)	–	–	$\sim 10^{-11}$	~300	–	5.19 ± 0.05	FE	[853,2511]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt(320)	–	–	$<10^{-10}$	80	–	5.22	FE	[428]
Pt(321)	–	–	$\sim10^{-11}$	~300	–	5.24 ± 0.05	FE	[853,2511]
Pt(321)	–	–	$<1 \times 10^{-10}$	78	–	5.4	FE	[414,848,2728]
Pt(331)	–	–	$<10^{-10}$	80	–	5.12	FE	[428]
Pt(331)	–	–	–	–	–	5.27	TC	[3224]
Pt(331)	–	–	–	–	–	5.62	TC	[1293]
Pt(331)	–	–	–	–	–	5.69	TC	[1293]
Pt(410)	–	–	$\sim10^{-11}$	~300	–	5.50 ± 0.05	FE	[853,2511]
Pt(430)	–	–	$\sim10^{-11}$	~300	–	5.21 ± 0.05	FE	[853,2511]
Pt(520)	–	–	$\sim10^{-11}$	~300	–	5.30 ± 0.05	FE	[853,2511]
Pt(533)	–	–	–	–	–	5.90	TC	[1293]
Pt(533)	–	–	–	–	–	5.93	TC	[1293]
Pt(533)–(755)	–	–	$<1 \times 10^{-10}$	78	–	5.7	FE	[849]
Pt(741)	–	–	$\sim10^{-11}$	~300	–	5.19 ± 0.05	FE	[853,2511]
Pt(997)	–	–	1×10^{-10}	~300	–	5.78 ± 0.15	PE	[174]
Pt	–	–	?	~300	–	3.94	PE	[2460]
Pt	–	–	?	?	–	4.18	TE	[3019]
Pt	–	–	3×10^{-8}	~300	–	4.3	FE	[2082]
Pt	–	–	?	~300	–	4.34	PE	[3018]
Pt	–	–	$<10^{-6}$	~300	–	4.4	PE	[2919]
Pt[338]	Cs	Cs^+	2×10^{-7}	$\sim1400–2000$	$4.40 \pm 0.03*$	–	PSI	[50]
Pt	–	–	?	?	–	4.43	TE	[2567]
Pt	–	–	6×10^{-3}	~300	–	4.43 ± 0.06	PE	[2079,2080]
Pt	–	–	1×10^{-5}	$\sim1700–1900$	–	4.46	TE	[2458]
Pt[338]	K	K^+	2×10^{-7}	$\sim1300–2000$	$4.48 \pm 0.01*$	–	PSI	[50]
Pt[338]	Rb	Rb^+	2×10^{-7}	$\sim1200–2000$	$4.49 \pm 0.01*$	–	PSI	[50]
Pt	K	K^+	2×10^{-7}	$\sim1300–2000$	4.49 ± 0.01	–	PSI	[1285]
Pt	–	–	?	~300	–	4.52	CPD	[2297]
Pt/glass	–	–	$\sim10^{-6}$	$\sim300–720$	–	4.54	PE	[3585]
Pt/GaP	–	–	–	–	–	4.55	TC	[1653]
Pt	–	–	?	?	–	4.57	TE	[3019]
Pt/Si	–	–	–	–	–	4.57	TC	[1653]
Pt	–	–	?	$\sim1600–1700$	–	4.6	TE	[2312]
Pt/Si	–	–	–	–	–	4.60	TC	[1653]
Pt	–	–	–	–	–	4.65	TC	[3318]
Pt	–	–	$\sim10^{-7}$	~300	–	4.65 ± 0.05	CPD	[1890]
Pt/GaP	–	–	–	–	–	4.66	TC	[1653]
Pt	–	–	7×10^{-9}	?	(5.45–5.78)	4.66 ± 0.2	TE	[74]
Pt	–	–	–	–	–	4.67	TC	[2005]
Pt	–	–	?	$\sim1350–1600$	–	4.7	TE	[1753]
Pt	–	–	–	–	–	4.71	TC	[1796]
Pt[339]	–	–	?	?	–	4.72	TE	[2299,2300]
Pt	–	–	?	~300	–	4.76	PE	[1371]
Pt	–	–	?	~300	–	4.79	CPD	[2761]
Pt	–	–	$\leq1 \times 10^{-6}$	293	–	4.80	PE	[2289]
Pt	–	–	–	–	–	4.86	TC	[3476]
Pt	–	–	?	~300	–	$4.87 \pm 0.06*$	CPD	[1953]
Pt	–	–	–	–	–	4.89	TC	[1066]
Pt	–	–	–	–	–	4.9	TC	[3318]
Pt	K	K^+	$<10^{-9}$	$\sim1100–1200$	$4.9 \pm 0.1*$	–	PSI	[2579]
Pt	–	–	–	–	–	4.90	TC	[4420]
Pt	–	–	$\sim10^{-8}$	~300	–	4.93 ± 0.03	PE	[1751]
Pt[340]	K	K^+	$\leq3 \times 10^{-9}$	$\sim1200–1700$	4.94 ± 0.23	(5.27 ± 0.1)	PSI	[3055]
Pt	–	–	?	?	–	4.99	TE	[3019]
Pt/W	Pt	–	$\leq10^{-6}$	$\sim1600–1800$	–	5.0	TE	[2301]
Pt	–	–	?	~300	–	5.0	CPD	[1597,1600]
Pt	–	–	6×10^{-9}	$\sim1350–1950$	–	5.00 ± 0.05	TE	[2125]
Pt	–	–	–	–	–	5.03	TC	[3264,3267]
Pt	–	–	–	–	–	5.03	TC	[3476]
Pt	Li	Li^+	5×10^{-9}	1150	$5.03*$	–	PSI	[1393]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt/ZrO$_2$	–	–	?	~300	–	5.05	CPD	[3681]
Pt{~80%(210)}[336]	–	–	? (Cs)	~1800–2000	–	5.1	TE	[3413,3414]
Pt/Ru(0001)	–	–	–	–	–	5.10	TC	[2554]
Pt	K	K$^+$	7×10^{-9}	~800–1800	≥5.1	(4.66 ± 0.2)	PSI	[74]
Pt	–	–	~10^{-9}	~300	–	5.12	PE	[3212]
Pt/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	5.12 ± 0.06	PE	[3246]
Pt	–	–	3×10^{-11}	~300	–	5.13	FE	[2227]
Pt	Na	Na$^+$	≤5×10^{-9}	~1250–1700	5.13 ± 0.01	–	PSI	[2594]
Pt	–	–	5×10^{-8}	1560–1920	(5.77 ± 0.05)	5.13 ± 0.05	TE	[106,667]
Pt/W[346]	Pt	–	~10^{-9}	77	–	5.2	CPD	[1137]
Pt	–	–	–	–	–	5.2	TC	[2583]
Pt/Nb	Pt	–	≤3×10^{-9}	~300	–	5.2*	CPD	[3263]
Pt	–	–	?	~300	–	5.2	PE	[3505]
Pt/W	Pt	–	?	~300	–	5.2	CPD	[2577]
Pt/W	Pt	–	?	1000	–	5.2	FE	[4115]
Pt	–	–	–	–	–	5.2	TC	[1645]
Pt	–	–	?	O^E	–	5.22	TE	[3020]
Pt/HfO$_2$	Pt	–	?	~300	–	5.23	CPD	[3651]
Pt	–	–	?	~300	–	5.25 ± 0.01	CPD	[1953]
Pt	–	–	?	~300	–	5.25 ± 0.07*	CPD	[3994]
Pt	–	–	?	>1900	–	5.27	TE	[674,1847]
Pt/W(110)	Pt	–	5×10^{-11}	~300 (880)	–	5.27*	CPD	[2420]
Pt	–	–	1×10^{-10}	~300	(4.94 ± 0.23)	5.27 ± 0.1	PE	[3055]
Pt	–	–	<3×10^{-8}	~1700–2000	–	5.28	TE	[177]
Pt	–	–	~10^{-7}	1560–1800	–	5.29*	TE	[176]
Pt/W(110)	Pt	–	5×10^{-11}	~300 (1200)	–	5.29*	CPD	[2420]
Pt	–	–	?	?	–	5.3	TE	[3402]
Pt	–	–	–	–	–	5.3	TC	[3030]
Pt	–	–	4×10^{-10}	~300	–	5.3	PE	[3124]
Pt/Ir	Pt	–	?	~300	–	5.3 ± 0.1	CPD	[1600]
Pt	–	–	4×10^{-10}	~300	–	5.3 ± 0.1	PE	[3132]
Pt	–	–	<5×10^{-11}	~300	–	5.3 ± 0.15	PE	[2724]
Pt	–	–	–	–	–	5.30	TC	[1885]
Pt/quartz	Pt	–	≤5×10^{-10}	78	–	5.30 ± 0.01	PE	[435]
Pt/Si(111)	Pt	–	<1×10^{-10}	~300 (≤320)	–	5.30 ± 0.05	CPD	[3270]
Pt	–	–	<3×10^{-8}	~1700–1900	–	5.31	TE	[177]
Pt	–	–	?	~1500–1850	–	5.31 ± 0.01	TE	[1306]
Pt	–	–	<3×10^{-8}	~1700–2000	–	5.32	TE	[177]
Pt	–	–	–	–	–	5.32	TC	[1399]
Pt	Li	Li$^+$	2×10^{-7}	~1800–1950	5.32 ± 0.05*	–	PSI	[50]
Pt	–	–	–	–	–	5.34	TC	[3931]
Pt	Tl	Tl$^+$	5×10^{-9}	~1250–1370	5.34	–	PSI	[1393]
Pt	–	–	3×10^{-9}	~1000–1600	–	5.36	TE	[159]
Pt	–	–	?	~300	–	5.36	CPD	[3256]
Pt[341]	Cs	Cs$^+$	≤6×10^{-9}	~1600–1900	5.36 ± 0.06	(5.41 ± 0.05)	PSI	[282]
Pt	–	–	?	~300	–	5.36 ± 0.06	CPD	[2762]
Pt/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	5.39 ± 0.08	CPD	[3246]
Pt	–	–	–	–	–	5.4	TC	[3161]
Pt/W	Pt	–	≤10^{-6}	~1600–1800	–	5.4	TE	[2301]
Pt	–	–	1×10^{-6}	~1600–1900	–	5.4	TE	[675]
Pt/Mo(112)	Pt	–	<1×10^{-10}	~300 (~1300)	–	5.4	CPD	[3210]
Pt/Pt(110)	Pt	–	7×10^{-11}	90, 150	–	5.4 ± 0.1	PE	[856]
Pt	–	–	?	~300	–	5.4 ± 0.1	CPD	[1600]
Pt	–	–	–	–	–	5.40	TC	[3264,3265,3267]
Pt	–	–	–	–	–	5.40	TC	[3224]
Pt	–	–	~10^{-7}	~1550–1800	–	5.40 ± 0.03	TE	[176]
Pt	–	–	?	>1900	–	5.40 ± 0.08	TE	[674,1847]
Pt/SiO$_2$/Si	Pt	–	?	~300	–	5.41	CPD	[4330]
Pt[341]	–	–	≤6×10^{-9}	~1600–1900	(5.36,5.52)	5.41 ± 0.05	TE	[282]
Pt	–	–	~10^{-6}	~1450–1550	–	5.42	TE	[3384]
Pt	–	–	<3×10^{-8}	~1700–2000	–	5.43	TE	[177]
Pt[341]	K	K$^+$	≤6×10^{-9}	~1600–1900	5.43	(5.41 ± 0.05)	PSI	[282]
Pt[341]	Cs	Cs$^+$	≤6×10^{-9}	~1600–1900	5.43	(5.41 ± 0.05)	PSI	[282]
Pt	Na	Na$^+$	4×10^{-10}	~1500–1660	5.44*	–	PSI	[3336]
Pt	–	–	–	–	–	5.45	TC	[3476]
Pt	–	–	~10^{-5}	≤1200	–	5.45	TE	[2216]
Pt/W	Pt	–	≤10^{-6}	~1600–1800	–	5.45	TE	[2305]
Pt/glass[342]	Pt	–	~10^{-10}	78	–	5.45	PE	[428,1497,2719]
Pt[457]	Li	Li$^+$	7×10^{-9}	~1300–1800	5.45 ± 0.02	(4.66 ± 0.2)	PSI	[74]
Pt	–	–	≤3×10^{-9}	1570–1720	–	5.45 ± 0.02	TE	[171]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt[343]	–	–	$\leq 6 \times 10^{-9}$	~1000–1700	(5.5)	5.45 ± 0.05	TE	[98]
Pt	–	–	?	~90	–	5.45 ± 0.2	PE	[3403]
Pt/glass[363]	Pt	–	~10^{-10}	~78	–	5.46	PE	[436]
Pt/cnt/Si(111)[25]	–	–	~10^{-10}	~300	–	5.46 ± 0.07	CPD	[3246]
Pt/glass	Pt	–	<10^{-9}	77	–	5.48	PE	[2931]
Pt	Na	Na$^+$	2×10^{-7}	~1700–2050	5.49 ± 0.01*	–	PSI	[50]
Pt[457]	Na	Na$^+$	7×10^{-9}	~1050–1800	5.49 ± 0.05	(4.66 ± 0.2)	PSI	[74]
Pt[343]	Cs	Cs$^+$	$\leq 6 \times 10^{-9}$	~1400–1800	5.5	(5.45 ± 0.05)	PSI	[98]
Pt//Si^n[482]	Pt	–	?	~300	–	5.5	CPD	[4375]
Pt	–	–	~10^{-10}	~300	–	5.5 ± 0.1	PE	[858]
Pt/glass[369]	Pt	–	~10^{-10}	77	–	5.50	PE	[2133]
Pt	–	–	?	?	–	5.50	TE	[2105]
Pt[458]	Na	Na$^+$	7×10^{-9}	~1050–1800	5.51 ± 0.1	(4.66 ± 0.2)	PSI	[74]
Pt[170,341]	K	K$^+$	$\leq 6 \times 10^{-9}$	~1600–1900	5.52 ± 0.05	(5.41 ± 0.05)	PSI	[282]
Pt	–	–	?	~300	–	5.53 ± 0.1	PE	[3711]
Pt[458]	Li	Li$^+$	7×10^{-9}	~1300–1800	5.54 ± 0.07	(4.66 ± 0.2)	PSI	[74]
Pt[170,345]	NaNO$_3$	Na$^+$	5×10^{-7}	~1250–1350	5.54 ± 0.07	–	PSI	[178]
Pt	–	–	–	–	–	5.55	TC	[298]
Pt	–	–	4×10^{-9}	~1500–1800	–	5.55	TE	[1295]
Pt	–	–	~10^{-10}	~300	–	5.55 ± 0.02	PE	[2487]
Pt{mainly(111)}[344]	–	–	<1×10^{-9}	~1300–1800	–	5.55 ± 0.1	TE	[434]
Pt[345]	NaNO$_3$	Na$^+$	5×10^{-7}	~1250–1350	5.56	–	PSI	[178]
Pt/quartz	Pt	–	$\leq 5 \times 10^{-10}$	293	–	5.58 ± 0.04	PE	[435]
Pt/SiO$_2$	Pt	–	?	?	–	5.59	CPD	[3519,3520]
Pt	–	–	<3×10^{-8}	~1700–2000	–	5.6	TE	[177]
Pt	–	–	?	~300	–	5.6	PE	[3235]
Pt	Na	Na$^+$	2×10^{-10}	1000	5.6 ± 0.1	–	PSI	[75]
Pt	–	–	?	~300	–	5.6 ± 0.2	CPD	[3867]
Pt	–	–	?	~1500–1800	–	5.60	TE	[1753]
Pt/glass	Pt	–	<3×10^{-10}	78 (~300)	–	5.62	PE	[2722]
Pt/glass[342]	Pt	–	~10^{-10}	78 (293)	–	5.63	PE	[428,1497,2719]
Pt/glass	Pt	–	<10^{-9}	77 (293)	–	5.63	PE	[2931]
Pt/Pt(111)[335]	Pt	–	<10^{-10}	130	–	5.64	PE	[421,773]
Pt/quartz	Pt	–	$\leq 5 \times 10^{-10}$	293 (~550)	–	5.64	PE	[435]
Pt	–	–	6×10^{-9}	~300	–	5.65	PE	[1139]
Pt	–	–	?	?	–	5.65	TE	[1]
Pt/quartz	Pt	–	~10^{-10}	~300	–	5.65 ± 0.1	PE	[304]
Pt	NaBr	Na$^+$	2×10^{-7}	1450	5.66	–	PSI	[58]
Pt	–	–	$\leq 10^{-9}$	1500	–	5.66	TE	[650]
Pt	–	–	~10^{-7}	~1550–1800	–	5.66 ± 0.07	TE	[176]
Pt/glass	Pt	–	~10^{-10}	~300	–	5.68 ± 0.03	PE	[1141]
Pt/glass	Pt	–	<1×10^{-10}	78 (373)	–	5.69	PE	[414]
Pt	–	–	<5×10^{-10}	~300	–	5.7	PE	[1296]
Pt/Pt(111)[335]	Pt	–	<10^{-10}	250	–	5.7	PE	[421]
Pt/TiO$_2$(001)	Pt	–	~10^{-10}	~300	–	5.7	CPD	[1567]
Pt	–	–	2×10^{-10}	293	–	5.7 ± 0.05	PE	[1542]
Pt/glass	Pt	–	<1×10^{-10}	78 (473)	–	5.70	PE	[414]
Pt	–	–	$\leq 5 \times 10^{-10}$	~300	–	5.70 ± 0.07	PE	[3354]
Pt	–	–	<8×10^{-11}	~300	–	5.700 ± 0.100	CPD	[342,3868]
Pt/glass[369]	Pt	–	~10^{-10}	77 (323)	–	5.71	PE	[2133]
Pt[458]	Tl	Tl$^+$	7×10^{-9}	~1300–1800	5.71 ± 0.03	(4.66 ± 0.2)	PSI	[74]
Pt/glass[363]	Pt	–	<1×10^{-10}	78 ($\geq$500)	–	5.72	PE	[414,436]
Pt/glass[342]	Pt	–	<10^{-10}	78 (593)	–	5.72	PE	[428,1497]
Pt/glass	Pt	–	~10^{-10}	~300 (473)	–	5.72 ± 0.01	PE	[1141]
Pt	–	–	–	–	–	5.73	TC	[3016]
Pt	–	–	5×10^{-10}	~300	–	5.73	AI[38]	[4027]
Pt	–	–	<3×10^{-8}	~1700–2000	–	5.75	TE	[177]
Pt[337]	–	–	2×10^{-11}	~300	–	5.77	PE	[429]
Pt	Bi	Bi$^+$	5×10^{-8}	1560–1920	5.77 ± 0.05	(5.13 ± 0.05)	PSI	[106,667]
Pt[457]	Tl	Tl$^+$	7×10^{-9}	~1300–1800	5.78 ± 0.02	(4.66 ± 0.2)	PSI	[74]
Pt{80%(210)}[336]	–	–	1×10^{-9}	1620–1950	–	5.79 ± 0.09	TE	[179,650,3413]
Pt{(111)rich}	–	–	~10^{-10}	~300	–	5.8	CPD	[437]
Pt	–	–	~10^{-10}	~300	–	5.8 ± 0.1	PE	[858]
Pt	–	–	$\leq 10^{-9}$	1900	–	5.83	TE	[650]
Pt/Nb(110)	Pt	–	7×10^{-11}	~300	–	5.85	PE	[2874]
Pt/W(110)	Pt	–	4×10^{-11}	400	–	5.85	CPD	[2408]
Pt/W	Pt	–	$\leq 10^{-6}$	~1600–1800	–	6	TE	[2301]
Pt	–	–	–	–	–	6.0	TC	[706]
Pt	–	–	?	~1600–2000	–	6.0	TE	[3020]
Pt	–	–	~10^{-5} (O_2)	~300	–	6.0	PE	[2487]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pt/W(110)[346]	Pt	–	($\leq 10^{-10}$)	~300	–	6.05	CPD	[1137]
Pt/W(110)[346]	Pt	–	($\leq 10^{-10}$)	~300{800}	–	6.05	CPD	[1137]
Pt	–	–	?	~1500–1800	–	6.05	TE	[1753]
Pt	–	–	<10^{-7}	~1100–1200	–	6.1	TE	[3384]
Pt/Re	Pt	–	?	~300	–	6.1 ± 0.1	PE	[401]
Pt	–	–	?	1540–1780	–	6.16	TE	[1753]
Pt	–	–	1×10^{-9}	~600–700	–	6.17	CPD	[171]
Pt	–	–	?	~300	–	6.17	PE	[2924]
Pt	–	–	~10^{-8}	1370–1750	–	6.27 ± 0.07	TE	[860]
Pt	–	–	~10^{-8}	~300	–	6.30 ± 0.05	PE	[1751,1753]
Pt	–	–	?	?	–	6.33	TE	[1754]
Pt	–	–	–	–	–	6.35	TC	[1744]
Pt	–	–	?	1540–1780	–	6.35	TE	[1753]
Recommended	–	–	–	–	**5.58 ± 0.11**	**5.30 ± 0.07**	–	–

79. Gold Au

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au(100)	–	–	–	–	–	3.318	TC	[2914]
Au(100)	–	–	–	–	–	3.65	TC	[475]
Au(100)	–	–	–	–	–	3.816	TC	[2914]
Au(100)/NaCl[137]	Au	–	?	~300 (473)	–	4.02 ± 0.02	PE	[3324,3328,3330]
Au(100)	–	–	–	–	–	4.99	TC	[1159,1980,3067]
Au(100)	–	–	–	–	–	5.02	TC	[705]
Au(100)	–	–	–	–	–	5.022	TC	[4414]
Au(100)	–	–	–	–	–	5.04	TC	[4233]
Au(100)	–	–	–	–	–	5.05	TC	[4233]
Au(100)	–	–	–	–	–	5.071	TC	[4091]
Au(100)	–	–	–	–	–	5.08	TC	[1939]
Au(100)	–	–	–	–	–	5.10	TC	[4087,4410]
Au(100)	–	–	–	–	–	5.10	TC	[4326]
Au(100)	–	–	–	–	–	5.11	TC	[1939]
Au(100)	–	–	–	–	–	5.14	TC	[2702]
Au(100)	–	–	1×10^{-10}	~300	–	5.22 ± 0.04	PE	[1068]
Au(100)	–	–	?	~300	–	5.35 ± 0.05	PE	[2995]
Au(100)	–	–	–	–	–	5.39	TC	[1873]
Au(100)	–	–	–	–	–	5.41	TC	[1011]
Au(100)/Cr(100)	–	–	–	–	–	5.42	TC	[1011]
Au(100)	–	–	–	–	–	5.43	TC	[1011]
Au(100)	–	–	–	–	–	5.44	TC	[1719]
Au(100)/Cr(100)	–	–	–	–	–	5.44	TC	[1011]
Au(100)	–	–	–	–	–	5.45	TC	[1939]
Au(100)	–	–	?	~300	–	5.47	CPD	[959]
Au(100)	–	–	–	–	–	5.48	TC	[3217]
Au(100)	–	–	–	–	–	5.53	TC	[480,4398]
Au(100)	–	–	–	–	–	5.53 ± 0.10	TC	[3217]
Au(100)	–	–	–	–	–	5.56	TC	[3317]
Au(100)	–	–	–	–	–	5.61	TC	[1928]
Au(100)	–	–	–	–	–	5.66	TC	[1011]
Au(100)	–	–	–	–	–	5.67	TC	[2803]
Au(100)	–	–	–	–	–	5.92	TC	[1011]
Au(100)	–	–	–	–	–	5.96	TC	[1011]
Au(100)	–	–	–	–	–	6.13	TC	[1011]
Au(100)	–	–	–	–	–	6.16	TC	[334]
Au(100)	–	–	–	–	–	6.16	TC	[321]
Au(100)	–	–	–	–	–	6.23	TC	[3194]
Au(100)	–	–	–	–	–	6.26	TC	[3194]
Au(100)	–	–	–	–	–	6.4	TC	[389]
Recommended	–	–	–	–	–	**5.39 ± 0.07**	–	–
Au(110)	–	–	–	–	–	3.148	TC	[2914]
Au(110)	–	–	–	–	–	3.50	TC	[475]
Au(110)	–	–	–	–	–	3.629	TC	[2914]
Au(110)	–	–	–	–	–	4.65	TC	[1159,3067]
Au(110)	–	–	–	–	–	4.91	TC	[4091]
Au(110)	–	–	–	–	–	4.93	TC	[4233]
Au(110)	–	–	–	–	–	4.98	TC	[4233]
Au(110)	–	–	–	–	–	5.04	TC	[4087,4410]
Au(110)	–	–	5×10^{-10}	298	–	5.12 ± 0.07	CPD	[1069]
Au(110)	–	–	1×10^{-10}	~300	–	5.20 ± 0.04	PE	[1068]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au(110)[347]	–	–	–	–	–	5.32	TC	[2543]
Au(110)	–	–	–	–	–	5.36	TC	[4404]
Au(110)	–	–	?	~300	–	5.37	CPD	[959]
Au(110)[347]	–	–	–	–	–	5.38	TC	[2543]
Au(110)	–	–	–	–	–	5.38	TC	[480]
Au(110)[347]	–	–	–	–	–	5.39	TC	[2543]
Au(110)	–	–	?	~300	–	5.39 ± 0.06	CPD	[4404]
Au(110)	–	–	–	–	–	5.40	TC	[334]
Au(110)	–	–	–	–	–	5.41	TC	[480,4398]
Au(110)	–	–	–	–	–	5.42	TC	[3317]
Au(110)/W(112)[348]	Au	–	<2 × 10⁻¹⁰	78{540}	–	5.45 ± 0.03	FE	[2256]
Au(110)	–	–	–	–	–	5.5	TC	[2167]
Au(110)	–	–	–	–	–	5.80	TC	[321]
Au(110)	–	–	–	–	–	5.85	TC	[3194]
Au(110)	–	–	–	–	–	5.86	TC	[3194]
Recommended	–	–	–	–	–	**5.33 ± 0.09**	–	–
Au(111)	–	–	–	–	–	3.478	TC	[2914]
Au(111)	–	–	–	–	–	3.80	TC	[475]
Au(111)/NaCl[137]	Au	–	?	~300 (423)	–	4.12 ± 0.02	PE	[3324,3328,3330]
Au(111)	–	–	–	–	–	4.165	TC	[2914]
Au(111)	–	–	<1 × 10⁻¹⁰	~300	–	4.6	PE	[3140]
Au(111)	–	–	–	–	–	4.83	TC	[2077]
Au(111)	–	–	–	–	–	4.94 ± 0.11	TC	[2902]
Au(111)	–	–	–	–	–	4.95	TC	[2077]
Au(111)	–	–	–	–	–	5.1	TC	[4233]
Au(111)	–	–	–	–	–	5.11	TC	[2702]
Au(111)	–	–	–	–	–	5.110	TC	[4091]
Au(111)	–	–	–	–	–	5.13	TC	[4233]
Au(111)	–	–	–	–	–	5.14	TC	[1939]
Au(111)	–	–	–	–	–	5.15	TC	[2068]
Au(111)	–	–	–	–	–	5.15	TC	[343]
Au(111)	–	–	–	–	–	5.15	TC	[4087,4410]
Au(111)	–	–	?	70	–	5.15 ± 0.1	PE	[1297]
Au(111)	–	–	–	–	–	5.17	TC	[4140]
Au(111)	–	–	–	–	–	5.18	TC	[1939]
Au(111)/Si(111)[419]	Au	–	~10⁻¹⁰	~300	–	5.2	PE	[3999,4000]
Au(111)/Cu(111)	Au	–	<1 × 10⁻¹⁰	~300	–	5.2 ± 0.3	CPD	[1186,3417]
Au(111)	–	–	–	–	–	5.20	CT	[4151,4408]
Au(111)	–	–	–	–	–	5.21	TC	[4155]
Au(111)	–	–	–	–	–	5.23	CT	[4181]
Au(111)	–	–	–	–	–	5.25	TC	[4152]
Au(111)	–	–	–	–	–	5.25	TC	[4154]
Au(111)	–	–	–	–	–	5.25	TC	[1197,4157,4215, 4413]
Au(111)	–	–	–	–	–	5.26	TC	[4153]
Au(111)/W(110)	Au	–	?	~300 (<934)	–	5.25 ± 0.03	CPD	[3076]
Au(111)	–	–	1 × 10⁻¹⁰	~300	–	5.26 ± 0.04	PE	[1068]
Au(111)	–	–	–	–	–	5.27	TC	[2902]
Au(111)	–	–	1 × 10⁻¹⁰	~300	–	5.3	PE	[1070]
Au(111)	–	–	5 × 10⁻¹⁰	~300	–	5.3	PE	[1142]
Au(111)/mica	Au	–	?	~300	–	5.3	CPD	[1600]
Au(111)	–	–	–	–	–	5.3 ± 0.1	TC	[3494]
Au(111)	–	–	5 × 10⁻¹⁰	298	–	5.30 ± 0.05	PE	[1069]
Au(111)	–	–	–	–	–	5.31	TC	[2551]
Au(111)	–	–	?	~300	–	5.31	CPD	[959]
Au(111)	–	–	–	–	–	5.31	TC	[3497]
Au(111)	–	–	–	–	–	5.32	TC	[1159,1980,3067]
Au(111)/W(110)[349]	Au	–	<2 × 10⁻¹⁰	78{420}	–	5.32 ± 0.03	FE	[2256]
Au(111)	–	–	5 × 10⁻¹¹	100 (730)	–	5.35	PE	[4156]
Au(111)	–	–	?	5 (900)	–	5.36	PE	[4257]
Au(111)/quartz[350]	Au	–	~10⁻⁹	~300	–	5.38	PE	[3313]
Au(111)/mica[420]	Au	–	4 × 10⁻¹⁰	~300{570}	–	5.4	PE	[4001]
Au(111)	–	–	?	~300	–	5.40 ± 0.05	PE	[2995]
Au(111)/quartz[350]	Au	–	~10⁻⁹	~300 (623)	–	5.42	PE	[3313]
Au(111)	–	–	?	30	–	5.44	PE	[2228]
Au(111)	–	–	–	–	–	5.45	TC	[4426]
Au(111)/mica	Au	–	4 × 10⁻¹¹	~300 (623)	–	5.47	PE	[1202]
Au(111)/mica(111)	Au	–	<5 × 10⁻¹¹	~300 (~700)	–	5.47 ± 0.15*	CPD	[1897]
Au(111)	–	–	–	–	–	5.5	TC	[1723]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au(111)	–	–	?	~300	–	5.5 ± 0.1	PE	[1297]
Au(111)/W(110)	Au	–	≤2 × 10⁻¹⁰	~300	–	5.50*	CPD	[1538]
Au(111)	–	–	8 × 10⁻¹¹	~300	–	5.50	PE	[4080]
Au(111)/W(112)[351]	Au	–	≤7 × 10⁻¹¹	~300	–	5.51	CPD	[2385]
Au(111)	–	–	–	–	–	5.52	TC	[1939]
Au(111)	–	–	–	–	–	5.54	TC	[233]
Au(111)	–	–	–	–	–	5.54	TC	[4174,4284]
Au(111)[351]	–	–	≤7 × 10⁻¹¹	~300	–	5.55	CPD	[2385,2871]
Au(111)	–	–	?	~300	–	5.55	PE	[2999]
Au(111)	–	–	?	~300	–	5.55 ± 0.03	PE	[4213]
Au(111)	–	–	–	–	–	5.56	TC	[3217]
Au(111)/Ir(111)	Au	–	≤5 × 10⁻¹⁰	~300 (>673)	–	5.60 ± 0.04	CPD	[415,3266]
Au(111)	–	–	–	–	–	5.60 ± 0.10	TC	[3217]
Au(111)	–	–	–	–	–	5.63	TC	[480,4398]
Au(111)	–	–	–	–	–	5.65	TC	[3317]
Au(111)	–	–	–	–	–	5.7	TC	[1723]
Au(111)	–	–	–	–	–	5.71	TC	[2803]
Au(111)	–	–	–	–	–	6.01	TC	[334]
Au(111)	–	–	–	–	–	6.05	TC	[3179]
Au(111)	–	–	–	–	–	6.08	TC	[3194]
Au(111)	–	–	–	–	–	6.65	TC	[321]
Recommended	–	–	–	–	–	**5.46 ± 0.07**	–	–
Au(112)	–	–	–	–	–	5.09	TC	[2702]
Au(113)	–	–	5 × 10⁻¹⁰	298	–	5.16 ± 0.07	CPD	[1069]
Au(210)	–	–	5 × 10⁻¹⁰	298	–	4.96 ± 0.07	CPD	[1069]
Au(532)	–	–	–	–	–	5.03	TC	[2702]
Au	–	–	–	–	–	3.07	TC	[2493]
Au	–	–	–	–	–	3.16	TC	[2493]
Au	–	–	–	–	–	3.19	TC	[521]
Au	–	–	–	–	–	3.44	TC	[2629]
Au	–	–	–	–	–	3.49	TC	[475]
Au/Si(100)ⁿ[478]	Au	–	?	~300	–	~3.5–3.8	CPD	[4368]
Au	–	–	–	–	–	3.52	TC	[2474]
Au/quartz	Au	–	~10⁻⁶	~300	–	4	PE	[2941]
Au	–	–	~10⁻⁶	~300	–	4 ± 0.5	FE	[2675]
Au/quartz[51]	Au	–	~10⁻⁵	~300	–	4.0	PE	[1973]
Au	–	–	?	?	–	4.00–4.58	TE	[1362]
Au/Ag	Au	–	~10⁻⁶	~300	–	4.03	PE	[2941]
Au/?	Au	–	~10⁻⁶	~300	–	4.1	PE	[3332]
Au(fp)[352]	–	–	–	–	–	4.1	TC	[2973]
Au/glass	Au	–	~10⁻⁶	373	–	4.17 ± 0.01	PE	[3507]
Au/glass	Au	–	~10⁻⁶–10⁻⁸	~300	–	4.2	PE	[1894]
Au[437]	–	–	?	~300	–	4.20	PE	[2760]
Au/glass	Au	–	~10⁻⁶	463	–	4.21	PE	[3507]
Au	–	–	≤4 × 10⁻¹⁰	~300	–	4.24	CPD	[2118]
Au	–	–	–	–	–	4.25	TC	[2629]
Au/glass	Au	–	~10⁻⁶	613	–	4.26	PE	[3507]
Au/glass	Au	–	~10⁻⁶	523	–	4.27	PE	[3507]
Au/graphite	Au	–	?	1170–1280	–	4.27 ± 0.03	TE	[2236]
Au	–	–	–	–	–	4.28	TC	[1626,2914]
Au	–	–	–	–	–	4.33	TC	[3318]
Au	–	–	?	~300	–	4.36 ± 0.06*	CPD	[1953]
Au/GaP	–	–	–	–	–	4.38	TC	[1653]
Au	–	–	2 × 10⁻⁵	~300	–	4.4–4.6	?	[2836]
Au(fp)[352]	–	–	–	–	–	4.4	TC	[2973]
Au	–	–	?	1323	–	4.41	TE	[1944]
Au	–	–	≤4 × 10⁻¹⁰	~300	–	4.42	CPD	[2118]
Au	–	–	–	–	–	4.45	TC	[1645]
Au	–	–	?	~300	–	4.46	CPD	[2297]
Au/?	Au	–	?	~300	–	4.48	CPD	[2708]
Au/GaP	–	–	–	–	–	4.49	TC	[1653]
Au/W(100)	Au	–	?	825	–	4.5*	FE	[2263]
Au	–	–	–	–	–	4.50	TC	[3352]
Au/Si	–	–	–	–	–	4.53	TC	[1653]
Au/Cu	Au	–	~10⁻¹⁰	~300	–	4.54 ± 0.02	PE	[2765]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au	–	–	$\sim10^{-7}$	~300	–	4.55	PE	[1890]
Au	–	–	–	–	–	4.56	TC	[1976]
Au/Si	–	–	–	–	–	4.56	TC	[1653]
Au	–	–	–	–	–	4.6	TC	[1993]
Au(fp)[352]	–	–	–	–	–	4.6	TC	[2973]
Au/W(100)	Au	–	?	900	–	4.6*	FE	[2263]
Au[353]	–	–	$<10^{-9}$	~300	–	4.64	CPD	[1072]
Au/glass[368]	Au	–	$<10^{-8}$	~300	–	4.68 ± 0.03	CPD	[133]
Au/Si(111)	–	–	–	–	–	4.69	TC	[2688]
Au/Al$_2$O$_3$/Al	Au	–	?	~300	–	4.69	CPD	[3057]
Au	–	–	–	–	–	4.69	TC	[2005]
Au/glass[367]	Au	–	$<10^{-9}$	~300	–	4.7	CPD	[1893]
Au/W(100)	Au	–	?	825	–	4.7	FE	[2263]
Au/W(110)	Au	–	?	20	–	4.7	FE	[2956]
Au	–	–	–	–	–	4.7	TC	[2583]
Au/TiO$_2$(110)	–	–	–	–	–	~4.7–5.2	TC	[4182]
Au	–	–	$<3 \times 10^{-9}$	~300	–	4.70 ± 0.01	CPD	[486,904]
Au/glass[365]	Au	–	$\sim10^{-8}$	~300	–	4.70 ± 0.03	CPD	[133]
Au/W	Au	–	$<10^{-10}$	~300	–	4.705 ± 0.010	CPD	[2940]
Au/W	Au	–	$\sim10^{-10}$	~300	–	4.709 ± 0.006	CPD	[2938]
Au	–	–	$<10^{-6}$	~300	–	4.71	PE	[2919]
Au	–	–	–	–	–	4.71	TC	[1399]
Au/glass[365]	Au	–	$<10^{-9}$	~300 (523)	–	4.71 ± 0.02	CPD	[349,1160,1163]
Au/W[365]	Au	–	$\sim10^{-10}$	~300	–	4.714 ± 0.004	CPD	[349,1161,2935]
Au	–	–	?	~300	–	4.72	PE	[3021]
Au/cnt/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.72 ± 0.06	PE	[3246]
Au[354]	–	–	1×10^{-8}	1013	–	4.73	PE	[2560]
Au	–	–	–	–	–	4.74	TC	[1066]
Au	–	–	?	~300	–	4.74 ± 0.01	CPD	[1953]
Au	–	–	?	~300	–	4.76	PE	[3023]
Au/Ta(112)[358]	–	–	$<1 \times 10^{-10}$	$\sim300\{1000\}$	–	4.76	CPD	[878]
Au	–	–	–	–	–	4.77	TC	[3476]
Au/glass[365]	Au (Hg)	–	5×10^{-11}	~300	–	4.77	CPD	[1071]
Au	–	–	–	–	–	4.78	TC	[3264,3265]
Au	–	–	$<10^{-7}$	~300	–	4.79–4.97	PE	[3393]
Au/steel	Au	–	?	~300	–	4.8	PE	[2466,2475]
Au	–	–	–	–	–	4.8	TC	[3268]
Au/Ta(111)	Au	–	$<1 \times 10^{-10}$	~300	–	4.8	CPD	[2440]
Au/W(100)	Au	–	?	900	–	4.8*	FE	[2263]
Au/Nb	Au	–	$\leq5 \times 10^{-9}$	~300	–	4.8*	CPD	[3261]
Au/Mo	Au	–	7×10^{-11}	~300	–	4.8	PE	[2226]
Au/glass	Au	–	$<10^{-8}$	78	–	4.8 ± 0.02	CPD	[1646]
Au[354]	–	–	–	293–1013	–	4.81 ± 0.02	TC	[1760]
Au	–	–	–	–	–	4.82	TC	[1885]
Au[354]	–	–	1×10^{-8}	293	–	4.82	PE	[2560]
Au/Ta[356]	Au	–	?	~300	–	4.83 ± 0.02	CPD	[1162]
Au	–	–	?	~300	–	4.84 ± 0.02	PE	[4155]
Au/Al$_2$O$_3$/Al	Au	–	?	~300	–	4.84 ± 0.06*	CPD	[3057]
Au/Cu	Au	–	?	~300	–	4.85 ± 0.05	PE	[3178]
Au/cnt/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.85 ± 0.11	CPD	[3246]
Au	–	–	–	–	–	4.88	TC	[298]
Au	–	–	–	–	–	4.88 ± 0.05	TC	[3358]
Au[355]	–	–	–	733	–	4.89	TC	[3586]
Au/W(110)[366]	–	–	5×10^{-10}	78 (300)	–	4.89 ± 0.01	FE	[1673]
Au[353]	–	–	$<10^{-9}$	~300	–	4.89 ± 0.06	CPD	[1072]
Au	–	–	?	~300	–	4.9	PE	[3639]
Au/quartz	Au	–	5×10^{-9}	~300	–	4.9	CPD	[2606]
Au	–	–	?	?	–	4.9	?	[1838]
Au$_2$/TiO$_2$(110)	–	–	–	–	–	~4.9–5.2	TC	[4182]
Au	–	–	?	~300	–	4.9 ± 0.1	PE	[3014]
Au[354]	–	–	–	296–1013	–	4.90 ± 0.03	TC	[1135]
Au	–	–	1×10^{-9}	~300	–	4.91	CPD	[1252]
Au	–	–	–	–	–	4.91	TC	[339]
Au[355]	–	–	–	1013	–	4.92	TC	[3586]
Au[355]	–	–	–	733, 1013	–	4.92	TC	[1135]
Au/W	Au	–	$<5 \times 10^{-9}$	78	–	4.92	FE	[2240]
Au/cnt/Si(111)[25]	–	–	$\sim10^{-10}$	~300	–	4.92 ± 0.10	CPD	[3246]
Au	–	–	–	–	–	4.93	TC	[3476]
Au[354]	–	–	–	296–1013	–	4.93 ± 0.03	TC	[1135]
Au	–	–	?	~300	–	4.95	PE	[2752]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au/W(111)[361]	Au	–	$\sim 10^{-11}$	~ 300 (~ 1000)	–	4.96*	CPD	[2647]
Au/glass[369]	Au	–	$\sim 10^{-10}$	77	–	4.96	PE	[2133]
Au/Ta[356]	Au	–	?	~ 300	–	4.97 ± 0.02	CPD	[1162]
Au	–	–	1×10^{-10}	~ 300	–	5.0	PE	[1678]
Au/glass	–	–	$< 10^{-9}$	~ 300	–	5.0	PE	[2717]
Au/?	Au	–	$\sim 10^{-5}$	~ 300	–	5.0	CPD	[1376]
Au(fp)[352]	–	–	–	–	–	5.0	TC	[2973]
Au/W(100)	Au	–	?	750	–	5.0*	FE	[2263]
Au/W	Au	–	?	~ 300	–	5.0	FE	[2225]
Au/Si	Au	–	1×10^{-9}	~ 300	–	5.0	PE	[3221]
Au	–	–	4×10^{-10}	~ 300	–	5.0 ± 0.1	PE	[3132]
Au	–	–	?	~ 300	–	5.00	PE	[4159]
Au[357]	–	–	$\sim 10^{-9}$	~ 300	–	5.01	CPD	[2473]
Au	–	–	?	~ 300	–	5.03 ± 0.05	PE	[4003]
Au/Ta(112)[358]	Au	–	$< 1 \times 10^{-10}$	~ 300	–	5.04	CPD	[878]
Au/W(100)	Au	–	$\leq 2 \times 10^{-10}$	$\sim 300\{900\}$	–	5.05*	CPD	[1538]
Au/ZrO_2/Si(100)	Au	–	?	~ 300	–	5.05[48]	PE	[1442]
Au/SiO_2/Si	Au	–	?	~ 300 (570)	–	5.06	PE	[2355]
Au/glass	Au	–	$< 1 \times 10^{-10}$	78	–	5.06	PE	[414]
Au/W(111)	–	–	–	–	–	5.07	TC	[531]
Au/W(100)	Au	–	?	20 (330)	–	5.07*	FE	[2959]
Au[357]	–	–	$\sim 10^{-9}$	~ 300	–	5.08	CPD	[2473]
Au/Mo(111)[364]	Au	–	$< 1 \times 10^{-10}$	~ 300	–	5.08	CPD	[1842]
Au/Ta(112)[358]	Au	–	$< 1 \times 10^{-10}$	~ 300	–	5.08	CPD	[878]
Au/W(112)[361]	Au	–	$\sim 10^{-11}$	~ 300 (~ 1000)	–	5.08*	CPD	[2647]
Au/CdTe(110)	Au	–	$\leq 2 \times 10^{-11}$	~ 300	–	5.08 ± 0.02	CPD	[3068]
Au/quartz	Au	–	$\leq 5 \times 10^{-10}$	78	–	5.08 ± 0.04	PE	[435]
Au/Al_2O_3/Si(100)	Au	–	?	~ 300	–	5.1[48]	PE	[1442]
Au	–	–	4×10^{-10}	~ 300	–	5.1	PE	[3120]
Au/quartz	Au	–	$\leq 5 \times 10^{-9}$	~ 300	–	5.1	PE	[2309]
Au/W(111)	Au	–	?	20	–	5.1	FE	[2956]
Au	–	–	?	~ 300	–	5.1	PE	[1449]
Au/ITO	Au	–	5×10^{-10}	~ 300	–	5.1*	PE	[4183]
Au	–	–	$\sim 10^{-9}$	~ 300	–	5.1 ± 0.1	PE	[1267]
Au/quartz	Au	–	$\sim 10^{-10}$	~ 300	–	5.1 ± 0.1	PE	[304]
Au–Cu(2.4%)/Si	Au, Cu	–	?	293	–	5.1 ± 0.1	PE	[3998]
Au	–	–	?	~ 300	–	5.1 ± 0.15	CPD	[1600]
Au	–	–	–	–	–	5.10	TC	[3637]
Au/Ir[359]	Au	–	?	78 (520)	–	5.10	FE	[2189]
Au/Si(111)	Au	–	5×10^{-11}	~ 300	–	5.10 ± 0.05	CPD	[613,636]
Au/Si(111)	Au	–	$< 4 \times 10^{-10}$	~ 300	–	5.11 ± 0.04	PE	[3279]
Au/W	Au	–	$< 5 \times 10^{-9}$	78	–	5.12	FE	[2240]
Au/Au[360]	Au	–	$< 5 \times 10^{-8}$	~ 300	–	5.12*	PE	[3502]
Au[357]	–	–	$\sim 10^{-9}$	~ 300 (~ 1200)	–	5.13	CPD	[2473]
Au/W(100)[361]	Au	–	$\sim 10^{-11}$	~ 300 (~ 1000)	–	5.14*	CPD	[2647]
Au/W(100)	Au	–	?	20	–	5.14*	FE	[2959]
Au/W(110)	Au	–	($< 1 \times 10^{-11}$)	~ 300	–	5.15 ± 0.02	FE	[2251]
Au	–	–	–	–	–	5.16	TC	[3016]
Au	–	–	$\sim 10^{-5}$	≤ 1200	–	5.16	TE	[2216]
Au/W(111)[361]	Au	–	$\sim 10^{-11}$	~ 300	–	5.17*	CPD	[2647]
Au[357]	–	–	$\sim 10^{-9}$	~ 300 (~ 1200)	–	5.18	CPD	[2473]
Au/W(112)	–	–	–	–	–	5.18	TC	[531]
Au/Si(111)[419]	Au	–	$\sim 10^{-10}$	~ 300	–	5.2	PE	[3999,4000]
Au/W(100)	Au	–	?	750	–	5.2	FE	[2263]
Au	–	–	$\sim 10^{-10}$	100	–	5.2	PE	[2720]
Au	–	–	–	–	–	5.2	TC	[1561]
Au/Re	Au	–	$< 4 \times 10^{-10}$	~ 300	–	5.2*	CPD	[515]
Au	–	–	$\sim 4 \times 10^{-10}$	~ 300	–	5.2 ± 0.05	PE	[1298]
Au	–	–	2×10^{-11}	~ 300	–	5.2 ± 0.1	PE	[1251]
Au/W(111)	Au	–	?	20	–	5.2 ± 0.1	FE	[3509]
Au	–	–	$\leq 1 \times 10^{-10}$	~ 300	–	5.2 ± 0.3	PE	[1695]
Au/W[362]	Au_n	–	$\sim 10^{-5}$ (He, Ar)	77	–	5.2 ± 0.4	FE	[1713]
Au/W(112)[361]	Au	–	$\sim 10^{-11}$	~ 300	–	5.20*	CPD	[2647]
Au/W(115)	Au	–	$\sim 10^{-11}$	~ 300	–	5.20*	CPD	[2647]
Au/W(100)	Au	–	$< 2 \times 10^{-10}$	78	–	5.20	FE	[2256]
Au	–	–	?	~ 300	–	5.20	PE	[4242]
Au/W	Au	–	($< 1 \times 10^{-11}$)	~ 300	–	5.20 ± 0.02	FE	[2251]
Au[353]	–	–	$< 10^{-9}$	~ 300 (1170)	–	5.20 ± 0.05	CPD	[1072]
Au	–	–	4×10^{-10}	~ 300	–	5.20 ± 0.05	PE	[1181]
Au/glass	Au	–	5×10^{-11}	~ 300	–	5.20 ± 0.07*	CPD	[1071]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au(f.p.)[149]	–	–	<10⁻⁹	~300	–	5.20 ± 0.1	PE	[1562,3190]
Au/Mo(111)[364]	Au	–	<1 × 10⁻¹⁰	~300{1000}	–	5.22	CPD	[1842]
Au/glass[363]	Au	–	~10⁻¹⁰	~78	–	5.22	PE	[436]
Au/glass[365]	Au	–	5 × 10⁻¹¹	~300	–	5.22 ± 0.05	CPD	[1071,2100]
Au	–	–	<1 × 10⁻⁹	~300	–	5.22 ± 0.05	CPD	[1072]
Au	–	–	<5 × 10⁻⁹	78	–	5.23	FE	[2240]
Au	–	–	~10⁻⁹	~300 (~1100)	–	5.24	CPD	[2473]
Au/W(110)[366]	Au	–	2 × 10⁻¹⁰	~300 (750)	–	5.25 ± 0.01	FE	[1670,1673]
Au/glass	Au	–	5 × 10⁻¹¹	~300	–	5.25 ± 0.08*	CPD	[1071]
Au/Cu	Au	–	?	~300	–	5.26	CPD	[3716]
Au/glass	Au	–	2 × 10⁻¹⁰	~300	–	5.26	PE	[1621]
Au/W	Au	–	(<1 × 10⁻¹¹)	~300 (600)	–	5.26	FE	[730]
Au[357]	–	–	~10⁻⁹	~300	–	5.27	CPD	[2473]
Au[357]	–	–	~10⁻⁹	~300 (~1100)	–	5.27	CPD	[2473]
Au/glass	Au	–	<1 × 10⁻¹⁰	78 (293)	–	5.28	PE	[414,2722]
Au/quartz	Au	–	≤5 × 10⁻¹⁰	293	–	5.28 ± 0.01	PE	[435]
Au/Ru[368]	Au	–	~10⁻¹⁰	~300	–	5.28 ± 0.02	CPD	[1073]
Au/glass	Au	–	5 × 10⁻¹¹	~300	–	5.28 ± 0.06*	CPD	[1071]
Au/Ir[359]	Au	–	?	78 (501)	–	5.29	FE	[2189]
Au	–	–	≤1 × 10⁻¹⁰	~300	–	5.29	CPD	[2198]
Au/Si(111)	Au	–	<5 × 10⁻¹¹	60 (770)	–	5.3	PE	[2893]
Au/Ta	Au	–	~10⁻¹⁰	~300	–	5.3	PE	[2985]
Au/Nb(110)	Au	–	7 × 10⁻¹¹	~300	–	5.3	PE	[2986]
Au/W	Au	–	?	~300	–	5.3	FE	[3095]
Au/W	Au	–	?	?	–	5.3	FE	[1501]
Au/W(100)	Au	–	?	~300	–	5.3*	FE	[2263]
Au/W(110)[349]	Au	–	<2 × 10⁻¹⁰	78	–	5.3	FE	[2256]
Au/W(112)[348]	Au	–	<2 × 10⁻¹⁰	78	–	5.3	FE	[2256]
Au/W(112)	Au	–	?	20	–	5.3	FE	[2956]
Au/glass[367]	Au	–	<10⁻⁹	~300 (520)	–	5.3	CPD	[1893]
Au	–	–	<5 × 10⁻¹⁰	~300	–	5.3	PE	[1296]
Au	–	–	<2 × 10⁻¹⁰	~300	–	5.3	CPD	[4214]
Au/glass	Au	–	~10⁻¹⁰	323	–	5.30	PE	[1074]
Au/W(100)	Au	–	1 × 10⁻¹¹	330	–	5.30	FE	[2965]
Au/Co/Pt	Au	–	?	~300	–	5.30 ± 0.06	PE	[4423]
Au[357]	–	–	~10⁻⁹	~300	–	5.31	CPD	[2473]
Au/Au[360]	Au	–	<5 × 10⁻⁸	~300 (≤723)	–	5.31*	PE	[3502]
Au/Ru(0001)	Au	–	1 × 10⁻¹⁰	~300	–	5.31*	CPD	[2880]
Au[357]	–	–	~10⁻⁹	~300	–	5.32	CPD	[2473]
Au/W(100)	Au	–	<2 × 10⁻¹⁰	78{200}	–	5.32	FE	[2256]
Au/glass	Au	–	<1 × 10⁻¹⁰	78 (≤573)	–	5.32 ± 0.01	PE	[414]
Au/W	Au	–	(<1 × 10⁻¹¹)	~300	–	5.32 ± 0.02	FE	[2251]
Au	–	–	–	–	–	5.33	TC	[3476]
Au/W(100)	Au	–	~10⁻¹⁰	~300{≤900}	–	5.33	CPD	[2858]
Au[357]	–	–	~10⁻⁹	~300	–	5.33	CPD	[2473]
Au/W(100)	Au	–	≤10⁻¹⁰	78	–	5.33 ± 0.02	FE	[356]
Au/O–Si(100)	Au	–	~10⁻¹⁰	~300	–	5.33 ± 0.05	PE	[2281]
Au/W(110)	–	–	–	–	–	5.34	TC	[531]
Au/W(110)	Au	–	~10⁻¹¹	~300	–	5.34*	CPD	[2647]
Au/W(100)	–	–	–	–	–	5.35	TC	[531]
Au/W(100)[361]	Au	–	~10⁻¹¹	~300	–	5.36*	CPD	[2647]
Au/quartz	Au	–	≤5 × 10⁻¹⁰	293 (~550)	–	5.36 ± 0.01	PE	[435]
Au/Re	Au	–	(<1 × 10⁻¹¹)	~300 (600)	–	5.37	FE	[730]
Au/W(100)	Au	–	~1 × 10⁻¹¹	20	–	5.37	FE	[2965]
Au/steel	Au	–	<6 × 10⁻⁹	~300	–	5.37 ± 0.02	FE	[1540]
Au/glass[363]	Au	–	~10⁻¹⁰	~300 (≥400)	–	5.38	PE	[436,1074]
Au	–	–	–	–	–	5.38	TC	[3016]
Au/glass	Au	–	~10⁻¹⁰	~300	–	5.38 ± 0.02	PE	[1141]
Au/quartz[350]	Au	–	~10⁻⁹	~300	–	5.38 ± 0.02	PE	[3313]
Au/glass	Au	–	~10⁻¹⁰	~300 (473)	–	5.39 ± 0.01	PE	[1141]
Au/W(100)	Au	–	?	78	–	5.4*	FE	[2263]
Au	–	–	2 × 10⁻¹⁰	130	–	5.4	PE	[4212]
Au/W(112)	Au	–	~10⁻¹⁰	~300{≤1000}	–	5.4	CPD	[2858]
Au/W(110)[349]	Au	–	<2 × 10⁻¹⁰	78{160}	–	5.4	FE	[2256]
Au/Pt(100)	Au	–	1 × 10⁻¹⁰	~300	–	5.4 ± 0.15	PE	[174]
Au/glass[369]	Au	–	~10⁻¹⁰	77 (373)	–	5.40	PE	[2133]
Au	–	–	?	?	–	5.40	?	[2610]
Au/Mo(110)	Au	–	<1 × 10⁻¹⁰	~300{900}	–	5.40*	CPD	[2864]
Au	–	–	–	–	–	5.400	TC	[2649]
Au/steel	Au	–	≤2 × 10⁻¹¹	~300	–	5.40 ± 0.05	CPD	[3068]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Au/glass	Au	–	$\sim10^{-10}$	~300	–	5.41	PE	[1141]
Au/quartz	Au	–	$\sim10^{-9}$	~300 (673)	–	5.41	PE	[3313]
Au/quartz[350]	Au	–	$\sim10^{-9}$	~300 (623)	–	5.42	PE	[3313]
Au/W(110)	Au	–	$\leq7\times10^{-11}$	~300 (≤1200)	–	5.42	CPD	[2388]
Au/Pt(100)	Au	–	$\sim10^{-10}$	~300	–	5.42 ± 0.02	PE	[3136]
Au/Mo(110)	Au	–	$<1\times10^{-10}$	~300	–	5.43*	CPD	[2864]
Au/glass[368]	Au	–	2×10^{-10}	77	–	5.43 ± 0.01	CPD	[945]
Au/glass	Au	–	10^{-9}	~300 (>573)	–	5.45	CPD	[1074]
Au/W(110)	Au	–	$<7\times10^{-11}$	78 (750)	–	5.45	FE	[2279]
Au/glass[368]	Au	–	2×10^{-10}	77	–	5.45 ± 0.01	CPD	[945]
Au/W(100)	Au	–	?	~300	–	5.5	FE	[2263]
Au/W(110)	Au	–	$\sim10^{-10}$	~400	–	5.5 ± 0.05*	CPD	[3676]
Au/W (110)	Au	–	5×10^{-11}	~300	–	5.51	CPD	[2384]
Au/Pt (997)	Au	–	1×10^{-10}	~300	–	5.52 ± 0.15	PE	[174]
Au/W(110)	Au	–	$\sim10^{-10}$	$\sim300\{\leq900\}$	–	5.55	CPD	[2858]
Au/W(100)	Au	–	$<2\times10^{-10}$	78{500}	–	5.55	FE	[2256]
Au/Cr/Au(100)	–	–	–	–	–	5.57	TC	[1911]
Au/ZnO(1120)	Au	–	$\leq2\times10^{-11}$	~300	–	5.59 ± 0.03	CPD	[3068]
Au/CdS(1120)	Au	–	$\leq2\times10^{-11}$	~300	–	5.59 ± 0.03	CPD	[3068]
Au	–	–	–	–	–	5.6	TC	[706]
Au/W(100)	Au	–	?	78	–	5.6	FE	[2263]
Au/W(100)	Au	–	?	78 (330)	–	5.6*	FE	[2263]
Au/Cr	Au	–	4×10^{-11}	~300	–	5.6	CPD	[2123]
Au/V(100)	Au	–	$<8\times10^{-11}$	120	–	5.6 ± 0.1	PE	[3372]
Au/Ru(001)	Au	–	$<5\times10^{-10}$	60	–	5.60 ± 0.05	PE	[2651]
Au/Cr/Au(100)	–	–	–	–	–	5.65	TC	[1911]
Au/W(110)	Au	–	$\sim10^{-10}$	900	–	5.65 ± 0.05*	CPD	[3676]
Au/Si(111)	Cs, Li	Cs$^+$	?	~300	5.7*	–	CPD	[1342]
Au/W[362]	Au$_n$	–	$\sim10^{-5}$ (He, Ar)	77	–	5.7 ± 0.5	FE	[1713]
Au/W(110)	Au	–	$\sim10^{-10}$	600	–	5.70 ± 0.05*	CPD	[3676]
Au/W(100)	Au	–	?	78 (330)	–	5.8	FE	[2263]
Au/Pt(111)	Au	–	1×10^{-10}	~300	–	5.8 ± 0.15	PE	[174]
Au/Ir(100)[359]	Au	–	?	78 (520)	–	5.80	FE	[2189]
Au/Ir(100)[359]	Au	–	?	78 (482)	–	5.86 ± 0.02	FE	[2189]
Au/W[362]	Au$_n$	–	$\sim10^{-5}$ (He, Ar)	77	–	5.9 ± 0.6	FE	[1713]
Au/Pt(100)	–	–	–	–	–	6.17	TC	[855]
Au	–	–	–	–	–	6.79	TC	[2551]
Recommended	–	–	–	–	–	**5.30 ± 0.04**	–	–

80. Mercury Hg

Liquid (T > 234 K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hg	–	–	–	–	–	3.33	TC	[3211]
Hg	–	–	?	~300	–	3.9–4.9	PE	[1745]
Hg	–	–	–	–	–	3.9–5.0	TC	[2261]
Hg	–	–	?	~300	–	4.054 ± 0.027	PE	[3247]
Hg/Ag	Hg	–	$\sim10^{-9}$	~300	–	4.16 ± 0.07*	CPD	[1530]
Hg/Ag/Al	Hg	–	$\sim10^{-6}$	~300	–	4.3 ± 0.1	CPD	[2250]
Hg	–	–	?	~300	–	4.33	PE	[2081]
Hg/Mo	Hg	–	?	~240	–	~4.4	FE	[3074]
Hg$_n$(n → ∞)	–	–	–	–	–	4.42 ± 0.58	TC	[4261]
Hg	–	–	–	–	–	4.43*	TC	[1955]
Hg/W(110)	Hg	–	7×10^{-11}	~240	–	4.46	PE	[3566]
Hg	–	–	?	243	–	4.475 ± 0.01	PE	[2770,2771]
Hg	–	–	?	~300	–	4.48 ± 0.02	CPD	[2334,2597]
Hg	–	–	–	–	–	4.49	TC	[2005]
Hg[370]	–	–	$<2\times10^{-10}$	273	–	4.49 ± 0.01	PE	[1669]
Hg[156]	–	–	$<10^{-8}$	298	–	4.49 ± 0.05	PE	[2470,4207,4209, 4223–4225]
Hg	–	–	–	–	–	4.5	TC	[1645]
Hg	–	–	–	–	–	4.5	TC	[2583]
Hg/Cu/Al	Hg	–	$\sim10^{-6}$	~300	–	4.5 ± 0.1	CPD	[2250]
Hg	–	–	–	–	–	4.50	TC	[3264,3265,3267]
Hg	–	–	?	~300	–	4.50	PE	[1634]
Hg	–	–	–	–	–	4.50	TC	[3352]
Hg	–	–	$\sim10^{-6}$	~300	–	4.50	CPD	[2942]
Hg	–	–	$\sim10^{-6}$	~300	–	4.50 ± 0.01	PE	[1752]
Hg	–	–	$\sim10^{-7}$	~300	–	4.50 ± 0.03	CPD	[1542,2767]
Hg	–	–	? (N$_2$)	~300	–	4.51	CPD	[2186]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Hg	–	–	?	~300	–	4.51	PE	[2290]
Hg	–	–	–	–	–	4.51	TC	[1399]
Hg	–	–	?	~300	–	4.51 ± 0.02	PE	[2920]
Hg	–	–	–	–	–	4.510	TC	[2649]
Hg	–	–	–	–	–	4.52	TC	[1990]
Hg	–	–	<10⁻⁵	~300	–	4.52	PE	[2291]
Hg	–	–	?	~300	–	4.52 ± 0.02	PE	[2081]
Hg/O=Fe	Hg	–	?	>234	–	4.52 ± 0.02	PE	[2921]
Hg	–	–	–	–	–	4.53	TC	[1885]
Hg/W(100)	Hg	–	2 × 10⁻¹⁰	~300	–	4.55	PE	[1859]
Hg	–	–	~10⁻⁹	298	–	4.55 ± 0.05*	PE	[2613]
Hg	–	–	–	–	–	4.59	TC	[298]
Hg/W	Hg	–	?	293	–	4.59 ± 0.04*	CPD	[2573]
Hg/W[371]	Hg	–	?	~240	–	~4.6	FE	[3074]
Hg	–	–	?	~300	–	4.60	PE	[2614]
Hg	–	–	?	~300	–	4.60	PE	[2081]
Hg/W	Hg	–	~10⁻⁹ (Hg)	295	–	4.616 ± 0.046*	FE	[3143]
Hg/Mo	Hg	–	~10⁻⁹	~300	–	4.62 ± 0.07*	CPD	[1530]
Hg/Au	Hg	–	<10⁻⁹ (Hg)	~300	–	4.64	CPD	[1072]
Hg/W	Hg	–	~10⁻⁹ (Hg)	900–980	–	4.647 ± 0.007*	FE	[3143]
Hg/W	Hg	–	~10⁻⁹ (Hg)	750,780	–	4.680 ± 0.004*	FE	[3143]
Hg	–	–	–	–	–	4.7	TC	[706]
Hg/Au/Al	Hg	–	~10⁻⁶	~300	–	4.7 ± 0.1	CPD	[2250]
Hg/W	Hg	–	~10⁻⁹ (Hg)	295	–	4.73 ± 0.04*	FE	[3143]
Hg	–	–	?	~300	–	4.744	PE	[2806]
Hg/Au/glass	Hg	–	5 × 10⁻¹¹	~300	–	4.77	CPD	[1071]
Hg	–	–	–	–	–	4.79	TC	[1744]
Hg	–	–	? (O₂, air)	~300	–	4.83	PE	[2081]
Hg/Au	Hg	–	2 × 10⁻⁹ (Hg)	~300	–	4.89 ± 0.06	CPD	[1072]
Hg/W[371]	Hg	–	1 × 10⁻¹⁰	~300	–	4.9	FE	[3726]
Hg/Ni(111)[372]	Hg	–	<10⁻¹⁰	240–310	–	4.90 ± 0.08	PE	[3165,3166]
Hg/Re	Hg	–	~10⁻⁹	~300	–	5.08 ± 0.03*	CPD	[1530]
Hg/Au	Hg	–	~10⁻⁹	~300	–	5.15 ± 0.08*	CPD	[1530]
Recommended	–	–	–	–	–	**4.50 ± 0.02**	–	–
Rhombohedral (α, $T < 234$ K for bulk)								
Hg/W(110)	Hg	–	7 × 10⁻¹¹	200	–	4.46	PE	[3566]
Hg	–	–	?	173	–	4.47 ± 0.03	PE	[2770]
Hg[370]	–	–	<2 × 10⁻¹⁰	<234	–	4.49 ± 0.01	PE	[1669]
Hg[156]	–	–	<10⁻⁸	<234	–	4.49 ± 0.05	PE	[2470]
Hg	–	–	?	83–230	–	4.49 ± 0.04	PE	[2920]
Hg/O=Fe	–	–	?	83	–	4.52 ± 0.02	PE	[2921]
Hg/W(110)	Hg	–	?	90	–	4.59	CPD	[3562]
Hg/W	Hg	–	?	~200	–	~4.6	FE	[3074]
Recommended	–	–	–	–	–	**4.52 ± 0.05**	–	–

81. Thallium Tl

hcp (α, $T < 503$ K)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tl(0001)	–	–	–	–	–	3.90	TC	[4005]
Tl(0001)	–	–	–	–	–	4.48	TC	[321]
Tl(1010)	–	–	–	–	–	3.93	TC	[4005]
Tl(1010)	–	–	–	–	–	4.27	TC	[321]
Tl(1124)	–	–	–	–	–	3.75	TC	[321]
bcc (β, $T > 503$ K)								
Tl(100)	–	–	–	–	–	3.52	TC	[321]
Tl(110)	–	–	–	–	–	4.10	TC	[321]
Tl(111)	–	–	–	–	–	3.36	TC	[321]
Tl(112)	–	–	–	–	–	3.75	TC	[321]
hcp (α, $T < 503$ for bulk)								
Tl	–	–	–	–	–	3.03	TC	[1066]
Tl	–	–	–	–	–	3.23	TC	[1744]
Tl$_n$(n → ∞)	–	–	–	–	–	3.23 ± 0.11	TC	[4261]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tl	–	–	–	–	–	3.40	TC	[521]
Tl/?	Tl	–	?	?	–	3.68	PE	[3029]
Tl	–	–	?	293	–	3.69	PE	[4139]
Tl	–	–	–	–	–	3.7	TC	[1993]
Tl	–	–	–	–	–	3.7	TC	[2583]
Tl	–	–	–	–	–	3.70	TC	[1885]
Tl	–	–	?	~300	–	3.70	PE	[2614]
Tl/Au(100)	–	–	–	–	–	3.71	TC	[3168]
Tl	–	–	?	567	–	3.72	PE	[4139]
Tl	–	–	–	–	–	3.73	TC	[3168]
Tl	–	–	–	–	–	3.75*	TC	[1955]
Tl	–	–	–	–	–	3.76	TC	[1399]
Tl	–	–	–	–	–	3.78	TC	[2629]
Tl	–	–	–	–	–	3.83	TC	[4418,4420]
Tl	–	–	?	~300	–	3.84	CPD	[2297]
Tl	–	–	–	–	–	3.84	TC	[3264,3265]
Tl	–	–	9×10^{-10}	~300	–	3.84 ± 0.05	PE	[3437]
Tl	–	–	–	–	–	3.88	TC	[298]
Tl$_n$(n → ∞)	–	–	?	~300	–	3.89	IP, TC	[4197]
Tl	–	–	–	–	–	3.90	TC	[1613]
Tl	–	–	–	–	–	4.0 ± 0.05	TC	[1990]
Tl	–	–	–	–	–	4.02	TC	[3264,3265,3267]
Tl/Cu(100)	Tl	–	$<5 \times 10^{-10}$	~300	–	4.04	PE	[1555]
Tl	–	–	–	–	–	4.07	TC	[2005]
Tl	–	–	–	–	–	4.08	TC	[3264]
Tl/Si(111)	Tl	–	2×10^{-10}	~300	–	4.1*	PE	[3634]
Tl	–	–	–	–	–	4.2	TC	[706]
Recommended	–	–	–	–	–	**3.82 ± 0.05**	–	–

Liquid ($T > 577$ K)

Tl	–	–	?	587	–	3.64	PE	[4139]
Tl	–	–	9×10^{-10}	~680	–	3.84 ± 0.05	PE	[3437]

82. Lead Pb

fcc

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pb(100)	–	–	–	–	–	3.04	TC	[1159,3067]
Pb(100)	–	–	–	–	–	3.45	TC	[476]
Pb(100)	–	–	–	–	–	3.48	TC	[3211]
Pb(100)	–	–	–	–	–	3.50	TC	[231]
Pb(100)	–	–	–	–	–	3.57	TC	[553]
Pb(100)	–	–	–	–	–	3.67	TC	[476]
Pb(100)	–	–	–	–	–	3.76	TC	[3467]
Pb(100)	–	–	–	–	–	3.79	TC	[3004]
Pb(100)	–	–	–	–	–	3.79 ± 0.02*	TC	[3521]
Pb(100)	–	–	–	–	–	3.8	TC	[1088]
Pb(100)	–	–	–	–	–	3.81	TC	[1030]
Pb(100)	–	–	–	–	–	3.84	TC	[3492]
Pb(100)	–	–	–	–	–	3.88	TC	[1030]
Pb(100)	–	–	–	–	–	3.95	TC	[475]
Pb(100)	–	–	–	–	–	4.0	TC	[1088]
Pb(100)	–	–	–	–	–	4.07	TC	[3004]
Pb(100)	–	–	–	–	–	4.07 ± 0.01*	TC	[3521]
Pb(100)	–	–	–	–	–	4.10	TC	[556,1030]
Pb(100)	–	–	–	–	–	4.12	TC	[2516]
Pb(100)	–	–	–	–	–	4.31	TC	[555]
Pb(100)	–	–	–	–	–	4.4	TC	[1712,1714]
Pb(100)	–	–	–	–	–	4.5	TC	[1711]
Pb(100)	–	–	–	–	–	4.50	TC	[475]
Pb(100)	–	–	–	–	–	4.65	TC	[1095]
Pb(100)	–	–	–	–	–	4.95	TC	[321]
Recommended	–	–	–	–	–	**3.96 ± 0.11**	–	–
Pb(110)	–	–	–	–	–	2.99	TC	[1159,3067]
Pb(110)	–	–	–	–	–	3.26	TC	[1684]
Pb(110)	–	–	–	–	–	3.46	TC	[553]
Pb(110)	–	–	–	–	–	3.51	TC	[3467]
Pb(110)	–	–	–	–	–	3.64 ± 0.01*	TC	[3521]
Pb(110)	–	–	–	–	–	3.73	TC	[2516]
Pb(110)	–	–	–	–	–	3.77	TC	[231]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pb(110)	–	–	–	–	–	3.8	TC	[1088]
Pb(110)	–	–	–	–	–	3.80	TC	[3004]
Pb(110)	–	–	–	–	–	3.80	TC	[475]
Pb(110)	–	–	–	–	–	3.82	TC	[476]
Pb(110)	–	–	–	–	–	3.84	TC	[3004]
Pb(110)	–	–	–	–	–	3.84	TC	[1030]
Pb(110)	–	–	–	–	–	3.89	TC	[3211]
Pb(110)	–	–	–	–	–	3.90	TC	[556,1030]
Pb(110)	–	–	–	–	–	3.92 ± 0.01*	TC	[3521]
Pb(110)	–	–	–	–	–	3.98	TC	[555]
Pb(110)	–	–	–	–	–	4.01	TC	[476]
Pb(110)	–	–	–	–	–	4.08	TC	[1030]
Pb(110)	–	–	–	–	–	4.4	TC	[1088]
Pb(110)	–	–	–	–	–	4.50	TC	[1095]
Pb(110)	–	–	–	–	–	4.66	TC	[321]
Recommended	–	–	–	–	–	**3.84 ± 0.09**	–	–
Pb(111)	–	–	–	–	–	3.16	TC	[1159,3067]
Pb(111)	–	–	–	–	–	3.31	TC	[476]
Pb(111)	–	–	–	–	–	3.39	TC	[1684]
Pb(111)	–	–	–	–	–	3.51	TC	[476]
Pb(111)	–	–	–	–	–	3.59	TC	[231]
Pb(111)	–	–	–	–	–	3.65	TC	[1030]
Pb(111)	–	–	–	–	–	3.7	TC	[1086,1088]
Pb(111)	–	–	–	–	–	3.71	TC	[1086]
Pb(111)	–	–	–	–	–	3.78 ± 0.01	TC	[3521]
Pb(111)	–	–	–	–	–	3.79	TC	[3004]
Pb(111)	–	–	–	–	–	3.80	TC	[1086]
Pb(111)	–	–	–	–	–	3.82 ± 0.02	TC	[3483]
Pb(111)	–	–	–	–	–	3.85	TC	[475]
Pb(111)	–	–	–	–	–	3.9	TC	[1088]
Pb(111)	–	–	–	–	–	3.90	TC	[553]
Pb(111)	–	–	–	–	–	4.05	TC	[1086]
Pb(111)	–	–	2×10^{-11}	20 ± 5	–	4.05	PE	[2268]
Pb(111)	–	–	?	30	–	4.05	PE	[2228]
Pb(111)	–	–	–	–	–	4.06	TC	[1086]
Pb(111)	–	–	–	–	–	4.08 ± 0.01	TC	[3521]
Pb(111)	–	–	–	–	–	4.11	TC	[3004]
Pb(111)	–	–	–	–	–	4.12	TC	[1086]
Pb(111)	–	–	–	–	–	4.14	TC	[1086]
Pb(111)	–	–	–	–	–	4.14	TC	[2516]
Pb(111)	–	–	–	–	–	4.15	TC	[475]
Pb(111)/W(100)	Pb	–	$\sim 10^{-9}$	~300	–	4.28	CPD	[2002]
Pb(111)	–	–	–	–	–	4.30	TC	[555]
Pb(111)	–	–	–	–	–	4.34	TC	[3467]
Pb(111)	–	–	–	–	–	4.55	TC	[1095]
Pb(111)/W(110)	Pb	–	5×10^{-11}	548	–	4.70	CPD	[1525]
Pb(111)	–	–	–	–	–	4.79	TC	[3211]
Pb(111)	–	–	–	–	–	5.21	TC	[1089]
Pb(111)	–	–	–	–	–	5.23	TC	[1030]
Pb(111)	–	–	–	–	–	5.24	TC	[1089]
Pb(111)	–	–	–	–	–	5.35	TC	[321]
Pb(111)	–	–	–	–	–	5.47	TC	[1089]
Pb(111)	–	–	–	–	–	5.9	TC	[1086]
Pb(111)	–	–	–	–	–	5.9	TC	[3137]
Recommended	–	–	–	–	–	**4.14 ± 0.09**	–	–
Pb	–	–	–	–	–	3.0–4.6	TC	[2704]
Pb	–	–	–	–	–	3.31	TC	[1066]
Pb	–	–	–	–	–	3.50	TC	[521]
Pb	–	–	–	–	–	3.50	TC	[3211]
Pb	–	–	–	–	–	3.51	TC	[231]
Pb	–	–	–	–	–	3.55	TC	[3211]
Pb	–	–	$\sim 10^{-8}$	298	–	3.58	PE	[4206]
Pb/Si(111)	Pb	–	8×10^{-11}	77{~300}	–	3.6 ± 0.1	CPD	[4400]
Pb	–	–	–	–	–	3.73	TC	[231]
Pb	–	–	–	–	–	3.79	TC	[2005]
Pb	–	–	–	–	–	3.80	TC[3]	[475]
Pb/Ge(111)	–	–	–	–	–	3.81 ± 0.01	TC	[2286]
Pb	–	–	–	–	–	3.82	TC	[2286]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pb/glass[373]	–	–	?	~300	–	3.83 ± 0.02	CPD	[1381]
Pb	–	–	–	–	–	3.84	TC	[230]
Pb	–	–	–	–	–	3.87	TC	[3467]
Pb/ins/Al[47]	Pb	–	?	~300	–	3.89 ± 0.06	CPD	[2028]
Pb/Cu(111)	–	–	–	–	–	3.91	TC	[2286]
Pb	–	–	1×10^{-5}	~300	–	3.92	CPD	[1883]
Pb/Si(111)	Pb	–	1×10^{-10}	78	–	3.92	CPD	[4311]
Pb	–	–	–	–	–	3.92	TC	[2629]
Pb	–	–	?	~300	–	3.92 ± 0.02	TC	[4265]
Pb	–	–	?	~300	–	3.94	CPD	[2297]
Pb/quartz	Pb	–	$\sim10^{-10}$	~300	–	3.95	PE	[2718]
Pb/Cu	Pb	–	$\sim10^{-10}$	~300	–	3.95	PE	[2718]
Pb[374]	–	–	5×10^{-10}	~300	–	3.95 ± 0.05	PE	[3437]
Pb/steel	Pb	–	2×10^{-10}	~300	–	3.95 ± 0.05	PE	[1537]
Pb	–	–	?	~300	–	3.97	PE	[2460]
Pb	–	–	–	–	–	3.98	TC	[1399]
Pb	–	–	$\sim10^{-9}$	293	–	3.98	PE	[2362]
Pb/quartz	Pb	–	$<10^{-6}$	20	–	3.983 ± 0.004	PE	[1467]
Pb/quartz	Pb	–	$<10^{-6}$	20 (90)	–	3.995 ± 0.004	PE	[1467]
Pb	–	–	–	–	–	4.0	TC	[298]
Pb	–	–	–	–	–	4.00	TC	[3352]
Pb/glass[373]	Pb	–	?	~300	–	4.00 ± 0.02	CPD	[1381]
Pb	–	–	? (N_2)	~300	–	4.00 ± 0.02	CPD	[2361,4083]
Pb	–	–	–	–	–	4.01	TC	[3264,3265]
Pb/quartz	Pb	–	$<10^{-6}$	20 (250)	–	4.013 ± 0.004	PE	[1467]
Pb	–	–	?	~300	–	4.05 ± 0.05	CPD	[1542,2334]
Pb	–	–	?	293	–	4.06	PE	[4139]
Pb	–	–	?	~300	–	4.06	PE	[4249]
Pb	–	–	–	–	–	4.09	TC	[553]
Pb	–	–	–	–	–	4.09	TC	[3477]
Pb	–	–	–	–	–	4.1	TC	[1993]
Pb/Ag(111)/mica	Pb	–	2×10^{-10}	~300	–	4.1*	CPD	[3276]
Pb	–	–	–	–	–	4.10	TC	[3211]
Pb	–	–	–	–	–	4.10	TC	[1613]
Pb	–	–	?	597	–	4.11	PE	[4139]
Pb/Cu(100)	Pb	–	?	~300	–	4.11 ± 0.01*	CPD	[1423]
Pb	–	–	–	–	–	4.12	TC	[1885]
Pb	–	–	?	298	–	4.13	PE	[4305]
Pb	–	–	6×10^{-3}	~300	–	4.14 ± 0.07	PE	[2079,2080]
Pb/brass	Pb	–	$\leq10^{-8}$	~300	–	4.14 ± 0.1	PE	[2848]
Pb	–	–	–	–	–	4.18	TC	[3264,3265,3267]
Pb/Al(111)	Pb	–	$<1 \times 10^{-10}$	~300	–	4.2	PE	[249]
Pb/Ni(111)	Pb	–	$<1 \times 10^{-10}$	~300	–	4.2	PE	[249]
Pb	–	–	–	–	–	4.2 ± 0.05	TC	[1990]
Pb/Si(111)	Pb	–	5×10^{-11}	~300	–	4.25 ± 0.05	CPD	[613,636]
Pb/Ni(111)	Pb	–	2×10^{-11}	~300	–	4.3	PE	[2269]
Pb/Cu(111)	Pb	–	?	~300	–	4.34*	CPD	[1423]
Pb	–	–	$\sim6 \times 10^{-9}$	~300	–	4.36	PE	[1139]
Pb/Pt(111)	Pb	–	$<3 \times 10^{-10}$	~300	–	4.39 ± 0.07*	CPD	[2670]
Pb/W(110)	Pb	–	?	~300	–	4.4	CPD	[1984]
Pb/Pt(111)	Pb	–	$<3 \times 10^{-10}$	~300	–	4.4 ± 0.1	CPD	[2670]
Pb/Ni(100)	Pb	–	3×10^{-10}	~300	–	4.4 ± 0.1	CPD	[1439]
Pb/W	Pb	–	$(<1 \times 10^{-11})$	~300 (526)	–	4.40 ± 0.02	FE	[2254]
Pb/Mo(110)	Pb	–	$\leq5 \times 10^{-11}$	550	–	4.45*	CPD	[3290]
Pb/W(110)	Pb	–	5×10^{-11}	~300	–	4.45	CPD	[1525,3588]
Pb/Mo(110)	Pb	–	$\leq5 \times 10^{-11}$	680	–	4.48*	CPD	[3290]
Pb	–	–	–	–	–	4.5	TC	[706]
Pb/W	Pb	–	$(<1 \times 10^{-11})$	~300 (730)	–	4.50 ± 0.02	FE	[2254]
Pb/Mo(110)	Pb	–	$\leq5 \times 10^{-11}$	350 (550)	–	4.50*	CPD	[3290]
Pb/Mo(110)	Pb	–	$\leq5 \times 10^{-11}$	350 (680)	–	4.56*	CPD	[3290]
Pb/W(100)	Pb	–	?	300–800	–	4.56	FE	[2257]
Pb/W(100)	Pb	–	?	77 (415)	–	4.58 ± 0.03*	FE	[2260]
Pb/W(112)	Pb	–	$(<1 \times 10^{-11})$	~300 (526)	–	4.59 ± 0.02	FE	[2254]
Pb/W(100)	Pb	–	$(<1 \times 10^{-11})$	~300 (843)	–	4.59 ± 0.02	FE	[2254]
Pb	–	–	–	–	–	4.64	TC	[3467]
Pb/Si(111)	Pb	–	$<8 \times 10^{-11}$	100 (600)	–	4.68*	PE	[2445]
Pb/W(100)	Pb	–	$(<1 \times 10^{-11})$	~300 (463)	–	4.68 ± 0.02	FE	[2254]
Pb/W	Pb	–	$\leq5 \times 10^{-10}$	300 (520)	–	4.70 ± 0.05	FE	[3548]
Pb/W(100)	Pb	–	?	77 (415)	–	4.71 ± 0.01	FE	[2260]
Pb/W(112)	Pb	–	$<8 \times 10^{-11}$	80	–	4.72 ± 0.01	FE	[3959]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pb/W(112)	Pb	–	($<1 \times 10^{-11}$)	~300 (730)	–	4.74 ± 0.02	FE	[2254]
Pb	–	–	–	–	–	4.76	TC	[3477]
Pb	–	–	–	–	–	4.84	TC	[2629]
Pb/W(110)	Pb	–	($<1 \times 10^{-11}$)	~300 (≤658)	–	4.94 ± 0.02	FE	[2254]
Recommended	–	–	–	–	–	**4.07 ± 0.05**	–	–

Liquid ($T > 601$ K)

Pb[374]	–	–	8×10^{-10}	~700	–	3.95 ± 0.05	PE	[3437]
Pb	–	–	?	617	–	4.04	PE	[4139]

83. Bismuth Bi

Rhombohedral (arsenic structure)

Bi(0001)	–	–	~10^{-7}	~300	–	4.35 ± 0.02	PE	[2807]
Bi(0001)	–	–	5×10^{-10}	100, ~300	–	4.5*	PE	[2480]
Bi(0001)	–	–	~10^{-6}	~300	–	4.81 ± 0.02	PE	[2807]
Bi(1011)	–	–	5×10^{-10}	100, ~300	–	4.3*	PE	[2480]
Bi	–	–	–	–	–	3.77	TC	[1744]
Bi/Pt(111)	Bi	–	?	110–625	–	3.8 ± 0.1*	CPD	[2868]
Bi/ins/Al[47]	Bi	–	?	~300	–	3.85 ± 0.07	CPD	[2028]
Bi	–	–	–	–	–	3.92	TC	[2005]
Bi/Au(111)[375]	Bi	–	$<5 \times 10^{-10}$	298	–	3.94*	CPD	[3678]
Bi	–	–	–	–	–	4.1	TC	[298]
Bi	–	–	–	–	–	4.1	TC	[706]
Bi	–	–	–	–	–	4.12	TC	[1885]
Bi	–	–	?	~300	–	4.14	PE	[2080]
Bi	–	–	?	~300	–	4.17	CPD	[2297]
Bi	–	–	?	~300	–	4.17	PE	[4249]
Bi/quartz	Bi	–	$<10^{-6}$	6.5–12.5	–	4.1746	PE	[1467]
Bi/quartz	Bi	–	$<10^{-6}$	20	–	4.2160	PE	[1467]
Bi/glass	Bi	–	$<10^{-9}$	90	–	4.22	PE	[1383,1389,3038, 3052]
Bi/Au(111)	Bi	–	2×10^{-10}	~300	–	4.22	PE	[4448]
Bi	–	–	–	–	–	4.22	TC	[4418,4420]
Bi/glass	Bi	–	$<10^{-9}$	90	–	4.223	PE	[3038]
Bi/glass	Bi	–	2×10^{-8}	297–299	–	4.23 ± 0.01	PE	[2234]
Bi/quartz	Bi	–	$<10^{-6}$	20 (270)	–	4.2348	PE	[1467]
Bi/glass	Bi	–	≤10^{-7}	90	–	4.243	PE	[3040]
Bi/glass[376]	Bi	–	$<10^{-9}$	90 (293)	–	4.245	PE	[3038]
Bi/glass[376]	–	–	–	–	–	4.25	TC	[1403]
Bi/glass	Bi	–	$<10^{-9}$	90 (363)	–	4.25	PE	[1383]
Bi[377]	–	–	5×10^{-10}	~300	–	4.25 ± 0.05	PE	[3437]
Bi/glass	Bi	–	≤10^{-7}	90	–	4.251	PE	[3040]
Bi/glass	Bi	–	$<10^{-9}$	90 363)	–	4.26	PE	[1389]
Bi/Ni, etc.	Bi	–	$<5 \times 10^{-8}$	~300	–	4.26	PE	[1375]
Bi/InAs(111)[n]	Bi	–	?	~300 (503)	–	4.28	PE	[4090]
Bi/glass	Bi	–	$<10^{-9}$	293{90}	–	4.288	PE	[3038]
Bi	–	–	–	–	–	4.29	TC	[3264,3265]
Bi	–	–	–	–	–	4.29	TC	[1399]
Bi	–	–	–	–	–	4.3	TC	[1993]
Bi	–	–	–	–	–	4.3	TC	[1955]
Bi	–	–	–	–	–	4.3 ± 0.05	TC	[1990]
Bi/glass	Bi	–	≤10^{-7}	293	–	4.307	PE	[3040]
Bi	–	–	–	–	–	4.32	TC	[3352]
Bi	–	–	? (N_2)	~300	–	4.32 ± 0.02	CPD	[2361,4083]
Bi/Mo, etc.	Bi	–	$<5 \times 10^{-8}$	~300	–	4.34	PE	[1375]
Bi	–	–	?	293	–	4.35	PE	[4139]
Bi	–	–	–	–	–	4.36	TC	[3264,3267]
Bi/glass[376]	Bi	–	$<10^{-9}$	90 (293)	–	4.370	PE	[3038]
Bi	–	–	?	534	–	4.39	PE	[4139]
Bi/W	Bi	–	5×10^{-10}	~300	–	4.40	FE	[2018]
Bi/glass	Bi	–	?	~300	–	4.43	PE	[3397]
Bi/glass	Bi	–	?	20, 77	–	4.44	PE	[3028]
Bi/W(100)	Bi	–	?	77 (415)	–	4.45 ± 0.04*	FE	[2260]
Bi/W	Bi	–	≤10^{-10}	~300{700}	–	4.5	FE	[2966]
Bi/glass	Bi	–	$<10^{-9}$	90 (363)	–	4.54	PE	[1389]
Bi/W(100)	Bi	–	?	77 (415)	–	4.58 ± 0.03	FE	[2260]
Bi/glass[376]	–	–	–	–	–	4.6	TC	[1403]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Bi/glass	Bi	–	?	220–298	–	4.76–5.06	PE	[3395]
Bi/glass	Bi	–	?	220–298	–	4.82–5.03	PE	[3395]
Bi[378]	–	–	?	<544	–	4.86*	CPD	[1755]
Bi/glass	Bi	–	?	195–295	–	4.969 ± 0.011	PE	[3398]
Recommended	–	–	–	–	–	**4.28 ± 0.05**	–	–

Liquid (T > 544 K)

Bi[377]	–	–	8×10^{-10}	~640	–	4.25 ± 0.05	PE	[3437]
Bi	–	–	≤10^{-9}	573	–	4.34 ± 0.05	PE	[2349,2353]
Bi	–	–	?	554	–	4.42	PE	[4139]
Bi[378]	–	–	?	>544	–	4.88*	CPD	[1755]

84. Polonium Po

Cubic (α, T < 348 K for bulk)

Po[160]	–	–	–	–	–	4.6	TC	[1355]
Po[379]	–	–	–	–	–	4.8	TC	[1955]
Po	–	–	–	–	–	5.0	TC	[298]

85. Astatine At

At	–	–	–	–	–	5.3		[1955]

87. Francium Fr

bcc

Fr(111)	–	–	–	–	–	2.13	TC	[2410]
Fr[160]	–	–	–	–	–	1.5	TC	[1355]
Fr[379]	–	–	–	–	–	1.8	TC	[1955]
Fr	–	–	–	–	–	2.0	TC	[298]
Fr	–	–	–	–	–	2.01	TC	[550]
Fr	–	–	–	–	–	2.02	TC	[550]
Fr	–	–	–	–	–	2.14	TC	[550]

88. Radium Ra

bcc

Ra(110)	–	–	–	–	–	2.25	TC	[334]
Ra(111)	–	–	–	–	–	2.03	TC	[2410]
Ra	–	–	–	–	–	2.0	TC	[3928]
Ra[379]	–	–	–	–	–	2.2*	TC	[1955]
Ra[379]	–	–	–	–	–	2.4	TC	[1955]
Ra	–	–	–	–	–	2.78	TC	[550]
Ra	–	–	–	–	–	2.8	TC	[298]
Ra	–	–	–	–	–	3.23	TC	[550]

89. Actinium Ac

fcc

Ac(111)	–	–	–	–	–	3.44	TC	[2410]
Ac[379]	–	–	–	–	–	2.7	TC	[1955]
Ac	–	–	–	–	–	3.0	TC	[3928]
Ac	–	–	–	–	–	3.20	TC	[550]
Ac	–	–	–	–	–	3.38	TC	[550]
Ac	–	–	–	–	–	3.58	TC	[298]

90. Thorium Th

fcc (α, T < 1623 K)

Th(100)	–	–	–	–	–	3.52	TC	[1254]
Th(100)	–	–	–	–	–	3.57	TC	[1980]
Th(110)	–	–	–	–	–	3.38	TC	[1980]
Th(111)	–	–	–	–	–	3.44	TC	[2410]
Th(111)	–	–	–	–	–	3.75	TC	[1980]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Th/Pt	Th	–	?	~1500	–	2.40	TE	[1306]
Th/Ta	Th	–	?	~1500	–	2.54	TE	[1306]
Th/ThO₂-W[380]	–	–	?	~1300 (2200)	–	2.63	TE	[1749,1750]
Th/ThO₂-W[380]	–	–	?	1230 (1920)	–	2.64	TE	[3667,3668]
Th/ThO₂-W	–	–	?	~1300–2500	–	2.7	TE	[3652]
Th/Ta	Th	–	2×10^{-8}	1468	–	2.73	TE	[2566]
Th/ThO₂-W	–	–	1×10^{-9}	~1800 (~2800)	–	2.75 ± 0.15	FE	[3050]
Th/ThO₂-W	–	–	~10^{-8}	~900–1200	–	2.77	TE	[196]
Th/ThO₂-W	–	–	?	1160–1600	–	2.77	TE	[2925]
Th/ThO₂-W	–	–	~10^{-7}	?	(3.3*)	2.8 ± 0.1	TE	[216]
Th/ThO₂-W	–	–	~10^{-8}	~900–1200	–	2.82	TE	[196]
Th/ThO₂-W	–	–	<10^{-7}	~1300 (2040)	–	2.91	TE	[3800]
Th	–	–	<10^{-6}	?	–	2.94	TE	[2919]
Th[174]	–	–	–	0[E]	–	2.94	TC	[1747]
Th(foil)[381]	–	–	<10^{-10}	~300	–	2.988 ± 0.008	CPD	[2932]
Th/W	–	–	?	?	–	3.0	TE	[2459]
Th/ThO₂-W	–	–	<10^{-7}	~1300 (2040)	–	3.0	TE	[3800]
Th/W(111)	Th	–	?	~300	–	3.0	FE	[2574]
Th/W	Th	–	≤3×10^{-9}	~300	–	3.0	FE	[218]
Th/Re–Th(2%)	–	–	10^{-8}	1600	–	3.09	TE	[4252]
Th/ThO₂-W	–	–	?	~1250–1600	–	3.1	TE	[3801]
Th	–	–	–	–	–	3.1	TC	[1744]
Th/W	–	–	–	1400	–	3.1	TC	[3271]
Th/W	Th	–	≤7×10^{-8}	~300	–	3.1	FE	[1804]
Th/ThO₂-W	–	–	?	0[E]	–	3.18–3.60	CPD	[3972]
Th/ThO₂-W	–	–	<10^{-9}	~1300 (2040)	–	3.26	TE	[3800]
Th	–	–	–	–	–	3.28	TC	[550]
Th/W(foil)	Cl	Cl⁻	2×10^{-7}	1721–1831	3.29 ± 0.16[N]	–	NSI	[597]
Th/ThO₂-W	KCl	K⁺	≤1×10^{-6}	1800	3.3*	(2.8 ± 0.1)	PSI	[216]
Th	–	–	4×10^{-10}	~300	–	3.3 ± 0.2	PE	[3132]
Th/ThO₂-W	–	–	?	1230 (1920)	–	3.3 ± 0.2	TE	[3668]
Th/Re	Th	–	~10^{-10}	1354	–	3.31	TE	[165]
Th/W	Th	–	≤3×10^{-9}	~1500–1800	–	3.31 ± 0.02	TE	[218]
Th/Re(0001)	–	–	–	–	–	3.33	TC	[3848]
Th/W	Th	–	5×10^{-9}	1150–1540	–	3.34	TE	[1453]
Th[382]	–	–	–	–	–	3.35	TC	[1759]
Th/ThO₂-Mo,Pt	–	–	<1×10^{-6}	~1100–1700	–	3.35	TE	[3035]
Th	–	–	?	?	–	3.36	?	[1761]
Th/W(114)	Th	–	~10^{-10}	1360	–	3.36 ± 0.02	TE	[1394,1854]
Th/Ni	Th	–	?	~300	–	3.38	PE	[2922]
Th	–	–	?	?	–	3.39	TE	[1844]
Th/W	ThI₄	–	?	~300 (?)	–	3.39	PE	[2927]
Th/W(114)	Th	–	~10^{-10}	1118	–	3.39 ± 0.02	TE	[1394,1854]
Th	–	–	–	–	–	3.4	TC	[2456]
Th/ThO₂-W	K	K⁺	≤1×10^{-6}	1800	3.4*	(2.8 ± 0.1)	PSI	[216]
Th	–	–	?	?	–	3.4	TE	[3402]
Th/W	–	–	–	–	–	3.4	TC	[509]
Th/W(110)	Th	–	<10^{-8}	~1300–1500	–	3.4	TE	[148]
Th/W(111)	Th	–	<10^{-8}	~1350–1500	–	3.4	TE	[148]
Th/ThO₂-W	–	–	<10^{-7}	~1300 (2040)	–	3.40	TE	[3800]
Th[382]	–	–	–	–	–	3.41	TC	[2932]
Th/W	Th	–	<10^{-9}	~300	–	3.42	FE	[3529]
Th[382]	–	–	–	–	–	3.44	TC	[2932]
Th/Mo, Pt[383]	–	–	–	–	–	3.44	TC	[2932]
Th	–	–	?	~300	–	3.44	PE	[2924]
Th/W	Th	–	<10^{-10}	~300	–	3.44 ± 0.01	CPD	[13,349]
Th/W(100)	Th	–	≤3×10^{-9}	~1200	–	3.45	TE	[1854]
Th[382]	–	–	?	1250–1800	–	3.45 ± 0.01	TE	[3524,3525]
Th/ThO₂W[381]	Th	–	<10^{-10}	~300	–	3.455 ± 0.012	CPD	[2932]
Th	–	–	?	~300	–	3.46	CPD	[2297]
Th/ThO₂-W	–	–	~10^{-7}	~1300–2000	(3.60*[N])	3.46	TE	[827]
Th/W	Th	–	<10^{-10}	~300	–	3.460 ± 0.010	CPD	[2938]
Th/Ni	Th	–	?	~300	–	3.47	PE	[2927]
Th/W(100)	–	–	–	–	–	3.5	TC	[913,4344]
Th/ThO₂-W	–	–	?	~1000 (?)	–	3.5 ± 0.5	TE	[3973]
Th	–	–	–	–	–	3.52	TC	[1254]
Th/ThO₂-W[383]	–	–	?	1260 (≥1300)	–	3.55	TE	[872]
Th/ThO₂-Pt[383]	–	–	?	1260 (≤1650)	–	3.55	TE	[872]
Th	–	–	?	~300	–	3.57	PE	[2080]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Th/ThO$_2$-W	I	I$^-$	~10^{-7}	1422	3.58*[N]	(3.46)	NSI	[827]
Th/W(100)	Th	–	6×10^{-11}	~300	–	3.6*	CPD	[2825]
Th/ThO$_2$-W	–	–	≤3×10^{-9}	2000 (2700)	–	3.6	TE	[3960]
Th/ThO$_2$-W	I$_2$	I$^-$	~10^{-7}	1405	3.60*[N]	(3.46)	NSI	[827]
Th/W[383]	–	–	–	–	–	3.61	TC	[2932]
Th	–	–	?	~300	–	3.66	PE	[3027]
Th	–	–	<10^{-10}	~300	–	3.71 ± 0.01	CPD	[13,349]
Th(foil)[381]	–	–	<10^{-10}	~300 (1900)	–	3.728 ± 0.010	CPD	[2932]
Th/Ta	Th	–	2×10^{-8}	1214	–	3.83	TE	[2566]
Recommended	–	–	–	–	–	**3.37 ± 0.04**	–	–

91. Protactinium Pa

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pa(111)	–	–	–	–	–	3.76	TC	[2410]
Pa[160]	–	–	–	–	–	3.3	TC	[1355]
Pa	–	–	–	–	–	3.3	TC	[1955]
Pa	–	–	–	–	–	3.5	TC	[1955]
Pa	–	–	–	–	–	3.73	TC	[550]

92. Uranium U[400]

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
bcc (γ, $T > 1050$ K)								
U(100)	–	–	–	–	–	3.49	TC	[321]
U(100)	–	–	–	–	–	3.60	TC	[2180]
U(100)	–	–	–	–	–	3.82	TC	[2180]
U(110)	–	–	–	–	–	4.07	TC	[321]
U(111)	–	–	–	–	–	3.33	TC	[321]
U(112)	–	–	–	–	–	3.72	TC	[321]
Rhombic (α, $T < 940$ K for bulk)								
U	–	–	–	–	–	2.94	TC	[1744]
U (foil)	–	–	<5×10^{-11}	~300	–	3.080 ± 0.005	CPD	[2933]
U/W	U	–	<8×10^{-12}	~300	–	3.181 ± 0.013	CPD	[1161]
U/W	U	–	<5×10^{-11}	~300	–	3.19 ± 0.01	CPD	[13,349,2939]
U/W	U	–	<5×10^{-11}	~300	–	3.203 ± 0.013	CPD	[2933]
U (foil)	–	–	≤10^{-10}	~300–938	–	3.47 ± 0.01	PE	[1884]
U	–	–	4×10^{-10}	~300	–	3.5	PE	[3124]
U	–	–	5×10^{-9}	~300	–	3.5 ± 0.03	FE	[3110]
U	–	–	4×10^{-10}	~300	–	3.5 ± 0.1	PE	[3132]
U/W	U	–	<2×10^{-10}	295	–	3.56 ± 0.05	FE	[1657]
U/W(116)	U	–	<1×10^{-10}	295	–	3.57 ± 0.03	FE	[1664]
U/W(113)	U	–	<1×10^{-10}	295	–	3.60 ± 0.03	FE	[1664]
U/W	U	–	<2×10^{-10}	295	–	3.60 ± 0.03	FE	[1654,1655,1657]
U/Ni	U	–	?	~300	–	3.63	PE	[2922]
U/W	U	–	<2×10^{-10}	~300–940	–	3.63 ± 0.01	CPD	[1476,1484,2103]
U/W(111)	U	–	<1×10^{-10}	295	–	3.64 ± 0.03	FE	[1664]
U/W	U	–	<2×10^{-10}	295–900	–	3.65 ± 0.01	PE	[2467]
U/W(113)[408]	U	–	<5×10^{-10}	~300	–	3.66 ± 0.03	PE	[2471]
U/W(113)[408]	U	–	<5×10^{-10}	~300	–	3.67 ± 0.03	CPD	[2471]
U/W	–	–	–	–	–	3.68	TC	[2478]
U/W(112)	U	–	<1×10^{-10}	295	–	3.70 ± 0.03	FE	[1664]
U/W(100)[408]	U	–	<5×10^{-10}	~300	–	3.73 ± 0.02	CPD	[2471]
U/W(100)[408]	U	–	<5×10^{-10}	~300	–	3.73 ± 0.02	PE	[2471]
U/W(113)[408]	U	–	<5×10^{-10}	~300	–	3.73 ± 0.04	CPD	[2471]
U/W(100)[408]	U	–	<5×10^{-10}	~300	–	3.78 ± 0.03	CPD	[2471]
U/W(100)	U	–	?	~300	–	3.80 ± 0.03	CPD	[3076]
U/W(100)	U	–	<1×10^{-10}	295	–	3.88 ± 0.03	FE	[1664]
U/W(110)	U	–	?	~300	–	3.90 ± 0.03	CPD	[3076]
U/W(110)[408]	U	–	<5×10^{-10}	~300	–	3.90 ± 0.03	CPD	[2471]
U/W(110)[408]	U	–	<5×10^{-10}	~300	–	3.90 ± 0.03	PE	[2471]
U	–	–	–	–	–	3.97	TC	[550]
U/W(110)[408]	U	–	<5×10^{-10}	~300	–	4.00 ± 0.04	CPD	[2471]
U/W(110)	U	–	<1×10^{-10}	295	–	4.04 ± 0.03	FE	[1664]
U	–	–	?	~300	–	4.32 ± 0.05	CPD	[2297]
Recommended	–	–	–	–	–	**3.64 ± 0.04**	–	–

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Tetragonal (β, $T \simeq$ 940–1050 K for bulk)								
U/W	U	–	$<2 \times 10^{-10}$	1040	–	3.05 ± 0.03	FE	[1657]
U/W(111)	U	–	$<1 \times 10^{-10}$	950	–	3.36 ± 0.03	FE	[1664]
U(foil)	–	–	$\leq 10^{-10}$	940–1040	–	3.52 ± 0.01	PE	[1884]
U/W	U	–	$<1 \times 10^{-10}$	~1000	–	3.53 ± 0.03	FE	[1654,1655,1657]
U/W	U	–	$<2 \times 10^{-10}$	950–1050	–	3.58 ± 0.01	CPD	[1484]
U/W	U	–	$<2 \times 10^{-10}$	940–1030	–	3.59 ± 0.01	PE	[2467]
U/W(100)	U	–	$<1 \times 10^{-10}$	950	–	3.61 ± 0.03	FE	[1664]
U/W(112)	U	–	$<1 \times 10^{-10}$	960	–	3.64 ± 0.03	FE	[1664]
U/W(110)	U	–	$<1 \times 10^{-10}$	950	–	3.99 ± 0.03	FE	[1664]
Recommended	–	–	–	–	–	**3.58 ± 0.04**	–	–
bcc (γ, $T >$ 1050 K for bulk)								
U/W	U	–	?	?	–	2.84	TE	[1750]
U/W[384]	U	–	$<6 \times 10^{-10}$	1250–1400	–	3.0	TE	[232]
U/W[386]	U	–	$<2 \times 10^{-10}$	~1000–1300	–	3.14 ± 0.02	TE	[1484]
U/W[385]	U	–	$\sim 10^{-10}$	1250	–	3.2*	TE	[2098]
U(wire)[388]	–	–	$\sim 10^{-8}$	~950–1300	–	3.27 ± 0.05	TE	[2085,3961]
U[174,387]	–	–	–	0^E	–	3.28	TC	[1747]
U/W(112)	U	–	$<1 \times 10^{-10}$	1120	–	3.29 ± 0.03	FE	[1664]
U/W(111)	U	–	$<1 \times 10^{-10}$	1120	–	3.31 ± 0.03	FE	[1664]
U/W[386]	–	–	–	1400	–	3.36 ± 0.04	TC	[1484]
U/W[384]	–	–	–	1400	–	3.38	TC	[1484]
U(foil)	–	–	$\leq 10^{-10}$	1040–1060	–	3.39 ± 0.01	PE	[1884]
U/W	U	–	$<2 \times 10^{-10}$	~1200–1400	–	3.4 ± 0.2	FE	[1657]
U[387]	–	–	–	1100	–	3.42*	TC	[1747]
U/W[386]	U	–	$<2 \times 10^{-10}$	~1000–1400	–	3.42 ± 0.04	TE	[1484]
U/W	U	–	$<1 \times 10^{-10}$	1200	–	3.43 ± 0.03	FE	[1654]
U/W(116)	U	–	$<1 \times 10^{-10}$	1120	–	3.43 ± 0.03	FE	[1664]
U/W[386]	–	–	–	1400	–	3.44 ± 0.03	TC	[Here]
U/W[388]	–	–	–	–	–	3.45	TC	[2467]
U/W	U	–	$<2 \times 10^{-10}$	1060–1200	–	3.45 ± 0.01	PE	[2467]
U/W[386]	–	–	–	1400	–	3.45 ± 0.1	TC	[1484]
U/W[386]	U	–	$\leq 10^{-5}$ (H$_2$)	~1000–1400	–	3.46 ± 0.02	TE	[1484]
U/W[384]	U	–	$<5 \times 10^{-10}$	~1250–1400	–	3.47 ± 0.03	TE	[232,2930]
U/W[384]	–	–	–	1400	–	3.48 ± 0.03	TC	[1484]
U/W[385]	–	–	–	1250	–	3.5*	TC	[Here]
U/W	U	–	$<2 \times 10^{-10}$	~1050–1500	–	3.53 ± 0.01	CPD	[1484]
U/Mo	U	–	5×10^{-11}	1275	–	3.53 ± 0.01	TE	[2644]
U/W(113)	U	–	$<1 \times 10^{-10}$	1120	–	3.53 ± 0.03	FE	[1664]
U/Mo	U	–	5×10^{-11}	~1100–1300	–	3.54	TE	[2644]
U(wire)[388]	–	–	–	–	–	3.56 ± 0.05	TC	[2467]
U/W(100)	U	–	$<1 \times 10^{-10}$	1120	–	3.82 ± 0.03	FE	[1664]
U/W(110)	U	–	$<1 \times 10^{-10}$	1120	–	4.00 ± 0.03	FE	[1664]
U(wire)	F$_2$	UF$_6^-$	5×10^{-5}(F$_2$)	1140–1290	4.20 ± 0.14^N	–	NSI	[2630]
Recommended	–	–	–	–	–	**3.42 ± 0.05**	–	–

93. Neptunium Np

Np(111)	–	–	–	–	–	4.00	TC	[2410]
Np	–	–	–	–	–	2.8	TC	[1955]
Np	–	–	–	–	–	3.90	TC	[550]

94. Plutonium Pu

Monoclinic (α, $T <$ 398 K)								
Pu(020)	–	–	–	–	–	3.51	TC	[1448]
Pu(020)	–	–	–	–	–	3.62	TC	[1448]
fcc (δ, $T =$ 593–736 K)								
Pu(100)	–	–	–	–	–	2.97 ± 0.05	TC	[3488]
Pu(100)	–	–	–	–	–	3.01 ± 0.06j	TC	[3488]
Pu(100)	–	–	–	–	–	3.05 ± 0.03	TC	[3488]
Pu(100)	–	–	–	–	–	3.11	TC	[2069]
Pu(100)	–	–	–	–	–	3.14 ± 0.01	TC	[2549]
Pu(100)	–	–	–	–	–	3.43 ± 0.06	TC	[3488]
Pu(100)	–	–	–	–	–	3.44 ± 0.06	TC	[3488]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
Pu(100)	–	–	–	–	–	3.5	TC	[2172]
Pu(100)	–	–	–	–	–	3.68	TC	[2172]
Pu(100)	–	–	–	–	–	3.7	TC	[1870]
Recommended	–	–	–	–	–	**3.3 ± 0.2**	–	–
Pu(110)	–	–	–	–	–	2.99	TC	[2069]
Pu(111)	–	–	–	–	–	2.85 ± 0.20	TC	[3012,3013]
Pu(111)	–	–	–	–	–	3.260	TC	[1446–1448]
Pu(111)	–	–	–	–	–	3.32	TC	[1447]
Pu(111)	–	–	–	–	–	3.41	TC	[2069,2070]
Pu(111)	–	–	–	–	–	3.488	TC	[1446]
Pu(111)	–	–	–	–	–	3.49	TC	[1448]
Pu(111)	–	–	–	–	–	3.98	TC	[2410]
Pu(111)	–	–	–	–	–	4.14	TC	[2172]
Pu(111)	–	–	–	–	–	4.3	TC	[2165]
Pu(111)	–	–	–	–	–	8.4	TC	[2165]
Recommended	–	–	–	–	–	**3.8 ± 0.3**	–	–
Monoclinic (α, $T < 398$ K for bulk)								
Pu	–	–	–	–	–	3.3	TC	[1955]
fcc (δ, $T = 593$–736 K for bulk)								
Pu	–	–	–	–	–	3.1–3.3	TC	[1833,1841]
Pu	–	–	–	–	–	3.72	TC	[550]
Pu	–	–	–	–	–	3.89	TC	[550]

95. Americium Am

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
dhcp (α, $T < ?$ K)								
Am(0001)	–	–	–	–	–	2.90	TC	[2075]
Am(0001)	–	–	–	–	–	4.35	TC	[321]
Am(1010)	–	–	–	–	–	4.21	TC	[321]
Am(1124)	–	–	–	–	–	3.70	TC	[321]
fcc (β, $T = ?$–$?$ K)								
Am(100)	–	–	–	–	–	2.93	TC	[2071,2076]
Am(110)	–	–	–	–	–	2.86	TC	[2071,2076]
Am(111)	–	–	–	–	–	3.06	TC	[2071,2076]
hcp (α, $T < ?$ K for bulk)								
Am	–	–	–	–	–	3.3	TC	[1955]
Am	–	–	–	–	–	3.33	TC	[550]
Am	–	–	–	–	–	3.7	TC	[550]

96. Curium Cm

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp								
Cm	–	–	–	–	–	3.3	TC	[1955]
Cm	–	–	–	–	–	3.32	TC	[550]
Cm	–	–	–	–	–	3.9	TC	[550]

97. Berkelium Bk

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp								
Bk	–	–	–	–	–	3.3	TC	[1955]
Bk	–	–	–	–	–	3.37	TC	[550]
Bk	–	–	–	–	–	3.8	TC	[550]

98. Californium Cf

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
hcp								
Cf	–	–	–	–	–	3.3	TC	[1955]
Cf	–	–	–	–	–	3.38	TC	[550]
Cf	–	–	–	–	–	4.0	TC	[550]

Table 1 (*continued*)

Surface	Beam	Ion	P_r (Torr)	T (K)	ϕ^+ (eV)	ϕ^e (eV)	Meth.	Refs.
				99. Einsteinium Es				
fcc								
Es	–	–	–	–	–	2.88	TC	[550]
Es	–	–	–	–	–	3.3	TC	[550]

[1] The Li films at 3–5 or 4–6 monolayers on W(110) and Mo(110) are suggested to have the (110) bcc orientation at 300 K, in contrast to the (0001) rhombohedral one at 77 K [3361].

[2] The value of 2.32 ± 003 eV for Li/glass [349] is based on the correction [349] of 2.49 ± 0.02 eV [1374] by taking $\phi^e = 2.35 \pm 0.03$ eV [349] instead of 2.52 eV [1374] as the reference work function of Ba.

[3] For further information about the theoretical calculation [475] and comparison between the calculated values [475] and the recommended ones for Li, Na, Mg, Al, K, Zn, Rb, Cs and Pb in Table 2 [Here], see Section 6.

[4] The Be-films on mica ($\phi^e = 4.98$ eV) [2009] and on glass (5.08 eV) [1782] presumably consist, to a considerable extent, of the (0001) surface [2025], which is generally expected to have 5.27 ± 011 eV (see Table 2).

[5] The values of $\phi^e = 2.9$ and 3.6 eV for C(100)^B correspond to the diamond cone-height to -radius ratios of $\beta = h/r = 700$ and 1000, respectively [2751].

[6] The work function of C(100)^B [1830] changes from 5.3 to 5.7 eV as the boron content increases from 10^{16} to 10^{20} atoms/cm^3.

[7] As the mean grain size (S_d) of diamond prepared by electrophoresis onto a Mo-sheet [544,4059] increases from 0.32 to 3.9 and to 108.0 μm, the surface area (A_d) of the (111) plane on the film increases from 76 to 92 and to 99%, thereby changing in ϕ^e from 5.1 to 3.2 and to 4.8 eV, respectively, determined by PE [544,4059]. Similarly, other films with (S_d, A_d) = (0.25, ~76), (3, ~88) and (6, ~96) on another Mo-sheet are found to have $\phi^e = 3.8$, 3.3 and 3.2 eV, respectively, done by PE [1205].

[8] By the same way as above (Footnote 7), the diamond films on Mo-tips [1205] having (S_d μm, A_d%) = (0.25, 76), (3, ~88) and (6, ~96) are observed to have $\phi^e = 3.8$, 3.5 and 3.4 eV, respectively, determined by FE [1205]. The first value of 3.8 eV on the tip is equal to that for the film of (0.25, ~76) on a Mo-sheet [1205] (see Footnote 7).

[9] For both systems of C/Si and C/Mo prepared by dielectrophoresis [3568], ϕ^e is found to have 3.7 and 7.1 eV for thin and thick diamond films, respectively.

[10] This diamond-like-carbon having 4.1 eV [2230] is formed on a tungsten tip by electro-deposition in methanol. For further information, see Ref. [3938].

[11] This is the mean value calculated for C(0001), whose ϕ^e ranges from 4.44 to 5.23 eV depending complicatedly upon the slab thickness of 1–14 [1174].

[12] The value of 3.93 eV for a freshly prepared monocrystalline graphite decreases to 3.25 eV after exposing to air [2581].

[13] The specimens of C(HOPG) cleaved in air and vacuum [3215] have different values of $\phi^e = 4.7$ and 5.0 eV, respectively.

[14] The sample of C/Si having $\phi^e = 4.2$ or 4.3 eV [1611] is used as received from other workers, but ϕ^e is decreased from 4.2 to 4.0 eV by annealing in vacuum at ~770 K [1611].

[15] By incidence of C_6H_6 upon a heated Re foil, graphitic layers ($\phi^e = 4.4 \pm 0.3$ eV) are formed at $T < 1900$ K, above which carbidic ones (5.25 eV) are done [407,408].

[16] The surface of C/Pt–W(8%) ($\phi^+ = 4.42$ eV) at 1290 K has the ionization efficiency (β^+) of 50% for the incident K atoms, but only $\beta^+ = 1$% for KI molecules [1299], thereby suggesting that the degree of dissociation (γ) of KI is greatly decreased on the graphitic carbon surfaces, in contrast to carbidic or carbon-free metal surfaces (see Section 4.2.4 [1351]).

[17] The surface of C/Mo [791] having $\phi^e = 4.71$ or 4.73 eV is due to carbon contamination, and its ϕ^e is reduced to 4.28 or 4.33 corresponding to an essentially clean Mo surface after it is heated in O_2 [791].

[18] The surface consisting of carbon layers sputtered onto an Al–Mg alloy disk [2743] changes in ϕ^e from 4.79 eV (unlubricated) to 5.32 eV (lubricated) as proceeding to saturation.

[19] The values of 4.81 and 5.23 eV are calculated for mono- and dilayers of graphite, respectively [296].

[20] The values of 5.8 and 5.85 eV for graphite are estimated from Fig. 2 [1735] by other workers [291,3223].

[21] The value of 4.73 eV corresponding to graphene [767] is determined from the linear relationship between the work function of semiconducting single-walled carbon nanotubes and their inverse diameter ($1/d$) after extrapolation of $d \to \infty$, whilst 4.84 eV [767] is done similarly from metallic tubes.

[22] On the basis of the calculated data on $\phi^e = 4.85$ and 5.54 eV for Ag(111) and Au(111) [233], the systems of C_{60}-monolayer adsorbed on Ag(111) and Au(111) are determined, respectively, to have 4.96 and 4.94 eV evaluated from the work function changes ($\Delta\phi_\mu = +0.11$ and -0.60 eV) calculated from the changes in the surface dipole moment ($\Delta\mu = +0.24$ and -1.37 debye) induced by adsorption of C_{60} [233]. Direct calculation made for the respective systems yields $\phi^e = 4.99$ and 4.96 eV [233]. The four values agree excellently with each other irrespective of the differences in both calculation method and substrate species, and also do well with 4.87 ± 0.06 eV recommended for C_{60} in Table 2 [Here]. In addition by taking $\Delta\phi_\mu = -0.09$ eV due to $\Delta\mu = -0.21$ debye [233] and $\phi^e = 4.94$ eV determined for Cu(111) [316], C_{60}/Cu(111) is calculated to have $\phi^e = 4.85$ eV, which agrees exactly with 4.86 determined by PE [316].

[23] The monolayer of C_{60} on Ru(111) is stable ($\phi^e = 5.05$ eV) until ~750 K, above which C_{60} is decomposed to graphitic carbon remaining on Rh(111) at ~1000–1300 K [1007].

[24] By doping N and B (1–2% in concentration), the pristine tube is calculated to change in ϕ^e from ~4.5 to ~3.9 and ~5.2 eV, respectively, each value of which fluctuates dependently upon the tube diameter (~0.5–1 nm), in a narrow range of about ±0.1 eV [1168].

[25] The value of $\phi^e_{PE} = 4.62 \pm 0.06$ eV determined for the single-walled cnt/Si(111) system by PE is smaller than $\phi^e_{CPD} = 4.97 \pm 0.07$ and 4.86 ± 0.10 eV done by CPD-measurements before and after the PE-measurement, respectively [3246]. The same tendency that ϕ^e_{PE} is always smaller than ϕ^e_{CPD} even after PE-measurement is found also for several metal/cnt/Si(111) systems having Pd, Ag, Pt and Au [3246]. Typically for Pt/sw-cnt/Si(111), the successive measurements by CPD, PE and CPD yield $\phi^e_{CPD} = 5.46$ eV, $\phi^e_{PE} = 5.12$ eV and $\phi^e_{CPD} = 5.39$ eV, showing that ϕ^e_{CPD} decreases after PE-measurement and also ϕ^e_{PE} is smaller than both of ϕ^e_{CPD}. For further information, see Section 2.8.2.

[26] For the system of cnt/Si(111) treated with HNO_3 acid, ϕ^e_{CPD} by CPD-measurement is decreased from 5.01 to 4.94 eV by exposure of UV during PE-measurement [3246], quite similarly to the normal system free from the acid treatment (see Footnote 25 just above).

[27] The open-ended tubes at mouth before and after relaxation are calculated to have slightly different values of 4.86 and 4.95 eV, respectively, whilst those at the first neighbor to the mouth are done similarly to have different ones (5.25 and 5.20 eV) according to the relaxation [3570].

[28] The value of 5.08 eV calculated for a perfect tip of chirality (5, 5) is considered [3570] to be close to experimental data of ~5 eV [291,1171]. About the structure and property of single-walled carbon nanotubes with several types of chirality, see excellent review papers [3969,4030].

[29]The polycrystalline diamond films prepared by chemical vapor deposition onto p-type Si(100) are decreased in ϕ^e from 5.6 to 5.2 eV by arc discharge activation [698].

[30]Oxygen contamination of C(pentagon)/Ta decreases ϕ^e from ~4.8 to 4.2–4.3 eV [3942].

[31]The vertically aligned type of C/Si having $\phi^e = 4.4$ eV is smaller by 0.2 eV compared with the random one [3223].

[32]The conductive (metallic) and semiconductive types of multi-walled carbon nanotube are found to have $\phi^e = 4.7$ and 5.6 eV, respectively, depending upon their helical angles [545].

[33]The values of 5.7 and 5.75 eV for the random multi-walled carbon nanotubes are estimated from the spectral data [1735] by other workers [291,3223], together with such a comment that both values seem too large.

[34]Individual tubes are stacked onto a W-tip by the van der Waals-forces alone or by a conductive carbon glue, and they are heated in vacuum at ~1000 K for 30 s to remove contaminants [1170].

[35]The clean Na(110) layers [1417] are prepared on the clean Ni(100) surface ($\phi^e = 5.20 \pm 0.11$ eV, essentially equal to 5.19 ± 0.05 eV in Table 2) at 173 K and ~10^{-11} Torr, and the layers (2.90 eV) are checked to have the bcc structure exposing the (110) surface parallel to the Ni(100) surface. For further information, see Refs. [3944,3945].

[36]Work function measurements of the Na/Mo systems prepared at either 293 K or 80 K (preannealing at 293 K) by both Fowler and photoemission threshold methods yield nearly the same result of either 2.36 ± 0.02 or 2.45 ± 0.04 eV [3336].

[37]Similarly to the above cases (Footnote 36), the values of ϕ^e at 80 K (no annealing) are virtually the same (2.45 ± 0.05 eV and 2.40 ± 0.03 eV) between the two methods of Fowler and threshold, respectively [3336].

[38]Work function is determined from AI (autoionization) electron spectra observed by 700 eV–Ne^+ impact of both a clean reference surface of Al (ϕ^e taken as 4.26 eV) and a sample surface of Na/Cr, which show the peak positions of Ne-II at the kinetic energies of 23.55 and 22.08 eV, respectively (see Fig. 1 and Table 1 [1103]). Consequently, we have $\phi^e = 4.26 - (23.55 - 22.08) = 2.79$ eV for Na [1103,4027]. The reference value for Al is the same with ours (4.26 ± 0.03 eV), but the value for Na itself is slightly larger than ours (2.54 ± 0.03 eV) (see Table 2 herein). Similarly to another case [3789], $\phi^e = 2.80$ and 3.80 eV are estimable for Na and Mg, respectively, when 4.25 eV [3789] is taken for Al, while 2.70 eV for Na is so by taking 3.70 eV [3789] for Mg. Additionally, 1 keV–Ne^+ is impinged on Cs/Pt and Na/Cs/Pt systems [3496], thereby determining $\phi^e = 2.1$ and 2.62 eV for Cs and Na, respectively [3496].

[39]By taking $\phi^e = 5.2$, 4.6 and 4.4 eV for the substrates of W(110), W(112) and W(111), respectively, Li is estimated to be 2.75 eV by FE [1974], which may be improved to be 2.87, 2.93 and 2.80 eV if we take 5.32, 4.78 and 4.45 eV recommended for the respective substrates in Table 2. All of the latter values become closer to our most probable value of 2.90 ± 0.03 eV for Li (Table 2). Later by the same group of workers, Li/W(112) is found to have 2.88 or 2.93 eV by CPD [380].

[40]By extension of n→∞ (cluster → bulk) for closed-shell Na clusters (n = 2–137), ϕ^e is experimentally determined to be 2.68 eV from a plot of $n^{-1/3}$ vs. the ionization energy of each cluster, whilst $\phi^e = 2.56$ eV is theoretically evaluated from the classical law [2171] (see Section 11.3).

[41]Bulk sodium work function is determined to be 2.75 eV [2860] by such a graphic method that a plot of $1/r$ (inverse cluster radius) vs. $\phi_c - W_{im}$ (difference between cluster's work function and image force equal to $3e^2/8r$) is extrapolated as $r \to \infty$, where ϕ_c is taken from the experimental data on ionization potential [2383].

[42]Analysis of the photo-ionization yield observed for fine particles (3–5 nm radius, 2×10^3–3×10^4 atoms) of Li, Na and K reveals that the ionization threshold energies for Fowler plots (2.93, 2.75 and 2.28 eV, respectively) [3482] are substantially equal or close to our respective values of $\phi^e = 2.90$, 2.54 and 2.30 eV (Table 2).

[43]The value of 2.8 eV calculated for the Na/Al(111) system at one monolayer is near to 2.9 eV done for Na(100) by five-layer slab model following the same calculational scheme [2222].

[44]Sodium clusters having the atom number (n) up to 22 000 are employed to determine the bulk work function of Na (2.81 eV) by extrapolation of n→∞ (cluster → bulk) in a plot of $n^{-1/3}$ vs. the ionization energy of each cluster [2053].

[45]The sample cut from a pure Mg boule and mechanically polished is cleaned in vacuum by sputtering with 1 keV–Ne^+ and then annealed to 500 K for 10 min, thereby yielding 3.65 eV for Mg(0001) [3174].

[46]The work function of Mg(0001) free-standing thin films with the thickness of up to 30 ML is calculated by first-principles, thus yielding 3.75 ± 0.05* eV for relaxed atomic geometry at 10–30 ML [2552].

[47]Each surface system consists of such a sandwich structure as sample metal/barium stearate-Al_2O_3/Al/glass, where the metal is Mg, Cr, Mn, Zn, Cd, Sn, Te, Pb or Bi [2028]. Both preparation and properties of the systems are summarized in Ref. [3948].

[48]Each work function for an M/oxide/Si(100) system (M = Mg, Al, Ni or Au) is evaluated by other workers [3519] using the data on conduction band barrier height at metal–dielectric interface [1442].

[49]The work function (3.78 eV) for the Mg/glass system [1368] is corrected to be 3.61 eV by other workers [13,349] taking the reference (ϕ^e for Ba) as 2.35 ± 0.03 eV instead of 2.52 eV.

[50]A mirror-like surface of Mg/glass ($\phi^e = 3.65$ eV) [1368] is smaller in ϕ^e by 0.13 eV than a macrocrystalline (matte) one (3.78 eV) [1368].

[51]The sample systems of Mg, Al, Fe and Au layers on quartz prepared in a poor vacuum (~10^{-5} Torr) are as thick as ~100–110, ~80–100, ~40–50 and ~30–40 nm, respectively [1973]. The work function determined for Al (3.47 eV, lower than the generally accepted value of ~4.3 eV, for example, seems unlikely to correspond to its clean surface. Such a low value is probably due to the adsorption of water vapor [725]. For further information about the adsorption, see Footnote 59.

[52]The system of Al(100)/Ge(100) is theoretically constructed by a lattice-matched interface model using an ideal Ge(100) substrate and a 45°-rotated Al(100) film, thus resulting in $\phi^e = 3.94$ eV [3949].

[53]Each monocrystalline surface is prepared by deposition of Al-vapor on each monocrystalline bulk substrate of aluminium at ~300 K and annealed often at 473–573 K during the course of the deposition [612]. A linear relationship is found between surface atom density (D_s) and work function (ϕ^e) among Al(111), Al(100) and Al(110), as illustrated in Fig. 4 [612]. The values of both D_s and ϕ^e for the surfaces [612] are listed in Table 8 [Here]. By intermittent repetition of Ar^+-impact and annealing (473–573 K), ϕ^e of Al(110) is decreased from 4.26 to 4.06 ± 0.03 eV [612].

[54]The work function of Al(111) ought to lie in 3.83–4.59 eV [1101], whose middle value may be calculated to be 4.21 eV, virtually equal to the most provable value of 4.24 ± 0.04 eV estimated in the present article and also to other recommended ones (4.24–4.28 eV) listed in Table 2.

[55]By annealing at 623 K for 1 h, the Al-layer (0.15 nm thick) prepared on quartz at ~300 K is decreased in ϕ^e from 4.31 to 4.29 eV as the degree (δ_m) of monocrystallization forming the (111) face is increased from 57 to 88% [3313].

[56]Deposition of Al-vapor up to 4 monolayers on an Ag(111) surface at 150 or 300 K causes a work function decrease by up to 0.38 eV [2888], which accords with the work function difference (0.40 ± 0.07 eV) between the most provable values of 4.64 ± 0.06 eV for Ag(111) and 4.24 ± 0.04 eV for Al(111), as shown in Table 2 [Here]. This accordance may give an additional evidence to support the conclusion [2888] that the Al-layers have the same orientation as the Ag(111) substrate.

[57]By consideration of the work function decrease by 1.17 eV after Al-deposition of 5 monolayers on Ru(0001) [301] and also by employment of the work function values for Ru(0001) as 5.35 ± 0.06 eV [Here], 5.42 eV [2652] and 5.58 eV [3160], we find those values for Al(111)/Ru(0001) [301] to be 4.18 ± 0.06, 4.25 and 4.41 eV, respectively, the middle (or average = 4.28 ± 0.10 eV) of which is nearest to the most probable value of 4.24 ± 0.04 eV for Al(111) in Table 2 [Here].

[58]Both experiment and theory indicate that Al-plates are decreased in ϕ^e from 4.3 to ~4.1 eV by deformation due to tension or compression [2550]. Similarly, a decrease (from 4.99 to ~4.7 eV) is observed also for Cu-ones [2550].

[59]Fresh Al-film ($\phi^e = 4.17 \pm 0.07$ eV) and oxygen pre-exposed one (4.08 ± 0.05 eV) on glass are reduced by up to ~1 eV by admission of water vapor from ~10^{-7} to 10^{-4} Torr min [2100] (see also Footnote 51).

[60]The ionization potential (IP) measurement of clusters (Al_{2000} and Al_{32000} at different charge states, $Z = -1$ up to +5) makes it possible to determine the bulk work function ($\phi^e(\infty)$) from Eq. (20). The value of 4.28 ± 0.03 eV thus determined [2199] is essentially the same with ours (4.26 ± 0.03 eV) recommended for polycrystalline Al in Table 2 [Here] (see Section 11.3).

[61]The Al-surface (~300–600 K) is scratched by irradiation with an increased light power, thereby decreasing in ϕ^e from 4.90 to 4.75 eV [1222].

[62]The work function of 4.41 eV for Si(100) at 300 K is evaluated from $\phi^e(T) = 4.30 + 3.75 \times 10^{-4}\ T$ found at ~1300–1650 K [1225].

[63]A free energy model is employed to derive the work function (ϕ^+) effective for positive ion emission from alkali (Li, Na or K) or Tl atom incident upon Si(100)^n and Si(111)^n, thereby yielding nearly the same values (averages derived from free energies) of $\phi^+ = 4.80 \pm 0.05$ eV for Si(100)^n and 4.82 ± 0.05 eV for Si(111)^n, irrespective of the difference in four incident atom species [74]. On the other hand, the value of $\phi^+ \approx 4.8$ eV for Si(100)^n and Si(111)^n are different from $\phi^e \approx 4.5$ eV for the two monocrystalline surfaces [74], affording $\Delta\phi^* \equiv \phi^+ - \phi^e \simeq 0.3$ eV $\neq 0$. The authors [74] suggest that the discrepancy ($\Delta\phi^* \neq 0$) would be accounted by partial covering with graphitic carbon or SiC having lower work function (4.4–4.6 eV).

[64]Similarly as above in Footnote 63, another enthalpy model is adopted to determine ϕ^+ by PSI of four different samples on Si(100)^n and Si(111)^n, yielding the averages of $\phi^+ = 4.67 \pm 0.08$ and 4.77 ± 0.05 eV for Si(100)^n and Si(111)^n, respectively [74]. Each of the values is nearly equal to that determined by the free energy model (see Footnote 63).

[65]On the basis of $\phi^e = 4.30 + 5.6 \times 10^{-4}\ T$ [2097], each ϕ^e of both Si(100) and Si(110) is evaluated to be 4.47, 4.86 or 5.14 eV for 300, 1000 or 1500 K. The theoretical value of the temperature coefficient (5.6×10^{-4} eV/K) [2097] is close to the experimental one (3.75×10^{-4} eV/K) determined for the both surfaces by another worker [1225].

[66]The value of ϕ^e for Si(111)^p by TE is determined to be 4.84 ± 0.14 or 4.86 ± 0.10 eV at ~1500 K by electron retarding method [73]. Each value is in excellent agreement with $\phi^+ = 4.85 \pm 0.08$ and 4.88 ± 0.10 eV by PSI of Cs incident upon the same Si(111)^p specimen at ~1100–1600 K [73] and, hence, $\Delta\phi^* \equiv \phi^+ - \phi^e$ is essentially zero, quite similarly as found generally for monocrystalline metals (see Table 5). On the contrary, ϕ^e of the same specimen is found to be as small as 4.07 ± 0.05 eV from Richardson plots at virtually the same temperature range (~1300–1600 K) as above [73], where the apparent Richardson constant is very small ($A_r = 0.2$–0.4 A/cm² K²) [73]. Quite similarly, $\phi^e = 4.05 \pm 0.04$ eV and $A_r \approx 0.2$–2 A/cm² K² for another Si(111)^p specimen are determined by another group of workers [635]. The above results suggest that the internal reflection coefficient (r^e) of electron is very large, as may be understandable from the inequality of $A_r \equiv A_R(1 - r^e) < A_R = 120$ A/cm²/K² [2]. Therefore, it may be concluded for silicon surfaces that the true value of the thermionic contrast ($\Delta\phi^*$) can hardly be obtainable by direct comparison between ϕ^+ (by PSI) and ϕ^e (by TE using Richardson plots) without correcting ϕ^e by a suitable method. It should be noted that $\phi^e = 4.07$ eV [73] may be corrected to be 4.83 ± 0.04 eV by substitution of $A_r = 0.3 \pm 0.1$ A/cm² K² into Eq. (8) (see Section 2.8.6), and hence that $\Delta\phi^* = 4.85 - 4.83 \approx 0$ eV instead of $4.85 - 4.07 \approx 0.8$ eV. In the same way, $\phi^e = 4.04 \pm 0.05$ eV for Si(111)^n [72] is corrected to be 4.80 ± 0.04 eV, which yields $\Delta\phi^* = 0.06 \pm 0.08$ eV, 0.07 ± 0.05 eV and 0.10 ± 0.11 eV since $\phi^+ = 4.86 \pm 0.07$, 4.87 ± 0.03 and 4.90 ± 0.10 eV by PSI of Li, Na and In, respectively [72]. See the data with the superscript of d in Table 4.

[67]The samples of Si(111)^n and Si(111)^p are found to have the same value of 5.05 eV at ~300 K, but to show a large difference of either 4.65 and 5.56 eV or 4.5 and 5.4 eV at 60 K for n- and p-types, respectively [2660,2893].

[68]The sample of Si(111)^n freshly cleaved at ~300 K has the 2×1 super structure with $\phi^e = 4.83$ eV, stable for a few hours at $P_r < 3 \times 10^{-11}$ Torr. But, it is changed to 4.56 and 4.74 eV by annealing at 550 and 800 K according to changes to the 1×1 and 7×7 structures, respectively [1228].

[69]The surfaces of Si(111)^p heated to 1000 K after cleaving and done so after sputtering are little different in ϕ^e between the two [118].

[70]The Richardson constants (A_R) determined for Si(110)^n having $\phi^e = 3.76$ and 4.14 eV are 0.1 ± 0.03 and 3 ± 0.1 A/cm² K² at 1250–1400 and 1400–1625 K, respectively, while those for Si(110)^p having 3.17 and 4.12 eV are 0.03 ± 0.01 and 1 ± 0.3 A/cm² K² in the above respective temperature ranges [1500]. Regarding both n- and p-types of Si(112) and Si(541), nearly the same values are found to range from 0.04 ± 0.01 to 2 ± 0.8 A/cm² K² [1500], all of which are very small similarly as in the cases [73,635] mentioned in Footnote 66. For further information, see Section 2.8.6.

[71]The nanowires of Si (20 nm in diameter) and Ge (17 nm) are found to have $\phi^e = 4.13$ and 4.43 eV, respectively [2200], which are smaller than the respective values of 4.65 ± 0.09 and 4.76 ± 0.06 eV (see Table 2) recommended for much larger sizes of usual specimens.

[72]The work function of the Si/Ba/W(110) system changes from 4.2 to 4.6 eV depending upon the Ba-thickness of ~(1–9) × 10^{14} atoms/cm² [2013]. The upper value (4.6 eV) is close to our recommended one (4.65 ± 0.09 eV) as shown in Table 2.

[73]The surface of Si/Si(111) consists of vapor-quenched amorphous silicon films [2822].

[74]As the Si-coverage increases from 0 to 1 monolayer on W, the work function calculated theoretically for the Si/W system changes from about 4.5 to 4.7 eV [913], the latter of which is in good agreement with the experimental value of 4.72 ± 0.02 eV [1231].

[75]The coverage of Si on Co/CoSi$_2$(111) is 3 monolayers [2169], where 4.70 ± 0.05 eV is very close to ours recommended for Si (Table 2).

[76]At the Si-coverage of $\theta = 3$–4 ML, the Si/W system prepared at 77 K is found to have $\phi^e = 4.78$ and 4.6 eV after annealing at 460 (or 525) and 580 (or 640) K, respectively. Such a decrease by 0.2 eV as found around 600 K is due to the diffusion of Si into W. When annealing is done at 990 K, $\phi^e = 4.6$ eV is kept at $\theta = 2$–3 ML, above which ϕ^e is sharply decreased down to 3.7 eV by alloying between Si and W [2248].

[77]The calculated values of $\phi^e = 4.98$, 4.999 and 5.08 eV for the monolayer adsorption of S on Fe(110) correspond to the hollow, bridge and atop sites, respectively [4313].

[78]The layer of S ($\theta = 0.53$ ML) on Fe(100) is formed by effusion of S included in Fe(100) after annealing at 970 K. Its work function increases from 5.21 to 5.26 eV as θ increases from 0.53 to 0.66 ML [565,3311].

[79]Incidence of S$_2$ upon Pd(111) forms a bulk sulfide layer, three-dimensional sulfide crystallites and elemental bulk sulfur layer at ~300, 550 and 100 (or 150) K, thereby decreasing the work function by ~0.3, 0.35 and 0.24 (or 0.20) eV, respectively, at ~6× 10^{15} S$_2$ molecules/cm² [2877]. By taking $\phi^e = 5.55$ eV [1351] for Pd(111), we have 5.25, 5.20 and 5.31 (or 5.35) eV at the respective temperatures.

[80]At 273 K, K is deposited on KF(100) and NaCl(100) to form K(100) and K(110), respectively, and their work functions are measured, the respective values of which are determined to be 2.33 and 2.41 eV after extrapolation to 0° K [2946].

[81]On the basis of $\phi^e = 5.85$ eV for W(110), K/W(110) is determined to have 2.0 eV at $\theta = 1.1$ ML by both theory and experiment [267,3818].

[82]The value of $\phi^e = 2.55$ eV determined for K/W(110) according to $\phi^e = 5.80$ eV for W(110) [373] may be revised to be 2.05 eV by taking the latter as 5.30 eV (see Table 2).

[83]The work function of K/Ag/glass [1456] depends upon the K-coverage of $\theta = 2$, 3 and 30 ML and holds $\phi^e = 2.16$, 2.12 and 2.24 eV, respectively, thereby affording 2.17 ± 0.05 eV as their average. However, it should be noted that the last (2.24 eV) is nearest to the values of 2.22–2.30 eV recommended by several authors (see Table 2). This fact suggests that such layers as thick as $\theta = 30$ ML have essentially the same property of a usual polycrystalline surface. In other words, the bulk work function can hardly be determined correctly unless θ is much greater than several ML.

[84]The plot of ϕ^e vs. θ observed for a K/Ru(001) system at 130 K shows $\phi^e \approx 2.2$ eV at $\theta = 0.8$ ML and 2.4 eV at much higher values of θ, corresponding to the bulk potassium [528].

[85]The substrate consists of microcrystallites having the same (0001) direction [2193] with $\phi^e = 4.7$ eV [1725], resulting in about 2.5 eV for K/C(0001) [1725,2193].

[86]The value of 3.3 eV observed for a system of K-encapsulated into single-walled carbon nanotubes [3229] is rather close to 3.6 eV calculated for a K-doped (10, 10) tube bundle of $K_{0.1}C$ [767].

[87]The system of Ca/silica is found to have $\phi^e = 2.2$, 2.55 and 2.98 eV for the layers of 5.5, 3 and 10 nm, respectively [1418].

[88]Each sample of Mg, Ca, Cu and Sr is deposited onto glass at 77 K to form a layer of $\theta = 2$–3 ML, and their work functions at ~300 K are measured to be 3.7, 3.0, 4.4 and 2.8 eV, respectively [1526].

[89]The systems of Ca/Mo consist of the Mo-foils implanted with 50- and 60-keV Ca^+ ions in doses of $2 \times$ and 1×10^{17} ions/cm^2, showing the minimum work functions of 3.13 and 3.26 eV, respectively, much lower than ~4.5 for pure Mo [2211].

[90]The system of Sc(0001)/W(110) with $\phi^e = 3.8$ eV is found at the surface concentration of 1.5×10^{15} Sc-atoms/cm^2 at 300 K. Even at the same concentration, however, ϕ^e shows different constant values of 4.0, 3.6 and 4.6 eV at 1050, 1200 and 1500 K, respectively [1982], suggesting that the Sc-layers have different structures.

[91]The Sc/W systems have $\phi^e = 2.8$ and 2.9 eV at $\theta = 1.0$ and 2.0 ML, respectively [1811].

[92]The Sc-layers with $\phi^e = 3.3$–3.4 eV are prepared from the alloys of Re–Sc (4–9%) after heating at 1700–1800 K for a long time [1979].

[93]The value of 4.10 eV is estimated for the (0001)-oriented titanium microcrystal grown on W(110) at 600–700 K [2196].

[94]The value of 5.0 eV corresponds to Ti(0001) formed as a main component of the titanium layers on glass, while the layers over the entire surface area are found to have 4.76 eV as the mean value of Ti(poly) [2378].

[95]The work function values of 4.15 and 4.75 eV correspond to Ti(1010) and Ti(1011), respectively, formed as the major and minor components of titanium layers on oxidized titanium (O=Ti), where they have 4.60 eV as the average over the entire surface area [2378].

[96]The surface layer structures of Ti grown on W(011) and both W(111) and W(001) are epitaxially oriented toward Ti{0001} and Ti<11$\bar{2}$0>, respectively having 3.52, 3.50 and 3.75 eV, in contrast to 3.03 eV for Ti/W(016) and 3.95 eV for Ti/W(112) [3222].

[97]The systems ($\theta \gtrsim 3$ ML) of Ti/W(001) and Ti/Re(10$\bar{1}$0) with $\phi^e = 3.88$ and 4.00 eV, respectively, have the same structure of α-hcp at 293 K [1404], but the former undergoes allotropic transformation to β-bcc after annealing at 1300 K for 1 min, thereby changing in ϕ^e from 3.88 to 3.65 eV [1404,1405].

[98]Similarly as mentioned above in Footnote 97, Ti/W(111) shows the allotropic transformation from α- to β-Ti after heating at 1100 K, together with a decrease in ϕ^e from 3.95 to 3.6 eV [2194].

[99]The same phenomenon as just above Footnotes (97 and 98) is found for Ti/W, changing ϕ^e from 3.95 to 3.65 eV according to transforming from α- to β-Ti, respectively, after annealing at 1100 for 15 s [1522].

[100]The theoretical values of 4.61 and 4.19 ± 0.02 eV are obtained for the non-magnetic V(100) films consisting of 1 and 3–7 layers, respectively [3671].

[101]At $T = 4.2$ and 15 K, the thin film system of V/quartz is measured to have $\phi^e = 3.1 \pm 0.2$ and 2.9 ± 0.2 eV by CPD, respectively, and ϕ^e seems to change by 0.2 ± 0.3 eV at the superconducting transition temperature ($T_S = 5.4$ K), although $\phi^e = 3.1$ and 2.9 eV are considerably smaller than 3.77 eV found for bulk-V by FE at the same range of 4.2–15 K [1686]. About the quantitative relation between ϕ^e and T around T_S, fine measurements at a meV level may be necessary in general to determine accurately the minute change in ϕ^e according to the transition (see Section 9 and Table 14).

[102]At 4.2 and 5 K slightly above the superconducting transition temperature (1.2 K), Al/quartz and Al-bulk systems are observed to have 4.1 ± 0.2 and 4.20 eV by CPD and FE, respectively [1686], where the disagreement between the two is smaller compared with the case of V mentioned just above (Footnote 101).

[103]Although the system of Cr(100)/Au(100) as well as Cr(011)/Au(010) satisfies the exceptionally close lattice match (0.02%), Cr forms fcc alloy with Au even at room temperature, and Au diffuses to the Cr-surface. Consequently, ϕ^e of the surface even at $\theta \simeq 60$ ML shows a value (4.05 ± 0.1 eV) higher by ~0.15 eV compared with that (3.90 ± 0.1 eV) of pure bulk Cr(100) [2870,3951].

[104] The system of Cr/Au/glass [3207] is prepared at room temperature by deposition of Cr (10 nm thick) on Au (250 nm thick) and determined to have $\phi^e = 4.6$ eV for Cr by taking $\phi^e = 5.1$ eV for Au [304], while the former is evaluated to be 4.8 eV if the latter is taken as 5.3 eV from Table 2 [Here]. However, both of 4.6 and 4.8 eV are considerably higher than 4.38 ± 0.04 eV recommended in Table 2, thereby suggesting that the system is alloyed to some extent by diffusion of Au (see Footnote 103).

[105]The work function of Cr/Au(100) [3557] is evaluated to be 4.87 eV for Cr by taking 5.47 eV for Au(100) [959,1045,1358], but the former is larger than both 4.10 eV [2638] and 4.46 eV [3445,3446] for Cr(100) and also than both 4.5 eV [304,1045,1358] and 4.38 eV [Here, see Table 2] for Cr (poly). Such discrepancies may suggest again the alloy formation between Cr and Au due to diffusion of Au, quite similarly as already mentioned above (see Footnotes 103 and 104).

[106]Mn atoms deposited onto Cu(111) at ~300 K are incorporated into the first Cu layer, and they form compact alloy islands according to further deposition, thereby decreasing ϕ^e by ~1.0 eV for the Mn/Cu(111) system (3.9 eV) [3710]. Here, ϕ^e for Cu(111) is taken as 4.94 eV [953].

[107]The Mn/Cu(100) system at $\theta \simeq 2.5$ ML at 293 K is found to have $\phi^e = 4.2 \pm 0.1$ eV, which corresponds to bulk Mn [1554], in contrast to the above case [3710] (see Footnote 106). It is generally 4.1 eV that is recommended for Mn (see Table 2).

[108]The system of Mn/ins/Al (see Footnote 47 for the sandwich structure) [2028] is determined to have $\phi^e = 3.60$ eV by taking the reference work function as 3.43 eV for Al [2028], in contrast to 4.40 eV by doing as 4.23 eV recommended for Al (Table 2 [1351]).

[109]The values of $\phi^e = 3.7$ and 3.9 eV calculated for the strained and unstrained Fe(100) crystals, respectively, are much smaller than 4.24 eV by experiment [2901].

[110]The value of $\phi^e = 4.17$ eV for Fe(100) [920,3044] is corrected to be 4.24 eV by another worker [13] taking not 4.49 eV [826] but 4.54_5 eV [828] for W (see Footnote 303) as the reference for CPD measurements.

[111] The ions of Na$^+$ and K$^+$ are due to the impurities (Na and K) occluded in the Fe filament employed [277], thereby making it possible to measure $\phi^+ = 3.6$ and 3.8 (or 4.3) eV by PSI.

[112] Regarding the γ- and β-phases of Fe [303], the differences of both ϕ^+ and ϕ^e between the two phases are estimated to be $\Delta\phi^+_{\gamma\beta} \equiv \phi^+_\gamma - \phi^+_\beta = 4.55-4.49 = 0.06$ eV and $\Delta\phi^e_{\gamma\beta} \equiv \phi^e_\gamma - \phi^e_\beta = 0.09$ eV, respectively [303] (see Table 11).

[113] The Richardson plot for Fe has a break at ~1170 K, below and above which both slopes are identical, thus yielding 4.77 eV for β- and γ-Fe [3024].

[114] The films of Fe(100) and Fe grown epitaxially on Cu(100) are found to have *metastable* and ferromagnetic fcc-structure, whose Curie temperature (T_C) changes depending upon the film thickness in contrast to the stable and ferromagnetic α-bcc-bulk iron with T_C constant at 1042 K. For details, see Section 8.2.

[115] By temperature increase from 703 to 763 K, α-hcp-Co(0001) with $\phi^e = 5.264$ eV is allotropically transformed to β-fcc-Co(111) with 5.266 eV [3192,3193].

[116] The Co sample cooled slowly from above 1120 K to ~300 K is found to have the α-hcp structure with $\phi^e = 4.12 \pm 0.04$ eV, whilst that done so suddenly retains the β-fcc one with 4.25 ± 0.08 eV [1631,1632].

[117] The systems of Co/substrate prepared by deposition of Co at 4.2 and 400 K consist of noncrystal and polycrystal Co-layers having $\phi^e = 4.4 \pm 0.1$ and 4.9 ± 0.1 eV, respectively [1506].

[118] The Co/Si(111) system at $\theta \simeq 3$–10 ML is found to have $\phi^e = 4.86 \pm 0.05$ eV at ~300 K, but it forms Co- and Si-rich CoSi$_2$ films with 4.94 ± 0.01 and 4.81 ± 0.01 eV depending upon the annealing temperatures at 610–690 and 760–870 K, respectively [2451].

[119] The values of $\phi^e = 4.960$ and 4.923 eV are determined at 300 and 663 K, respectively, for α-hcp-Co, whereas 4.925 and 4.966 eV are found at 673 and 300 K (extrapolated from ~770 K passing through the allotropic transition temperature of 663–673 K) for β-fcc-Co, respectively [1148]. For further information, see Section 7.1.

[120] The specimen of β-Co is found to have $\phi^e = 4.6 \pm 0.3$ eV (ferromagnetic state) and 4.8 ± 0.3 eV (paramagnetic one) below (1340–1390 K) and above (1390–1440 K) the Curie point (1390 K), respectively [3604].

[121] The Co films (1–9 ML) grown epitaxially on Cu(100) at 300–400 K are ferromagnetic and have the β-like fcc structure with $\phi^e = 5.0 \pm 0.2$ eV [2879,4377].

[122] The β-like fcc-Co films on Cu(100) is theoretically evaluated to have 5.34 eV, being ferromagnetic at temperatures up to the Curie point (~1400 K) [3654].

[123] The work function of Ni(100) after Ar$^+$ impact is found to have 5.08 eV, which is increased to 5.12 and 5.22 eV by annealing at 623 and 1023 K for 4 and 30 min, respectively [903].

[124] The Ni films (>1000 Å thick) prepared on vacuum- and air-cleaved mica at 593 K consist mainly (85 and 92%) of Ni(100), respectively, both having $\phi^e = 5.12 \pm 0.02$ eV [314], which is very close to 5.19 ± 0.05 eV for bulk Ni(100) (Table 2).

[125] About 67% of the Ni film surface (prepared on glass at 77 K and annealed at 523 K) have $\phi^e = 5.17 \pm 0.02$ eV [314], yielding nearly the same ϕ^e as above (see Footnote 124).

[126] Similarly as above (Footnotes 124 and 125), about 95 and 94% of the Ni film surfaces on glass at 573 and 523 K have 5.20 ± 0.02 eV [314,315] and 5.34 ± 0.02 eV [314], respectively, which are close to 5.19 ± 0.05 eV for Ni(100) and 5.32 ± 0.05 eV for Ni(111), respectively (Table 2).

[127] About 85–90% of the nickel layer surface on glass after annealing at 523 K have $\phi^e = 5.22$ eV, corresponding virtually to Ni(100) [1513].

[128] Identically as above (Footnote 126), 90% of the nickel surface have $\phi^e = 5.35$ eV [315,1513], essentially the same as 5.32 ± 0.05 eV for Ni(111) (Table 2).

[129] Only 3% of the whole surface area of Ni deposited on glass at 273 K (without annealing) correspond to $\phi^e = 4.82$ eV, with the remainders of 45 and 52% correspondent to 5.00 and 5.16 eV, respectively [314].

[130] Regarding fine particles of Ni, the calculated values (~2.9 eV) [2887] are found to be very discrepant from the experimental ones (~4.2 eV) [2887]. Such a discrepancy is found for Al, too; theory (~3.2 eV) and experiment (~3.7 eV) [2887].

[131] About 25 and 75% of the layer surface of Ni deposited on NaCl at 573 K correspond to 4.39 and 4.47 eV, respectively [314].

[132] The polycrystalline Ni is observed to have $\phi^e = 4.645$ eV (extrapolated from ~550 to 300 K), 4.660 eV (at 400 K), 4.690 eV (at 660 K, slightly above the Curie point of $T_C = 631$ K), or 4.700 eV (at 740 K) [503]. The ferromagnetic state at 400 K below T_C has the difference of $\Delta\phi^e_{PF} \equiv \phi^e_P - \phi^e_F = 4.653 - 4.660 = -0.007$ eV in comparison to the paramagnetic value extrapolated from 700 to 400 K [503]. The theoretical value of the difference is reported to be –135 meV [3673], –50 meV [3954] or 9 meV [2358] in contrast to –7 meV mentioned above (see Table 13).

[133] About 2, 13 and 85% of the overall surface area of Ni deposited on vacuum-cleaved mica at 593 K are found to have 4.82, 4.93 and 5.12 eV, respectively [314], the last of which is nearly the same with ϕ^e of Ni(100) (see Footnote 124).

[134] The Ni/W system is found to have 4.52 and 4.85 eV for the layers at 1 and 4–5 ML, respectively [2249].

[135] About 12, 35 and 53% of the layer surface area of Ni deposited on glass at 273 K have 4.9, 5.2 and 5.0 eV, respectively [315], the last of which is substantially the same with our recommended value (4.96 eV) for Ni(110) (see Table 2).

[136] The surface of Ni having 5.21 eV [1403] is partially oxidized.

[137] The Cu/NaCl systems annealed at 473 and 423 K are found to have the Cu(100) and Cu(111) orientations with $\phi^e = 3.96$ and 4.20 eV, respectively [3328]. After annealing at the same temperatures, Ag and Au on NaCl systems show the same orientations with $\phi(100) = 4.30$ eV and $\phi(111) = 3.98$ eV for Ag and with $\phi^e(100) = 4.02$ eV and $\phi^e(111) = 4.12$ eV for Au [3328]. Any of the above values, however, has a large difference ($\Delta\phi$) from ours recommended for each surface in Table 2. Typically for Ag, $\phi(100)$ and $\phi(111)$ are smaller by $\Delta\phi = 0.16$ and 0.66 eV than our respective values (Table 2), and $\phi(100) > \phi(111)$ does not follow the Smoluchowski rule of $\phi(111) > \phi(100) > \phi(110)$ found generally for Ag and also for many fcc metals except Al (see Table 10 and Section 5.3).

[138] The Cu(100) surface is determined to have 4.07 and 4.43 eV, neither of which is representative of a truly clean surface [1183].

[139] The layers (5–6 ML) of Cu deposited on Ir(100) at 78 K and annealed at 380 K are observed to have 4.55 ± 0.02 eV [2189], very close to both 4.59 ± 0.03 eV [953] and 4.58 ± 0.06 eV (Table 2) found for Cu(100).

[140] The work functions of Cu(100), Cu(110) and Cu(111) are estimated to be 4.68, 4.48 and 4.85 eV, respectively, by the present author using $\phi^e = 4.34$ eV estimated for SnO (the reference for CPD measurements) from the data in Table II [959], the reference value of which is constant in the presence of O$_2$ below ~10^{-6} Torr [831].

[141] The growth of Cu layers ($\theta > 3$ ML) on W(110) at ~300 K leads to recrystallization, thereby forming {111}-oriented patches with $\phi^e = 4.8$ eV (near to 4.92 ± 0.05 eV recommended for Cu(111) in Table 2) in a predominantly lateral direction on further condensation [1519]. On the other hand, $\phi^e = 4.5$ eV (equal to 4.51 ± 0.04 eV for Cu(poly) in Table 2) is found by deposition at 800 K [1519].

[142] When ϕ^e of the reference (W) is taken as 4.55 eV [828,1056,2103], the Cu layers prepared on W(110) at ~300 K [2598] are estimated to have 4.90 eV, essentially equal to our recommended value of 4.92 ± 0.05 eV (Table 2) for bulk Cu(111), whereas those on W(poly) [2598] are done to have 4.6 eV, nearly to $\phi^e = 4.51 \pm 0.04$ eV recommended for Cu(poly) (see Table 2). In a similar way, ϕ^e for W(110) [2598] is evaluated to be $4.55 + 0.73 = 5.28$ eV, well agreeing with our value (5.32 $\pm$ 0.02 eV in Table 2).

[143]In contrast to the work function decrease ($\Delta\phi = -0.32$ eV) upon Cu-condensation on Ru(0001) [2876], the large increase ($\Delta\phi = +0.40$ eV) reported for Cu/Ru(0001) [1683,1685] is due to an inadvertent error in the sign of $\Delta\phi$ measured with a Kelvin prove [3955], as stated in Ref. [2876]. In addition, $\phi^e = 4.5$ eV for Ru(0001) cited in Ref. [1683] from Ref. [2348] is too low [2266] compared with 5.52 ± 0.1 eV [2266] and also with our recommended value (5.35 ± 0.06 eV, see Table 2). Consequently, Cu/Ru(0001) [1683,1685] is estimated to have $\phi^e = 5.35 - 0.40 = 4.95$ eV, which is substantially equal to our value of 4.92 ± 0.05 eV for Cu(111). This result supports the conclusion [1683,1685] that Cu(111) is formed on Ru(0001).

[144]Around the melting point ($T_m = 1356$ K) of Cu, ϕ^e is found to be 4.4, 4.62 and 5.5 eV just below T_m, at T_m and above T_m, respectively [1465].

[145]Cu is deposited onto Ni by electroplating and found to have 4.47 eV [2294], which is very close to 4.51 ± 0.04 eV recommended for Cu (Table 2).

[146]When the reference work function of Ag used for CPD is taken as 4.36 eV [1351] by the present author instead of 4.74 eV adopted by the corresponding author [2087], the work function of Cu [2087] is corrected to be 4.48 eV instead of 4.86 eV [2087], the former of which is much closer to our recommended one (4.51 ± 0.04 eV, see Table 2).

[147]Regarding Cu/W(110) [2831], ϕ^e may be evaluated to be 4.58 eV [Here] and 5.20 eV [2831] for Cu by taking 5.31 eV [Here] and 5.93 eV [2831] for W(110) by the present and corresponding authors [2831], respectively, thereby yielding a more reasonable result ($4.58 \approx 4.51 \pm 0.04$ eV) from the former similarly as above (Footnote 146).

[148]Preparation of Cu layers on glass with 103 and 114 Å thick at 273 and 77 K affords $\phi^e = 4.64$ and 4.65 eV, respectively [3075].

[149]Fine particles ($r \approx 30$ Å in radius) of four metals are produced from each metal vapor by passing through He steam evaporating from liquid He [3190]. They are found to have $\phi^e(r) = 4.80$ eV (Cu), 5.45 eV (Pd), 4.50 eV (Ag) and 5.20 eV (Au) [3190], respective values of which are nearly equal to ours calculated from Eq. (17′) by citing $\phi^e(\infty)$ from Table 2 (see Section 11.1).

[150]The orientation of this single zinc crystal with 3.63 eV [2591,2601] is taken as (0001) in Ref. [475], although it is not clearly done so in Ref. [1312]. The crystal is treated as a polycrystal in CRC handbooks [11,1358,1859,4191] (see Section 3.2).

[151]Concerning the Zn/glass system [1370], $\phi^e = 4.28$ eV [1370] is corrected to be 4.11 eV [13,349] for Zn by other workers [13,349] taking $\phi^e = 2.35$ eV [13,349] instead of 2.52 eV [1370] as the reference work function for Ba used in CPD measurements.

[152]Employment of $\phi^e = 4.36$ eV [1351] instead of 4.74 eV [2087] for Ag (reference for CPD) yields 4.27 eV [Here] instead of 4.65 eV [2087] for Zn under study, the former of which is much closer to our recommended value (4.22 ± 0.11 eV for Zn in Table 2).

[153]Work function of the Ge(111) sample [2093] is measured to be 4.12 and 4.75 eV after cleavage in air and vacuum, respectively.

[154]The surface of Ge(111) cleaved in vacuum [2620] is found to have 4.9 eV, which changes to 4.5 and 4.7 eV after annealing at 370–470 and 570 K, respectively [2620].

[155]By both PE and CPD, exactly the same value of 4.80 eV is measured for Ge(111) cleaved in vacuum [1971]. See Section 2.8.2 for comparison of work function data obtained by different methods.

[156]Regarding K, Rb and Hg [2470], each of their work functions (2.29, 2.16 and 4.49 eV, respectively) does not undergo any substantial changes (less than 0.01 eV) during the transition through each melting point. See Table 12 for further information about the work function change due to liquefying.

[157]The layer ($\theta = 1.3$ or 1.5 ML) of Sr deposited onto W(110) at 77 K [2344] is measured to have 3.0 eV (by FE) or 3.2 eV (by CPD), the latter of which does not change even after annealing at 300 K.

[158]The systems of Y/W with $\theta = 1$ and 1.5–2.0 ML [1804] have $\phi^e = 2.6$ and 2.7 eV, respectively.

[159]The layer of Y deposited onto W(100) at ~300 K ($\phi^e = 3.1$ eV) is changed to that of Y(0001) ($\phi^e = ?$) after annealing up to ~1070 K [1985].

[160]The work functions of Sc, Y, Tc, In, Po, Fr and Pa are estimated to be 3.3, 3.3, 4.4, 4.0, 4.6, 1.5 and 3.3 eV, respectively, from the periodic trend of published data on ϕ^e for several elements neighbor to each metal [1355]. These values for Po, Fr and Pa have a trend to be smaller than other theoretical ones of 4.8–5.0, 1.8–2.14 and 3.3–3.73 eV, respectively. Of course, the three elements have no experimental data on ϕ^e available yet today.

[161]The smooth layers of Zr are formed by thermal processing of a Mo–Zr (5%) alloy heated to ~1000 K [790]. The value of 2.94 eV [790] is smaller than any other data on ϕ^e for α-Zr in this table.

[162]The specimen of Nb(100) with 68%-(100) orientation over the surface area [650,3414] is determined to have a "clean" cesiated work function of 4.1 eV [3414], whilst its really clean one is theoretically calculated to be 4.02 ± 0.07 eV [803], nearly the same between the two. It should be noted that the specimen is theoretically evaluated to have the thermionic contrast of $\Delta\phi^* = \phi^+ - \phi^e = 4.39 - 4.02 = 0.37$ eV [803].

[163]By Ar$^+$ impact on Nb(111), ϕ^e is decreased from 4.66 to 4.09 eV [780].

[164]At 4.2 K below the superconducting point ($T_s = 9.2$ K), the Nb/quartz system [1686] is found by CPD to have $\phi^e = 3.9 \pm 0.2$ eV, which is not clearly different from both 3.8 ± 0.2 and 3.9 ± 0.2 eV measured by CPD at 28 and 293 K above T_s. However, the above Nb film (3.9 eV at 4.2 K) is much smaller in ϕ^e than the bulk Nb (5.01 eV by FE) at 5 K below T_s [1686] (see Table 14).

[165]With respect to the niobium work function, it is criticized in Section 3.1.4 [13] that 3.88–3.91 eV determined by combination of both PSI and NSI of several alkali halides [120] is too low compared with 4.37 ± 0.03 eV by CPD [123]. The former [120] is also less than by ~0.2 eV compared with our recommended value (see Table 2). Such a discrepancy may be caused mainly by the implicit assumption [120] that the work functions (ϕ^+ and ϕ^-) effective for positive and negative ionic emissions are the same with each other without considering the thermionic contrast ($\Delta\phi^* = \phi^+ - \phi^- = \phi^+ - \phi^e = 4.81 \pm 0.05 - 4.11 \pm 0.05 = 0.70 \pm 0.07$ eV (see Table 5 and Section 4.1). It should be noted that the relation of $\phi^+ = \phi^- = \phi^e$ holds exactly with a clean and smooth monocrystalline surface alone, as already stated in Section 1.

[166]The layers of Nb, Mo, Ta and W on Si(111) ($\phi^e = 4.53$ eV) are as thick as ~30 ML, showing 4.12, 4.76, 4.15 and 4.87 eV, respectively [1430].

[167]Each molybdenum surface [125,129,572,573] is assigned to the (100) plane arranged naturally by recrystallization of Mo through annealing for many hours above 2200 K [573]. This assignment is supported by the result that $\phi^+ = \phi^e = 4.28 \pm 0.05$ eV [573] and hence $\Delta\phi^* = 0.0$ eV in contrast to ~0.7 eV for Mo (see Table 5). Such a work function change due to thermal monocrystallization is reported also for many other metals (see Section 4.5 in Ref. [1351]).

[168]The work function of Mo(100) is found to be 4.52 and 4.38 eV after heating at 1980 K by a.c. for initially 40 h and successively 50 h until giving constancy in ϕ^e, respectively, while it is 4.37 and 4.33 eV after doing so by d.c. for firstly 25 h and additionally 235 h until so, respectively [729]. In both cases, ϕ^e decreases gradually by the heating and finally becomes constant at 4.38 ± 0.03 and 4.33 ± 0.03 eV, both of which are essentially equal to our recommended values of $\phi^e = 4.38 \pm 0.03$ eV, $\phi^+ = 4.38 \pm 0.08$ eV and $\phi^- = 4.34 \pm 0.03$ eV (see Table 2 and also Footnote 258).

[169]The theoretical values of ϕ^e for Mo(110) layers (1–4 ML) on W(110) and for Mo(110) bulk are 4.8 and 4.83 eV, respectively, well agreeing with each other [2074].

[170]The work function (ϕ^+) for each specimen is calculated by either the corresponding workers or the present author substituting each of workers' data on ionic and neutral desorption energies (E^+ and E^0) [77,131,132,135,146,166,167,178,263,265,266,269,276,280,282,397,684,804,823,954,966,1049,3886] and also literature value (ionization energy, I) into the Schottky equation (9) of $\phi^+ + E^+ = E^0 + I$, where E^0 is cited in some cases (for details, see Section 4.1).

[171]The "clean" and "gassy" surfaces of Mo(111) are measured to have $\phi^e = 4.49$ and 4.67 eV, respectively [3421].

[172]About the Mo surface consisting of 70–72% (100), 20–22% (112), 5% (111) and less than 2% (110) [124,3414], ϕ^e is estimated to be 4.25 eV by another worker [1254], while our theoretical evaluation yields $\phi^e = 4.38 \pm$ eV and $\phi^+ = 4.51 \pm 0.03$ eV [803], and hence $\Delta\phi^* = 0.13 \pm 0.03$ eV in contrast to $\Delta\phi^* = 0.0$ eV for ∼100% Mo(100) (see Table 5). Experimentally on the other hand, ϕ^e is found to be temperature-dependent like as 4.32–4.17 and 4.18–4.01 eV at ∼1400 and 2000 K, respectively [124], or roughly 4.0–4.3 eV [124,3414].

[173]The Mo surface consists of the planes of mainly (116) and (331), and its ϕ^e is measured to be 4.33 eV by TE and 4.41 or 4.47 eV by PE [134].

[174]The work function at 0 K for each of the nine polycrystalline surfaces is evaluated from $\phi_0 = kb_0 = \phi_T - (3/2)kT$ after determination of b_0 using published data on thermionic emission from Ca, Y, Zr, Mo, Ce, Ta, W, Th or U at various temperatures [1747].

[175]By theory and experiment, ϕ^e for Ru(0001) is evaluated to be 5.3 and 5.4 eV, respectively [542], both of which are close to our recommended value of 5.35 ± 0.06 eV (see Table 2).

[176]The theoretical values of 5.36 and 5.57 eV correspond to the ferromagnetic and paramagnetic states of Rh(100), respectively [1258].

[177] The work function (4.70 eV) for a roughened surface of Rh(110) is lower than that (4.80 eV) for a smooth one [853], just as expected generally (see Section 4.2.5 in Ref. [1351]).

[178]The work function values of roughened surfaces of Rh(111) and Pt(111) are 4.95 and 5.53 eV, respectively [853], both of which are much smaller than the respective ones of 5.40 and 5.84 eV recommended mainly for smooth surfaces (see Table 2), quite similarly as above (see Footnote 177).

[179]The value (5.1 eV) for Rh(111) is deduced by Feibelman [456,1011] from the photoemission data obtained by other workers [1544,1546].

[180]The Rh layers (2–3 ML) on Mo(110) are found to have $\phi^e = 5.36$ eV [1035], very close to our value of 5.40 eV for Rh(111) (see Table 2).

[181]On the two species of insulator/semiconductor substrates, the Rh layers (>10 Å thick) are prepared from rhodium acetylacetonate at 423 K, resulting in $\phi^e = 5.25$ or 5.43 eV [2908].

[182]The work function of a 6 × (100) stepped face of Pd is calculated to be 5.50 eV, which is smaller than 5.80 eV for a normal Pd(100) face [704,795]. Similarly to Pd(111), 5.53 eV for a 6 × (111) stepped face is lower than 5.86 eV for the normal one [704,795].

[183]This is a stepped surface of Pd(S)–[8(100) × 1(110)] having 5.55 eV [1129]. For this nomenclature, see Ref. [1130].

[184]The value of ∼5 eV for Pd(110) [610] is roughly equal to 5.20 ± <0.1 eV determined later by the same group [914].

[185]The work function of 5.5 eV for Pd(110) is determined for thick layers (10 ML) of Pd deposited onto Al(110) ($\phi^e = 4.2$ eV) at ∼300 K [3495].

[186]The substrate of Cu(111) is prepared on mica at 398 K, after which Pd(111) layers are formed on Cu(111), thereby yielding $\phi^e = 5.61$ eV at ∼300 K [3364]. This is virtually the same with our recommended value (5.58 ± 0.05 eV, see Table 2).

[187]With respect to Pd(foil) and Pd layers (400–700 Å) on Ta, ϕ^e is determined to be 4.6 and 4.95 eV respectively [350], the latter being close to our value (5.17 eV).

[188]The values of 4.61, 4.69 and 5.07 eV for Pd [1953] are based on the Ag reference ones of 4.28 eV [1355], 4.36 eV [1351] and 4.74 eV [2087] for Ag, respectively, the last of which is too large compared with our recommended one of 4.39 eV for Ag (see Table 2).

[189]The work function of 4.2 eV is estimated by another worker [971] using the PE data for Ag(100) [2128], the topic of which is introduced in Ref. [1261].

[190]The value of 4.45 eV for 20%-vacant Ag(100) is much lower than 4.78 eV for normal one [2405].

[191]Preparation of an Ag-film on Ag(100) at ∼300 K or less makes ϕ^e lower by 0.1 eV than that of the clean substrate [2302], where the latter may be estimated to have 4.50 eV according to the value recommended for Ag(100) in Ref. [1351]. By heating the system to 308–313 K, however, the difference of 0.1 eV is decreased to ∼0 eV [2302], thereby indicating that the film becomes equivalent to the substrate. In other words, a polycrystalline metal film on a monocrystalline surface of the same metal species may be monocrystallized to have the same orientation by annealing at suitable temperatures.

[192]About the Ag(100)/NaCl system [1157], ϕ^e for Ag(100) is corrected to be 4.62 eV from 4.79 eV by other workers [349] taking 2.35 eV [13,349] instead of 2.52 eV [2232] for Ba employed as the reference [1157], the topic of which is mentioned in Ref. [626].

[193]The system of Ag/Ag(100) annealed at 525 K is found to have the same work function (4.64 eV) with bulk Ag(100) [626], quite similarly as mentioned already in Footnote 191.

[194]In the case of a low vacuum ($\leq 3 \times 10^{-8}$ Torr), both bulk Ag(100) and Ag film formed on the bulk at ∼300 K are found to have the same work function of 4.81 eV, which is decreased by 0.09 ± 0.03 eV after heating the film to red [1132]. The same decrease (from 4.75 to 4.66 eV) is observed also for the Ag film on bulk Ag(111) [1132].

[195]The work function of Ag film on V(100) (4.56 eV) is calculated to be 5.72, 5.44 and 5.02 eV at 1, 2 and ≫2 ML, respectively. For larger coverage, ϕ^e oscillates around the value (5.02 eV) for semi-infinite Ag(100) [1876].

[196]After annealing at 525 K, the Ag films formed on Ag(110) and on mica are found to have $\phi^e = 4.51$ eV, which is essentially the same (4.52 eV) with Ag(110) [626].

[197]A clean and smooth surface of Ag(111) is found to have $\phi^e = 4.46 \pm 0.02$ eV measured by PE [625,1693]. On the other hand, ϕ^e for a surface of Ag(111) damaged by Ar$^+$ impact is 4.18 eV done by PE, larger than 4.03 eV by CPD [1693]. This result does not follow the general trend of a normal surface that ϕ^e by PE is smaller than ϕ^e by CPD, thereby indicating that application of PE to such a damaged surface is not suitable because any surface defect gives some effect to the surface potential barrier and hence to photothreshold [1693]. For further information, see Section 2.8.2.

[198]By annealing at 773 K for 1 h, the Ag layer (1.7 nm thick) prepared on quartz at ∼300 K is increased in ϕ^e from 4.35 to 4.64 eV as the degree of monocrystallization (δ_m) forming the (111) face is increased from 54 to 86% by annealing at ∼773 K [3313]. Theoretically, 4.72 eV is evaluated for Ag(111) [3313], close to 4.64 eV (Table 2).

[199]The thick Ag-film (above ∼20 ML) formed at ∼300 K on the H-terminated Si(111) 1 × 1 ($\phi^e = 4.50 \pm 0.04$ eV) is found to have $\phi^e = 4.65 \pm 0.15$ eV [1198], which is essentially the same with our recommended value of 4.64 ± 0.06 eV for Ag(111) (see Table 2). On the other hand, the thin film (below ∼5 ML) prepared by annealing at ∼300 K after deposition at ∼210 K shows roughly 4.2 eV [1198], near to the selected value of 4.26 eV [1045] for polycrystalline Ag (see Table 2).

[200]The Ag-film (10 ML) formed on Pt(111) at ∼300 K has $\phi^e = 4.4$ eV, which is increased to 4.7 eV by annealing at 600 K, thereby changing the film structure from polycrystalline Ag to Ag(111) [2182].

[201]The Ag-film prepared on bulk Ag at 58 K is highly porous with $\phi^e = 4.25$ eV, which is increased to 4.72 eV after annealing at 330 K, corresponding to Ag(111) [1422].

[202]The Ag-film annealed at 525 K after deposition on mica at 425 K shows $\phi^e = 4.72 \pm 0.01$ eV, well agreeing with 4.74 ± 0.02 eV measured for bulk Ag(111) [626,1134].

[203]For the Ag-film (19 ML)/Ru(001) system annealed at 500 K after deposition at ∼60 K, ϕ^e is determined to be 4.90 ± 0.1 eV [2266], which does not well agree with 4.76 ± 0.1 eV measured for bulk Ag(111) at 50–60 K [2266] and also with our value of 4.64 ± 0.06 eV for Ag(111) (Table 2).

[204]The fine particles (50 ± 20 Å in radius) are produced by passing Ag-vapor through the He-gas boiling off from liquid He and found to have $\phi^e = 4.25 \pm 0.1$ eV [1562]. This is smaller than 4.39 ± 0.02 eV recommended for bulk Ag in Table 2. See Section 11.1.

[205]According to a patchy surface model of Ag [3720], work function is calculated to be 4.26 eV for a hypothetical polycrystalline surface of Ag [3280]. This value, however, corresponds to neither ϕ^e nor ϕ^+ but to a simple average (ϕ^a). It should be noted that $\phi^e < \phi^a < \phi^+$ holds with any polycrystalline surfaces (see Section 1). By substitution of the data included in the above model into Eqs. (2) and (1), ϕ^e and ϕ^+ are calculated to be 4.21 and 4.32 eV, respectively [3956]. Here, the polycrystalline surface of Ag is considered to consist of the three main faces of Ag(100), Ag(110) and Ag(111), and their compositions of (F_i, ϕ_i) are taken as (23%, 4.22 eV), (46%, 4.14 eV) and (31%, 4.46 eV), respectively [3720].

[206]The work function of fine particles of Ag is studied according to Eq. (17′), where the polycrystalline work function of ϕ^e ($r = \infty$) is estimated to be 4.37 eV for Ag [3442]. It well agrees with 4.39 ± 0.02 eV for the planar Ag (Table 2). No value of ϕ^e (r), however, is determined there [3442]. Further information about nanometer metal particles may be obtained from Section 11 and also from excellent reviews [3669,4138,4194,4261,4269,4301–4304].

[207]The heavy layer of Ag deposited onto Mo at ~300 K is observed to have $\phi^e = 4.41$ eV [1051], equivalent to our value (4.39 ± 0.02 eV). The former is increased to 4.78 eV by annealing at a high temperature (red), but returns to 4.41 eV by subsequent deposition of Ag [1051]. On the other hand, the annealing of the Ag layer (4.41 eV) at $T \leq 370$ K increases ϕ^e by 0.1–0.2 eV [1051], thereby affording the estimated value of 4.55 ± 0.05 eV.

[208]The work functions of fine particles of Ag (20, 27 and 30 Å in radius) are determined to be 4.65, 4.57 and 4.55 eV, respectively, yielding the average of 4.59 ± 0.05 eV [3127]. This is larger than 4.25 ± 0.1 eV for a larger particle of Ag (50 ± 20 Å in radius) [1562] (see Footnote 204), and also than $\phi^e(\infty) = 4.39 \pm 0.02$ eV recommended for Ag(poly), just as expected from Eq. (17′).

[209]Compared with 4.6 eV for Ag [2729], much lower value of 4.06 ± 0.05 eV is found for air-oxidized Ag [2729], strongly suggesting that these Ag-surfaces ($\phi^e \simeq 4.1$ eV or less) studied in low vacua may be oxygenated partly or considerably.

[210]For Ag/W(110), ϕ^e is determined to be 4.5 and 4.6 eV at $\theta \simeq 2$ and 3 ML, corresponding to a minimum and nearly a flat saturation, respectively [1828]. The latter is very near to our value of 4.64 ± 0.05 eV for Ag(111) (Table 2), the nearness to which is found also in many other cases of Ag/W(110) [2363,3472,3565], Ag/Pd(100) [1692], Ag/Ta(112) [878] and Ag/Nb(110) [2986], as may be seen in Table 1.

[211]The work function of Ag-layers (9 ML) on Re(1010) after annealing at 350–770 K is determined to be 5.30 ± 0.02 eV by FE [1421], which is too large compared with any other experimental data on Ag listed in Table 1. This may be mainly because ϕ^e of the substrate is taken as 5.95 ± 0.15 eV by FE [730], which is also extremely larger than any other data on Re(1010) in Table 1. If the latter is taken from our value of 5.12 ± 0.05 eV (see Table 2), then, ϕ^e of the above system is evaluated to be 4.47 eV, becoming very near to our value of 4.46 eV recommended for Ag(100) (see Table 2).

[212]By taking 4.74 ± 0.03 eV [1135] and 4.36 ± 0.06 eV [1351] as the reference work function of Ag, ϕ^e of Cd is evaluated to be 4.43 ± 0.01 eV [1953] and 4.05 ± 0.06 eV by the present author [Here], respectively, the latter of which is essentially the same with our value of 4.06 ± 0.05 eV recommended in Table 2. All of the above experimental data, however, are obtained in low vacua (above ~10^{-9} Torr), strongly suggesting that further work in ultrahigh vacua is needed to obtain more reliable data for Cd.

[213]Quite similarly as above (Footnote 212), ϕ^e of Cd [2087] is corrected from 4.49 eV [2087] to 4.11 eV by the present author, the difference (0.38 eV) of which corresponds to that (4.74–4.36 eV) for the reference work functions selected for Ag.

[214]About the Cd/Ta system [1380], ϕ^e is adjusted from 4.08 eV [1380] to 4.22 eV by others [13,349] taking the reference of $\phi^e = 2.66$ eV [13,349] instead of 2.52 eV [3582] for Ba, thereby yielding such a negative result that deviation from our value (4.06 eV) recommended for Cd increases from 0.02 to 0.16 eV. It should be noted that 2.52 eV [3582] is substantially the same with our value (2.50 ± 0.02 eV) recommended for Ba.

[215]Under the conditions without and with the magnetic field of 0.05 tesla, ϕ^e is measured to be 3.85 and 3.94 eV, respectively, for the In/quartz system [1475].

[216]About the specimen of Sn [2087], 4.63 ± 0.01 eV [2087] is corrected to be 4.26 ± 0.06 eV (close to our value, see Footnote 217) by the present author taking our value of 4.36 ± 0.06 eV [1351] instead of 4.73 ± 0.07 eV [3391] as the reference work function of Ag.

[217]The work function of 4.51 ± 0.02 eV measured for Sn [1945–1947] is improved to be 4.39 eV by another worker [1135] after theoretical analysis of the experimental data [1945–1947], thereby yielding the result that the latter [1135] approaches closely to our value (4.34 ± 0.06 eV) for β-Sn.

[218]Quite similarly as just above (Footnote 217), the work function values for γ- and liquid-Sn are adjusted from 4.38 eV [1945–1947] to 4.28 eV [1135] and from 4.22 eV [1945–1947] to 4.17 eV [1135], respectively.

[219]The Sb-films prepared on W(100) at ~300 and 423 K are found to have 4.55 and 4.98 eV, respectively, the former being apparently amorphous [1995]. On the other hand, the Sb-film on W(110) at ~300 K is concluded to form pseudocubic Sb(100) having 4.7 eV [1272].

[220]The systems of Te-layers (200 and 1000 Å thick) deposited onto glass at less than 5×10^{-6} Torr and 573 K are studied at ~300 K in the flowing Ar-gas (0.1 Torr), yielding $\phi^e = 4.62$ and 4.76 eV, respectively [2246].

[221]About the systems of K and Cs on Si(111) [1823], the plots of work function change vs. alkali deposition time do not show a clear minimum, and a small oxygen contamination is observed at 10^{-9} Torr, thereby yielding such a result that ϕ^e for the both systems is estimated to be 1.6 eV, smaller than ϕ^e usually expected.

[222]The work function of a Cs/Re system is measured to be 1.64 eV [3582], smaller than usual, whilst that of Ba/Re is 2.52 eV [3582], in excellent agreement with our value of 2.50 ± 0.02 eV for Ba (see Table 2).

[223]On the flat surface of Si(100) at ~300 K, Cs is deposited until the work function decrease ($\Delta\phi$) becomes independent of the Cs-deposition time (t), thereby yielding $\Delta\phi = -2.95$ eV = constant [2883]. This constancy, however, does not correspond to a saturation ($\theta \geq 1$ ML) but does to $\theta \leq 0.58$ [2883]. If ϕ^e of the substrate is taken as 4.82 eV from Table 2 [Here], ϕ^e of the Cs-film is estimated to be 1.87 eV. Such a constancy as above is observed also for the Cs-film prepared on stepped and Ar$^+$-sputtered surfaces of Si(100), showing $\Delta\phi$ = constant = −2.89 and −3.44 eV even at $\theta = 0.69$ and 0.78 eV, respectively [2883]. These results suggest that the film thickness of $\theta \geq 1$ ML is not always guaranteed simply because $\Delta\phi$ is found to be constant independently of t.

[224]The work function of Cs on Ag(110) is estimated to be 1.8 eV at ~300 K, where Cs as well as other alkali metals do not form multilayers [2144]. At lower temperatures (e.g., 80 K), ϕ^e of Cs-multilayers tends to rise up to 2.1 eV correspondent to metallic Cs [2144].

[225]About the Cs/W(100) system at $\theta \simeq 0.4$–0.7 ML, ϕ^e is found to be 1.81 eV [3435], which is the same with that at $\theta = 1$ [644,1480].

[226]By taking $\phi^e = 4.8$ eV for Si(100) from Table 2 [Here], Cs/Si(100) at $\theta \approx 1.5$ ML is estimated to have 1.9 eV [3811], while the Cs/Se/Si(100) systems at $\theta = 0.5$ and 1.0 ML of Se are done to have the sandwiching values of 2.0 and 1.7 eV, respectively, owing to formation of such compounds as CsSe and $Si_xCs_ySe_z$ [3811].

[227]In the plot of $\Delta\phi$ vs. θ, Na- and Cs-films on Cu(111) are found to have $\phi \approx$ constant at 2.7 and 1.9 eV at $\theta \geq 0.25$ and 0.35 ML, respectively [2496], even at less than 1 ML. It should be emphasized that the former and the latter are slightly larger and smaller than our recommended values of 2.54 and 2.05 eV for Na and Cs, respectively (see Table 2).

[228]About the relation between ϕ^e and θ, some interesting information is added by other workers [2122] to the Cs/W system (1.80 ± 0.05 eV) [340] after theoretical analysis of the data [340] from the viewpoints of Cs-flux and surface temperature [2122]. About a Cs/W system at 400 K, surface coverages are evaluated to be ~1.1 and 0.9 ML at the incident Cs-fluxes of ~10^{17} and 10^{15} atoms/cm^2 s [2122].

[229]Through the Cs$^+$-impact with the energy (E_i) of 45 or 90 eV, ϕ^e of the Cs/Mo system at $\theta \approx 1$ ML is estimated to be 1.9 ± 0.1 eV, which increases to about 2.0 and 2.6 eV at E_i = 150 and 450 eV according as θ decreases from ~1 to ~0.45 and 0.25 ML, respectively, at the same dosage of ~10^{16} ions/cm^2 [3283]. Here, ϕ^e of Mo is taken as 4.3 eV from our Table 2. For further information, see Footnote 232 below.

[230]From the experiments and data-analyses performed for 25 substrates (mainly pure metals) in Cs-vapor by TE and PSI, the minimum- and heavily-cesiated work functions are estimated to have a range of 1.45 to 1.95 eV, which show no correlation with both the effective vacuum work function (ϕ^e) and chemical property of each substrate species [650,3412].

[231]About the Cs/O/W(100) systems with saturation Cs coverage prepared after oxygen exposure of 1 and 1.5 Langmuirs onto W(100), ϕ^e is measured to be 1.95 and 2.05 eV, respectively, in contrast to 1.78 eV for Cs/W(100) [361,1667].

[232]For the Cs/Be system prepared by Cs$^+$-incidence up to the dosage of 1×10^{16} ions/cm^2 ($\theta = 1.0$ ML), ϕ^e is measured by both PE and CPD, showing the same value of 1.96 eV [3289] (see Section 2.8.2), in contrast to the case of Ar$^+$-bombarded Ag(111) with difference in ϕ^e between PE and CPD [1693] mentioned in Footnote 197. This value is independent of the Cs$^+$-impact energy (E_i) of 8–900 eV because θ is kept at 1.0 ML independently of E_i [3289]. For these substrate systems of Mo (96 amu) and W(183 amu) much heavier than Be (9.0 amu), on the other hand, ϕ^e remains higher by up to ~0.6 and ~1.6 eV above ϕ^e at 45 eV, respectively, as E_i increases from 45–50 up to 300 eV, where θ decreases from 1.0 down to 0.35 and to 0.15 ML, respectively [3289,3815]. At $E_i \leq 50$ eV alone, therefore, ϕ^e at $\theta = 1$ is found to have 1.9 eV for Cs/Mo and Cs/W [3289,3815].

[233]About the systems of Cs/Cu(111) at $\theta = 1$ and 2–4 ML, ϕ^e is theoretically evaluated to be 2.2 and 2.4 eV respectively [3697], both of which are in fair agreement with the experimental results [2512] (see the next Footnote).

[234]About Cs/Cu(111) at $\theta = 1$–2 and 3–4 ML at 200 K, ϕ^e is experimentally determined to be 2.2 and 2.3 eV, respectively [2512].

[235]By both theoretical and experimental studies made for a Cs/C(0001) system, the work function decrease is determined to be 2.19 eV [2782], from which ϕ^e of the system is evaluated to be 2.26 and 2.5 eV by taking ϕ^e = 4.45 eV [286,1174] and 4.7 eV [235,236,525] for C(0001), respectively.

[236]The work function is found to be 2.4 eV for the Cs-intercalated single-walled carbon nanotube bundles deposited on GaAs [291].

[237]The work function of Ba/Si(100) at $\theta = 4.0$ ML is found to be 2.3 eV, which tends to increase gradually with increasing θ, thereby getting close to 2.5 eV for bulk Ba [2170].

[238]For the systems of Ba/glass [1157], Ba/W [1365] and Ba/Ag/Ta [1050], Anderson has assumed or measured the Ba-work function as 2.520 eV [2232], 2.39 ± 0.05 eV [1365] and 2.520 eV [2232], which are corrected to be 2.35 ± 0.03, 2.42 ± 0.05 and 2.66 ± 0.01 eV, respectively, by Rivière [13,349].

[239]About Ba/Si(100), ϕ^e is determined to be 2.7 eV [1732], which may be corrected to be 2.5 eV by taking 4.7 eV [1351] instead of 4.9 eV [1732] for Si(100), thereby yielding a good agreement with our value (2.50 ± 0.02 eV) recommended for Ba in Table 2.

[240]Between Mg and Ba, the difference in ϕ^e is measured to be 1.08 eV [1367], which affords ϕ^e = 3.58 eV for Mg and 2.57 eV for Ba according to our citation of 2.50 eV for Ba and 3.65 eV for Mg, respectively, from Table 2.

[241]By employment of Kelvin and retarding potential methods [2104], ϕ^e = 2.560 and 2.69 eV are determined for Ba/W(100), respectively, and also 2.955 and 3.10 eV are done for Ba/W(110), respectively, clearly showing a difference (~0.14 eV) between the two methods [2104]. The difference can be explained either in terms of two-patch model [2104].

[242]In contrast to the cases of Ba/W(100) and Ba/W(110) [2104] mentioned just above in Footnote 241, ϕ^e of Ba/Ag/Ta is found to be essentially the same values of 2.52 and 2.53 eV by retarding and Kelvin methods, respectively [1050], while ϕ^e = 4.31 eV is determined for Ag/Ta [1050].

[243]At the residual gas pressure of 2×10^{-9} Torr, Ba/W is found to have ϕ^e = 2.6 eV, which increases to 2.7 eV at 3×10^{-7} Torr [3259].

[244]For the systems of Ca/W, Sr/W and Ba/W at ~300 K, ϕ^e is determined to be 2.90, 2.73 and 2.65 eV, respectively, all of which decrease to 2.84, 2.64 and 2.46 eV, respectively, at ~900 K, while Mg/W remains at 3.76 eV [3530].

[245]At $\theta = 10$ ML, ϕ^e is determined to be 2.7 eV for both Ba/W(100) and Ba/Ir(100), in contrast to 1.8 and 1.5 eV for BaO/W(100) and BaO/Ir(100), respectively [2149].

[246]Regarding La/Pt(111) at $\theta = 1.0$–1.2 ML, work function at 77 K is found to be 2.86 eV, which is increased to 5.0 eV by alloy formation after annealing at 900 K [3009]. Here, ϕ^e for Pt(111) is taken as 5.86 eV from Ref. [1351].

[247]About Ce/W [3022], ϕ^e is evaluated to be 2.5 eV at ~300 K according to the temperature dependence of $2.48 + 1.8 \times 10^{-4} T$ determined at 1060–1450 K [3022].

[248]For the systems of Ce/Pd/Ru(0001) at ~300 K with the thickness of 2.8 Å Pd and 5.5 Å Ce and at 6.2 Å Pd and 5.1 Å Ce [3718], ϕ^e is evaluated to be 2.5 ± 0.1 and 2.8 ± 0.1 eV, respectively, by the present author taking 5.4 eV for Ru(0001) from Table 2.

[249]By citing ϕ^e = 5.19 and 5.55 eV for Pd(110) and Pd(111) from Ref. [1351] (see Table 2), the systems of Ce/Pd(110) with 4.8 and 2.1 Å thick [3306] are estimated to have ϕ^e = 3.02 and 3.36 eV, respectively, while those of Ce/Pd(111) with 5.8 and 2.2 Å thick are done to have 3.10 and 3.55 eV, respectively. Due to alloy formation at 970 K, ϕ^e = 4.54 eV is found for the former, while 5.05 or 5.25 eV for the latter [3306].

[250]By citation of ϕ^e = 5.3 eV for Ni(111) from Table 2, ϕ^e of Sm/Ni(111) at 293 K [3000] is estimated to be 2.8 eV, which is increased to 3.3 eV at 800 K by formation of such a surface alloy as $Ni_{17}Sm_2$ [3000].

[251]The values of 3.67 and 3.84 eV correspond to the antiferromagnetic and ferromagnetic surfaces of Gd(0001), respectively [3462].

[252]About La/B/Mo(110) and La/Mo(110), ϕ^e is determined to be 2.8 and 3.4 eV, respectively [2700], while B/La/Mo(110) as well as B/Gd/Mo(110) and B/Mo(110) are done to have the same value of 5.8 eV [2700].

[253]The work function for Gd/B/Mo(110) is 3.0 eV, which is different from 3.5 eV for Gd/Mo(110) [2700], similarly as the above cases mentioned for La/B/Mo(110) and La/Mo(110) in Footnote 252.

[254]The ferromagnetic and paramagnetic surfaces of Gd are theoretically calculated to have ϕ^e = 3.76 and 3.77 eV, respectively [2358] (see Table 13), which are larger than 3.1 eV [304,1045] and also our value of 3.09 eV recommended for Ga in Table 2.

[255]At 1150–1500 K, the temperature dependence is expressed by $\phi^e = A + B \times 10^{-5} T$, where (A, B) is (3.126, 8.0) for Sc, (2.954, 2.0) for Y and (2.975, 6.5) for Er [3071]. Therefore, 3.23, 2.98 and 3.06 eV are evaluated for the respective polycrystals at 1300 K.

[256]The work function of Hf is reported to be 3.53 eV [3524,3527], which is claimed to hold only above 1900 K and also to be 3.20 eV below 1700 K [1756].

[257]For the layers of Hf on W, ϕ^e is measured to be 3.20 eV at 1100 K and 3.92 eV at 2000 K, the latter of which is gradually decreased to 3.70 ± 0.03 eV by formation of Hf–W alloy [1479]. When HfI_4 is deposited onto W at 500 K and decomposed at 1100 K, on the other hand, ϕ^e of the Hf/W system at 1900 K shows 4.00 ± 0.01 eV without forming the alloy [1479].

[258]The work function of Ta(111) is observed to be 4.28 and 4.08 eV after heating at 2100 K by a.c. for firstly 40 h and additionally 50 h until reaching to constancy in ϕ^e, respectively, while it is 4.14 and 4.46 eV after doing so by d.c. for initially 25 h and successively 235 h until so, respectively [729]. Similarly to Mo(100) (see Footnote 168), very long aging of Ta(111) at a high temperature around ~2000 K makes finally ϕ^e constant at 4.08 ± 0.03 or 4.46 ± 0.03 eV [729]. The former is close to 4.01 ± 0.04 eV recommended for Ta(111) (Table 2).

[259]With respect to Ta(130), ϕ^e is determined to be 3.96 eV without annealing, while it is 4.57 eV with annealing up to 1670 K after argon ion impact at 200–2000 eV [680].

[260]At 4.2 K below the superconducting transition temperature (T_S = 4.4 K), ϕ^e for Ta-film on quartz is found to be 3.8 ± 0.2 eV, while it is 3.5 ± 0.2 and 3.8 ± 0.2 eV at 35 and 293 K, respectively [1686]. This result does not show clearly how ϕ^e alters at T_S. In addition, any of the three values for the film by CPD is smaller than ϕ^e = 4.16 eV at 4.2–35 K for bulk Ta by FE [1686]. In considering the temperature dependence of ϕ^e (~10^{-5} eV/K for Ta, see Table 6 in Ref. [1351]), it may be necessary to measure ϕ^e continuously at a meV level in order to determine precisely a probably very minute change (<0.1 eV) around T_S (see Section 9 and Table 14).

[261]According to the Schottky equation (22) (see Section 8.1 in Ref. [1351]) of $\phi^- = E^- - E^0 + E = 11 - 7.94 + E$ [804], ϕ^- for Ta is determined to be 3.7 ± 0.4 and 3.9 ± 0.3 eV by taking the electron affinity (E) of 0.6 ± 0.4 eV [578] and 0.8 ± 0.3 eV [946], respectively. Here, E^- and E^0 are the desorption energies of Ta$^-$ and Ta^0, respectively. In the case of self-NSI, E^- can hardly be determined correctly owing to the space-charge effect due to much stronger thermal electron emission. For production of Ta$^+$ by self-PSI [77,804,805,3083], see Footnote 271.

[262]By critical analysis of the experimental data about Mo by both TE (4.15 eV at ~1400–2000 K) and PE (4.14 eV at 303 K and 4.16 eV at 940 K) [338], Becker deduces ϕ^e = 4.18 eV from TE [3586], well agreeing with 4.16 eV based on PE (4.14 eV at 303 K and 4.16 eV at 940 K) [338] at the same temperature of 940 K in spite of the difference in the two methods.

[263]By theoretical analysis of the experimental data on 4.73 and 4.56 eV obtained for Ag at 298 and 873 K, respectively [3391], Fowler finds 4.73 and 4.75 eV at 296 and 873 K, respectively [1135], the former agreeing excellently between experiment and theory, in contrast to the latter at the higher temperature.

[264]With respect to Pd at ~1200–1400 K, the work function value (4.99 ± 0.04 eV) obtained by TE [1189] is theoretically analyzed by Becker to estimate ϕ^e = 4.997 and 4.966 eV at much lower temperatures (typically, 925 and 400 K) [3586], the respective values of which well agree with 4.98 and 4.97 eV measured by PE [1189]. In other words, ϕ^e for Pd by TE may be extrapolated to be 4.985 ± 0.016 eV at 305–1078 K [3586].

[265]Similarly as above (Footnotes 217 and 218 for Sn and 263 for Ag), Fowler analyzes theoretically the experimental data on 4.12–4.13 eV at 293 K and 4.18–4.19 eV at 973 K observed for Ta by PE [1633,1636], and yields 4.10–4.13 eV and 4.14–4.18 eV at the respective temperatures [1135], fairly agreeing with each other between the two methods.

[266]By theoretical analysis of the data (4.12 ± 0.04 eV) obtained for Ta at ~1450–2050 K by TE [792], Becker yields ϕ^e = $4.07 + 6.0 \times 10^{-5}\,T$ [3586], which affords 4.09 and 4.13 eV at 293 and 973 K, respectively [3586]. The respective values thus extrapolated are in good agreement with the above values (4.10 and 4.14 eV, see Footnote 265) evaluated theoretically by Fowler [1135] from the experimental data achieved by PE [1633].

[267]About the Ta specimen consisting of 70%–(112) face [124], ϕ^e is calculated to be 4.15 eV [1254], which is smaller than the experimental value of 4.25 ± 0.05 eV determined by TE [124,650].

[268]With regard to the 82%–(112)-oriented Ta surface [3414], ϕ^e is determined experimentally to be 4.25 eV by TE [3414], whereas theoretical calculation yields ϕ^e = 4.34 ± 0.03 eV and ϕ^+ = 4.49 ± 0.04 eV [803].

[269]The values of ϕ^- = 4.22, 4.23 and 4.28 eV are determined at 2125 K by simultaneous two–electron capture of the ions of Br$^+$, I$^+$ and Cl$^+$ on Ta, respectively [600,641], where the incident beam flux is correctly countable and, hence, the negative surface ionization efficiency (β^-) by NSI (see Eq. (6)) is more readily determinable compared with the case of neutral halogen beam incidence. In fact, each of the above three values is very close to our recommended ones of ϕ^- = 4.17 ± 0.13 eV and also ϕ^e = 4.20 ± 0.03 eV (see Table 2).

[270]Instead of probing beam incidence upon Ta, W or W(110), the vacuum tube is filled with sodium vapor after evacuation below ~10^{-9} Torr [81,85,87]. Typically, the vapor pressure is ~2×10^{-5} Torr [81]. Thus, ϕ^+ = 4.64, 4.95 and 5.14 eV are determined for Ta [81], W [85] and W(110) [85,87], respectively. About a Na/W(110) system, see Footnote 280.

[271]By production of Ta$^+$ by self-PSI of Ta at very high temperatures (≥2000 K), the effective work function is estimated from Eq. (9). Namely, $\phi^+ = E^0 + I - E^+ = 7.94 + 7.88 - 11.18 \pm 0.1 = 4.64 \pm 0.14$ eV [804], where I is the ionization energy of tantalum atom. In the same way, ϕ^+ is determined to be 5.0 ± 0.5 eV for Ta [77], while ϕ^+ = 5.02 ± 0.11 eV is evaluated from the data on Ta$^+$ produced by self-PSI of Ta independently of Eq. (9) [805,3083]. For production of Ta$^-$ by self-NSI [804], see Footnote 261.

[272]Similarly as above [804] in Footnote 271, ϕ^+ for Ta is evaluated from $E^0 + I - E^+ = 7.97 \pm 0.03 + 7.88 - 10.0 \pm 0.3 = 5.85 \pm 0.3$ eV, where E^0 and I are cited from literatures. However, E^+ = 10.0 eV [137] is unreliable because positive ionic species is not assigned to be Ta$^+$ alone by mass spectrometry.

[273]The work function of W(100) at 1900 K is found to decrease from 4.61 to 4.53 eV as the dislocation density increases from $(4–5) \times 10^6$ to 1×10^8/cm^2 [651].

[274]For the (100) surface of Re (y-atomic %)–W alloys at ~1600–2300 K, two groups of workers [438,3086] and [353] find ϕ^e = 4.54 eV at y = 1% [3086], 4.56 eV at 2% [353], 4.52 eV at 5% after 40–50 h annealing at 2200 K [438] and 4.59 eV at 6% [353], all of which are nearly the same with 4.55 eV for pure W(100) [353], with little dependence upon y = 1–6%.

[275]About the (100) face of 2% Ir–W alloy [3086], ϕ^e is observed to be 4.54 eV at ~1800–2000 K, apparently correspondent to pure W(100). At ~2000–2200 K, on the other hand, ϕ^e increases to 5.28–5.30 eV, showing the same property of Ir (5.28 ± 0.04 eV, see Table 2) and hence suggesting the entire surface covering by Ir-spillover.

[276]Regarding the (100) surface of 1% Os–W alloy [3086], ϕ^e is measured to be 4.57 eV at ~1700–2000 K, corresponding to pure W(100). On the other hand, ϕ^e becomes 5.12 eV at ~2100–2300 K [3086], closing to 4.97 ± 0.17 eV for pure Os (see Table 2).

[277]With respect to the almost (100)-oriented W specimens [124,650,3414], ϕ^e is experimentally determined by TE to be 4.50 ± 0.07 eV [650] and 4.52 ± 0.07 eV (see Footnote 300) [124,3414]. On the other hand, ϕ^e is calculated to be 4.78 eV [1254]. The specimens are theoretically studied in detail by the present author (see Footnotes 300–302, and also both W(F) and W(G) in Table 6).

[278]Similarly as in Footnote 271, Schottky equation (9) is employed to evaluate ϕ^+ of W(100) by PSI of Cs. Namely, $\phi^+ = E^0 + I - E^+ = 2.77 \pm 0.05 + 3.89 - 2.05 \pm 0.05 = 4.61 \pm 0.07$ eV, which well agrees with ϕ^e = 4.65 ± 0.02 eV [266,2314–2316]. By the same way, ϕ^+ is evaluated to be 4.72 eV from $2.83 + 3.89 - 2.00$ eV by PSI of Cs on W(100) [265]. Similarly, ϕ^+ is estimated to be $2.61 \pm 0.07 + 3.89 - 1.84 \pm 0.09 = 4.66 \pm 0.11$ eV by PSI of Cs on W(100), well agreeing with ϕ^e = 4.60 ± 0.06 eV for W(100) by TE [280].

[279]Both PSI and NSI of Na$^+$ and Cl$^-$ from NaCl on W(110) yield $\phi^+ = \phi^- = 4.609 \pm 0.014$ eV [89] and 4.66 ± 0.09 eV [3690], which are much smaller than ϕ^e = 5.18 ± 0.08 eV by TE [89]. The discrepancy (~0.5 eV) between ϕ^+ and ϕ^e is mainly attributable to the fact that the ionization energy (I = 5.14 eV) of Na is smaller than $\phi^+ = \phi^e$ = 5.3 eV (generally expected) for clean W(110). It should be emphasized that the temperature dependence of ionization efficiency (β^+) for Na is generally insensitive to the actual value of work function unless $I > \phi^+$ (see pp. 76 and 77 in Ref. [1351]). In order to avoid such a systematic error due to the insensitivity, not NaCl but TlCl, for example, should have been adopted, where I = 6.11 eV for Tl is much larger than ϕ^+.

[280]By PSI of Ba on W(110), ϕ^+ is found to be 4.82 eV [87], which is much smaller than $\phi^e = 5.04$ or 5.30 eV [87]. The discrepancy (=0.2–0.5 eV) may be principally because the ionization energy ($I = 5.21$ eV) for Ba is not larger than ϕ^+ (~5.3 eV) and hence PSI is affected by the insensitivity mentioned just above in Footnote 279. Quite similarly, ϕ^+ is underestimated to be 5.14 eV (=I for Na) by PSI of Na on W(110) [87].

[281]With respect to W(110) at ~300 K by CPD, ϕ^e is measured to be 5.05 eV, which is increased to 5.15 eV by annealing at 2500 K for 20 h in O_2 at ~10^{-6} Torr [815].

[282]For the (2–4) overlayers of W(110) on Mo(110), ϕ^e is theoretically evaluated to be 5.10 ± 0.01 eV [2074], which is in good agreement with the theoretical value of 5.10 eV for bulk W(110) [2073,2074]. But, they are lightly smaller by 0.10–0.22 eV than any values (5.20–5.32 eV) recommended for W(110) in Table 2.

[283]The actual work function of W(110) is estimated to be $\phi^e = 5.2$ eV instead of 5.1 eV [2774] by the authors [2773,3768] considering a slight underestimation (by 0.1 eV) by a photoemission method [2774]. Consequently, $\phi^e = 5.2$ eV agrees with $\phi^+ = 5.2$ eV by PSI of fast Na atom (100 eV) incident on W(110) [2773,2774], thereby yielding $\Delta\phi^* = \phi^+ - \phi^e = 0.0$ eV just as expected by theory and experiment for clean monocrystalline surfaces (see Table 5). However, the above estimation seems to admit a question (for the detail, see Section 2.8.2).

[284]By applying Schottky equation (9) to PSI of Cs on W(110), the author [2314] mentioned in Footnote 278 determines $\phi^+ = 3.28 + 3.89 - 2.06 = 5.11$ eV, which is smaller than our recommended value of 5.28 ± 0.11 eV (see Table 2). On the other hand, ϕ^e is observed to be 5.33 ± 0.04 eV [2314], equal to our value of 5.32 ± 0.02 eV. The difference ($\Delta\phi^* \equiv \phi^+ - \phi^e = -0.22$ eV $\neq 0$ eV) suggests that some systematic errors are accompanied for E^+ and E^0 included in the equation. This result shows a large contrast to the case reported for PSI of Cs on W(100) by the same author who finds little difference between $\phi^+ = 4.61 \pm 0.07$ eV and $\phi^e = 4.65 \pm 0.02$ eV [266,2314–2316], as already mentioned in Footnote 278.

[285]By incidence of hyperthermal Na atom (0.5–9 eV) on W(110), ϕ^+ is determined to be 5.17 ± 0.01 eV [154,260] or 5.19 ± 0.01 eV [3768] at 1180 K. Similarly, $\phi^+ = 5.2$ eV is measured by 100 eV–Na incidence at ~300 K [2773,2774] (see Footnote 283).

[286]By production of W^+ by self-PSI of W(110), ϕ^+ is evaluated from Schottky equation (9). Namely, $\phi^+ = E^0 + I - E^+ = 8.79 + 7.98 - 11.31 \pm 0.11 = 5.46 \pm 0.11$ eV [146]. Here, the desorption energy of tungsten atom is evaluated from the data compiled in JANAF Thermochemical Tables [26].

[287]By thermal-field emission from W(111), ϕ^e is determined to be 4.43 eV at 80–500 K, while ϕ^e is 4.38 eV at 800–1300 K, according to dϕ/d$T < 10^{-5}$ eV/K [3440].

[288]The work function data on W having various orientations are compared between Refs. [920] and [150], thereby concluding $\phi^e = 4.42 \pm 0.05$ eV for W(114) [920]. Here, 4.17 eV is estimated as the reference work function of Fe(100) [920] (see also Footnote 110).

[289]Among the various single crystals grown in W-wire adopted for experimental study of thermionic emission from different planes, W(110) is estimated to have $\phi^e = 5.26$ eV by subtraction of spurious current to give 120 A/cm^2 K^2 just as the theoretical value of the Richardson constant (A_R) [150]. Both values are quite different really from own experimental data of (ϕ^e, A_r) = (4.58, 8.0) and (4.66, 12) [150]. Tentative substitution of the data into Eq. (8) in Section 2.8.6, on the other hand, yields 5.0 eV, smaller than the value estimated above.

[290]For W(123) and W(235), ϕ^e is found to decrease from 4.90 to 4.50 eV and from 4.72 to 4.30 eV, respectively, by the increase from 80–400 K up to 1200 K [2045]. Similarly for W(257), ϕ^e decreases from 5.00 to 4.80 eV according to the increase from 80–900 K to 1200 K [2045]. Each of the values at 1200 K seems to be nearer to the most probable one for each surface. Typically for W(123), 4.50 eV [2045] is the same with our value of 4.50 ± 0.05 eV (see Table 2).

[291]About the fine tungsten particles with the radius of ~8 and ~40–90 Å, ϕ^e is calculated to be 3.65 and 4.75 eV for real sphere, respectively, in contrast to the respective values of 3.80 and 4.40 eV for cube [2973]. As shown typically as above, ϕ^e changes according to the size, structure and shape of the particles [2973] (for detail, see Section 11.1).

[292]In the magnetic field of 10 kOe, the Fowler–Nordheim plots for W yield $\phi^e = 4.2$ and 4.6 eV above and below the applied voltage of 6 kV, respectively [1493]. In that of 15 kOe, the respective values are 4.25 and 4.35 eV, again different from 4.5 eV taken in absence of the field [1493].

[293]For the W/glass systems (50 Å thick) prepared at 77–90 K, ϕ^e is increased from 4.33 to 4.55 eV by annealing at 403 K [3049], and similarly from 4.36 to 4.63 eV at 438 K [2095], thus approaching to the bulk work function of 4.56 ± 0.03 eV (see Table 2).

[294]The work function of W is found to be 4.6 and 4.62 eV at $P_r = 2 \times 10^{-7}$ Torr and $P(Ar) = 12$ Torr, respectively, while ϕ^e is decreased to 4.42 ± 0.02 eV by ion impact in a high-current glow discharge in Ar [621].

[295]On the basis of such a patchy surface model that W consists of four faces of W(111), W(100), W(112) and W(110) having the local work function (ϕ_i) = 4.35, 4.56, 4.69 and 5.35 eV, respectively, with the fractional area (F_i) = 25% for each face [3843], ϕ^+ is calculated to be 4.51 eV from the ionization efficiency (β^+) = 0.954 for Cs at 2000 K, as shown in Fig. 1 [3843]. Under the same condition, on the other hand, ϕ^e and ϕ^+ are calculated to be 4.46 and 5.12 eV from Eqs. (2) and (1) by the present author, respectively, while $\phi^a = 4.74$ eV calculated from Eq. (4) is intermediate between ϕ^e and ϕ^+, just as predicted by theory [3844].

[296]Similarly as in Footnote 286, ϕ^+ is determined from the data on self-PSI of W according to Schottky equation (9). Namely, $\phi^+ = E^0 + I - E^+ = 8.44 + 7.98 - 11.93 \pm 0.14 = 4.49 \pm 0.14$ eV [823], which is much smaller than our value of $\phi^+ = 5.17 \pm 0.05$ eV for W (see Table 2) but rather near to ours of 4.62 ± 0.06 eV for W(100) (see Table 2). On the other hand, $\phi^e = 4.59 \pm 0.04$ eV [823] is essentially the same with our value of $\phi^e = 4.56 \pm 0.03$ eV for W and near to ours of 4.65 ± 0.02 eV for W(100) (see Table 2). Suppose that the W-specimen [823] is already changed mainly to W(100) by re-crystallization due to aging at high temperatures up to ~3000 K for a long time before the work function measurements, then, both of ϕ^+ and ϕ^e are generally expected to be near to ~4.6 eV (see Table 2). If so, both of the above values [823] may be accepted to be reasonable. If not so, on the other hand, the above result ($\phi^+ = 4.49$ eV $< \phi^e = 4.59$ eV) suggests that the measurements of E^+ as well as E^0 are accompanied with the systematic error of up to ~0.7 eV ($\approx \phi^+ - \phi^e$) mainly for E^+. About such re-crystallization as mentioned above, further information may be obtainable from Section 4.5 in Ref. [1351].

[297]The work function effective for negative ion emission by self-NSI of W is evaluated from the Schottky equation [966], thereby yielding $\phi^- = E^- - E^0 + E = 12.6 - 8.9 + 0.8 = 4.5$ eV. Here, the electron affinity (E) is cited by the present author from Refs. [972], [3957] and [3958], where $E = 0.815$–0.816 eV for W-atom is determined experimentally from negative ion photodetachment threshold. In addition, the data on self-PSI of W afford that $\phi^+ = E^0 + I - E^+ = 8.9 + 7.98 - 12.1 \pm 0.15 = 4.8 \pm 0.2$ eV [966], thereby yielding $\Delta\phi^* \equiv \phi^+ - \phi^e = \phi^+ - \phi^- = 4.8 - 4.5 = 0.3$ eV. This is smaller than our value of 0.6 eV for W (see Table 5). The decrease from 0.6 to 0.3 eV suggests that a considerable part (δ_m) of the tungsten surface is recrystallized to W(100) by high-temperature heating up to ~3000 K during measurements (see Fig. 1 for the relation between $\Delta\phi^*$ and δ_m).

[298]Both W and W_2C are found to have almost the same work functions of 4.5 ± 0.07 and 4.58 ± 0.08 eV, respectively [3533].

[299]The same value of $\phi^e = \phi^- = 4.51$ eV (or $\phi^- = 4.49$ eV for I-incidence) is determined for W [827], yielding $\Delta\phi^{**} \equiv \phi^- - \phi^e = 0$ eV, just as predicted by theory. Further information about the thermionic contrast ($\Delta\phi^{**}$) is obtainable from Table 7.

[300]Each W-surface consisting of 95 or 96%-W(100) and of the remainder with almost W(111) is determined experimentally to have $\phi^e = 4.52 \pm 0.07$ eV [124]. The latter taken as 96%-(100) and 4%-(111) is theoretically calculated to have $\phi^e = 4.59 \pm 0.04$ eV [630,2453], which is very close to the above experimental value [124]. However, both are smaller by $\Delta\phi = 0.13$ or 0.06 eV than $\phi^e = 4.65 \pm 0.02$ eV recommended for 100%-W(100) (see Table 2). This smallness is quite reasonable because $\phi^e = 4.45 \pm 0.03$ eV for W(111) (Table 2) is smaller by 0.20 eV than the above for W(100). In other words, only 4%-W(111) has a considerable contribution to lowering the work function of the 96%-W(100) specimen by $\Delta\phi \approx 0.1$ eV. On the contrary, our theoretical value of $\phi^+ = 4.60 \pm 0.04$ eV for the specimen [630,2453] is virtually the same with 4.62 $\pm$ 0.06 eV for 100%-(100) (Table 2). This result shows that 4%-W(111) with the work function smaller by 0.20 eV compared with W(100) has little contribution to lowering ϕ^+. This is mainly because positive ion is emitted predominantly from the higher work function face (100), in contrast to electron done so from the lower one (111) (see Section 1).

[301]For the W-surface consisting of 95%-(100), 1%-(110), <1%-(111) and 2%-(112) faces [3414], ϕ^e is theoretically evaluated to be 4.57 $\pm$ 0.00 eV [803] and 4.61 $\pm$ 0.04 eV [2453], the former of which is closer to $\phi^e = 4.52$ eV determined experimentally for the surface [3414]. Both are smaller by 0.04–0.08 eV than $\phi^e = 4.65 \pm 0.02$ eV for 100%-W(100) recommended in Table 2. This result, however, is quite natural because the (110) and (112) faces have the respective values of $\phi^e = 5.32 \pm 0.02$ eV and 4.78 $\pm$ 0.03 eV (Table 2), higher than 4.65 $\pm$ 0.02 eV for the (100) face. Consequently, both of the former have the smaller contribution to electron emission compared with the latter. On the other hand, the work function (ϕ^+) effective for positive ion emission from the 95%-W(100) specimen is calculated to be 4.69 $\pm$ 0.05 eV [803] and 4.70 $\pm$ 0.04 eV [2453], both of which are slightly larger by 0.07–0.08 eV than $\phi^+ = 4.62 \pm 0.06$ eV for 100%-W(100) (Table 2), on the contrary to the above case where ϕ^e is smaller by 0.04–0.08 eV. Again, this is reasonable because the (110) and (112) faces with larger work functions ($\phi^+ = 5.28 \pm 0.11$ and 4.70 $\pm$ 0.01 eV, see Table 2), compared with the (100) face ($\phi^+ = 4.62 \pm 0.06$ eV), have the larger contribution to positive ion emission in comparison with the latter.

[302]About the W-specimen having the surface composition of 95%-(100), 2%-(112), 1%-(110) and <1%-(111) [3414], ϕ^e is experimentally determined to be 4.52 eV in vacuum ($\sim 10^{-9}$ Torr) and 4.5 eV as the "clean" cesiated work function in Cs-vapor [3414]. Theoretical evaluation of both ϕ^e and ϕ^+ for the specimen is summarized in Footnote 301. It should be noted that this 95%-(100) specimen [3414] is different from another 95%-(100) one with the remainder consisting of almost (111) face [124], although the experimental value of $\phi^e = 4.52$ eV is the same between the two. With respect to the theoretical values of ϕ^e and ϕ^+, see Footnotes 300 and 301 and also W(F) in Table 6.

[303]By critical analysis of work function data obtained for W by several methods by many groups of workers, $\phi^e = 4.54_5$ eV for well-aged polycrystalline tungsten is recommended as the reference for CPD at $\sim$300 K by Hopkins and Rivière [828].

[304]By PSI of In on W at $\sim$2300–2700 and 2350 K, ϕ^+ of W is determined to be 5.05 $\pm$ 0.05 and 5.10 eV from the slope of a semi-Saha–Langmuir plot (see Section 4.2.1 in Ref. [1351]) and from the ionization efficiency (β^+) (see Eq. (6) in Ref. [1351]), respectively [94]. It should be emphasized that In has the ionization energy of $I = 5.79$ eV, larger than $\phi^+ = 5.10$ eV mentioned above and also than our value of 5.17 $\pm$ 0.05 eV (Table 2), thereby making it reasonable to employ the above plot. In addition, ϕ^e is measured to be 4.58 $\pm$ 0.05 eV by TE at 2300 K [94], consequently affording $\Delta\phi^* = \phi^+ - \phi^e = 0.47 \pm 0.07$ eV or 0.52 $\pm$ >0.05 eV (see Table 4).

[305]Regarding the W/Mo(100) system with $\theta = 0.6$–1.0 ML, ϕ^e at 77 K is determined to be 4.6 eV, which is increased to 4.7 eV by annealing up to 1300 K [2965].

[306]From the temperature dependence of Na$^+$ and Ag$^+$ currents originating from PSI of NaCl and Ag, ϕ^+ of W is determined to be 4.6 $\pm$ 0.1 and 5.16 $\pm$ 0.1 eV, respectively [3113], which are much smaller than and substantially equal to, respectively, our recommended value of $\phi^+ = 5.17 \pm 0.05$ eV (Table 2). In contrast to Ag (ionization energy, $I = 7.54$ eV), Na (5.14 eV) does not satisfy the prerequisite condition ($I \geq \phi^+ + 0.3 \simeq 5.5$ eV) for semi-Saha–Langmuir plot (Section 4.2.1 in Ref. [1351]). This may be the main reason for the above result. It should be noted that the by-production of Na$_2$Cl$^+$ is as small as $\sim 1 \times 10^{-4}$ in comparison with Na$^+$, consequently giving no effect to the above result.

[307]From the experimental data on W$^+$ and W$^-$ produced by self-PSI and self-NSI, respectively [965], the present author estimates $\phi^+ = 4.65 \pm 0.4$ eV, where he takes $E = 0.6 \pm 0.4$ eV for electron affinity of W [578] and also does $\phi^- = \phi^e = 4.55$ eV instead of $\phi^- = \phi^+ = 4.55$ eV [965] because of $\phi^- \neq \phi^+$ and of $\phi^e \neq \phi^+$ for any polycrystalline specimen (see Tables 4, 5 and 7).

[308]About the W-layers prepared by chemical vapor deposition (CVD) of WF$_6$ and WCl$_6$ together with H$_2$ onto Mo (or Nb, Ta or W), ϕ^e is measured to be 4.66 and 4.67 eV, respectively [1398], the former of which is increased slightly to 4.72 eV by electro-etching [1398]. This is close to 4.75 eV for bulk-W after the etching, instead of 4.68 eV for the bulk before the etching [1398].

[309]The system of W/W(100) prepared by CVD of WF$_6$ and H$_2$ at $\sim$1850–2450 K is determined to have $\phi^e = 4.69$ eV, which is changed to 4.71, 4.51, 4.59 and 4.98 eV by lightly electropolishing, both grinding and electropolishing, both grinding and 3h-heating at 2300 K, and chemically etching in NaOH-solution, respectively. The surface with 4.51 eV consists mainly of sections of grains oriented close to (100) [1053]. Similarly, W/W(110) done by WCl$_6$ and H$_2$ is found to have 4.66 eV, which changes to 4.47, 4.88 and 5.03 eV after electropolishing, both grinding and 3h-heating at 2600 K, and both grinding and electropolishing, respectively [1053]. In addition, W is deposited onto ground W(100) and W(110), both of which are observed to have 5.16 eV [1053]. This is very close to 5.13 and 5.15 observed for W(110) after both abrading and heating at 2800 K [1053], as outlined in Footnote 310 below.

[310]Under the same condition as above (Footnote 309), ϕ^e is measured to be 5.22 eV for W(110) after electropolishing or next heating at 2400 K for 16 h, and also to be 5.13 or 5.15 eV after both abrading and heating at 2800 K for 3 h [1053]. In addition, ϕ^e is determined to be 5.06 eV for W/W(110) prepared by W-deposition [1053]. This value is slightly lower than those for the above bulk surfaces subjected to several processing, but much larger than 4.54 eV found for the electropolished W(100) and W(111) faces [1053].

[311]With respect to the W-surface consisting fractionally of 80%-(110), 14%-(100), 5%-(112) and 1%-(111) [162], ϕ^e is theoretically evaluated to be 4.90 $\pm$ 0.05 eV [630] and 4.87 $\pm$ 0.06 eV [2453], both of which are near to 5.0 $\pm$ 0.2 eV determined after outgassing at temperatures up to 2600 K over 8 h [162] and also to 4.82 $\pm$ 0.02 eV done after heating at 2400 K for 17 h [162]. Theoretical evaluation of ϕ^+ yields 5.25 $\pm$ 0.02 eV [630] and 5.26 $\pm$ 0.02 eV [2453], thereby leading to $\Delta\phi^* = \phi^+ - \phi^e = 0.35 \pm 0.07$ eV [630] and 0.39 $\pm$ 0.07 eV [2453], respectively (see Table 4). For further information about the surface, see W(E) in Table 6.

[312]By PSI of KCl, KBr or KI on W, ϕ^+ is determined to be 4.65 $\pm$ 0.05 eV [46], which is corrected to 4.95 eV [3747] by theoretical analysis of the data on PSI of KCl [46].

[313]From the experimental data on PSI of NaCl on W, ϕ^+ is evaluated to be 4.82 eV [47], which is corrected to 5.05 eV [3747] by theoretical analysis of the data [47]. The latter is closer to our recommended value of $\phi^+ = 5.17 \pm 0.05$ eV (see Table 2).

[314]By NSI of KI on W, ϕ^- is determined to be 4.95 $\pm$ 0.05 eV [183], which is much larger than $\phi^- = 4.46$–4.58 eV [574,586,827,966] (see Table 7), and than our value of $\phi^- = 4.51 \pm 0.03$ eV (Table 2), and also than ϕ^e (=ϕ^- in general, see Table 7) = 4.56 $\pm$ 0.03 eV (Table 2). On the other hand, PSI of Cu and Ag on W yields $\phi^+ = 5.25 \pm 0.05$ eV [183], fairly agreeing with our value of $\phi^+ = 5.17 \pm 0.05$ eV (Table 2).

[315]In the strong electric fields of $F \approx 6 \times 10^4 - 1 \times 10^6$ V/cm [155,156] and $3 \times 10^3 - 2 \times 10^6$ V/cm [157], PSI of Li [155], NaCl and LiCl [156] and In and Tl [157] is performed on W at $\sim$1600–2700 K, thereby yielding $\phi^+ = 4.82$ and 5.12 eV [155], 4.83 and 5.11 eV [156], and 5.15 and 5.12 eV [157]. In these cases, the slope of semi-Saha–Langmuir plot is given by $\phi^+ + e(eF)^{1/2} - I$ [2], where I is the ionization energy of incident atom such as Li, In or Tl. In usual PSI, the Schottky term can be neglected since $e(eF)^{1/2}$ is less than 0.012 eV for $F < 1$ kV/cm [2]. In self-NSI of metals (typically, W and Re [966]) at very high temperatures, the term must be considered in general because F is usually applied so strongly as to overcome the space charge effect due to much stronger electron emission current accompanied with the negative metal ion current under study.

[316]Re is electroplated onto W in solution of KReO$_4$ [666], thereby resulting in 4.74 eV.

[317]This is a capillary type ion source consisting of six Re-wires ($\phi^+ = 4.9$ or 5 eV) in a Ta-tube [2944].

[318]From the experimental data on Re$^-$ produced by self-NSI of Re at high temperatures [966], the present author evaluates $\phi^- = E^- - E^0 + E = 12.55 \pm 0.15 - 7.8 \pm 0.15 \pm 0.10 \approx 4.9 \pm 0.2$ eV, where the electron affinity (E) of Re is cited from Ref. [578]. Similarly for Re$^+$ [966], ϕ^+ is estimated from $E^0 + I - E^+ = 7.8 + 7.87 - 10.72 \pm 0.12 \approx 5.0 \pm 0.1$ eV.

[319]With regard to Re/Mo prepared by CVD of ReCl$_3$ and H$_2$ on Mo, ϕ^e is determined to be 4.82 eV, which increases to 4.94 eV after electroetching [1398].

[320] The Re-surface composed of various patchy faces [3414] is found to have 4.8 eV as the "clean" cesiated work function in Cs-vapor [3414], but 4.96 ± 0.05 eV in vacuum [124,650,3414], exactly the same with our recommended value (Table 2).

[321] This Re-surface is prepared by electrolytic coating on W with ~1500 atomic layers [1850]. Its work function (5.0 eV) is virtually the same with ours (Table 2).

[322] To evaluate ϕ^- for Re [216], the electron affinity of CN is taken as 3.7 ± 0.2 eV from Ref. [930]. The result of $\phi^- = 5.06 \pm 0.1$ eV is essentially equal to 5.03 ± 0.1 eV by NSI of Cl and also to $\phi^e = 5.0 \pm 0.1$ eV for Re [99,216].

[323]The Re-film (2 nm thick) prepared on 6H-SiC(0001) ($\phi^e = 4.5 \pm 0.1$ eV) at ~300 K or annealed at ~500 K is found to have $\phi^e = 5.2 \pm 0.1$ eV, and decreases by ~0.4 eV after further annealing at 700 K [3646].

[324]The Re-surface ($\phi^e = 5.35 \pm 0.05$ eV) appears to be covered with oxygen at ~0.5 ML [166,3730], thereby being larger than the generally accepted value of about 5.0 eV (see Table 2).

[325]The work functions of 5.93 and 5.50 eV for Os and Ir, respectively [3322], are determined by another worker in the same laboratory [3536].

[326]For stepped faces of Ir(100), ϕ^e is determined by FE to be 5.2 and 5.4 eV [1810], which are lower than 5.70 ± 0.05 eV for a perfect face of Ir(100) [1797,1802]. The latter is near to our value of 5.60 ± 0.06 eV (Table 2). According to increase in step density, ϕ^e decreases in general, as already outlined in Section 4.2.5 [1351].

[327]The normal (1 × 1)Ir(100) with $\phi^e = 5.5$ eV [1534,1553,2961] is changed to the reconstructed (1 × 5)Ir(100) with 5.4 eV by heating above 1200 K [2961].

[328]Regarding the Ir surface consisting of 81%-(111), 15%-(100) and <3%-(110) faces [650,3414], ϕ^e is theoretically evaluated to be 5.36 ± 0.07 eV [803], which is slightly larger than the experimental value of 5.27 ± 0.05 eV [650,3414], but considerably smaller than ours (5.75 ± 0.06 eV for 100%-(111) face, see Table 2). This may be mainly due to the co-existent (110) face having the smallest value of 5.23 ± 0.19 eV (Table 2) among the three faces. On the other hand, the theoretical value of $\phi^+ = 5.73 \pm 0.01$ eV [803] for the above patchy surface [650,3414] is essentially the same with our value of 5.76 ± 0.04 eV for 100%-(111) surface (Table 2). Namely, the lower work function faces oriented with (110) and (100) have little contribution to ϕ^+ effective for positive ion emission, on the contrary to the above ϕ^e effective for electron emission occurring predominantly from lower work function faces.

[329] About the Ir-surface with 80%-(111) and 15%-(100) oriented [124], ϕ^e is calculated to be 4.68 eV [1254], which is smaller than 5.27 ± 0.05 eV determined experimentally [124]. Regarding almost the same surface of Ir [650,3414], see Footnote 328 just above.

[330]The "clean" work function of Ir-surface with 81%-(111), 15%-(100) and <3%-(110) oriented at ~1400–2200 K in Li-vapor ($\leq 2.5 \times 10^{-4}$ Torr) is measured to be $\phi^e = 5.35 \pm 0.05$ eV [169], which is larger than 5.2 eV for the "clean" cesiated one [3414] and also than 5.27 eV found in vacuum [650,3414], but which is essentially the same with our calculated value of 5.36 ± 0.07 eV [803]. For additional information, see Footnote 328. About PSI of Li, $\phi^+ = 5.4$ eV is evaluated from the data in Fig. 5 [169], from which $\beta^+ = 0.34$ at ~1100 K is selected by the present author.

[331]The work function of a 6 × (100) stepped surface of Pt is calculated to be 5.93 eV, which is smaller than 6.07 eV for a flat one [795]. Such a difference is found for Pd(100), too (see Footnote 182). For further information about stepped surfaces, see Section 4.2.5 [1351].

[332]A rough surface of Pt(110) is determined to have $\phi^e = 5.24$ eV, which is smaller than 5.35 eV for a smooth one [853]. Such a difference as ~0.1 eV depending upon surface roughness is observed for Rh(110), too [853] (see Footnote 177).

[333]With respect to the unreconstructed (1 × 1) and reconstructed (1 × 2) Pt(110) surfaces, ϕ^e is theoretically evaluated to be 5.52 and 5.71 eV, respectively [2543], the former of which is the same with our value of 5.54 ± 0.07 eV (Table 2).

[334]By three different experimental methods of ionic emission, atomic desorption and mean residence time of Li-atom incident upon Ir(111) at ~1100–1400 K, ϕ^+ is determined to be 5.68 ± 0.01, 5.69 ± 0.03 and 5.72 ± 0.03 eV, respectively, which yield the average of 5.70 ± 0.02 eV [167], well agreeing with our recommended value of $\phi^+ = 5.76 \pm 0.04$ eV for Ir(111) (see Table 2). Similarly, the respective methods applied to Pt(111) at ~1200–1500 K afford 5.80 ± 0.02, 5.76 ± 0.02 and 5.75 ± 0.02 eV and, hence, yield the mean of 5.77 ± 0.02 eV [167,319]. Again, this is in good agreement with our value of $\phi^+ = 5.80 \pm 0.06$ eV (Table 2).

[335]Onto the Pt(111) surface determined to have 5.84 ± 0.05 eV [421–423,773], Pt is deposited at 130 K, forming a highly disordered and complex surface ($\phi^e = 5.64$ eV) dominated probably by clusters. At 250 K, ϕ^e continues to decrease according to $\theta^{1/2}$-dependence down to about 5.7 eV at $\theta = 1$ ML because Pt-adatoms are organized in islands [421]. At 400 K, on the other hand, ϕ^e is kept virtually constant at 5.84 eV = ϕ^e (111) in the covered range of $\theta = 0$–1.25 ML, indicating that Pt-adatoms are incorporated rapidly at existing steps and hence ϕ^e remains unchanged [421].

[336]Regarding the Pt-surface estimated roughly to consist of 80%-(210), ~10%-(100) and 10%-(111) faces [179], ϕ^e is determined to be 5.79 ± 0.09 eV [179,650], while the "clean" cesiated work function is done to be 5.0 eV [650] or 5.1 eV [3413,3414].

[337]The Pt-surface [429] is experimentally determined to have $\phi^e = 5.77$ eV, which is very close to the theoretical values of 5.74 and 5.76 eV for Pt(221) [1293].

[338] The Pt-surface [50] seems to be not clean but considerably contaminated with carbon because its $\phi^+ = 4.40$–4.49 eV is much smaller than $\phi^+ = 5.58 \pm 0.11$ eV of our value recommended for a clean Pt surface (Table 2), but rather very close to $\phi^+ = 4.50 \pm 0.04$ eV of ours done for a C-film on metals (see Table 2). About the physico-chemical properties of the film, see Section 4.2.4 [1351]. Consideration of the above results and of the film properties outlined in the above section may suggest that many of the Pt-surfaces having $\phi^e \approx 4.3$–4.7 eV found in Table 1 may probably be heavily or considerably covered with graphitic films.

[339]The experimental data on Pt yields the empirical equation of $\log_{10} A = -6.85 + 1.87\phi^e$, affording $\phi^e = 4.72$ eV for $A = 92.8$ A/cm^2 K^2 [2299,2300].

[340]The work function of Pt measured by PE is found to be $\phi^e = 5.27 \pm 0.1$ eV [3055], well agreeing with our recommended value of 5.30 ± 0.07 eV (Table 2). However, $\phi^+ = 4.94 \pm 0.23$ eV by PSI of K [3055] is not larger than the above ϕ^e and it is smaller than ours of $\phi^+ = 5.58 \pm 0.11$ eV. This is probably because the ionization energy (I) of K (4.34 eV) does not satisfy the prerequisite condition of $I \geq \phi^+ + 0.3$ eV (see Section 4.2.3 in Ref. [1351]). In other words, not K but Ca or Tl, for instance, should have been adopted because the latter satisfies $I = 6.1 > 5.3 + 0.3$ eV.

[341]By PSI of Cs and K on Pt, $\phi^+ = 5.43$ eV [282] is determined from Saha–Langmuir equation (5) of $k^+/k^0 = \alpha^+ = 0.5 \exp[(\phi^+ - I)/kT]$. In addition, ϕ^+ is determined from Schottky equation (9) of $\phi^+ = E^0 + I - E^+ = 3.27 \pm 0.04 + 3.89 - 1.80 \pm 0.05 = 5.36 \pm 0.06$ eV according to the data on Cs and also from that of $\phi^+ = 3.65 \pm 0.03 + 4.34 - 2.47 \pm 0.04 = 5.52 \pm 0.05$ eV according to those on K [282], only the latter of which is larger than $\phi^e = 5.41 \pm 0.05$ eV determined from a Richardson plot [282]. In the above equations, k^+/k^0 is the ionic to atomic desorption rate constant ratio [98,282,397], whilst E^+, E^0 and I are the ionic and atomic desorption energies and ionization energy, respectively (see Section 4.1). The above values [282] do not well accord to ours of $\phi^+ = 5.58 \pm 0.11 > \phi^e = 5.30 \pm 0.07$ eV and $\Delta\phi^* = 0.28 \pm 0.13$ eV for Pt (Tables 2 and 4).

[342]The Pt-films prepared on glass at 78–80 K are found to have $\phi^e = 5.45$ eV, which increases to 5.63 and 5.72 eV after annealing at about 300 and 600 K, respectively [428,1497,2719], more deviating from our value of Pt (5.30 $\pm$ 0.07 eV, see Table 2) and much closing to ours of Pt(110) (5.54 $\pm$ 0.07 eV) or Pt(100) (5.75 $\pm$ 0.06 eV) by the annealing at higher temperatures.

[343]By PSI of Cs on Pt [98], $\phi^+ = 5.5$ eV is determined from the data on $\alpha^+ = k^+/k^0$, the method of which is outlined in Footnote 341.

[344]The Pt-specimen [434] is a considerably (111)-oriented wire prepared by aging at 1600 K for 150 h, thereby showing $\phi^e = 5.55 \pm 0.1$ eV [434]. This is intermediate between 5.84 eV for Pt(111) and 5.30 eV for Pt in Table 2.

[345]By PSI of NaNO$_3$ on Pt [178], ϕ^+ is determined to be 5.54 $\pm$ 0.07 and 5.56 eV from Schottky equation (9) and $\alpha^+ = 20$ in Saha–Langmuir equation (5), respectively [178], both values of which are virtually the same with ours of $\phi^+ = 5.58 \pm 0.11$ eV for Pt (Table 2).

[346]By deposition of Pt (1–2 ML thick) onto W(110) at $\sim$300 or 800 K, ϕ^e increases from 5.35 to 6.05 eV [1137], the latter of which is near to 5.7–5.9 eV recommended for Pt(111) in Table 2.

[347]Regarding the unreconstructed (1 $\times$ 1) and also reconstructed (1 $\times$ 2) and (1 $\times$ 3) Au(110) surfaces, ϕ^e is calculated to be 5.39, 5.38 and 5.32 eV, respectively [2543], all of which are virtually the same with 5.33 $\pm$ 0.09 eV recommended for Au(110) in Table 2.

[348]After Au-films ($\theta \geq 3.5$ ML) are prepared on W(112) at 78 and 540 K, ϕ^e is measured at 78 K to be 5.3 and 5.45 $\pm$ 0.03 eV, which correspond to Au and Au(110), respectively [2256]. The former agrees well with our recommended value of 5.30 $\pm$ 0.04 eV for bulk Au, but the latter is slightly larger than ours of 5.33 $\pm$ 0.09 eV (Table 2).

[349]The Au-films ($\theta = 5$ and 4 ML) formed on W(110) at 78 and 160 K are observed at 78 K to have $\phi^e = 5.3$ and 5.4 eV, respectively [2256]. On the other hand, Au-film ($\theta \geq 3.5$ ML) done at 420 K is found at 78 K to have 5.32 $\pm$ 0.03 eV with an Au(111) structure [2256], slightly smaller than our value of 5.46 $\pm$ 0.07 eV for Au(111) (Table 2).

[350]By annealing at 623 K for 1 h, the Au-film (0.12 nm thick) prepared on quartz at $\sim$300 K is increased in ϕ^e from 5.38 to 5.42 eV as the degree (δ_m) of monocrystallization forming the (111) face is increased from $F_i = 61$ to 91% [3313]. The latter is essentially the same with 5.46 $\pm$ 0.07 eV for Au(111) (Table 2). For further information about δ_m and F_i (fractional surface area), see Sections 4.2 and 4.3.

[351]The Au-film ($\theta = 7$ ML) formed on W(112) at $\sim$300 K is observed to have $\phi^e = 5.51$ eV [2385], which is virtually the same with 5.55 eV for the bulk Au(111) surface studied in a similar way [2385,2871].

[352]Regarding the fine Au-particles of $\sim$8 and 90 Å in radius, ϕ^e is calculated to be about 4.1 and 4.6 eV for real sphere, respectively, and also to be about 4.4 and 5.0 eV for octahedron, respectively [2973]. For further information, see Section 11.1.

[353]For an Au-ribbon at $\sim$300 K in an Hg-pumping system at the residual gas pressure less than $\sim$10^{-9} Torr (2 $\times$ 10^{-9} Torr as the partial pressure of Hg), ϕ^e is found to be 4.64 or 4.89 $\pm$ 0.06 eV [1072]. However, it increases to 5.20 $\pm$ 0.05 eV when the measurement by CPD is done soon after flashing to remove Hg-adatoms, all of which desorb at 1170 K [1072]. About the work function change due to amalgamation, see Point (6) in Section 3.2.

[354]With respect to a gold filament at 293 and 1013 K, ϕ^e is determined by PE to be 4.82 and 4.73 eV, respectively [2560], the theoretical analysis of which yields 4.81 $\pm$ 0.02 eV [1760] and also 4.90 $\pm$ 0.03 or 4.93 $\pm$ 0.03 eV [1135] in the above temperature range.

[355]By theoretical analysis of the data on temperature dependence of work function for ordinary metals [3586], the thermionic work function of Au is estimated to be 4.89 and 4.92 eV at 733 and 1013 K, respectively [3586]. They are in good agreement with 4.92 eV theoretically evaluated [1135] from the photoelectric data (nearly the same values in Footnote 354) [2560] at the respective temperatures, but they are smaller than ours (see Table 2).

[356]In regard to an Au/Ta system, ϕ^e is determined to be 4.83 $\pm$ 0.02 eV [1162], which is corrected to be 4.97 $\pm$ 0.02 eV [349] by taking the reference work function of Ba as 2.66 $\pm$ 0.01 eV [1050] (see Footnote 238) instead of 2.51 eV [2232] adopted by the author [1162]. However, both values are still much smaller than ours (5.30 $\pm$ 0.04 eV, Table 2), probably because the above system is contaminated with Hg (see p. 77 in Ref. [1351]).

[357]For an Au-ribbon at $\sim$10^{-9} Torr evacuated by an Hg-pump [2473], ϕ^e is found to be 5.01 and 5.08 eV at $\sim$300 K after Ar$^+$-impact (335 V), the values of which increase to 5.13 and 5.18 eV, respectively, after annealing up to $\sim$1200 K. Similarly, $\phi^e = 5.27$ and 5.31–5.33 eV at $\sim$300 K after the impact (85 and 635 eV by Ar$^+$) become common at 5.27 eV after the annealing at $\sim$1100 K [2473], thus yielding the data affected little by Hg-contamination.

[358]About the Au-layers (10 and 5 ML thick) deposited onto Ta(112) at $\sim$300 K, ϕ^e is measured to be 5.04 and 5.08 eV at $\sim$300 K [878], while the layers deposited at 1000 K have 4.76 eV, corresponding likely to a surface alloy with Ta [878].

[359]With regard to Au-layers ($\theta \approx$ 4–5 ML) prepared on Ir(100) at 78 K, ϕ^e is found to be 5.86 $\pm$ 0.02 and 5.80 eV after annealing at 482 and 520 K, respectively [2189]. On the other hand, the Au-layers ($\theta \approx$ 2–3 ML) on Ir is observed to have the different values of 5.29 and 5.10 eV after annealing at 501 and 520 K, respectively, indicating a change in overlayer structure in the above temperature range [2189].

[360]By deposition of Au onto bulk Au at $\sim$300 K, ϕ^e is decreased by 0.19 eV, which becomes zero by heating up to 723 K [3502]. Provided that the latter corresponds to 5.31 eV [1351], the former may be estimated to 5.12 eV.

[361]About the Au-films ($\sim$30 ML thick) on W of (111), (112) and (100) faces at $\sim$300 K, ϕ^e is measured to be 5.17, 5.20 and 5.36 eV, the respective values of which are decreased to 4.96, 5.08 and 5.14 eV by annealing at $\sim$1000 K [2647].

[362]Regarding the Au-clusters (Au$_n$) on W systems at 77 K, ϕ^e is determined to be 5.2 $\pm$ 0.4 and 5.7 $\pm$ 0.5 (or 5.9 $\pm$ 0.6) eV for the incident cluster diameters of 30 and 15 Å, respectively [1713]. Supposing that $r = 15$ and 7.5 Å are kept unchanged on W, $\phi^e \approx 5.7$ and 6.0 eV for Au$_n$/W, respectively, may be estimated from Eq. (17′), where $\phi^e(\infty)$ is taken as 5.3 eV. The latter seems to be consistent with the experimental data.

[363]The layers (250–500 Å thick) of Ru, Pt and Au deposited on glass at $\sim$78 K are found to have $\phi^e = 4.52$, 5.46 and 5.22 eV, respectively, which are increased to the stable values of 5.10, 5.72 and 5.38 eV by annealing at the temperatures (T_a) above $\sim$800, $\sim$500 and $\sim$400 K, respectively [436]. These results indicate that T_a should be selected to satisfy the condition of roughly $T_a \geq T_m/3$ in order to make the layers equilibrated fully on glass [436]. Here, T_m is the melting points of 2723, 2047 and 1336 K for the respective metals (see Section 2.5).

[364]The Au-layers formed on Mo(111) at $\sim$300 and 1000 K are found to have $\phi^e = 5.08$ and 5.22 eV at $\sim$300 K, respectively [1842]. The latter is nearer to the recommended value of 5.30 $\pm$ 0.04 eV (Table 2), just as expected from the annealing condition mentioned in Footnote 363.

[365]The work function of Au/glass at $\sim$300 K is measured to be 5.22 $\pm$ 0.05 eV, which is decreased to 4.77 eV by intentional admission of Hg [1071]. The latter corresponds to $\sim$4.7–4.8 eV found for Au in Hg-pumping systems [typically, 133,1160–1162,1893], where the surface reaction (amalgamation) is ready to occur between Au and Hg (see Point (6) in Section 3.2). For related subject, see Footnote 368.

[366]The Au-layers ($\theta > 2$ ML) formed on W(110) at 78 K in an Hg-pumping system is found to have $\phi^e = 4.89$ eV at $\sim$300 K, but ϕ^e increases to 5.25 eV after heating at 750 K [1670,1673]. The heating is effective for removing Hg from the Au-layers.

[367]Similarly as above (Footnote 366), ϕ^e of an Au/glass system is found to increase from 4.7 to 5.3 eV after heating at 520 K [1893], which is also effective for making an Ag/glass surface substantially free from Hg.

[368]By using an ion-pumping system in order to escape from Hg-contamination, ϕ^e for Au/Ru is measured to be 5.28 eV [1073], which is much higher than 4.68 and 4.71 eV determined previously for Au/glass and Au/W, respectively, by the same author [133,1161] using an Hg-pumping system. In brief discussion, the Hg-contamination data on 4.68–4.97 eV for Au on glass, W and Ta [133,1160–1162] are compared with the Hg-free ones on 5.22–5.45 eV for Au/glass [945,1071,1073]. For related subject, see Footnote 365.

[369]For metal films (7–12 nm thick) made on glass at 77 K, ϕ^e is found to increase from m to n eV by annealing (smoothing) at 323 K (or 373 K for Au alone). Namely, metal ($m \to n$ in eV) results in α-Fe (4.10 → 4.40); Co (4.44 → 4.91); Ni (4.55 → 4.88); Cu (4.40 → 4.64); Pt (5.50 → 5.71); and Au (4.96 → 5.40) [2133]. Typically, α-Fe and Ni are made to approach their work function values to ours (4.55 and 5.06 eV, respectively, in Table 2) by the annealing.

[370]The work function of Hg is found to be 4.49 ± 0.01 eV at 273 K, and no measurable change around the melting point of 234 K can be observed [1669].

[371]The W covered "fully" with Hg at 300 K is found to have ϕ^e = 4.9 eV [3726]. This value, however, corresponds not to $\theta \geq 1$ ML but to ~0.4 ML [3074] according to the data on Hg/W at the equilibration temperature of 370 K [3074]. At about 240 K, the Hg/W system is found to have ~4.6 eV at $\theta \approx 1$ ML [3074].

[372]About Hg/Ni(111) at $\theta = 0.75$ ML and $T = 240$–310 K, ϕ^e is determined to be 4.90 eV [3166]. This value is much larger than ours (4.50 eV in Table 2), similarly as in the case [3726] in Footnote 371.

[373]With respect to Pb/glass at ~300 K, ϕ^e is determined to be 4.00 eV [1381], which is corrected to be 3.83 eV [349] by taking the reference work function of Ba as 2.35 eV [13,349] instead of 2.52 eV [1380,1381]. As shown in Table 2, our values for Pb and Ba are 4.07 ± 0.05 and 2.50 ± 0.02 eV, respectively, to which the former (4.00 and 2.52 eV) [1381] is nearer than the latter (3.83 and 2.35 eV) [349]. It should be noted that $\phi^e = 2.52$ eV employed as the reference work function of Ba is cited from the original value (2.520 eV at ~300 K) in Ref. [2232]. See also Ref. [1157] in Footnote 238.

[374]The work function of Pb at ~300 K is found to be 3.95 ± 0.05 eV, which does not change at the melting point (601 K) [3437] (see Table 12).

[375]The work function of a Bi/Au(111) system is found to decrease by 1.52 eV as θ increases to 1 ML, and ϕ^e remains constant up to at least 4 ML. Here, Bi forms a monolayer followed by the growth of a Bi–Au compound beneath the former consisting of Bi alone [3678]. The system is estimated to have $\phi^e = 3.94$ eV provided that ϕ^e is 5.46 eV for Au(111) (Table 2).

[376]Regarding the Bi-layers deposited on glass at 90 K and also annealed at 293 K, ϕ^e is determined to be 4.245 and 4.370 eV, corresponding to an emission from the conduction and valence bands, respectively [3038]. Theoretical analysis of the respective data yields 4.25 and 4.6 eV [1403].

[377]The work function of Bi at ~300 K is measured to be 4.25 ± 0.05 eV, which does not change even at ~640 K much above the melting point (544 K) [3437] (see Table 12).

[378]From the experimental data on the work function difference (−0.020 eV) between Bi(sol) and Bi(liq) and also that (0.350 eV) between Bi(sol) and Cu(sol) [1755], $\phi^e = 4.86$ and 4.88 eV are estimated for Bi(sol) and Bi(liq), respectively, by taking $\phi^e = 4.51$ eV for Cu(sol) from Table 2 (see Table 12).

[379]From the empirical equation (7) of $\phi^e = 2.27X + 0.34$ [1955], ϕ^e for Ra is evaluated to be 2.2 and 2.4 eV by taking the electronegativity (in Pauling unit) of $X = 0.8$ [Here] and 0.9 [1955], respectively. Similarly for Pm, Po, Fr and Ac, any of which has no experimental data available still today, ϕ^e is evaluated to be 3.0, 4.8, 1.8 and 2.7 eV, respectively, from the above equation. Also for Sc, Y and In, ϕ^e is calculated to be 3.2, 3.0 (corrected from 2.0) and 3.6, respectively [1955], but they are not in good agreement with our values (almost by experiment) of 3.33 ± 0.04, 3.16 ± 0.06 and 4.05 ± 0.06 eV (Table 2), respectively.

[380]With respect to the Th-monatomic layer prepared by activation of thoriated W (1.8%-ThO$_2$ contained) at temperatures up to 2200 K, ϕ^e is determined to be 2.63 eV [1749,1750]. Similarly, ϕ^e is measured to be 2.64 eV for W–ThO$_2$ (1%) activated at 1920 K [3667,3668].

[381]The work function of Th-foil is measured initially to be 2.988 ± 0.008 eV, which increases to 3.728 ± 0.010 eV after electron impact at 1900 K [2932]. On the other hand, Th/W is found to have 3.455 ± 0.012 eV [2932], nearer to our value (3.37 ± 0.04 eV, see Table 2).

[382]Experimentally, the work function of Th is determined to be 3.45 ± 0.01 eV [3524,3525], by critical analysis of whose data ϕ^e is theoretically evaluated to be 3.41 or 3.44 eV [2932] and 3.35 eV [1759]. The last is essentially the same with our value (3.37 ± 0.04) recommended in Table 2.

[383]For the Th-films which are prepared by coating ThO$_2$ on W or Pt by a molecular gun and then activated at 1300–1650 K in vacuum, ϕ^e at 1260 K is determined to be 3.55 eV for Th/W (3 ML of the coating) and Th/Pt (4–8 ML) [872]. When W and Mo are employed as the substrate, reduction of ThO$_2$ to Th becomes insufficient at the coating thickness above 3 ML, thereby yielding $\phi^e \approx 2.4$ and 2.6 eV, respectively [872]. By critical analysis of the data on Richardson constant, the above value (3.55 eV) is corrected to 3.61 eV [2932]. Similarly, 3.44 eV is theoretically evaluated [2932] from the experimental data (3.3–3.4 eV) on Th/Mo and Th/Pt systems [3035].

[384]About the γ-U/W systems ($\theta = 1$ and 10–200 ML), ϕ^e is determined to be 3.0 and 3.47 ± 0.03 eV, respectively [232], which are corrected to be 3.38 and 3.48 ± 0.03 eV [1484] by substituting $A_r = 5$ and 114 ± 12 A/cm^2 K^2 and $T = 1400$ K into Hensley's equation (8); $\phi^e = \phi^e_r + kT \ln(120/A_r)$ [3623]. Here, ϕ^e_r is the work function corresponding to $A_r \neq 120$ A/cm^2 K^2. Especially the former, as well as the latter, is well corrected to be essentially the same with our value of 3.42 ± 0.05 eV for γ-U (Table 2).

[385]A γ-U/W system is found to have the relation of $\phi^e = 2.9 + 2.3 \times 10^{-4}\,T$ [2098], from which ϕ^e is evaluated to be 3.2 eV at 1250 K. This is corrected to be 3.5 eV [Here] by substituting $A_r = 8$ A/cm^2 K^2 and $T = 1250$ K into Hensley's equation (8) (see Footnote 384 and Section 2.8.6), thereby becoming very close to our recommended value (3.42 ± 0.05 eV) for γ-U (see Table 2).

[386]For the γ-U/W systems ($\theta = 1$–2 and 10–20 ML) at ~1000–1300 and ~1000–1400 K, ϕ^e is found to be 3.14 ± 0.02 and 3.42 ± 0.04 eV, respectively [1484]. Again, the respective values are appropriately corrected to be 3.36 ± 0.04 and 3.45 ± 0.1 eV [1484] by substituting $A_r = 20 \pm 7$ and 80 ± 30 A/cm^2 K^2 and also $T = 1400$ K into Hensley's equation (8). Similarly for the γ-U/W system ($\theta = 50$ ML) in H$_2$ ($\leq 10^{-5}$ Torr) at 1250–1400 K, $\phi^e = 3.46 \pm 0.02$ eV under $A_r = 140 \pm 20$ A/cm^2 K^2 [1484] is corrected to be 3.44 ± 0.03 eV [Here], becoming closer to our value for γ-U (3.42 ± 0.05 eV). The more A_r deviates from 120 A/cm^2 K^2, the more ϕ^e is effectively corrected as we may expect in general if A_r itself is free from systematic errors.

[387]Theoretical analysis of thermionic emission data on U yields $\phi^e = 3.28 + (3/2)kT$ [1747], which yields 3.28 and 3.42 eV for γ-U at 0 and 1100 K. The latter accords exactly with our value (see Table 2).

[388]By correction of the thermionic emission data on $\phi^e = 2.9 + 2.3 \times 10^{-4}\,T$ found for U/W [2098], ϕ^e is evaluated to be 3.45 eV for γ-U [2467]. Similarly, 3.27 ± 0.05 eV for U (wire) [2085] is corrected to be 3.56 ± 0.05 eV for γ-U [2467].

[389]By the theories of LDA and LECP models about Li-clusters (n = 2–68, Z = 1, $r_s = 3.25$ bohr and $d_G = 1.31$ bohr), $\phi^e(\infty)$ is evaluated to be 2.25 and 3.21 eV together with $C_p = 0.51$ and $0.48 \approx 1/2$, respectively [4262] (see Section 11).

[390]About a Be/Al$_2$O$_3$/Al system, ϕ^e is determined to be 3.89 eV [3057], which is corrected to be 3.905 eV [13] and 4.04 [Here] by taking the reference work function of Al as 4.095 eV [13] and 4.23 eV [1351], respectively, instead of 4.08 eV [3057], thereby approaching to our recommended value of 4.28 eV for α-Be (Table 2).

[391]Each specimen consists of monocrystal of β-rhombohedral boron [1415,3100].

[392]The work function dependence upon θ of B on W is found to agree well between theory [913,4344] and experiment [3503] over the entire range of θ = 0–1 ML, showing 4.5 eV at monolayer [913,3503].

[393]By incidence of C_2H_4 upon TaC(111) at 1570 and 1270 K, single- and double-layer graphite films are formed to have $\phi^e = 3.7 \pm 0.1$ and 4.2 ± 0.1 eV, respectively [290], both of which are considerably lower than 4.6 ± 0.1 eV for graphitic crystal [290] and also than 4.47 ± 0.05 eV found for a graphitic carbon film (see Table 2).

[394]For C_{60}-layers of $\theta = 1$ and 2–8 ML on freshly cleaved GeS(001), the films of C_{60}(111) are found to have $\phi^e \approx 4.7$ and 4.8 eV, respectively [457,543].

[395]About the C_{60} films on clean metals (Cu, Ag and Au) at 5 and 500 nm in thickness, ϕ^e is found to range from 4.60 to 4.72 and from 4.39 to 4.47 eV, yielding the average (μ) of 4.65 and 4.44 eV, respectively [2198]. Similarly, $\mu = 4.62$ and 4.42 eV are observed, respectively, for the thin and thick C_{60} ones formed on the metals exposed preliminarily to air [2198]. By deposition onto Cu at ~300–600 nm thick, sublimation-purified C_{60} yields $\phi^e = 4.59$ eV, larger than 4.39 eV found for as-received C_{60} [2198].

[396]The work function is measured to be 5.4 eV for a C_{60}/Ta(110) system at ~300 K, where some fraction of the C_{60} film decomposes on the clean substrate, leading to a thin film of carbon between the assembled film and the substrate [460]. Such a system [460] is discussed in comparison with other various ones of monolayer-C_{60} (4.82–5.25 eV) [316,1007,2681,3002] on monocrystalline metals (Al, Ni, Cu, Rh and Au) by other workers [316].

[397]The C_{60}-film formed on Pt(111) at 100 K and annealed at 900 K is estimated to have $\phi^e = 5.7$ eV and found to be stable up to ~1050 K, above which C_{60} decomposes to leave disordered graphitic multidomains [697]. On the other hand, an ordered C_{60} layer grown on Ni(110) at 700 K decomposes at 760 K and forms a carbidic carbon layer, which transforms into graphitic carbon at higher temperatures [697]. In another case of a C_{60}/Si(111) system prepared at ~300 K, C_{60} decomposes on the substrate at ~1100 K and reacts with the Si atoms to form SiC islands [3941]. See p. 80 [1351] for further information about the work function and thermal stability of C_{60} on various substrates.

[398]For the Al/Ta(110) and Pd/Ta(110) systems at ~300 K, ϕ^e is found to be 4.27 and 5.1 eV [2271], the respective values of which are substantially equal to 4.26 ± 0.03 and 5.17 ± 0.06 eV (Table 2). In addition, deposition of Al on Pd/Ta(110) decreases from initially 5.1 eV finally to a constant at 4.1 eV [2271], roughly corresponding to bulk Al. By deposition of Pd on Al/Ta(110), on the contrary, ϕ^e increases slowly from 4.27 eV ($\theta = 0$ ML) to 4.38 eV (1 ML) and up to 5.25 eV (5.0 ML), at which Pd forms surface alloys of both $PdAl_3$ and PdAl intermetallic compounds at ~300 K [2271].

[399]Allotropic transformation temperatures are listed for 13 rare earth metals other than Pm, Eu, Er and Lu [3966].

[400]According to the literature values summarized for U [3967], the allotropic transition temperature of β to α has a range of 918–948 K, while that of γ to β has 1037–1053 K.

[401]Both synthesis and structure of graphene overlays on monocrystalline metals are reviewed together with their electronic structure and promising potential [3968,4173]. Ir(111) films grown on Si(111) wafers with buffer layers are successfully applied to scalable synthesis of graphene, which has the quality comparable to that grown on bulk Ir(111) [4007]. A review about graphene is focused on production, structure, reactivity, etc. from the viewpoint of chemistry [4104]. Another review is focused on the experimental methods and conditions for preparing mono-, di- and multilayer graphene on various substrates by chemical vapor deposition [4106].

[402]Field emission studies reported for carbon nanotubes during the first five years after 1995 are reviewed comprehensively about their structural and electronic properties, fabrication of their field emitters, their emission characteristics, etc., containing some data on their work function [3969].

[403]About the C/Si(100)^p system, $\phi^e \approx 5$ eV for cnt [3649] is reported to be 5.3 ± 0.2 eV in related studies [698,2425,3943].

[404]Regarding Ag-films on various substrates, much data on ϕ^e are listed together with each experimental method and condition [3280]. There, ϕ^e ranges from 4.0 to 4.46 eV and has the mean of 4.30 ± 0.13 eV, which is nearly equal to our value of 4.39 ± 0.02 eV recommended for polycrystalline Ag (Table 2).

[405]With respect to Ni at the ferromagnetic state, ϕ^e is determined to be 5.06 and 5.05 ± 0.05 eV at ~300 and 623 K below the Curie point (631 K), respectively [943]. At the paramagnetic state, ϕ^e is found to be 5.10, 5.17, 5.20 and 5.24 eV at 770, 975, 1108 K and above 1150 K, respectively [943]. See Table 13 for the work function change due to magnetic transformation.

[406]With respect to the α-phase ($T < 1042$ K) of Fe, ϕ^e is measured to be 4.70 and 4.65 eV at ~300 and 870 K, respectively [305]. For β (1042–1179 K) and γ (1179–1674 K), ϕ^e is found to be 4.62 and 4.68 eV at 1125 and 1243 K, respectively [305]. About the work function change due to the allotropic transformation of several metals, see Table 11.

[407]As an interesting phenomenon, the metastable Fe-layers grown epitaxially on Cu(100) at ~300 K are found to show a structural transition from m-fcc Fe(100) to α-bcc Fe(110) when θ increases beyond ~10 ML [3913]. Unfortunately to us, no data on work function are given there. About the features of such metastable iron layers, see Sections 7.1 and 8.2.

[408]By application of Kelvin, photoelectric and electron beam retarding methods to the U-layers ($\theta \approx 2$ ML) on W(100) at ~300 K, ϕ^e is determined to be 3.73 ± 0.02, 3.73 ± 0.02 and 3.78 ± 0.03 eV, respectively, for α-U [2471] (see Section 2.8.2).

[409]From the position of a primary peak appearing in TCS (total current spectrum; $dJ(E)/dE$ vs. $E - E_F$, the difference between the incident energy and the Fermi level), ϕ^e of 6 layers of Cu on ZnO(0001) is determined to be 4.5 eV [2679]. This is equal to our value of 4.51 ± 0.04 eV recommended for bulk Cu (Table 2), but much smaller than 4.94 eV [953,2006] and 4.92 ± 0.05 eV (Table 2) done for bulk Cu(111). This is because the substrate is covered by Cu(111) islands without its surface covered completely [2679].

[410]Regarding Si(111) [73], $\phi^e = 4.07 \pm 0.05$ eV may be corrected to be 4.83 ± 0.04 eV from Eq. (8), as described in Section 2.8.6. For further information about related subject, see Footnote 66.

[411]With respect to a tungsten specimen consisting of these faces of (310), (111), (100), (112) and (110) having $(\phi_i, F_i) = $ (4.25 eV, 46.3%), (4.47, 5.4), (4.65, 14.0), (4.76, 15.5) and (5.25, 18.9), respectively [489], $\phi^a = 4.6$ eV calculated from Eq. (4) is taken as ϕ^e and considered to agree well with $\phi^e = 4.8$ eV measured by FE [489]. However, both values are much larger than those estimated from the fact that the main face of (310) is lowest in ϕ_i and largest in F_i among the five faces. Namely, ϕ^e is naturally expected to be ~4.3 eV or so corresponding to face (310). In fact, our calculation from Eq. (2) yields $\phi^e = 4.34 \pm 0.05$ eV [630] or 4.38 ± 0.05 eV [2453] (see Footnote (22) for W(D) in Table 6).

[412]The metastable β-like fcc-Co(100) film is grown by sublimation of Co onto Cu(100) at ~300 K, thereby resulting in $\phi^e = 4.72$ eV [2673]. Similarly, fcc-Fe(100) is done so, yielding 4.62 or 4.67 eV [2673] (see Footnote 114). The former and latter values are much smaller than ours (Table 2) of 5.25 eV for normal β-fcc-Co(100) and 5.28 eV for γ-fcc-Fe(100), rather near to 4.50 eV for β-fcc-Co(poly) and 4.54 eV for γ-fcc-Fe(poly), respectively (see Section 8.2).

[413]Ni is found to have bivalued work functions of 4.5 and 5.0 eV by PE at ~300 K [942], and 4.41 ± 0.02 eV (1170–1250 K) and 4.80 ± 0.02 eV (1440–1490 K) by TE [179,650,3410,3413]. It is worthwhile to solve perfectly the interesting problem why this phenomenon occurs, especially at quite different temperature ranges between the two cases.

[414]In regard to the system of the Ni-film (~1500 Å thick) prepared on a monocrystalline Ni ($T_C = 6.31$ K), $\phi^e = 4.97$ and 4.87 eV are measured by PE at 295 and 678 K, respectively [3971]. This difference by 0.10 ± 0.04 eV, however, does not originate from ferro- to paramagnetic transition alone but does considerably from the thermal effect due to α (~-10^{-4} eV/K for Ni, see Table 6 in Ref. [1351]). For further information, see Section 8.1.

[415]From the data on $\phi^+(Re) - \phi^+(C/Re) = 0.466$ eV [3753], $\phi^+(C/Re)$ is estimated to be 4.94 eV by taking $\phi^+(Re) = 5.41$ eV from Table 2.

[416]A comprehensive review on Re affords us general information about thermionic properties and chemico-physical characteristics of Re in comparison with Mo, Ta and W [190].

[417]High strength metallurgical graphene (ϕ^e = 4.63–4.79, ±0.01 eV) is formed by chemical vapor deposition (CVD) of a mixture (C_2H_2, CH_2CH_2, H_2) on a 72%Cu–28%Ni composite at ~1500 K in Ar-atmosphere (750 Torr) [3996], while a commercially available CVD graphene grown on a Cu-foil is found to have 4.67–4.78, ±0.01 eV [3996].

[418]Graphene ($\phi^e = 4.81 \pm 0.06$ eV) is formed on Si(100) covered with silicon oxide (300 nm thick) [3997], whilst another (4.92 ± 0.06 eV) is grown from CH_4 (83 Torr) on a Cu-foil at 1308 K [3997].

[419]The Au-layers (200 nm thick) prepared on Si(111) have a dominant (111) orientation with 5.2 eV [3999,4000]. The Au-layers in these systems of K/Au/Si(111) and K/C_{12}/Au/Si(111) are similarly predominant in the (111) plane, resulting in 2.0 and 2.66 eV, respectively, for K. Here, C_{12} is $C_{12}H_{25}SH$(1-dodecanethiol) [3999].

[420]The film (200–300 nm thick) of Cu, Ag or Au is grown on mica (~570 K), and it is sputtered by Ar^+ (800–1500 eV) and also annealed at ~520–620 K for several hours, thereby forming a nearly defect-free (111) terrace with 4.8, 4.5 and 5.4 eV, respectively [4001]. Each of them is very near to ours (see Section 2.5 and Table 2).

[421]The work function of Ge(111) is found to have 4.73 ± 0.05 eV immediately after vacuum cleavage, but to change to 5.45 ± 0.05 eV at the moment of the $2 \times 1 \rightarrow 1 \times 1$ structural transition [1991].

[422]The work function values of Li/Si(100)^p and K/Si(100)^p are determined to be 2.53 and 2.2 eV [4016] by citing two different values of 4.85 eV for vacuum-cleaved Si^n [613,1045] and 4.7 eV for Si(111)^n [1228], respectively [4016]. By citing our best estimate of 4.82 eV for Si(100) (Table 2), for instance, the latter becomes 2.3 eV, nearer to 2.29 eV recommended for K(poly) in Table 2.

[423]On the basis of the calculated values of $\Delta\phi^e$ = 1.1, 1.9 and 2.6 eV due to adsorption of S on the hollow, bridge and atop sites on Fe(100) [4019], ϕ^e for S/Fe(100) is estimated to be 5.0, 5.8 and 6.5 eV, respectively, by the present author citing the theoretical value of $\phi^e = 3.94$ eV for α-Fe(100) from Table 1 [4019].

[424]Regarding the B-doped Si(111)-specimens of p-type (0.002 and 260 Ω cm), ϕ^e is measured by PE to be 4.9 and 5.2 eV, respectively, while As-doped one of n-type (0.002 Ω cm) is done to be 5.0 eV [1226].

[425]Similarly by the same authors above [1226], ϕ^e of Si(111) is found to vary from about 4.7 to 4.9 eV in going from extremely n- to p-types, being close to 4.83 eV throughout most of the doping range [117].

[426]The work function of Si(111) is observed to have a difference of 0.18 ± 0.02 eV between p- and n-types, which are estimated to have 4.97 and 4.79 eV, respectively [1889].

[427]Regarding the adsorption of C, S and P on paramagnetic β-bcc-Fe(100), the work function changes are calculated to be 2.1, 1.3 and 0.9 eV, which yield ϕ^e = 6.3, 5.5 and 5.1 eV for the respective surface systems [4026] since ϕ^e for the substrate is calculated to be 4.2 eV [1104].

[428]A "missing" metastable phase of single-crystalline bcc-Co film is successfully synthesized on GaAs(110) by molecular beam epitaxial growth [4028]. A later study, however, indicates that the bcc-Co film does not correspond to a true metastable state and suggests that the existing bcc-Co film is stabilized by the presence of impurities or other defects [4205]. Interestingly, on the other hand, monocrystals of GaAs are usable as the substrates for preparing single-crystalline films of Fe [4028,4095–4097] and of Al [4098]. A distorted bcc–Co phase can be stabilized on Au(001)–hex [4325].

[429]The values of 5.10 and 5.55 eV correspond to the paramagnetic five- and monolayer of metastable bcc-Co(100) slabs, respectively [4023].

[430]The data on 4.66, 4.75 and 5.20 eV are obtained theoretically for the spin-polarized five-, nine- and monolayer bcc-Co(100) films, respectively [4023].

[431]Compared with literature values such as 4.31 eV [1050] and 4.33 eV [690], ϕ^e = 2.04 eV determined for Ag by TE at ~1150–1230 K [1466] is extremely small, but it is corrected by the present author to be 4.25 eV by substitution of ϕ_r^e = 2.04 eV, T = 1200 K and $A_r = 6.4 \times 10^{-8}$ A/cm^2 K^2 into Eq. (8), thereby coming close to our value of 4.39 ± 0.02 eV (Table 2).

[432]For Si(111) of p-type, ϕ_r^e and A_r are measured to be 3.2 eV and 4×10^{-3} A/cm^2 K^2 at ~1100–1150 K [3540], by substitution of which ϕ^e is calculated to be 4.2 eV from Eq. (8). This value agrees exactly with 4.2 eV determined directly from a Richardson plot for the same specimen at ~1150–1450 K, where A_r is found to be 130 A/cm^2/K^2 [3540]. This result suggests that the reflection coefficient of $r^e = 1 - 4 \times 10^{-3}$ has a very high value of above 0.99 in the former temperature range in contrast to ~0.0% in the latter. However, 4.2 eV is much smaller than 4.6–4.8 eV recommended for Si(111) (Table 2).

[433]Formation of C_{60}(111) is observed on various substrates as follows: GeS(001) at ~400–500 K [457,543,4037], CaF$_2$(111) at ~500 K [4038], MoS$_2$(0001) at ~300 K [4039], Au(111)/Ag(111)/mica at ~500 K [4040], Cu(111)/mica and Cu(111)/Ag(111)/mica at ~400–500 K [4041]. Unlike graphite and diamond, solid C_{60} is a molecular crystal, the structure of which is illustrated in Fig. 1 [3940].

[434]By PSI of Na (or K) on Si(110)^p, ϕ^+ as well as ϕ^e is found to increase linearly from ~3.3 to 4.3 eV as T increases from ~1000 to 1300 K [1472]. At ~1500–1600 K, on the other hand, ϕ^+ remains virtually constant at ~4.4 eV and decreases gradually from ~4.4 to 4.1 eV by incidence of weak and strong sample beams, respectively, while ϕ^e gradually increases from ~4.3 eV up to a constant of ~4.7 eV at ~1500–1600 K without the beam incidence [1472]. Consequently, the discrepancy between ϕ^+ and ϕ^e increases from ~0 up to ~0.6 eV, which suggests the chemical reaction of the beam with the substrate [1472].

[435]Recently, anomalies in the temperature dependence of ϕ^e have been found for Ru(11$\bar{2}$2) and Ru(11$\bar{2}$5) having the three phases of α, β and γ, and the respective values of ϕ^e at β (1510–1540 K) are lower by 0.38 and 0.55 eV than those at both α (<1510 K) and γ (>1560 K) [3686]. See Section 7.1 for further information about the phase transitions in Ru.

[436]For the n- and p-types of Ge-samples (B and D) doped with As and In having 0.005 and 0.10 Ω cm, the work function difference of $\phi(100) - \phi(111)$ is found to be 0.064 ± 0.005 and 0.045 ± 0.009 eV, respectively, while $\phi(110) - \phi(111)$ is 0.013 ± 0.05 and 0.022 ± 0.009 eV, respectively, by CPD. Here, Ge(110) is determined to have $\phi(110) = 4.72 \pm 0.3$ eV equally for both types [1382]. Similarly for n- and p-types of Ge(110) doped with Sb and In having 0.058 and 0.39 Ω cm, the work function difference between the two is found to be as small as 0.002 ± 0.004 eV by CPD [3611].

[437]The surfaces of Au (4.20 eV) and both substrates (Au and Hg/Au to be adsorbed with iodine) are not clean, but heavily contaminated with air [2760] and also with Hg.

[438]According to the temperature coefficient of 1.2×10^{-2} eV/K, work function of liquid indium increases from 3.88 to 4.13 eV with increasing temperature from 470 to 670 K [2111].

[439]First-principles calculations of ϕ^e for graphene yield 4.5 eV, which increases up to 4.8 or 5.2 eV according to isotropic strains [4105].

[440]An Yb/Si(111) system at θ = 6.0 ML is determined to have $\phi^e = 3.00 \pm 0.03$ and 3.95 eV at ~300 and 800 K, respectively. The latter corresponds to ytterbium silicide [4109].

[441]About doped silicon samples, ϕ^e is theoretically evaluated to be 5.03–5.10 eV for Si^p (7.5–20 Ω cm) and 4.42–4.63 eV for Si^n (0.071–14.5 Ω cm) [4119].

[442]The single- and double-layer graphene samples prepared by mechanical exfoliation on Si-wafers are found to have $\phi^e = 4.57$ and 4.69 eV, respectively [4128].

[443]Regarding the two-dimensional graphite films on various metals, a compact review outlines their structure and physico-chemical properties [450].

[444]A comprehensive review entitled "Unravelling the secrets of Cs controlled secondary ion formation: Evidence of the dominance of site-specific surface chemistry, alloying and ionic bonding" [4118] contains both experimental data on work function changes and their analytical results achieved for various substrates (Be, Al, Si, etc.) covered mainly with Cs.

[445]With respect to an Eu-film ($\theta = 1.1$ ML)/Si(111) system, ϕ^e is determined by CPD to be 2.8, 2.9 and 3.8 eV at $\sim$300, 500 and 900–1000 K, respectively, the last case of which corresponds to europium silicide [4111].

[446]The work function of Gd is 3.55 ± 0.15 eV at the Curie temperature of 290.85 K [3899].

[447]At room temperature, Ag is found to have 4.26 ± 0.03 eV, which decreases to 4.15 ± 0.07 and 4.04 ± 0.08 eV at 530 and 780 K, respectively, thereby affording $\alpha = -4.58 \times 10^{-4}$ eV/K [4114,4132].

[448]For the nickel particles (usually, $r = 60$–100 Å in radius) produced by a spark discharge in He, $\phi(r) = 5.1$ eV is determined by PE [2667]. This is in good agreement with our value of $\phi(r) = 5.13 \pm 0.06$ eV calculated from Eq. (17') by using both $\phi(\infty) \equiv \phi(\text{poly}) = 5.06 \pm 0.06$ eV (Table 2) and $r = 80$ Å, although it is 4.9 eV that is estimated as $\phi(\infty)$ for a flat nickel surface [2667] from these values of 4.90 eV [414] and of 4.5 and 5.0 eV [942] measured by PE at $\sim$300 K (see Section 11.1).

[449]The values of 4.36 ± 0.03 and 4.51 ± 0.03 eV are calculated from Eq. (17') by the present author using the data on $e^2/R_{\text{eff}} = 0.272$ and 0.66 eV [2199], which afford 52.9 and 22 Å as the effective values of radius ($R_{\text{eff}} \equiv r_c + \delta$) in Eq. (20) for Al$_{32000\pm150}$ and Al$_{2000}$, respectively. Here, each value of $\phi^e(r) = 4.36$ or 4.51 eV is calculated from both $\phi^e(\infty) = 4.26 \pm 0.03$ eV (Table 2) and $3e^2/8(r_c + \delta) = 0.10$ or 0.251 eV, while $\phi^e(\infty) = 4.28 \pm 0.03$ eV is determined by experiment [2199] (see Footnote 60 in Table 1 and also Results (1)–(2) in Section 11.1).

[450]According to the data in Fig. 1 [4146], where ϕ^e for Tb(0001) increases from 3.09 to 3.18 eV with decreasing temperature from $\sim$1440 to 1380 K [3920], α is estimated to be -1.5×10^{-3} eV/K, which affords 4.8 eV at $\sim$300 K. Above $\sim$1450 K, on the other hand, ϕ^e retains a constant at 2.94 ± 0.05 eV, thereby yielding $\Delta\phi^e_{\beta\alpha} = -0.15 \pm 0.07$ eV (see Table 11).

[451]According to the Burgers orientation relationship [4163], α-hcp-Zr(0001) transforms to β-bcc-Zr(110) at the allotropic transition temperature (1135 K) (see Section 7.1).

[452]With respect to the ultra-thin films of graphite, their formation, structure and physical properties are outlined together with the work function data (3.7–4.8 eV) for the films prepared on several metals and carbides [695].

[453]The nanowires ($\sim$10–15 bohr in width) of Na and Al are found by a theoretical study to have $\phi^e = 2.55 \pm 0.05$ and 4.15 ± 0.05 eV, which are slightly lower than 2.75 and 4.28 eV for respective semi-infinite metals [4178].

[454]Regarding the films prepared by simultaneous incidence of both a C$_{60}$/C$_{70}$ mixture (85:15 in weight) and Ni-acetate upon a Mo-tape, photoelectric measurements reveal $\phi^e = 2.93 \pm 0.1$ eV (3% in weight of Ni-content), 2.65 ± 0.1 eV ($\sim$5%) and 2.76 ± 0.1 eV (11.7%), the last of which decreases to 2.4 eV after cleaning by pulsed laser beam [4176]. It is very interesting that all of the above values are much lower than any of 4.47 ± 0.05 eV for graphite film, 4.87 ± 0.06 eV for C$_{60}$(poly) and 5.06 ± 0.06 eV for Ni(poly) (see Table 2).

[455]The work function for cnt with the armchair conformation is calculated to be $\sim$4.5 eV being close to 4.48 eV for graphene, while that for the zigzag and chiral conformations increases drastically from $\sim$4.5 eV up to $\sim$5.9 eV as the diameter decreases from $\sim$7 to 3 Å [3240].

[456]The value of 4.32 eV for liquid Ag is obtained by substitution of $T = 1240$ K, $\phi^e_r = 3.86$ eV and $A_r = 1.6$ A/cm^2 K^2 [1466] into Eq. (8). The value corrected by the present author is equal to 4.32 eV determined experimentally for solid Ag at $T_m = 1234$ K [1466], thereby indicating that work function change due to liquefying is less than ± 0.01 eV.

[457]All the values of $\phi^+ = 5.1$–5.78 eV for Pt [74] are derived by the free energy model using the data on PSI of Li, Na, K or Tl.

[458]Each of ϕ^+ for Pt ($\geq$5.1, 5.51, 5.54 or 5.71 eV) [74] is determined by the enthalpy model according to the PSI data on alkali or Tl.

[459]Theoretical evaluation of both ionization energy (I) and electron affinity (E) of Al$_n$ ($n = 3$–70 and 3–150) yields $\phi^e(\infty) = 4.25$ eV for Al(poly) [4194,4197], which is strongly supported by the experimental data on I [4196] and E [4197] and also by $\phi^e = 4.26 \pm 0.03$ eV recommended in Table 2.

[460]See Section 11.1 about the details of $\phi^e(\infty)$ determined from the data on IP for these fine particles ($r \approx 3$–30 Å) of Na, K and Ag [4198].

[461]According to the experimental data ($\phi^e_r = 2.57$ eV, $A_r = 0.023$ A/cm^2 K^2 and $T \approx 1300$–1500 K) for liquid Ge contained in a crucible (graphite or quartz made) [1466], Eq. (8) yields 3.60 eV, which is near to the upper value of 3.5 eV for solid Ge around $T_m = 1232$ K [1466]. The latter, however, is much smaller than 4.76 eV [Here, [1354]] and 5.0 eV [1045,1358] recommended for Ge (see Table 2).

[462]A simple method by chemical vapor deposition of CH$_4$ and H$_2$ on melted Cu (1360 K) is reported for synthesizing large 200 μm single crystals of monolayer graphene within a continuous film [4201].

[463]As the root-mean-square roughness of a Cu surface increases from $\sim$30 to 65 nm, ϕ^e is found experimentally to decrease from 4.76 to 4.52 eV, the result of which accords well with the theoretical prediction [931,2547]. For further information about such a dependence, see Section 4.2.5 of the "Effect of local surface irregularities" [1351].

[464]Theoretical study of the work function decrease due to adsorption of K on graphite yields 2.34 eV at 1.0 ML [4211], which affords $\phi^e = 2.36$ and 2.29 eV for K when 4.7 and 4.63 eV are taken for graphite from a book [4211] and Table 2 [Here], respectively. The latter value for K well agrees with ours of 2.29 ± 0.02 eV (Table 2).

[465]The work function of 4.85 eV measured for the fresh surface of Si cleaved at $\sim$5 $\times$ 10^{-11} Torr is very close to that for Si(100) (see Table 2) in contrast to 4.45 eV found after exposing it to the residual gases for $\sim$100 h [613].

[466]Regarding PSI on Ta(110) [279], L represents lanthanides (12 elements).

[467]Experimental and theoretical studies about conical carbon nanotubes seem to be scanty compared with single- and multi-walled ones, but further information about the former may be obtained from several articles [4287–4295], which well outline its synthesis, structure, property, applicability, etc.

[468]In contrast to free-standing graphene ($\phi^e = 4.48$ eV), adsorbed graphene is calculated to have 3.66, 4.03 and 4.87 eV on the substrates of Ni(111), Pd(111) and Pt(111) [4174,4284], the dependence of which may be supported by the experimental data of 3.9, 4.3 and 4.8 eV [695], respectively. Such a dependence is caused by the formation of an interface dipole and the electron transfer between the metal and graphene levels driven by the work function difference, as well as the chemical interaction between graphene and the substrate metal [4174,4284].

[469]A comprehensive review is focused on the work function data published for Li in 1916–2009, thereby concluding that ϕ^e for Li is recommended to be not less than 2.64 eV [4298].

[470]Regarding multi-walled nanotubes heated directly at $\sim$1800–2200 K, Richardson plots are found to exhibit an upward bend deviating from linearity and also a current density much higher than that usually expected from Richardson's law, thereby concluding it necessary to devise new theoretical descriptions of thermal electron emission from individual low-dimensional nanostructures [4307].

[471]A theoretical study of graphene yields that ϕ^e changes from $\sim$4.3 to 4.6 eV depending upon the size (length and width) and upon the shape (armchair or zigzag) [4332].

[472]The value (4.3 eV) for Zn [4329] is estimated by the present author by extrapolating the plot (I vs. $n^{-1/3}$) for Zn-clusters (n = 2–20) in Fig. 5 [4329] based on classical CSD model [4101]. For general information about clusters, see Section 11.

[473]The original value of 4.21 eV for γ-Fe [310] may be corrected to be 4.66 eV according to Eq. (8) (see Section 2.8.6).

[474]With respect to Co, the allotropic transition temperature (T_A) for hcp $\leftrightarrow$ fcc is estimated to be 695 K [4336] in contrast to 720 K [364]. It should be noted that supported cobalt crystallites with a small size ($\sim$10–500 Å) have the fcc structure even below T_A [4338].

[475]The specimen of W{46%(100)} [390,391,533–535,659,825] corresponds to W(C) [825] in Table 6, where our theoretical value of $\phi^+ = 5.00 \pm 0.05$ eV [2453] is much larger than $\phi^a = 4.72$ eV [825,2453], in contrast to $\phi^+ = 4.61 \pm 0.05$ eV $< \phi^a = 4.72$ eV [825]. For further information, see Table 6 and Section 4.

[476]For the Ag-films ($\sim$1–50 nm thick) on two perylene derivatives (DiMe–PTCDI and PTCDA (10 nm thick)) prepared on S–GaAs(100), their work functions are found to be constant at 4.37 $\pm$ 0.05 eV and to increase up to 4.61 $\pm$ 0.05 eV at 50 nm thick [4341], the respective values of which are substantially equal to ours of 4.39 $\pm$ 0.02 and 4.64 $\pm$ 0.06 eV recommended for Ag(poly) and Ag(111) in Table 2. In fact, a stronger peak of Ag(111) is observed for the latter system by X-ray analysis [4341].

[477]The films ($\sim$5–50 nm thick) of In on DiMe–PTCDI and PTCDA (see Footnote 476 just above) are found to have $\phi^c = 4.10 \pm 0.05$ and 4.44 $\pm$ 0.05 eV, respectively [4341], the former of which is nearly equal to 4.05 $\pm$ 0.06 eV recommended for In(poly) in Table 2. According to X-ray analysis, the latter consists mainly of In(101) [4341], but its work function has not yet been reported probably by any other worker (see Tables 1 and 2).

[478]For Au-nanoparticles formed on a Si-wafer covered with a monolayer of alkyl chains providing a tunnel junction, ϕ^c is found to change from $\sim$3.5 to 3.8 eV as the particle radius increases from $\sim$20 to 80 Å together with doing from -2 to -8 in charge state inside the particle [4368].

[479]Regarding the boron sheets of alpha, distorted hexagonal and buckled triangular types, ϕ^c is theoretically evaluated to be 4.09, 4.89 and 5.39 eV, respectively [4359].

[480]With respect to heavily phosphorus-doped nano-crystalline diamond prepared by CVD of PH_3, CH_4 and H_2 on Mo at $\sim$1200 K, ϕ^c is measured by TE ($\sim$600–800 K) to be 2.3 eV [4371], which is corrected to be $\sim$2.4 eV by substituting $A_r = 15$ A/cm^2 K^2 into Eq. (8).

[481]A comprehensive review is focused on the theoretical problems connecting with both development and operation of carbon nanotube field emitters [4372].

[482]For the film ($\sim$15 nm thick) of Pt deposited on n-type silicon, ϕ^c is found to be decreased from 5.5 to 5.3 eV by illumination (18 mW/cm^2) [4375]. Similarly for W and Au films, ϕ^c is done so from 4.8 and 5.2 eV to 4.7 and 5.1 eV, respectively [4375].

[483]Together with typical work function data, a concise review summarizes the first-principles density-functional study about graphene which is expected as a potential device material for gas sensor applications [4403].

[484]The data on $\phi(100) = 4.46$ eV and $\phi(110) = 4.85$ eV measured according to the reference of $\phi(111) = 4.80$ eV by FE for Ge [3539] are taken erroneously for Si [Ref. 2040 in [1354]].

[485]Both $\phi(110) = 4.90 \pm 0.05$ eV and $\phi(111) = 4.14 \pm 0.05$ eV determined by TE for Mo [1400] are taken erroneously for W [Ref. 39 in [1354]].

[486]The datum on $\phi(poly) = 4.74 \pm 0.02$ eV measured by TE for Re [666] is taken not only for Re but also for Rh erroneously [Ref. 1522 in [1354]].

[487]Each of the work function values (3.27–3.46 eV) corresponds to these two-dimensional islands which are formed from Hf (0.05–0.2 ML) near (100) faces of W heated up to 1100 K [501].

[488]A comprehensive review is focused on the alkali metal adsorption on various types of carbon by outlining the theoretical and experimental studies on the surface structure, charge transfer, work function change, etc. [1860].

[489]Graphene films with a very high uniformity in work function are epitaxially grown by heating silicon carbides at $\sim$1300–1900 K in vacuum or argon [4455–4457].

[490]Only a part of the very plentiful work function data included in the articles [4460,4461] is added to Table 1 because the present author found the articles just before sending the final version of this article to the Editor.

2.1. Column 1; Surface species

For each chemical element, the surface species of various monocrystals under study are listed according to the face of lower crystallographic index, ahead of any polycrystalline surface of bulk and layers. The system of A/B means that A is the sample layer(s) or film(s), and that B is the substrate (metal, insulator, etc.) for supporting A. The superscript of n (or p) in such a form typically as Si(100)^n means the n-type silicon including typically antimony as a dopant [2059]. Similarly, Si(100)^p is the p-type silicon doped typically with boron [1872]. With respect to C(100)^B, the diamond specimen is doped with boron, for instance [224,1830,2751, etc.]. The annex of (fp) to Ag, for example, indicates that the Ag sample (4.25 $\pm$ 0.1 eV) consists of fine particles having a radius of 5 $\pm$ 2 nm [1562] (see Footnote 204 in Table 1 and also Section 11.1). The expression of W{46.3%(310)} [489] indicates that the sample surface consists *mainly* (46.3% = δ_m) of the (310) plane. This sample corresponds to W(D) [489] in Table 6 to be shown later.

Other symbols included in this column are as follows; HOPG = highly oriented pyrolytic graphite [e.g., 284], cnt = carbon nanotube exemplified as Cs/cnt/GsAs [291] and Cs/cnt/Si [3225], ins = insulator such as Al_2O_3-barium-stearate layers in Mg/ins/Al [2028], ITO = indium tin oxide, like as cnt of C/ITO [284,1441,3795], nw = nanowire, shown typically as diamond of C/Si(nw)/Si [3305], O=Ti = oxygenated titanium such as Ti/O=Ti [2378] (see Footnote 95 in Table 1), ss = stainless steel substrate such as Se/ss and Te/ss [3429], and d = diameter, like as cnt of C (d $\geq$ 1 nm) [1169].

The crystal structures (bcc, fcc, hcp, etc.) of various chemical elements are compactly summarized in tables and figures [4021], and the theoretically predicted structures of 3d–5d transition metals are found to accord with the experimental ones with only one exception ($_{79}$Au) [4022].

2.2. Column 2; Incident beam (or vapor) for either probing work function or forming sample layers on a substrate

In an A/B system, the surface material (A) to be studied is directed onto the substrate (B, generally foreign material) in the form of beam or vapor in order to prepare the sample film(s) or layer(s) of A. In stead of such a beam direction, the "spillover" is utilized for preparing a Th-film by activation of thoriated tungsten (1–2% ThO_2 contained) at $\sim$2000 K [1749,1750,3667,3668] (see

Footnote 380 in Table 1 and also the typical data (1)–(4) in Section 2.8.6). In a similar way, the layers of Sc and Y are successfully formed from the alloys of Re–Sc (4–9%) [1979] (see Footnote 92) and Re–Y (4%) [4240], respectively. Occasionally, A is formed on B not in vacuum but in solution by electroplating, typically preparing the systems of Cu/Ni [2294] and Re/W [1850]. Usually, A on B is annealed (equilibrated) at a temperature higher than that of sample deposition. Then, work function of the sample (A) is measured by a usual method (e.g., CPD = contact potential difference method). For the film or layer (A) having the coverage (θ) above 1 ML, ϕ^e is listed in Table 1 in order to estimate the bulk work function of the sample (A) under study.

In some cases, A is prepared by chemical vapor deposition (CVD), where a sample gas (e.g., C_6H_6) is impinged to form a layer (e.g., graphitic carbon) on B (e.g., Pt(111), initially $\phi^e = 4.95$ eV) heated tentatively to a moderate temperature (e.g., 1200 K), and the work function of the graphitic film (C/Pt(111)) thus prepared on Pt(111) is measured to be 4.45 eV at a lower temperature (e.g., ~300 K) [527,857,889].

In the case of thermal ion emission (usually called the "surface ionization"), on the other hand, a foreign beam (or vapor) of alkali halide (MX), for example, is impinged as a probing gas to be changed into positive or negative ions (M^+ or X^- in Column 3) on a heated sample surface (Column 1) in order to determine ϕ^+ or ϕ^- (Column 6) by PSI or NSI (see Column 8). Typically for Mo(100) (see Footnote 167 in Table 1), $\phi^+ = 4.28 \pm 0.05$ eV by PSI of Li to Li^+ [129,572,573] and $\phi^- = 4.29 \pm 0.02^N$ eV by NSI of CsI to I^- [572,573] are entered in the same column (6) but on the separate lines adjacent with each other. Here, "N" means that the work function value originates from NSI, corresponding to ϕ^- instead of ϕ^+.

As known very well, ϕ^e of any A/B system changes largely depending upon the surface coverage (θ), reaching to a nearly constant value (saturation) usually at $\theta \geq 1$ ML after passing a minimum (ϕ_μ^e). In Table 1, such a saturated value is adopted as ϕ^e of the sample A (bulk) under study. For a variety of A/B systems, the quantitative relation between ϕ^e and θ or ϕ^e and ϕ_μ^e has long been investigated both experimentally and theoretically by great many workers. The Cs/metal systems, for instance, are deduced empirically to have the relation of $\phi_\mu^e = 1.94 - 0.09\phi^e$ or $\phi_\mu^e - \phi^e = 1.09(1.78 - \phi^e)$ [4362]. For estimating the relation, ϕ^e is cited from the data reported for Ru, Rh, Hf, W, Os, Ir and Pt [2105]. Much further information about the work function dependence upon θ is obtainable from excellent reviews [1209,1312,3818,3901,4118, etc.].

2.3. Column 3; Ionic species employed to measure the work function effective for positive or negative ion emission

This column shows the species of thermal positive or negative ion (e.g., K^+ or Cl^-) produced from a probing beam or vapor (e.g., KCl, see Column 2) incident upon a hot sample surface (e.g., Nb at $1853-2025$ K) [120] listed in Column 1 (for further information, see Footnote 165 in Table 1). From the data on thermal positive or negative ion current, the effective work function (ϕ^+ or ϕ^-) is determined according to Saha–Langmuir's equation applicable to PSI or NSI (see Eq. (5) or (6) herein and also Sections 2.1 or 8.1 in Ref. [1351]).

In some special cases, the probing ion (M^+ or M^-) to be used for work function measurement by PSI or NSI is produced by self-surface ionization (SSI), where the ion is produced directly from the sample surface itself by heating to very high temperatures (usually, above 2000 K). The species of ion thus produced is given in the parentheses like as (M^+) or (M^-) in the 3rd column. Such production is reported to be applicable to graphite ($C_1^- - C_8^-$) [3872], nickel (Ni^+) [3874–3876], niobium (Nb^+) [120,121,946,3401, 3874,3877,3878] and (Nb^-) [946], molybdenum (Mo^+) [77,131,132,946–954,961,3869–3871,3877,3879,3880,3884,3886,3891] and (Mo^-) [946,961], rhodium (Rh^+) [3874,3877,3879], tantalum (Ta^+) [77,137,804,805,946,3083,3877–3881,3887,3888,3891] and (Ta^-) [804,946], tungsten (W^+) [3,77,146,805,924,946,965,966,3083,3869,3870,3877,3879,3880,3882,3885,3887–3891] and (W^-) [946,965,966], and also rhenium (Re^+) [77,805,946,966,3083,3882,3883] and (Re^-) [946,966]. It should be noted that the above metals have both high melting point (~2700–3800 K except Ni and Rh) and moderate values of effective work functions ($\phi^+ \approx 4.8$–5.4 and $\phi^e \approx 4.1$–5.0 eV, see Table 2) and, hence, that production of both M^+ and M^- from the same metal by SSI is strongly governed by $\Delta\phi^* \equiv \phi^+ - \phi^e \approx 0.4$–0.7 eV for Nb, Mo, Ta, W and Re (see Table 5). Further information about the determination of ϕ^+ by positive SSI or usual PSI may be obtained from Footnote 170 in Table 1.

Especially, negative SSI is employed as a useful technique to produce negative ions directly from both refractory metals and graphite, and also it is applied successfully to the determination of electron affinity (E) of C_1–C_3 [3872,3873], Nb [946], Mo [946,961], Ta [946], W [946,965,966] and Re [946,966], although it is not easy to measure accurately the temperature dependence of the negative ion current according to Eq. (18) [1351] because the current is subject to the space charge effect due to much stronger electron current arising from TE simultaneously [946,965,966].

2.4. Column 4; Pressure of residual gases around a sample surface

Since all of the work functions (ϕ^+, ϕ^e and ϕ^-) are generally very sensitive to the pressure (P_r) of residual gases surrounding the sample surface under study, it is very important to consider whether or not the sample surface in the vacuum system employed is essentially free from any gas adsorption effect. Usually, P_r in Column (4) is the background pressure during each measurement of work function. Here and there, unfortunately, P_r is marked with a question mark in the column although the present author has tried to do best for finding its value.

In an A/B system, on the other hand, P_r is somewhat higher than the value indicated therein during the periods while A is deposited on B and also while A is annealed on B to prepare equilibrated (smoothed) layers. The value in parentheses, such as ($<10^{-10}$) for a Li/W system [2711], is not the total gas pressure but the partial one of active (chemisorptive) gases such as oxygen and its compounds.

Here, the pressure units have the relation of 1 Torr = 133.3 Pa (or N/m^2) = 1333 dyne/cm^2 = 1.333 mbar = 1.316 matm.

2.5. Column 5; Surface temperature or its range for measuring work function

This column indicates the surface temperature (or its range) at which each work function is measured. In ultrahigh vacuum such as below $\sim 10^{-10}$ Torr, a contact potential difference (CPD) method, for example, is generally applicable safely to the surface even much below ~ 1000 K. Even in usual high vacuum around $\sim 10^{-8}$ Torr, thermal ionic and electronic emissions from refractory metals (e.g., Ta and Re), on the other hand, may be applied normally to those surfaces kept at $T > 1800$ K [65,67,104]. Under such conditions, the surfaces are usually expected to be substantially clean.

With respect to A/B systems, work function (usually, ϕ^e to be measured) of the sample layers (A) is very sensitive to the thermal processing after deposition upon the substrate (B). Each figure in parentheses in Column 5 is the annealing temperature (T_a) for equilibrating (smoothing) the layers under study. For instance, the expression of ~ 300 (~ 900) for B/Mo(110) [2698] in Table 1 indicates that ϕ^e is measured at ~ 300 K after the boron layers are annealed at ~ 900 K or in the range of 600–1200 K.

In typical cases of the layers (250–590 Å) of Ru, Pt and Au deposited on quartz or glass at 85 or 78 K [436], T_a should be selected to be higher than roughly one-third ($T_a \geq T_m/3 \approx 900$, 680 and 450 K, respectively) of melting point ($T_m = 2723, 2047$ and 1336 K, respectively) in order that each of the layers may be expected to have the work function corresponding to each bulk [436]. The respective values ($\phi^e = 5.10, 5.72$ and 5.38 eV measured after annealing above $T_m/3$) are much higher than those (4.52, 5.46 and 5.22 eV) observed before the annealing [436] (see Footnote 363 in Table 1). In other words, any layers deposited much below room temperature are generally low in ϕ^e, and the *bulk* work function is hardly determinable for the sample (A) without moderate annealing.

According to Fig. 1 [3280] based on much data on Ag-films prepared on glass, mica, etc. [349,414,1893,1897, etc.], the annealing above ~ 460 K $> T_m/3 \approx 410$ K yields a constant value of 4.4 eV, which is considerably higher than both of 4.2 and 4.25 eV found at 78 and 300 K without annealing, respectively [3280], and also which is essentially the same with ours of 4.39 ± 0.02 eV recommended for *bulk* Ag, as will be shown in Table 2.

Such data as exemplified above suggest that the lattice defects in deposited layers at start may largely be removed on annealing [3610]. As may be known well, ϕ^e decreases generally as the surface defects (e.g., step, kink, dislocation, vacancy) increase in density. Typically for a W/W(110) system at ~ 290–370 K, ϕ^e is found to decrease by up to 0.6 eV linearly as a function of the square root of coverage (θ) with increasing step atom density [1039,1093]. A similar phenomenon is observed for bulk-W(110), too, reducing from ~ 5.2 to 4.9 eV as the step density increases from ~ 0 to 7×10^6/cm [1037], as shown clearly in Fig. 19 [1037] in Ref. [1351]. The local work function reductions at Au–Au and Cu–Cu monatomic steps are theoretically evaluated to be ~ 0.8 and ~ 1.3 eV, the respective values of which are in good agreement with those determined experimentally, as shown in Figs. 2 and 3 [1186]. For much further information about the effect of local surface irregularities upon work function, see Sections 3.3 [1313], 4.2 [1312] and 4.2.5 [1351].

In addition, a moderate annealing is very effective for promoting the monocrystallization of sample layers. Typically for an Ag(111)/quartz system prepared at ~ 300 K, its work function is increased by annealing at 773 K from 4.35 eV (54%) to 4.64 eV (86%) [3313], the latter of which is equal to 4.64 ± 0.06 eV ($\sim 100\%$) recommended for Ag(111) (see Table 2). Here, each value in parentheses is the fractional surface area ($F_{111} = \delta_m$) largest among various ones (F_i's), and it *mainly* governs ϕ^e for the "polycrystal" ($\delta_m < 50\%$ in general) and also for the "submonocrystal" ($50 < \delta_m < 100\%$), as will be demonstrated typically for W(A)–W(D) ($\delta_m = 33.6$–46.3%) and also for W(E)–W(G) ($\delta_m = 80$–96%) in Section 4 and Table 6. For further information about such an annealing effect for forming the "monocrystals" of Al(111), Ni(100), Ag(111) and Au(111), see Footnotes 55, 125, 198 and 350 in Table 1, respectively. Of course, Table 1 includes a variety of monocrystal/substrate systems such as Li(110)/Mo(111) [3361], Be(1010)/W(110) [3122], C$_{60}$(111)/GeS(001) [457,543], Na(110)/Ni(110) [1417], Al(100)/Ge(100) [3949], Si(100)/W(110) [3448], K(100)/KF(100) [2946], Sc(0001)/W(110) [1982], Ti(0001)/W(110) [4234], Sb(100)/W(110) [1272], La(0001)/Mo(100) [640], Pt(111)/Ni(111) [773] and Au(110)/W(112) [2256]. Similarly, the plates of mica, quartz, glass and so on are very useful as the substrate under a selected condition for preparing monocrystalline samples such as (1) Be(0001) [2009], Ni(100) [314], Cu(111) [4001,4041,4379], Pd(111) [4379], Ag(110) [626,4001], Ag(111) [626,1897,3276,4001,4040,4041,4378,4380–4382] and Au(111) [1202,1600,1897,4001,4380,4381] on mica, (2) Al(111) [612, 3313], Ag(111) [3313,4001], Pt(111) [2448] and Au(111) [3313] on quartz, and (3) Be(0001) [1782], K(110) [2476], Ti(0001) [2378] and Ni(100) [314,315,1523], Ni(111) [314,315,1513,2934,3058] on glass, and also (4) Pt(111) on garnet or sapphire [2448].

Typically for growing Au(111) at ~ 300–700 K, the substrates of mica and quartz make it possible to yield the results of $\phi^e = 5.3$–5.47 eV [1202,1600,1897,4001] and 5.38–5.42 eV [3313] (Table 1), all of which are in fair or good agreement with our values of 5.46 ± 0.07 eV and also with 5.31 eV [959] recommended for Au(111) in Refs. [1045,1358] (see Table 2). In addition, various species of foreign metal substrates as well as those exemplified above are employed to grow a variety of metal monocrystals and also to find their work function data to be acceptable today, as may be seen here and there in the first and 7th columns, respectively, in Table 1.

When the sample deposition temperature (T_d) is higher than the work function measurement one (T), both of them are shown as $T\{T_d\}$ in Table 1. For example, 78{540} [2256] means that Au is deposited onto W(112) at 540 K and, then, ϕ^e is measured at 78 K, thereby yielding that Au(110)/W(112) has $\phi^e = 5.45 \pm 0.03$ eV without additional annealing. The value thus determined is close to ours of 5.33 ± 0.09 eV recommended for bulk Au(110) in Table 2. On the other hand, $T = T_d = 78$ K yields $\phi^e = 5.3$ eV [2256], which corresponds not to Au(110) but to Au(poly) (see Table 1). Such an effect due to the difference between T and T_d for gold/W(mono) systems [2256] may be typically summarized below. Here, the first item is the sample layer/surface system whose layer structure is assigned by the authors [2256] and also {A/B}, $< C >$ and (D/E) show that $A = T$ (K), $B = T_d$ (K), $C = \theta$ (ML) and $D = \phi^e$ (eV) measured experimentally [2256] and $E = \phi^e$ (eV) cited from Column 3 in Table 2.

(1) Au/W(100) // {78/78} < ≥3 > (5.20/5.30 ± 0.04).
(2) Au/W(100) // {78/200} < ≥3 > (5.32/5.30 ± 0.04).
(3) Au/W(100) // {78/500} < ≥3 > (5.55/5.30 ± 0.04).
(4) Au/W(110) // {78/78} < 5 > (5.3/5.30 ± 0.04).
(5) Au/W(110) // {78/160} < 4 > (5.4/5.30 ± 0.04).
(6) Au(111)/W(110) // {78/420} < ≥3.5 > (5.32 ± 0.03/5.46 ± 0.07).
(7) Au/W(112) // {78/78} < ≥3.5 > (5.3/5.30 ± 0.04).
(8) Au(110)/W(112) // {78/540} < ≥3.5 > (5.45 ± 0.03/5.33 ± 0.09.

As may be seen above, the increase in T_d has a tendency to increase ϕ^e for Au(poly), and that to form Au(mono) according to its suitable selection. Further information about (4)–(6) and (7)–(8) is obtainable from Footnotes 349 and 348 in Table 1, respectively.

For depositing a sample onto a substrate successfully, it is very important to select T_d properly. For instance, C_{60} forms the layers (~1500 Å thick) on Si(111) at $T_d \approx 300$ K, but it does not appear to stick to the substrate at such a slightly high temperature as 393 K [3990]. It should be underlined that C_{60} on Mo(100) at ~300 K remains intact in the adsorbed state up to 760 K [322]. Similarly, C_{60}/Rh(111) at ~300 K is stable up to 750 K, above which it is decomposed into graphite like carbon [1007]. Interestingly, C_{60} decomposes on Ta(110) even at room temperature [316]. Formation of C_{60}(111) is observed on various substrates at ~300–500 K, and its typical examples [457,543,4037–4041] are outlined in Footnote 433 in Table 1.

Instead of such a type of ribbon, wire or tip for supporting a sample to be investigated, another type of boat or box (typically, quartz or ceramic made) is employed to prepare a binary system of metals with low melting point, and both temperature and composition dependences of ϕ^e have long been investigated [2613,4144]. Typically for these systems of Na–Rb, Na–Cs, K–Rb and K–Cs, each plot of work function vs. alloy component ($\gamma_c = 0$–100% in mole fraction) is found to overlap well between theory [4150] and experiment [2613, etc.]. Experimental results thus obtained at $\gamma_c = 0$ or 100% afford us work function data for a variety of pure metals, too; such as Na [2612,2613], K [2470,2612–2614], Cu [2626,2634], Zn [2624], Rb [2470,2613,4150,4297], Cd [2626], In [2624,2626], Sn [2624], Sb [2624,2626], Cs [2612,2613,4150,4297], Hg [2470,2613,2614] and Tl [2614] (for each data on ϕ^e, see Table 1). In contrast to the other substrate systems (wire, ribbon and tip types) mentioned above, the boat or box system is generally free from the physico-chemical effect of the supporting system upon the sample under study and, hence, it provides us bulk work function data even after preheating the sample up to melting point or over.

The expression of 0^E in Column 5 (e.g., Ca, Y, Zr, etc. [1747], see Footnote 174 in Table 1) means that the work function given in Column 7 corresponds to ϕ_0^e at 0 K after extrapolation of ϕ_T^e measured at higher temperature(s) according to $\phi_0^e = \phi_T^e - \alpha T$, where α is taken as $3\,k/2 = 1.29 \times 10^{-4}$ eV/K [1747]. Strictly speaking, however, the temperature coefficient (α) is not universal at $3\,k/2$, but dependent upon the surface species. It is reported to have a wide range between $\sim \pm 10^{-4}$ and $\pm 10^{-5}$ eV/K (see Table 6 in Ref. [1351]). Such a dependence makes it very difficult to determine exactly a minute work function change (usually, $\sim 10^{-2}$–10^{-3} eV to be estimated as the *net* change due to each transition alone) initiated either by allotropic, magnetic or superconductive transformation or by solid to liquid phase transition occurring at each critical temperature (e.g., Curie point), as will be outlined later (see Tables 11–14 and Sections 7–10).

2.6. Column 6; Work function (ϕ^+ or ϕ^-) effective for positive or negative ion emission

This column shows mainly the work function value (ϕ^+) generally determined by positive surface ionization (PSI) from the data on thermal positive ion current (i^+) of M$^+$ entered in Column 3, and ϕ^+ is listed according to an increase in value as exactly following the increasing value of ϕ^e for each surface species. The figure in parentheses such as (4.44 ± 0.03) for Mo(100) [727,2210,3103] is the value of ϕ^+ determined for the same specimen done for ϕ^e such as 4.40 ± 0.03 [727, etc.] entered on the identical line. Here, all of the items in Columns 2–5 and 8 (TE) correspond to ϕ^e instead of ϕ^+. On the other hand, the items corresponding to ϕ^+ are given on another line below by six lines (PSI), where $\phi^+ = 4.44 \pm 0.03$ eV and $\phi^e = (4.40 \pm 0.03)$ eV are determined for the *same* specimen in a separate experiment [727, etc.].

Experimentally, ϕ^+ is usually determined from the slope ($\phi^+ - I$) of a semi-Saha–Langmuir plot (ln i^+ vs. $1/kT$) based on Eq. (5) [2,1351].

$$\alpha^+ = \beta^+/(1 - \beta^+) = (w^+/w^0)\exp[(\phi^+ - I)/kT]. \tag{5}$$

Here, α^+ is the ionization coefficient, β^+ is the ionization efficiency of incident atom or molecule (e.g., M or MX), w^+/w^0 is the statistical weight ratio of ion to atom (e.g., 1/2 for alkali metal), and I is the ionization energy of M. The ratio is equivalent to exp $[\Delta S^+/k]$, where ΔS^+ is the entropy change due to the ionization of M. Typically for alkali metals, the ratio is calculated to be 0.503–$0.496 \approx 1/2$ at ~1000–2000 K by using entropy data compiled in thermochemical tables [26–28].

The value of ϕ^- is measured usually by negative surface ionization (NSI) and evaluated from another Saha–Langmuir equation [2,1351].

$$\alpha^- = \beta^-/(1 - \beta^-) = (w^-/w^0)\exp[(E - \phi^-)/kT]. \tag{6}$$

Here, E is the electron affinity of the sample atom (X), and w^-/w^0 equivalent to exp $[\Delta S^-/k]$ is the statistical weight ratio of X$^-$ to X (e.g., 1/4 for halogen). The latter is calculable from the entropy change (ΔS^-) by using thermochemical data [26–28]. Column 3 shows the species of X$^-$ produced by NSI of the beam (e.g., MX or X$_2$ specified in Column 2) under the condition in Columns 4 and 5. The data on ϕ^- are given in Column 6, as in the form of either 5.4^N for diamond of C(111) [3771] or (4.4^N) for a graphite

film of C/Pt [675] in order to avoid the confusion with the data on ϕ^+. The latter example [675] shows that the surface of C/Pt has the same value of $\phi^- = (4.4)$ eV and $\phi^e = 4.4$ eV determined for the *same* specimen (see the same line in Column 7 for ϕ^e). The condition and method employed for determining $\phi^e = (4.4)$ eV in Column 7 [675] are entered on the adjacent line just above, where ϕ^- is shown as (4.4^N) in Column 6 [675]. Quite similarly, $\phi^- = 4.36 \pm 0.05^N$ eV determined for Mo(100) by NSI of I_2 [571] is essentially equal to $\phi^e = (4.35 \pm 0.05)$ eV listed on the same line. The latter is determined by thermal electron emission (TE) from the *same* specimen in a separate experiment under substantially the same condition, as shown above by three lines including (4.36 $\pm$ 0.05^N) [571] (for further information, see Fig. 28 [571] in Ref. [1351]).

Each of the values with an asterisk, such as $\phi^+ = 4.66 \pm 0.11^*$ eV determined by PSI of Cs on W(100) [280] (see Footnote 278 in Table 1) and as $\phi^- = 4.49^{*N}$ eV done by NSI of KCl on W [574], is evaluated by the present author using the respective data on PSI and NSI reported therein [280,574] and also citing other factor(s) from other literatures. Typically, the latter [574] is evaluated from the experimental data on the slope of a semi-Saha–Langmuir plot of $\phi^- - E = 0.87$ eV found by NSI of KCl upon W [574] and also from the literature value of $E = 3.62$ eV as the electron affinity of Cl [577]. The feature of such a plot is outlined in Section 4.2.1 in Ref. [1351].

Interestingly, the thermal positive ion emission from the thick layers of a binary mixture (1:1 in mole ratio) of alkali halides (e.g., LiI and NaI) deposited on a metal surface shows such a "suppression effect" that the integrated ion current of Li ($I = 5.39$ eV) at 1080 K is reduced to 60% by the presence of NaI, although the ion emission of Na (5.14 eV) is little affected by the coexistent LiI [1950]. This result is consistent with Eq. (5) predicting that the metal having a higher value of I is less ionizable by PSI. Similarly, the thermal negative ion emission of I ($E = 3.06$ eV) from CsI is reduced by the coexistence (50% in mole fraction) of CsBr, in contrast to little change in that of Br (3.36 eV) from CsBr [3626]. This result consists with Eq. (6) indicating the less efficiency in negative ion emission by NSI in accordance with the smaller electron affinity.

Generally, there holds the relation of 1 eV = 0.07350 Ryd = 0.03675 hartree = 1.602 picoerg = 96.49 kJ/mol = 23.06 kcal/mol. In a Fowler plot, ϕ^e (in eV) is determinable from $12336/\lambda_0$, where λ_0 is the threshold wave length in Å (10^{-8} cm).

2.7. Column 7; Work function (ϕ^e) effective for electron emission

In this column, the work function (ϕ^e) effective for electron emission is listed according to the order of increasing value for each surface species. The value of ϕ^e in parentheses in Column 7 and that of ϕ^+ (or ϕ^-) in Column 6 on the same line are determined separately for the *same* specimen in Column 1 under essentially the same condition specified in Columns 4 and 5. Typically, the condition (5×10^{-9} Torr and ~1200−2000 K) for $\phi^+ = 5.25 \pm 0.05$ eV determined for W(110){>90% = δ_m} by PSI of Na is listed on the same line [86,90,2094] together with $\phi^e = (5.25 \pm 0.05)$ eV, whilst that (5×10^{-9} Torr and ~1500−1900 K) for $\phi^e = (5.25 \pm 0.05)$ eV by TE is given on the adjacent line just above [86,90,2094] together with $\phi^+ = (5.25 \pm 0.05)$ eV. Such arrangement of either both ϕ^+ and (ϕ^e) or both (ϕ^+) and ϕ^e listed on the same line makes it ready to recognize the thermionic contrast ($\Delta\phi^* \equiv \phi^+ - \phi^e = 5.25 - 5.25 = 0.00$ eV), the data of which will be summarized in Tables 4 and 5. Similarly on the adjacent lines, either both $\phi^- = (4.51^{*N})$ eV and $\phi^e = 4.51$ eV by TE [827] or both $\phi^- = 4.51^{*N}$ eV by NSI of I_2 and $\phi^e = (4.51)$ eV for W [827] are listed each on the same line (see Footnote 299 in Table 1). Therefore, this specific arrangement affords us directly the contrast ($\Delta\phi^{**} \equiv \phi^- - \phi^e = 0.00$ eV). Such a result is compiled later together with many other data on $\Delta\phi^{**}$ for both mono- and polycrystals in Table 7.

When either ϕ^e and ϕ^+ or ϕ^e and ϕ^- are determined by either TE and PSI or TE and NSI during incidence of a sample such as either Yb on Ir(111) [104] or I_2 on Mo(100) [571], of course, it is very important to select the working temperature to be high (either > 1800 K or > 1500 K) enough to avoid any sample adsorption effect on the measurements of either ϕ^e and ϕ^+ or ϕ^e and ϕ^- (see either Fig. 17 [104] or Fig. 28 [571] in Refs. [1351]).

2.8. Column 8; Method employed for evaluating each work function

The symbols contained in this column are explained briefly below, and some of the typical methods are outlined together with their results and accuracy compared with those by other methods.

2.8.1. General aspect

Each symbol listed as the method for evaluating the work function (ϕ^+, ϕ^e or ϕ^-) is fully expressed below. An outline about the principle, technique, feature, etc. for each method may be obtained from the references given at each end. A full detail for each method is omitted in this article because it is outside the present scope, which is intended mainly to establish an up-to-date and enriched database on work functions (ϕ^e, ϕ^+ and ϕ^-) for almost all the chemical elements and also which is aimed to estimate the most probable values for various surface species as much as possible.

AI = autoionization [1103,3496,3789,4027] (see Footnote 38 in Table 1).
CPD = contact potential difference [12,13,1312,1354,3256,3894,3898,3902,3970].
CS = conductance spectroscopy [2993].
FE = field emission [12,13,1312,1354,3894,3906].
IP = ionization potential [2199,3208] (see Footnote 60 in Table 1).
NSI = negative surface ionization (thermal negative ion emission) [2,13,15,18,1351,3896].
PE = photoelectric effect [12,13,1312,1354,3894].
PSI = positive surface ionization (thermal positive ion emission) [12,13,15,18,1351,3896].
SP = stopping potential [2349,3922].

TC = theoretical calculation [12,475,723,1312,1354,2427,3895,3901,3904,3905].

TCS = total current spectroscopy [2679,4050,4184] (see Footnote 409 in Table 1).

TE = thermal electron emission [1,12,13,1312,1351,1354,2129,3623,3724,3892–3894].

A brief discussion is made on the features of the absolute methods (FE, PE, PSI, TE) and the relative one (CPD), together with comparison of the work function values obtained by different methods [13,358,654,890,1058,1693,2471,3586,3897]. Typically, application of PE and CPD to Si(111)^p yields 5.10 and 4.83 eV, respectively [1971], while that to Ge(111)^p does the same value of 4.80 eV [1971] (see Footnote 155 in Table 1). For another example about several metals (Mo, Pd, Ag, Ta and Au), work function values estimated at various temperatures (293–1078 K) are found to have little difference (0.00–0.09 eV) at each temperature between the methods of PE and TE [3586]. Such a comparison among different methods will be discussed briefly in Section 2.8.2.

Regarding TC, many workers have tried to estimate ϕ^e using a variety of methods based on empirical or semi-empirical equations, which correlate ϕ^e quantitatively with various chemico-physical properties such as (1) atomic sublimation energy (in 1928) [3926], (2) atomic volume (1932–1936) [3927–3930] (see Section 2.8.4), (3) compressibility factor (1934) [3931] (see Section 2.8.4), (4) specific surface energy (1947, 1969) [837,4049], (5) zero charge potential and atomic radius (1953–1956) [3932,3933], (6) first ionization energy and either surface atomic density (1955) [1066] or covalent radius (1970) [4053], (7) electronegativity (1956–1978) [706,1645,1955,3267,3512,3975] (see Section 2.8.3), (8) atomic radius (1958) [3318], (9) atomic weight, density and the number of free electrons (1958) [3318], (10) both surface atom size and the sum of fractional bond numbers (1967–1979) [1159,1980,2129,3067], (11) electronegativity and covalent radius of metal atom (1970) [1993], (12) surface energy of monocrystal, lattice constant and number of valence electrons (1970) [4078] (see Section 5.5.2), (13) atomic sublimation entropy (1979) [3925,4051], (14) melting point of monocrystal and atomic volume (1979) [1684] (see Section 5.5.4), (15) first ionization energy and electron affinity (1982) [4136], and (16) atomic chemical potential (1999) [4270].

In contrast to the above classical theory, a modern theory about work function has been developed by many workers and, nowadays, quantum theory is widely employed to calculate ϕ^e of various surface species, as will be outlined roughly for some of the typical models in Section 2.8.5 and also discussed briefly in Section 6.

2.8.2. Comparison of work function data among different methods

A theoretical study of ϕ^e yields that $\phi^e_{PE} \geq \phi^e_{TE} \geq \phi^e_{true}$ and also $\phi^e_{PE} \geq \phi^e_{FE} \geq \phi^e_{true}$ for a given species [3897]. Here, ϕ^e_{PE}, ϕ^e_{TE} and ϕ^e_{FE} are the work functions to be measured by PE, TE and FE, respectively, and ϕ^e_{true} is the true work function. For monocrystals, however, the above inequalities are not fully examined by experiment mainly because of the poverty in available experimental data [3897]. For polycrystals, on the other hand, the data on ϕ^e_{CPD} measured for various metal films and bulk by CPD [349] are taken as those on ϕ^e_{true} [3897], and the experimental data obtained by the three different methods for 14 metals reported by other authors [488,1763, etc.] are compared among the above four species of ϕ^e's [3897], thereby yielding several exceptions against the above inequalities. In addition, the above relation of $\phi^e_{PE} \geq \phi^e_{true} \equiv \phi^e_{CPD}$ is opposite to that of $\phi^e_{PE} < \phi^e_{CPD}$, as will be discussed later in this section.

It should be noted that the above comparison of the data on ϕ^e_{CPD}, ϕ^e_{PE}, etc. reported for each metal species is made neither for the same specimen nor under the identical conditions. We should always take it into consideration that ϕ^e for any surface species is apt to change considerably from worker to worker or specimen to specimen, as may be seen in Table 1. Typically, ϕ^e for even Ag-bulk (neither film nor layer) is found to have the wide ranges of 3.09–4.7 eV by TE, 3.64–4.90 eV by PE and 3.94–4.73 eV by CPD, although these ranges are partly or considerably responsible for possible errors in measuring and/or processing.

In contrast to the above, let's consider the application of both PE and CPD to the *same* specimen under *common* conditions (P_r and T). About the Cs/Be system prepared by Cs$^+$ incidence up to $\theta = 1.0$ ML, for instance, ϕ^e is measured by both PE and CPD, thereby yielding the same value of 1.96 eV [3289]. By application of Kelvin, photoelectric and electron beam retarding methods to the U-layers ($\theta \approx 2$ ML) on W(100) at ~300 K, ϕ^e is determined to be 3.73 ± 0.02, 3.73 ± 0.02 and 3.78 ± 0.03 eV, respectively, for α-U [2471], thus showing essentially the same among the three.

In principle, the photoelectrically measured work function (ϕ^e_{PE}) of a patchy surface is known to be weighted towards *low* values (smaller local work functions), whereas the work function (ϕ^e_{CPD}) measured by CPD yields the *mean* value (local work function average) of the inhomogeneous surface under study [1693]. In practice, however, it is not so easy to confirm experimentally the inequality of $\phi^e_{PE} < \phi^e_{CPD}$ and also very difficult to evaluate accurately the difference between the two, because ϕ^e_{CPD} depends largely upon the accuracy of the reference work function value to be employed. Typically for a Ba/W system [1365], $\phi^e_{CPD} = 2.39 \pm 0.05$ eV [1365] is corrected to be 2.42 ± 0.05 eV [349] by taking 4.55 ± 0.02 eV [349] instead of 4.52 eV [1365] as the reference work function of W (see Footnote 238 in Table 1). Similarly to Ba/glass [1157], 2.52 eV [1157] may be corrected to be 2.35 ± 0.03 eV [349] by taking not 4.79 [1147] but 4.62 ± 0.03 eV [349] as the reference for Ag(100). Regarding Ba/Ag/Ta [1050], $\phi^e = 2.53$ eV [1050] is corrected to be 2.66 ± 0.01 eV [349] by taking 4.44 ± 0.01 eV [349] instead of 4.31 ± 0.03 eV [1050] as the reference work function of Ag. In another case where the reference work function of Au cited as 5.1 ± 0.1 eV [304] by the authors [4159] is replaced with 5.30 ± 0.04 eV (Table 2, to be shown later), $\phi^e_{CPD} = 4.47$ eV for Sn [4159] is corrected to be 4.27 ± 0.04 eV. These four examples indicate that ϕ^e_{CPD} is subject to change by up to ~0.2 eV depending upon the choice of the reference work function and hence upon its accuracy. The above change (0.03–0.20 eV) due to the selected reference work function seems generally to be not negligibly small compared with the probably minute difference between ϕ^e_{CPD} and ϕ^e_{PE}.

Comparison of the data obtained for the *same* specimen in each measurement is summarized below as in the form of (ϕ^e_{PE}/ϕ^e_{CPD}) in eV. Namely,

  (1) $(3.82 \pm 0.05/3.825 \pm 0.01)$ for In [2814].
  (2) $(1.96/1.96)$ for Cs/Be [3289].
  (3) $(4.73 \pm 0.07/4.73 \pm 0.07)$ for Si(111)^n [117,118].
  (4) $(3.73 \pm 0.02/3.73 \pm 0.02$ or $3.78 \pm 0.03)$ for α-U/W(100) [2471].
  (5) $(3.90 \pm 0.03/3.90 \pm 0.03$ or $4.00 \pm 0.04)$ for α-U/W(110) [2471].
  (6) $(3.66 \pm 0.03/3.67 \pm 0.03$ or $3.73 \pm 0.04)$ for α-U/W(113) [2471].
  (7) $(4.62 \pm 0.06/4.97 \pm 0.07$ or $4.86 \pm 0.10)$ for cnt/Si(111) [3246].
  (8) $(5.05 \pm 0.06/5.19 \pm 0.08$ or $5.06 \pm 0.04)$ for Pd/cnt/Si(111) [3246].
  (9) $(4.75 \pm 0.06/4.84 \pm 0.10$ or $4.76 \pm 0.09)$ for Ag/cnt/Si(111) [3246].
 (10) $(5.12 \pm 0.06/5.46 \pm 0.07$ or $5.39 \pm 0.08)$ for Pt/cnt/Si(111) [3246].
 (11) $(4.72 \pm 0.06/4.92 \pm 0.10$ or $4.85 \pm 0.11)$ for Au/cnt/Si(111) [3246].
 (12) $(5.38/5.45)$ for Au/glass [1074].
 (13) $(4.56/4.60)$ for Sb [1375].
 (14) $(4.26/4.34)$ for Bi [1375].
 (15) $(4.79/4.72)$ for As [1375].
 (16) $(4.14/4.27 \pm 0.04)$ for Sn [4159].
 (17) $(3.91/3.97 \pm 0.04)$ for Sn_{91}–Zn_9 [4159].
 (18) $(4.12/4.27 \pm 0.04)$ for $Sn_{96.5}$–$Ag_{3.5}$ [4159].
 (19) $(4.28/4.38 \pm 0.04)$ for Sn_{90}–Au_{10} [4159].
 (20) $(4.59/4.64 \pm 0.04)$ for Sn_{20}–Au_{80} [4159].

Results (1), (2) (see Footnote 232 in Table 1) and (3) indicate that $\Delta\phi^e_{C-P} \equiv \phi^e_{CPD} - \phi^e_{PE} \approx 0.0$ eV. Those (4) (see Footnote 408 in Table 1), (5) and (6) yield $\Delta\phi^e_{C-P} = 0.00$–$0.01$ and 0.05–0.10 eV by Kelvin and electron current retarding methods, respectively. Results (7)–(11) (see Footnote 25 in Table 1) show $\Delta\phi^e_{C-P} = 0.09$–$0.35$ and 0.01–0.27 eV before and after PE-measurements, respectively. Those (13)–(15) afford that $\Delta\phi^e_{C-P} = 0.04$ and 0.08 eV for Sb and Bi, respectively, in contrast to -0.07 eV for As. Those (16)–(20) indicate that $\Delta\phi^e_{C-P}$ is as small as 0.05–0.15 eV for both Sn and its binary alloys. This is because the work function of Au used as the reference for CPD [4159] is corrected from 5.1 ± 0.1 eV [304] to 5.30 ± 0.04 eV for Au (Table 2), as already indicating above that $\phi^e = 4.27$ eV corrected from 4.47 eV [4159] becomes nearer to our value of 4.34 eV recommended for β-Sn in Table 2. Here, the former $(5.1$ eV) [304] is included in Michaelson's review [1045] (see Table 2) and in a CRC Handbook (77th Ed., 1996–1997) [4137], but not done in any of the CRC handbooks (82nd–97th Eds., 2001–2017). It should be noted that $\Delta\phi^e_{C-P} = 0.05$–$0.15$ eV for Results (16)–(20) becomes larger by 0.20 eV unless the reference work function is corrected. Provided that each reference work function employed is free from a systematic error, then, many of the above results (1)–(20) except (15) may be concluded to have a tendency of $\phi^e_{CPD} > \phi^e_{PE}$ as an average of $\Delta\phi^e_{C-P} = 0.07 \pm 0.08$ eV for various *polycrystalline* surfaces with inhomogeneity in work function over the entire surface area, just as expected by consideration of each principle in work function measurement. This conclusion is opposite to that of $\phi^e_{PE} \geq \phi^e_{true} \equiv \phi^e_{CPD}$ [3897], as already mentioned above in this section.

For a *monocrystalline* sample of W(110) having the most probable values of $\phi^+ = 5.28$ or 5.29 eV and $\phi^e = 5.32$ or 5.31 eV recommended in Table 2 [Here or 1351], the actual work function is estimated to be 5.2 eV rather than 5.1 eV [2774] measured by the authors [2773,3768] in considering a slight underestimation (by 0.1 eV) by a photoemission method [2774]. In consequence, $\phi^e = 5.2$ eV thus estimated reaches an agreement with $\phi^+ = 5.2$ eV determined by PSI of fast Na atom (100 eV) incident on W(110) [2773,2774], thereby affording $\Delta\phi^* \equiv \phi^+ - \phi^e = 0.0$ eV instead of 0.1 eV. However, it does not seem adequately acceptable to consider such a large correction of 0.1 eV due to the underestimation by PE if the surface of W(110) is really homogeneous $(\delta_m = 100\%$ and hence $\Delta\phi^* = 0.00$ eV) in work function over the entire surface area and also if the measurement itself is essentially free from any systematic errors. Suppose that the surface under study has $\delta_m \approx 95\%$ instead of 100% in the degree of monocrystallization, for example, such a large correction as 0.1 eV may be acceptable when we consider such an actual example that 95%-W(100) has $\Delta\phi^* \approx 0.1$ eV, as exemplified for W(F) having $\Delta\phi^* = 0.09 \pm 0.05$ eV (see Table 6). It should be noted that the difference $(\Delta\phi^*)$ between ϕ^+ and ϕ^e becomes larger from 0.0 up to ~0.5 eV for W according as δ_m decrease from 100% to ~50% or less (see Section 4.3).

A clean and smooth surface of Ag(111) is found to have $\phi^e = 4.46 \pm 0.02$ eV measured by PE [625,1693]. On the other hand, ϕ^e for a surface of Ag(111) damaged by Ar^+ impact (400 eV, 15 $\mu A/cm^2$, 30 min) is 4.18 eV done by PE, slightly larger than 4.08 eV by CPD [1693]. This result indicates that application of PE to such a damaged surface is not suitable because any surface defect gives some effect to the surface potential barrier and hence to photothreshold [1693].

In the case of β-Be ($T \approx 900$–1200 K), a marked discrepancy (1.0 eV) of ϕ^e is found between 3.67 ± 0.01 eV measured by TE for bulk (ribbon) by Wilson [179,650,3410,3413,3413] and 4.67 ± 0.10 eV done by CPD (electron beam retarding) for Be-films on W(100) or W(110) by Zuber et al. [3550] (see Table 1). Further studies are desired to settle the question whether the above discrepancy originates from the difference between the methods (TE and CPD) or/and that between the surface structures (bulk and film).

2.8.3. Evaluation of work function from electronegativity

Regarding the quantitative relation between electronegativity and work function, the following equation [1955] is proposed first by Gordy and Thomas (in 1956).

$$\phi^e = 2.27X + 0.34 \text{ (in eV)} \tag{7}$$

Here, X is the electronegativity of each element in Pauling unit, and all of the work function values are cited from the review (first edition) published by Michaelson in 1950 [1355] in order to establish this equation. The constant of 0.34 eV is the energy required for electron to overcome the image force, identical for all metals [4047]. Much later (in 1973) by Miedema et al. [4048], Eq. (7) is modified as $\phi^e = 2.6X + 0.3$ (in eV), which is based on the work function data in Ref. [10] (Fomenko in 1966) and Ref. [304] (Eastman in 1970), in addition to Ref. [1355] (Michaelson in 1950). Recently (2008), Zhou et al. have proposed other relations such as $\phi^e = 1.92X + 0.99$ and $1.06X + 2.51$ (eV) for $X = 0.5$–2.5 and 1.2–2.4 in Pauling unit, respectively [4203], where ϕ^e is based on the review (second edition) published by Michaelson in 1977 [1045]. Consequently, we can not deny the possibility that the above coefficient and the constant may change considerably according to the reference data on both ϕ^e and X to be taken from various literatures for establishing the quantitative relation between the two. Nevertheless, such a relation as Eq. (7) is very useful for estimating ϕ^e of some elements (e.g., Pm, Po and Ra), which have no experimental data still today (see Footnote 379 in Table 1). This equation is successfully applied to many metals such as Sc (3.30/3.33 ± 0.04), Rb (2.13/2.17 ± 0.05), Ag (4.43/4.39 ± 0.02), Cs (2.05/2.05 ± 0.05) and Hg (4.43/4.50 ± 0.02), where the numerator and denominator in each parentheses correspond to the work function values (in eV) calculated from Eq. (7) and to ours recommended in this article (see Table 2), respectively, clearly showing a good agreement between the two in each parentheses.

About many other metals, however, the work function values based on Eq. (7) are found to be considerably different from ours (Table 2); typically, graphite (6.02/4.63 ± 0.06), Mg (3.07/3.65 ± 0.05), Ni (4.43/5.06 ± 0.06), and Ga (3.75/4.27 ± 0.06), where the numerator and denominator originate from Eq. (7) and Table 2, respectively. Such a large difference or discrepancy found between the two values in each of the parentheses (Eq. (7)/Table 2) may originate probably from the uncertainty of X depending upon the methods for estimating X and also from the incorrectness in ϕ^e [1355] taken as the reference to establish Eq. (7). It should be noted that the mean of work function estimated for each element by Michaelson [1355] is based on those literatures published before 1950 and, hence, that many of the mean values therein are much different from ours (Table 2); typically, such as Se (4.72/5.27 ± 0.18), Ir (4.57/5.28 ± 0.04) and Au (4.58/5.30 ± 0.04). Here, (a/b) corresponds to (mean [1355]/ours (Table 2)). By taking other data (published before 1970) compiled by Fomenko [10,12], the quantitative relation between ϕ^e and X are examined, thereby reaching the conclusion that Eq. (7) is valid especially for some of the elements of low work functions [3975], in contrast to those of high work functions. The concept of both electronegativity and Pauling unit may be thoroughly understandable from the original paper [4006] and a comprehensive review [3974].

Gyftopoulos and Hatsopoulos show that the work function of a uniform surface equals the neutral orbital electronegativity of a spin-orbital localized around a surface atom [2153].

2.8.4. Evaluations of work function from atomic volume and from compressibility factor

As already mentioned in Section 2.8.1, work function studies have produced various ideas for expressing the quantitative relations between ϕ^e and physico-chemical properties. Among the sixteen ideas mentioned there, let's examine here the two typical examples of (2) atomic volume and (3) compressibility factor, which were published in an early stage (1930's) of the historical progress in work function calculations. In this section, some of the calculated results alone will be summarized compactly below.

The atomic volume model (2) proposed by Rother and Bomke (in 1933) [3928] yields the typical results of B (4.8/4.50 ± 0.09), Ti (3.5/3.87 ± 0.06), V (4.0/4.10 ± 0.05), Nb (3.9/4.11 ± 0.05), In (4.0/4.05 ± 0.06), La (3.2/3.27 ± 0.04), Hf (3.6/3.64 ± 0.06), Ra (2.0/2.4 ± 0.3) and Ac (3.0/3.2 ± 0.3). Here, the numerator and denominator in parentheses correspond to the calculated value [3928] and ours (Table 2) in eV, respectively. Between the two, a good or fair agreement is found for each element. Especially, the data on both Ra and Ac may be useful for supplementing several scanty data achieved to date by other theoretical models (see Table 1). It is worthy to underline that any experimental data are unavailable as yet today for the two as well as other radioactive elements such as Po, At, Fr, etc. (see Table 1). On the other hand, the values calculated for Be, Mn, Ga, Zr and U [3928] have a large difference (~0.6–1.5 eV) from ours in Table 2.

The model of compressibility factor (3) proposed by Chittum (in 1934) [3931] yields the data on nineteen elements, among which (numerator) a good agreement to our most probable value (denominator) is found for Ca (3.00/2.91 ± 0.03), Ag (4.33/4.39 ± 0.03) and Pt (5.34/5.30 ± 0.07) alone. The values calculated for the other sixteen elements (K, Co, Zn, Pd, W, etc.) result in a considerable difference (by ~0.2–1.0 eV) from ours in Table 2.

Unluckily, almost all the empirical or semiempirical equations based on the models (1)–(16) mentioned in Section 2.8.1 are limited to evaluating ϕ^e for polycrystals alone. It is only three equations based on the model (10) proposed by Steiner and Gyftopoulos (in 1967, 1980) [1159,1980,3067], on (12) by Zadumkin et al. (in 1970) [4078] and on (14) by Chatterjee (in 1979) [1684] alone, that are applicable to evaluation of ϕ^e for monocrystals. At present, however, such classical models are made less important by an amazing progress in quantum theory applicable not only to polycrystals but also to monocrystals with various orientations, as will be exemplified briefly below.

2.8.5. Evaluation of work function by quantum theory

Modern theory about work function is initiated by Wigner and Barden (in 1935), who apply the quantum calculation of ϕ^e to alkali metals [3725], thus evaluating $\phi^e = 2.19, 2.15, 2.20, 2.20$ and 2.15 eV for Li, Na, K, Rb and Cs, respectively, in addition to 2.0 or 2.35 eV for Na by Bardeen (in 1936) [1458]. Such values either much deviate from or well agree with ours of 2.90, 2.54, 2.29, 2.17 and 2.05 eV for respective alkali metals (see Table 2). In the next stage, Kohn has made a great contribution to developing the better calculation of ϕ^e, the effectual framework for which originates from the density functional theory reported in 1964–1966 by Kohn et al. [3638,4043,4044]. Further information about his brilliant achievements is obtainable from his Nobel lecture entitled the "Electronic structure of matter — wave functions and density functionals" [1698] and also from several

topics [4395–4397]. Hereafter, many workers have developed various models, the principle and feature of which are outlined in excellent reviews [723,1312,2004,2427,3895,3982,4035]. Some of the models are exemplified together with the results calculated for aluminum monocrystalline surfaces [1943]. For instance, the generalized gradient approximation with Perdew–Burke–Ernzerhof (GGA/PBE) functional model applied to Al(111) yields 4.06 eV [482,1175] and 4.09 eV [1177], both slightly smaller than our value of 4.24 ± 0.04 eV (see Table 2). On the other hand, the local density approximation with Coperly–Alder (LDA/CA) functional model done so affords 4.19 eV [557], 4.21 eV [1179], 4.22 eV [1943] and 4.25 eV [721], entirely well agreeing with ours cited just above. An outline about GGA etc. is given in each reference attached with the corresponding model. As brief supplements to the comprehensive data book published in 1981 [1354], Fomenko compiles the theoretical work function data published for mono- and polycrystals during the period of mainly ~1980–1990 [485,4116], and also he summarizes theoretical and experimental data reported for both Y and lanthanide monocrystals during 1976–1992 [4146].

In contrast to the above quite short and rough tracing about the development of quantum treatments of work function, much further information is obtainable from the excellent reviews mentioned above [723, etc.]. In addition, a long and interesting history of work function studies is compactly summarized as the "100 years of work function" by Halas in 2006 [4058] and as the "Electron work function — past, present and future" in 2005 [4099] together with the "Fundamental physics of vacuum electron sources" in 2006 [2243] by Yamamoto. Interesting information may be obtained from the "Hundred years of anniversary of the oxide cathode — A historical review" by Gaertner and den Engelsen in 2005 [1648] and also from the "Centennial Symposium on Electron" held in 1997 [1419].

The work function dependence upon both surface and bulk properties is theoretically investigated by Lang and Kohn using the uniform-positive-background model [475], a typical result of which will be outlined in Section 6.1, together with a brief comparison with our most probable values listed in Table 2.

2.8.6. Correction of work function values measured from Richardson plots

The Richardson constant of A_R in Richardson equation [1,2,1351] has seldom been measured exactly to be the theoretical value of 120 A/cm² K² for any surface species (e.g., Be, Si, Ta and Pt) by many experimental attempts, as may be seen in handbooks compiled by Fomenko [10,12,1354]. Typically, A_R for Si is reported to be 0.2–38 A/cm² K² [10,12,1354], similarly for Si(110), Si(111), Si(112) and Si (541) as to be 0.004–3 A/cm² K² with one exception of ~130 A/cm² K² [1354]. Particularly for molten Ag above 1234 K, A_R is found to be extremely as small as 6.4×10^{-8} A/cm² K² [1466] (see Footnote 431 in Table 1). Such a reduction in A_R is mainly because a great part of the electrons has no energy enough to escape from the surface into vacuum and also because such "internal reflection" is subject to dependence upon surface temperature and, hence, ϕ^e is generally measured to be considerably smaller than the normal value, as will be demonstrated just below.

Typically, Si(111) is found to have $\phi^e \approx$ ~4.0–4.8 eV by TE [72–75, etc.], in contrast to ~4.4–4.8 eV by PE [1181,3969, etc.] and also to ~4.6–4.9 eV by CPD [117,1959, etc.], as may be seen in Table 1. In addition, the former by TE is again smaller than $\phi^+ \approx 4.6$–5.2 eV [72–75] by PSI even in nearly the same temperature range. Consequently, Si(111) is often found to yield the results of $\Delta\phi^* \equiv \phi^+ - \phi^e \neq 0$ eV, although many other monocrystalline surfaces of Ta, W, etc. are usually determined to have $\Delta\phi^* = 0.0$ eV just as predicted by theory, as will be shown in Tables 4 and 5.

In order to avoid such a typical error due to the reduction in A_R, Hensley proposes the simple method (in 1961) that the work function to be measured directly by TE may be adequately corrected according [3623] to

$$\phi_H^e = \phi_r^e + kT \ln(120/A_r). \tag{8}$$

Here, ϕ_r^e is the work function (ϕ^e) measured directly together with $A_r \neq A_R = 120$ A/cm² K² from a Richardson plot, where A_r is the apparent Richardson constant corresponding to $(1 - r^e) A_R$ and r^e is the internal reflection coefficient [2,12,13,1354]. Firstly (in 1967) by Hopkins et al. [1484], Eq. (8) is applied to U/W systems ($\theta = 1$–50 ML), thereby yielding such a typical result that $\phi_r^e = 3.14 \pm 0.02$ is corrected to be $\phi_H^e = 3.36 \pm 0.04$ eV according to the data on $A_r = 20 \pm 7$ A/cm² K². The latter is nearer to 3.42 ± 0.05 eV for γ-U(poly) recommended by us in Table 2.

Regarding a specimen of p-type Si(111)^p measured to have $\phi_r^e = 3.2$ eV and $A_r = 4 \times 10^{-3}$ A/cm² K² at ~1100–1150 K [3540], for example, ϕ_H^e is calculated by the present author to be 4.2 eV from Eq. (8). This value agrees exactly with $\phi^e = 4.2$ eV determined directly with the same specimen at ~1150–1450 K [3540], where A_r is measured to be 130 A/cm² K² [3540]. Comparison of the results between the two temperature ranges indicates that the probability of these electrons escaping to vacuum after overcoming the surface barrier on Si(111) is extremely small in the lower temperature range and also suggests that the silicon specimen has $r^e > 0.99$ (larger than 99%) in the lower temperature range in contrast to the higher one of $r^e \approx 0$, if the above experimental data are free from any systematic errors.

In another case of Si(111)^p [73], $\phi_r^e = 4.07 \pm 0.05$ eV with $A_r = 0.2$–0.4 A/cm² K² at ~1300–1600 K by TE [73] may be corrected to be $\phi_H^e = 4.83 \pm 0.04$ eV $= \phi^e$, similarly above by the present author. This is essentially equal to 4.84 ± 0.14 and 4.86 ± 0.11 eV determined not from a Richardson plot but from an electron retarding field one (Anderson method [1365]) at ~1500 K [73]. In addition, ϕ_H^e ($=\phi^e$) is in good agreement with $\phi^+ = 4.88 \pm 0.10$ and 4.85 ± 0.08 eV determined for the same specimen by a cesium ion retarding method based on PSI at ~1500 K [73], thereby yielding $\Delta\phi^* \equiv \phi^+ - \phi^e = 0.02 \pm 0.02$ eV $= 0.0$ eV, just as predicted by theory for a monocrystalline surface under the normal condition accepted in general (see Footnote 66 in Table 1).

In the same way as Si(111)^p with $A_r = 0.2$–0.4 A/cm² K² [73] exemplified just above, $\phi_r^e = 4.04 \pm 0.05$ eV measured for n-type Si(111)^n ($A_r = 0.3$ A/cm² K², estimated) by TE (1340–1600 K) [72] may be similarly corrected to be 4.80 ± 0.04 eV $= \phi_H^e$, which yields $\Delta\phi^* = 0.06 \pm 0.08$, 0.07 ± 0.05 and 0.10 ± 0.11 eV since $\phi^+ = 4.86 \pm 0.07$, 4.87 ± 0.03 and 4.90 ± 0.10 eV by PSI of Li, Na and In on the same way, respectively [72]. Again, $\Delta\phi^* \approx 0.0$ eV is obtained in contrast to $\Delta\phi^* = 0.82$–0.86 $\neq 0$ eV in the former

($\phi^e = 4.04$ eV) measured directly from a Richardson plot. These results may suggest that many couples of the data on $\phi^+ > \phi^e$, such as $\phi^+ = 4.78 \pm 0.05$ eV $> \phi^e = 4.59 \pm 0.05$ eV determined for a specimen (A) of Si(111), as well as others (B–E) [75], are mainly caused by underestimation of ϕ^e due to $r^e > 0$ mentioned above. Additional information on the above problem is obtainable from Footnote 66 in Table 1.

In respect of γ-U (flat strip) [3961], $\phi_r^e = 3.27 \pm 0.05$ eV is corrected to be $\phi_H^e = 3.56 \pm 0.05$ eV, slightly larger than ours (3.42 $\pm$ 0.05 eV) in Table 2. This may be mainly because $A_r = 6$ A/cm^2 K^2 is only roughly estimated [3961].

Another study of β- and γ-Fe yields $\phi_r^e = 4.48 \pm 0.06$ eV with $A_r = 26$ A/cm^2 K^2 for β and $\phi_r^e = 4.21 \pm 0.05$ eV and 1.5 A/cm^2 K^2 for γ [310], the respective work function values of which may be corrected to be 4.64 ± 0.06 and 4.66 ± 0.05 eV by Eq. (8) (see Table 1). Consequently, the allotropic work function change ($\Delta\phi_{\gamma\beta}^e \equiv \phi_\gamma^e - \phi_\beta^e$) is corrected from -0.27 ± 0.08 to 0.02 ± 0.08 eV, only the latter of which is in fair agreement with any other five values of $\Delta\phi_{\gamma\beta}^e = 0.00$–0.09 eV and also well agrees with their mean value of 0.04 ± 0.03 eV, as will be shown in Table 11.

Regarding the two surface species of Th/ThO$_2$-W and γ-U/W, some of the typical data are summarized below as in the form of (T) in K, $\{A_r\}$ in A/cm^2 K^2 and (ϕ_r^e/ϕ_H^e) in eV, where ϕ_H^e with # is calculated by Hopkins et al. [1484] while the others are done by the present author. In addition, our most probable value of ϕ^e (Table 2) is given together with Means of ϕ_r^e and ϕ_H^e. For Data (1)–(4) below, the Th-films on W are prepared from a sintered cathode (67% thoria and 33% tungsten) by activation at 2040 K [3800], which corresponds to the "spillover" method mentioned in Section 2.2.

(1) Th/ThO$_2$-W ($\sim$1100–1500) // {69.1} (3.40/3.46) [3800].
(2) Th/ThO$_2$-W ($\sim$1100–1500) // {61.6} (3.26/3.33) [3800].
(3) Th/ThO$_2$-W ($\sim$1100–1500) // {10.6} (2.91/3.18) [3800].
(4) Th/ThO$_2$-W ($\sim$1100–1500) // {9.6} (3.0/3.28) [3800].
  (1)–(4) Means of $\phi_r^e = 3.14 \pm 0.40$ eV and $\phi_H^e = 3.31 \pm 0.10$ eV, while $\phi^e = 3.37 \pm 0.04$ eV (Table 2).
(5) γ-U/W (1250–1400) // {114 $\pm$ 12} (3.47 $\pm$ 0.03/3.48 $\pm$ 0.03#) [232].
(6) γ-U/W ($\sim$1000–1400) // {80 $\pm$ 30} (3.42 $\pm$ 0.04/3.45 $\pm$ 0.1#) [1484].
(7) γ-U/W ($\sim$1000–1300) // {20 $\pm$ 7} (3.14 $\pm$ 0.02/3.36 $\pm$ 0.04#) [1484].
(8) γ-U/W (1250) // {8} (3.2/3.5) [2098].
(9) γ-U/W (1250–1400) // {5} (3.0/3.38#) [232].
  (5)–(9) Means of $\phi_r^e = 3.25 \pm 0.18$ eV and $\phi_H^e = 3.43 \pm 0.06$ eV, while $\phi^e = 3.42 \pm 0.05$ eV (Table 2).

As may be seen in Data (1)–(4) as well as those (5)–(9) above, with exceptions of (3) and (8), ϕ_r^e tends to decrease generally with decreasing A_r, but each mean value of ϕ_H^e becomes nearer to ours of ϕ^e, just as expected in general. Additional information about such a correction according to Eq. (8) may be obtained from Footnotes 384–386, 431 and 456 in Table 1.

As a quantitative relationship between ϕ_r^e and A_r, the equation of $\log_{10} A_r = -6.85 + 1.87\phi_r^e$ is determined experimentally for Pt [2299,2300]. This is consistent with the above result that the more A_r becomes smaller, the more ϕ_r^e does so.

2.9. Column 9; References for each work function study

Plural references on the same line in the 9th column correspond to the same author(s) or group(s). References of [1]–[1350] are contained also in the previous review [1351], and many of them afford us further information and data on the work functions (ϕ^+, ϕ^e and ϕ^-) for both chemical elements and compounds. But, work function data on the latter (e.g., SiC, LaB$_6$ and ZrC) are not included in Table 1 herein. Of course, all of the data on the three kinds of work functions for about 400 surface species of 18 kinds of chemical elements ($_6$C–$_{79}$Au) covered previously [1351] are also included here together with newly cited ones (about 200 surface species of 70 elements) for both mono- and polycrystals covering the total of about 600 surface species of 88 elements ($_1$H–$_{99}$Es) on the bases of 4461 references published to date.

2.10. Footnotes for further information

Table 1 is attached with 490 footnotes, which afford additional information about the correlations of work function (ϕ^e or ϕ^+) with (1) its variation according to T, P_r, θ, etc. employed for the specimen under study, (2) its dependence on the size of either fine particles, nanowires or clusters, (3) its revision or correction by the present or other authors, (4) its dependence upon the degree of monocrystallization (δ_m) estimated for film or bulk samples, (5) its coincidence between theory and experiment done for the same specimen, (6) its changes at critical temperatures causing various physical transitions, (7) its increase by annealing (smoothing) the layer surface under study, (8) its coincidence among different measuring methods, and so on.

3. Most probable values of effective work functions (ϕ^+, ϕ^- and ϕ^e)

This section outlines the method to estimate the most probable values of the three kinds of work functions for essentially clean surfaces of both mono- and polycrystals after examining the reliability or acceptability for each of the great many data listed in Table 1 and also summarizes the results in Table 2 together with literature values recommended previously for each surface species independently by other several authors in order to examine the objective reliability or acceptability of our most probable value for each species.

Table 2

Effective work functions (ϕ^e, ϕ^+ and ϕ^-) recommended as the most probable values [Here] by the present author using the data in Table 1, and the effective one (ϕ^e) selected as either typical or preferable value by other authors [1045,1358], and also that (ϕ^e) recommended formerly by another author [12,1354] and previously by the present author [1351] for essentially clean surfaces.

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
1	H(100)[f(1)]	3.7[z(4)]	–	–	–	–	–	–
1	H(110)[f]	3.8[z]	–	–	–	–	–	–
1	H(111)[f]	3.8[z]	–	–	–	–	–	–
1	H(poly)[f]	3.89 ± 0.09[(3)]	–	–	–	–	–	–
3	Li(100)[b]	3.12 ± 0.03[(3)]	–	–	–	–	–	–
3	Li(110)[b]	3.37 ± 0.05	–	–	–	–	–	–
3	Li(111)[b]	3.04 ± 0.08	–	–	–	–	–	–
3	Li(112)[b]	3.3[z(4)]	–	–	–	–	–	–
3	Li(poly)[b]	2.90 ± 0.03	–	–	2.93 [363]	2.9 [363]	2.38	–
4	α-Be(0001)[hc]	5.27 ± 0.11	–	–	–	–	–	–
4	α-Be(1010)[hc]	4.6 ± 0.1[y(4)]	–	–	–	–	–	–
4	α-Be(0111)[hc]	5.1 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(0112)[hc]	4.9 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(0113)[hc]	4.6 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(1121)[hc]	4.7 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(1122)[hc]	4.9 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(1123)[hc]	4.3 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(1124)[hc]	5.7[z]	–	–	–	–	–	–
4	α-Be(2130)[hc]	4.3 ± 0.1[x]	–	–	–	–	–	–
4	α-Be(3140)[hc]	4.4 ± 0.2[x]	–	–	–	–	–	–
4	α-Be(poly)[hc]	4.28 ± 0.13	–	–	4.98 [2009][(8)]	4.98 [2009][(8)]	3.92	–
4	β-Be(poly)[h]	4.2 ± 0.5	–	–	–	–	–	–
5	B(poly)	4.50 ± 0.09	–	–	–	–	4.5	–
6	C(100)[d]	5.0 ± 0.6	–	–	–	–	–	–
6	C(111)[d]	5.4 ± 0.5	–	–	–	–	–	–
6	C(112)[d]	5.2[z]	–	–	–	–	–	–
6	C(poly)[d]	4.6 ± 0.6	–	–	–	–	–	–
6	C(0001)[h]	4.6 ± 0.3	–	–	–	–	–	–
6	C(HOPG)[h]	4.66 ± 0.05	4.65 ± 0.12	–	–	–	–	–
6	C(film)	4.47 ± 0.05	4.50 ± 0.04	4.4 ± 0.1[x]	–	–	–	–
6	C(poly)	4.63 ± 0.06	4.45 ± 0.05[x]	4.6 ± 0.2[z]	5.0 [299]	5.0 [299]	4.7	4.6 ± 0.1
6	C(graphene)	4.67 ± 0.11	–	–	–	–	–	–
6	C_{60}(111)	4.76 ± 0.05[y]	–	–	–	–	–	–
6	C_{60}(poly)	4.87 ± 0.06	–	–	–	–	–	–
6	C(swnt)	4.78 ± 0.06	–	–	–	–	–	–
6	C(mwnt)	4.63 ± 0.04	–	–	–	–	–	–
6	C(conical)	4.3 ± 0.2[y]	–	–	–	–	–	–
11	Na(100)[b]	2.80 ± 0.04	–	–	–	–	–	–
11	Na(110)[b]	3.05 ± 0.04	–	–	–	–	–	–
11	Na(111)[b]	2.68 ± 0.06	–	–	–	–	–	–
11	Na(112)[b]	3.1[z]	–	–	–	–	–	–
11	Na(poly)[b]	2.54 ± 0.03	–	–	2.36 [3337][(11)]	2.75 [3424][(11)]	2.35[(11)]	–
11	Na(liquid)	2.6 ± 0.2[y]	–	–	–	–	–	–
12	Mg(0001)[hc]	3.79 ± 0.07	–	–	–	–	–	–
12	Mg(1010)[hc]	3.7 ± 0.1[y]	–	–	–	–	–	–
12	Mg(0111)[hc]	3.8 ± 0.1[x]	–	–	–	–	–	–
12	Mg(0112)[hc]	3.7 ± 0.1[x]	–	–	–	–	–	–
12	Mg(0113)[hc]	3.6 ± 0.1[x]	–	–	–	–	–	–

(continued on next page)

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
12	Mg(1121)[hc]	3.6 ± 0.1^x	–	–	–	–	–	–
12	Mg(1122)[hc]	3.7 ± 0.1^x	–	–	–	–	–	–
12	Mg(1123)[hc]	3.6 ± 0.1^x	–	–	–	–	–	–
12	Mg(2130)[hc]	3.6 ± 0.1^x	–	–	–	–	–	–
12	Mg(3140)[hc]	3.6 ± 0.1^x	–	–	–	–	–	–
12	Mg(poly)[hc]	$\underline{3.65 \pm 0.05}$	–	–	3.66 [1968]	3.66 [1968]	3.64	–
13	Al(100)[f]	$\underline{4.28 \pm 0.05}$	–	–	4.20 [612]	4.41 [241]	–	4.36 ± 0.10
13	Al(110)[f]	$\underline{4.05 \pm 0.05}$	–	–	4.06 [612]	4.06 [612]	–	4.21 ± 0.09
13	Al(111)[f]	$\underline{4.24 \pm 0.04}$	–	–	4.26 [612]	4.24 [241]	–	4.28 ± 0.04
13	Al(poly)[f]	$\underline{4.26 \pm 0.03}$	4.9 ± 0.1^x	–	–	4.28 [612]	4.25	4.23 ± 0.06
14	Si(100)[d]	$\underline{4.82 \pm 0.05}$	4.72 ± 0.10	–	4.91^p [1225]	4.91^p [1225]	–	4.71 ± 0.16
14	Si(110)[d]	4.44 ± 0.24	$\underline{4.36 \pm 0.03}$	–	–	–	–	–
14	Si(111)[d]	$\underline{4.86 \pm 0.09}$	$\underline{4.83 \pm 0.07}$	–	4.60^p [118]	4.60^p [118]	–	4.79 ± 0.07
14	Si(112)[d]	4.1 ± 0.2	–	–	–	–	–	–
14	Si(541)[d]	4.0 ± 0.3^y	–	–	–	–	–	–
14	Si(poly)[d]	$\underline{4.65 \pm 0.09}$	–	–	4.85^n [613]	4.85^n [613]	4.8	4.6 ± 0.1
15	P(111)	1.4^z	–	–	–	–	–	–
15	P(poly)	5.0 ± 0.1^y	–	–	–	–	–	–
16	α-S(poly)[r]	$\underline{5.31 \pm 0.08}$	–	–	–	–	–	–
19	K(100)[b]	$\underline{2.47 \pm 0.04}$	–	–	–	–	–	–
19	K(110)[b]	$\underline{2.74 \pm 0.04}$	–	–	–	–	–	–
19	K(111)[b]	$\underline{2.39 \pm 0.02}$	–	–	–	–	–	–
19	K(112)[b]	2.7^z	–	–	–	–	–	–
19	K(poly)[b]	$\underline{2.29 \pm 0.02}$	–	–	2.29 [?]	2.30 [3337]	2.22	–
19	K(liquid)	2.28 ± 0.02^y	–	–	–	–	–	–
20	α-Ca(100)[f]	3.4 ± 0.4	–	–	–	–	–	–
20	α-Ca(110)[f]	3.3 ± 0.3	–	–	–	–	–	–
20	α-Ca(111)[f]	3.5 ± 0.2	–	–	–	–	–	–
20	γ-Ca(100)[b]	3.5^z	–	–	–	–	–	–
20	γ-Ca(110)[b]	3.5 ± 0.6^x	–	–	–	–	–	–
20	γ-Ca(111)[b]	3.4^z	–	–	–	–	–	–
20	γ-Ca(112)[b]	3.8^z	–	–	–	–	–	–
20	α-Ca(poly)[f]	$\underline{2.91 \pm 0.03}$	–	–	2.87 [1997]	2.87 [1997]	2.80	–
21	α-Sc(0001)[hc]	3.7 ± 0.1	–	–	–	–	–	–
21	α-Sc(1010)[hc]	3.5 ± 0.2^y	–	–	–	–	–	–
21	α-Sc(1124)[hc]	4.0^z	–	–	–	–	–	–
21	β-Sc(100)[f]	4.4^z	–	–	–	–	–	–
21	β-Sc(110)[f]	4.1^z	–	–	–	–	–	–
21	β-Sc(111)[f]	4.3 ± 0.4^x	–	–	–	–	–	–
21	α-Sc(poly)[hc]	$\underline{3.33 \pm 0.04}$	–	–	3.5 [304]	3.5 [304]	3.3	–
21	β-Sc(poly)[f]	3.4^x	–	–	–	–	–	–
22	α-Ti(0001)[hc]	$\underline{4.53 \pm 0.10}$	–	–	–	–	–	–
22	α-Ti(1010)[hc]	4.2 ± 0.4^y	–	–	–	–	–	–
22	α-Ti(1011)[hc]	4.8^z	–	–	–	–	–	–
22	α-Ti(1124)[hc]	4.2^z	–	–	–	–	–	–
22	β-Ti(100)[b]	3.9^z	–	–	–	–	–	–
22	β-Ti(110)[b]	4.6^z	–	–	–	–	–	–
22	β-Ti(111)[b]	3.8^z	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
22	β-Ti(112)[b]	4.2[z]	–	–	–	–	–	–
22	α-Ti(poly)[hc]	3.87 ± 0.05	–	–	4.33 [304]	4.33 [304]	3.95	–
22	β-Ti(poly)[b]	3.93 ± 0.16	–	–	–	–	–	–
23	V(100)[b]	4.27 ± 0.05	–	–	–	–	–	–
23	V(110)[b]	5.04 ± 0.07	–	–	–	–	–	–
23	V(111)[b]	4.13 ± 0.04[y]	–	–	–	–	–	–
23	V(112)[b]	4.3 ± 0.3[x]	–	–	–	–	–	–
23	V(116)[b]	4.0 ± 0.1[x]	–	–	–	–	–	–
23	V(poly)[b]	4.10 ± 0.05	–	–	4.3 [304]	4.3 [304]	4.12	–
24	Cr(100)[b]	4.43 ± 0.14	–	–	–	–	–	–
24	Cr(110)[b]	4.99 ± 0.19	–	–	–	–	–	–
24	Cr(111)[b]	3.8 ± 0.1[y]	–	–	–	–	–	–
24	Cr(112)[b]	4.1 ± 0.1[x]	–	–	–	–	–	–
24	Cr(116)[b]	3.8[z]	–	–	–	–	–	–
24	Cr(210)[b]	4.2[z]	–	–	–	–	–	–
24	Cr(poly)[b]	4.38 ± 0.04	–	–	4.5 [304]	4.5 [304]	4.58	–
25	γ-Mn(100)[f]	5.2 ± 0.3[y]	–	–	–	–	–	–
25	γ-Mn(110)[f]	4.7[z]	–	–	–	–	–	–
25	γ-Mn(111)[f]	5.3 ± 0.1[y]	–	–	–	–	–	–
25	δ-Mn(100)[b]	4.8 ± 0.4[y]	–	–	–	–	–	–
25	δ-Mn(110)[b]	5.3 ± 0.3[y]	–	–	–	–	–	–
25	δ-Mn(111)[b]	4.1[z]	–	–	–	–	–	–
25	δ-Mn(112)[b]	4.6[z]	–	–	–	–	–	–
25	$\alpha-\beta$-Mn(poly)[c]	4.08 ± 0.11	–	–	4.1 [304]	4.1 [304]	3.83	–
25	γ-Mn(poly)[f]	4.3 ± 0.1[x]	–	–	–	–	–	–
25	δ-Mn(poly)[b]	3.8[z]	–	–	–	–	–	–
26	α-Fe(100)[b]	4.64 ± 0.05	–	–	4.67 [921]	4.67 [921]	–	4.59 ± 0.13
26	α-Fe(110)[b]	4.99 ± 0.04	–	–	–	–	–	5.19 ± 0.08
26	α-Fe(111)[b]	4.4 ± 0.3	–	–	4.81 [487]	4.81 [487]	–	–
26	α-Fe(210)[b]	4.2 ± 0.1[x]	–	–	–	–	–	–
26	α-Fe(211)[b]	4.4 ± 0.4[y]	–	–	–	–	–	–
26	α-Fe(310)[b]	4.0 ± 0.1[x]	–	–	–	–	–	–
26	α-Fe(321)[b]	4.3 ± 0.1[x]	–	–	–	–	–	–
26	β-Fe(100)[b]	4.6 ± 0.4[y]	–	–	–	–	–	–
26	β-Fe(110)[b]	5.8[z]	–	–	–	–	–	–
26	β-Fe(111)[b]	4.8[z]	–	–	–	–	–	–
26	γ-Fe(100)[f]	5.28 ± 0.19	–.	–	–	–	–	–
26	γ-Fe(110)[f]	5.0[z]	–	–	–	–	–	–
26	γ-Fe(111)[f]	5.6 ± 0.1[x]	–	–	–	–	–	–
26	m-Fe(100)[f]/Cu(100)[(16)]	5.38 ± 0.22	–	–	–	–	–	–
26	α-Fe(poly)[b]	4.55 ± 0.05	–	–	–	4.5 [304]	4.31	4.66 ± 0.08
26	β-Fe(poly)[b]	4.52 ± 0.17	–	–	–	4.62 [305]	–	–
26	γ-Fe(poly)[f]	4.54 ± 0.05	–	–	–	4.68 [305]	–	–
26	δ-Fe(poly)[b]	4.76 ± 0.1[x]	–	–	–	–	–	–
26	m-Fe[f]/Cu(100)	4.58 ± 0.10[y]	–	–	–	–	–	–
27	α-Co(0001)[hc]	5.30 ± 0.18	–	–	–	–	–	–
27	α-Co(1010)[hc]	5.5[z]	–	–	–	–	–	–
27	α-Co(1011)[hc]	5.3[z]	–	–	–	–	–	–
27	α-Co(1120)[hc]	4.1[z]	–	–	–	–	–	–
27	α-Co(1124)[hc]	4.8[z]	–	–	–	–	–	–
27	β-Co(100)[f]	5.25 ± 0.17	–	–	–	–	–	–
27	β-Co(110)[f]	5.0[z]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
27	β-Co(111)[f]	5.39 ± 0.23	–	–	–	–	–	–
27	m-Co(100)[b] /GaAs(110)[(7)]	5.0 ± 0.3[y]	–	–	–	–	–	–
27	m-Co(100)[f] /Cu(100)[(17)]	4.7[z]	–	–	–	–	–	
27	α-Co(poly)[hc]	4.71 ± 0.03	–	–	5.0 [304]	5.0 [304]	4.41	–
27	β-Co(poly)[f]	4.50 ± 0.13	–	–	–	–	–	–
27	m-Co[f] /Cu(100)[(17)]	4.94 ± 0.30	–	–	–	–	–	–
28	Ni(100)[f]	5.19 ± 0.05	5.2[z]	–	5.22 [314]	5.22 [314]	–	5.23 ± 0.10
28	Ni(110)[f]	4.96 ± 0.10	5.0[z]	–	5.04 [314]	5.04 [314]	–	4.64 ± 0.05
28	Ni(111)[f]	5.32 ± 0.05	5.3[z]	–	5.35 [314]	5.35 [314]	–	5.28 ± 0.05
28	Ni(113)[f]	4.5[z]	–	–	–	–	–	–
28	Ni(133)[f]	4.4[z]	–	–	–	–	–	–
28	Ni(poly)[f]	5.06 ± 0.06	5.19 ± 0.12[y]	–	–	5.15 [304]	4.50	4.87 ± 0.16
29	Cu(100)[f]	4.58 ± 0.06	–	–	5.10 [358][(15)]	4.59 [953]	–	4.57 ± 0.08
29	Cu(110)[f]	4.43 ± 0.04	–	–	4.48 [953]	4.48 [953]	–	4.48 ± 0.06
29	Cu(111)[f]	4.92 ± 0.05	–	–	4.94 [953]	4.94 [953]	–	4.91 ± 0.03
29	Cu(112)[f]	4.52 ± 0.03	–	–	4.53 [953]	4.53 [953]	–	4.50 ± 0.04
29	Cu(113)[f]	4.5 ± 0.2[y]	–	–	–	–	–	–
29	Cu(114)[f]	4.6[z]	–	–	–	–	–	–
29	Cu(119)[f]	4.6[z]	–	–	–	–	–	–
29	Cu(122)[f]	4.5 ± 0.1[x]	–	–	–	–	–	–
29	Cu(124)[f]	4.5[z]	–	–	–	–	–	–
29	Cu(210)[f]	4.3 ± 0.1[x]	–	–	–	–	–	–
29	Cu(233)[f]	4.5 ± 0.1[x]	–	–	–	–	–	–
29	Cu(234)[f]	4.5 ± 0.1[x]	–	–	–	–	–	–
29	Cu(236)[f]	4.4[z]	–	–	–	–	–	–
29	Cu(321)[f]	4.1[z]	–	–	–	–	–	–
29	Cu(345)[f]	4.5[z]	–	–	–	–	–	–
29	Cu(356)[f]	4.5[z]	–	–	–	–	–	–
29	Cu(413)[f]	4.0[z]	–	–	–	–	–	–
29	Cu(018)[f]	4.7[z]	–	–	–	–	–	–
29	Cu(poly)[f]	4.51 ± 0.04	–	–	–	4.65 [3319][(10)]	4.40	4.51 ± 0.07
29	Cu(liquid)	4.6 ± 0.1[y]	–	–	–	–	–	–
30	Zn(0001)[hc]	4.35 ± 0.28	–	–	–	4.9 [1508][(14)]	–	–
30	Zn(1010)[hc]	5.8 ± 0.7[x]	–	–	–	–	–	–
30	Zn(1124)[hc]	5.8[z]	–	–	–	–	–	–
30	Zn(poly)[hc]	4.22 ± 0.11	–	–	3.63 [2601][(14)]	4.33 [3052]	4.24	–
31	Ga(100)[f]	3.4[z]	–	–	–	–	–	–
31	Ga(110)[f]	4.1[z]	–	–	–	–	–	–
31	Ga(111)[f]	3.8[z]	–	–	–	–	–	–
31	Ga(poly)[r]	4.27 ± 0.06	–	–	4.32 [2770]	4.2 [2767]	3.96	–
31	Ga(liquid)	4.33 ± 0.03	–	–	–	–	–	–
32	Ge(100)[d]	4.68 ± 0.08	–	–	–	–	–	–
32	Ge(110)[d]	4.79 ± 0.06	–	–	–	–	–	–
32	Ge(111)[d]	4.60 ± 0.09	–	–	–	4.80[p] [1971]	–	–
32	Ge(112)[d]	4.8 ± 0.1[x]	–	–	–	–	–	–
32	Ge(113)[d]	4.9[z]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
32	Ge(114)[d]	4.9^z	–	–	–	–	–	–
32	Ge(122)[d]	4.9^z	–	–	–	–	–	–
32	Ge(133)[d]	4.9^z	–	–	–	–	–	–
32	Ge(155)[d]	4.8^z	–	–	–	–	–	–
32	Ge(poly)[d]	4.76 ± 0.05	–	–	5.0 [1520]	5.0 [1520]	4.76	–
33	As(111)[rh]	3.8^z	–	–	–	3.75 [2952]	–	–
33	As(poly)[rh]	4.85 ± 014	–	–	–	–	5.11	–
34	Se(1010)[h]	5.9^x	–	–	–	–	–	–
34	Se(poly)[h]	5.27 ± 0.18	–	–	5.9 [3429]	5.9 [3429]	4.72	–
37	Rb(100)[b]	2.31 ± 0.08	–	–	–	–	–	–
37	Rb(110)[b]	2.65 ± 0.05	–	–	–	–	–	–
37	Rb(111)[b]	2.21 ± 0.09	–	–	–	–	–	–
37	Rb(112)[b]	2.6^z	–	–	–	–	–	–
37	Rb(poly)[b]	2.17 ± 0.05	–	–	2.261 [2119]	2.16 [2470]	2.16	–
37	Rb(liquid)	2.15 ± 0.02	–	–	–	–	–	–
38	α-Sr(100)[f]	3.3 ± 0.4	–	–	–	–	–	–
38	α-Sr(110)[f]	3.1 ± 0.3	–	–	–	–	–	–
38	α-Sr(111)[f]	3.4 ± 0.3	–	–	–	–	–	–
38	β-Sr(0001)[hc]	4.2^z	–	–	–	–	–	–
38	β-Sr(1010)[hc]	4.0^z	–	–	–	–	–	–
38	β-Sr(1124)[hc]	3.5^z	–	–	–	–	–	–
38	γ-Sr(100)[b]	3.0 ± 0.3^x	–	–	–	–	–	–
38	γ-Sr(110)[b]	3.2 ± 0.6^y	–	–	–	–	–	–
38	γ-Sr(111)[b]	3.0 ± 0.2^x	–	–	–	–	–	–
38	γ-Sr(112)[b]	3.6^z	–	–	–	–	–	–
38	α-Sr(poly)[f]	2.71 ± 0.08	–	–	2.59 [1401]	2.59 [1401]	2.35	–
38	β-Sr(poly)[hc]	2.9 ± 0.2^y	–	–	–	–	–	–
38	γ-Sr(poly)[b]	2.35 ± 0.05^x	–	–	–	–	–	–
39	α-Y(0001)[hc]	3.4 ± 0.2	–	–	–	–	–	–
39	α-Y(1010)[hc]	3.1^x	–	–	–	–	–	–
39	α-Y(1124)[hc]	3.3 ± 0.1^y	–	–	–	–	–	–
39	β-Y(100)[b]	3.7^z	–	–	–	–	–	–
39	β-Y(110)[b]	4.3^z	–	–	–	–	–	–
39	β-Y(111)[b]	3.5^z	–	–	–	–	–	–
39	β-Y(112)[b]	3.9^z	–	–	–	–	–	–
39	α-Y(poly)[hc]	3.16 ± 0.06	–	–	3.1 [304]	3.1 [304]	3.3	–
39	β-Y(poly)[b]	3.2^z	–	–	–	–	–	–
40	α-Zr(0001)[hc]	4.36 ± 0.09	–	–	–	–	–	–
40	α-Zr(1010)[hc]	4.1 ± 0.5^y	–	–	–	–	–	–
40	α-Zr(1124)[hc]	4.2^z	–	–	–	–	–	–
40	β-Zr(100)[b]	3.9^z	–	–	–	–	–	–
40	β-Zr(110)[b]	4.6^z	–	–	–	–	–	–
40	β-Zr(111)[b]	3.8^z	–	–	–	–	–	–
40	β-Zr(112)[b]	4.2^z	–	–	–	–	–	–
40	α-Zr(poly)[hc]	3.85 ± 0.06	–	–	4.05 [304]	4.05 [304]	3.9	–
40	β-Zr(poly)[b]	4.01 ± 0.05	–	–	–	–	–	–
41	Nb(100)[b]	4.02 ± 0.05	4.0^z	–	4.02 [779]	4.02 [779]	–	3.95 ± 0.05
41	Nb(110)[b]	4.77 ± 0.05	4.74 ± 0.10^x	–	4.87 [779]	4.87 [779]	–	4.83 ± 0.05
41	Nb(111)[b]	3.95 ± 0.09	3.84 ± 0.06^x	–	4.36 [779]	4.36 [779]	–	3.86 ± 0.03
41	Nb(112)[b]	4.33 ± 0.10	4.4^z	–	4.63 [779]	4.63 [779]	–	–
41	Nb(113)[b]	4.3^z	–	–	4.29 [779]	4.29 [779]	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
41	Nb(116)[b]	3.82 ± 0.12[y]	–	–	3.95 [779]	3.95 [779]	–	–
41	Nb(310)[b]	4.2[z]	–	–	4.18 [779]	4.18 [779]	–	–
41	Nb(335)[b]	4.6[z]	–	–	–	–	–	–
41	Nb(poly)[b]	<u>4.11 ± 0.05</u>	4.81 ± 0.05[y]	–	–	4.3 [304]	3.99	4.02 ± 0.05
42	Mo(100)[b]	<u>4.38 ± 0.03</u>	<u>4.38 ± 0.08</u>	<u>4.34 ± 0.03[y]</u>	4.53 [325]	4.53 [325]	–	4.40 ± 0.03
42	Mo(110)[b]	<u>4.98 ± 0.03</u>	5.1[z]	–	4.95 [325]	4.95 [325]	–	4.96 ± 0.06
42	Mo(111)[b]	<u>4.29 ± 0.03</u>	4.17 ± 0.09[y]	–	4.55 [325]	4.55 [325]	–	4.09 ± 0.07
42	Mo(112)[b]	<u>4.51 ± 0.03</u>	4.6[z]	–	4.36 [325]	4.36 [325]	–	4.58 ± 0.05
42	Mo(114)[b]	4.33 ± 0.15	–	–	4.50 [325]	4.50 [325]	–	–
42	Mo(116)[b]	<u>4.23 ± 0.08</u>	–	–	–	–	–	–
42	Mo(310)[b]	4.15 ± 0.03[y]	–	–	–	–	–	–
42	Mo(321)[b]	4.16 ± 0.03[y]	–	–	–	–	–	–
42	Mo(331)[b]	4.37 ± 0.04[x]	–	–	–	–	–	–
42	Mo(332)[b]	4.3 ± 0.2[y]	–	–	4.55 [325]	4.55 [325]	–	–
42	Mo(431)[b]	4.2 ± 0.1[x]	–	–	–	–	–	–
42	Mo(poly)[b]	<u>4.31 ± 0.02</u>	5.03 ± 0.06	–	–	4.6 [304]	4.3	4.34 ± 0.06
43	Tc(0001)[hc]	5.1 ± 0.2[y]	–	–	–	–	–	–
43	Tc(1010)[hc]	4.7 ± 0.2[y]	–	–	–	–	–	–
43	Tc(1011)[hc]	4.9 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1012)[hc]	4.5 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1013)[hc]	4.4 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1121)[hc]	4.3 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1122)[hc]	4.5 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1123)[hc]	4.4 ± 0.2[x]	–	–	–	–	–	–
43	Tc(1124)[hc]	4.4[z]	–	–	–	–	–	–
43	Tc(2130)[hc]	4.4 ± 0.2[x]	–	–	–	–	–	–
43	Tc(2140)[hc]	4.5 ± 0.2[x]	–	–	–	–	–	–
43	Tc(poly)[hc]	<u>4.67 ± 0.02</u>	–	–	–	–	–	–
44	Ru(0001)[hc]	<u>5.35 ± 0.06</u>	–	–	–	–	–	–
44	Ru(1010)[hc]	4.9 ± 0.2	–	–	–	–	–	–
44	Ru(1011)[hc]	5.1 ± 0.2[x]	–	–	–	–	–	–
44	Ru(1012)[hc]	4.7 ± 0.2[x]	–	–	–	–	–	–
44	Ru(1013)[hc]	4.6 ± 0.2[x]	–	–	–	–	–	–
44	Ru(1121)[hc]	4.6 ± 0.2[x]	–	–	–	–	–	–
44	Ru(1122)[hc]	4.3 ± 0.2[y]	–	–	–	–	–	–
44	Ru(1123)[hc]	4.6 ± 0.2[x]	–	–	–	–	–	–
44	Ru(1124)[hc]	4.5 ± 0.1[x]	–	–	–	–	–	–
44	Ru(1125)[hc]	4.5 ± 0.2[y]	–	–	–	–	–	–
44	Ru(2130)[hc]	4.7 ± 0.2[x]	–	–	–	–	–	–
44	Ru(3140)[hc]	4.7 ± 0.2[x]	–	–	–	–	–	–
44	Ru(poly)[hc]	<u>4.71 ± 0.05</u>	–	–	4.71 [414]	4.71 [414]	4.60	4.75 ± 0.11
45	Rh(100)[f]	<u>5.24 ± 0.07</u>	–	–	–	–	–	5.29 ± 0.07
45	Rh(110)[f]	<u>4.75 ± 0.06</u>	–	–	–	–	–	4.77 ± 0.06
45	Rh(111)[f]	<u>5.40 ± 0.08</u>	–	–	–	–	–	5.50 ± 0.10
45	Rh(112)[f]	5.1[z]	–	–	–	–	–	–
45	Rh(113)[f]	5.0[z]	–	–	–	–	–	–
45	Rh(210)[f]	4.6[z]	–	–	–	–	–	–
45	Rh(310)[f]	4.8[z]	–	–	–	–	–	–
45	Rh(320)[f]	4.7[z]	–	–	–	–	–	–
45	Rh(321)[f]	4.8[z]	–	–	–	–	–	–
45	Rh(410)[f]	4.9[z]	–	–	–	–	–	–
45	Rh(430)[f]	4.7[z]	–	–	–	–	–	–
45	Rh(520)[f]	4.7[z]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
45	Rh(531)[f]	4.7[z]	–	–	–	–	–	–
45	Rh(poly)[f]	4.87 ± 0.07	–	–	4.98 [414]	4.98 [414]	4.75	4.90 ± 0.08
46	Pd(100)[f]	5.48 ± 0.04	–	–	–	–	–	5.59 ± 0.05
46	Pd(110)[f]	5.12 ± 0.09	–	–	–	–	–	5.19 ± 0.04
46	Pd(111)[f]	5.58 ± 0.05	–	–	5.6 [616,1799]	5.6 [616,1799]	–	5.55 ± 0.07
46	Pd(113)[f]	5.6[z]	–	–	–	–	–	–
46	Pd(poly)[f]	5.17 ± 0.06	–	–	5.22 [1031]	5.12 [414]	4.8	5.24 ± 0.05
47	Ag(100)[f]	4.46 ± 0.05	–	–	4.64 [626]	4.64 [626]	–	4.50 ± 0.10
47	Ag(110)[f]	4.28 ± 0.08	–	–	4.52 [626]	4.52 [626]	–	4.16 ± 0.05
47	Ag(111)[f]	4.64 ± 0.06	–	–	4.74 [1134]	4.74 [1134]	–	4.56 ± 0.15
47	Ag(poly)[f]	4.39 ± 0.02	–	–	–	4.26 [626]	4.3	4.36 ± 0.06
47	Ag(liquid)	4.3[z]	–	–	–	–	–	–
48	Cd(0001)[hc]	4.9 ± 0.9[y]	–	–	–	–	–	–
48	Cd(1010)[hc]	5.5 ± 0.8[x]	–	–	–	–	–	–
48	Cd(1124)[hc]	5.5[z]	–	–	–	–	–	–
48	Cd(poly)[hc]	4.06 ± 0.05	–	–	4.08 [1380]	4.22 [1380][(9)]	4.1	–
49	In(100)[f]	4.5 ± 0.2[y]	–	–	–	–	–	–
49	In(110)[f]	4.4[z]	–	–	–	–	–	–
49	In(111)[f]	4.1[z]	–	–	–	–	–	–
49	In(poly)[f]	4.05 ± 0.06	–	–	4.09 [2770]	4.12 [3672]	3.8	–
49	In(liquid)	4.00 ± 0.08	–	–	–	–	–	–
50	α-Sn(100)[b]	4.5 ± 0.1[y]	–	–	–	–	–	–
50	α-Sn(110)[b]	4.8[z]	–	–	–	–	–	–
50	α-Sn(111)[b]	4.2 ± 02[y]	–	–	–	–	–	–
50	α-Sn(112)[b]	4.5[z]	–	–	–	–	–	–
50	α-Sn(poly)[b]	4.27 ± 0.06	–	–	–	–	–	–
50	β-Sn(poly)[t]	4.34 ± 0.06	–	–	4.42 [3057]	4.42 [3057]	4.38	–
50	γ-Sn(poly)[h]	4.29 ± 0.06[y]	–	–	–	–	–	–
50	Sn(liquid)	4.20 ± 0.02[y]	–	–	–	–	–	–
51	Sb(100)[p]	4.7 ± 0.1[x]	–	–	4.7 [1272]	4.7 [1272]	–	–
51	Sb(111)	4.3[z]	–	–	–	–	–	–
51	Sb(poly)[rh]	4.45 ± 0.09	–	–	–	–	4.08	–
51	Sb(amorphous)	4.5 ± 0.1[y]	–	–	4.55 [1995]	4.55 [1995]	–	–
52	Te(1010)[h]	4.80 ± 0.15[x]	–	–	4.95 [3429]	4.95 [3429]	–	–
52	Te(poly)[h]	4.86 ± 0.06	–	–	–	–	4.73	–
53	I[r]	2.8[z]	–	–	–	–	–	–
53	I[m]	5.4[z]	–	–	–	–	–	–
53	I(film)	5.1 ± 0.1	5.3[x]	–	–	–	–	–
53	I(amorphous)	6.3 ± 0.4[x]	–	–	–	–	–	–
55	Cs(100)[b]	2.24 ± 0.06	–	–	–	–	–	–
55	Cs(110)[b]	2.54 ± 0.07	–	–	–	–	–	–
55	Cs(111)[b]	2.09 ± 0.08	–	–	–	–	–	–
55	Cs(112)[b]	2.4[z]	–	–	–	–	–	–
55	Cs(poly)[b]	2.05 ± 0.05	–	–	1.95 [2613]	2.14 [1489]	1.81	–
55	Cs(liquid)	2.00 ± 0.12[y]	–	–	–	–	–	–
56	Ba(100)[b]	3.07 ± 0.06	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
56	Ba(110)[b]	3.46 ± 0.14	–	–	–	–	–	–
56	Ba(111)[b]	<u>2.81 ± 0.06</u>	–	–	–	–	–	–
56	Ba(112)[b]	3.2[z]	–	–	–	–	–	–
56	Ba(poly)[b]	<u>2.50 ± 0.02</u>	–	–	2.52 [379]	2.7 [330]	2.49	–
57	α-La(0001)[hc]	3.09 ± 0.05[y]	–	–	–	–	–	–
57	β-La(100)[f]	4.3 ± 0.5[x]	–	–	–	–	–	–
57	β-La(110)[f]	4.2 ± 0.6[x]	–	–	–	–	–	–
57	β-La(111)[f]	3.4 ± 0.5[x]	–	–	–	–	–	–
57	γ-La(100)[b]	4.0 ± 0.8[x]	–	–	–	–	–	–
57	γ-La(110)[b]	4.8 ± 1.1[x]	–	–	–	–	–	–
57	γ-La(111)[b]	3.1[z]	–	–	–	–	–	–
57	γ-La(112)[b]	3.4[z]	–	–	–	–	–	–
57	α-La(poly)[hc]	<u>3.27 ± 0.04</u>	–	–	3.5 [304]	3.5 [304]	3.3	–
57	β-La(poly)[f]	<u>2.98 ± 0.10</u>	–	–	–	–	–	–
58	β-Ce(100)[f]	4.3 ± 0.3[x]	–	–	–	–	–	–
58	β-Ce(110)[f]	4.4[z]	–	–	–	–	–	–
58	β-Ce(111)[f]	4.1 ± 0.9[x]	–	–	–	–	–	–
58	γ-Ce(100)[b]	4.0[z]	–	–	–	–	–	–
58	γ-Ce(110)[b]	4.6[z]	–	–	–	–	–	–
58	γ-Ce(111)[b]	3.8[z]	–	–	–	–	–	–
58	γ-Ce(112)[b]	4.2[z]	–	–	–	–	–	–
58	β-Ce(poly)[f]	<u>2.89 ± 0.07</u>	–	–	2.9 [304]	2.9 [304]	2.7	–
58	γ-Ce(poly)[b]	3.1 ± 0.1[y]	–	–	–	–	–	–
59	α-Pr(0001)[hc]	3.1[z]	–	–	–	–	–	–
59	β-Pr(100)[b]	3.3[z]	–	–	–	–	–	–
59	β-Pr(110)[b]	3.9[z]	–	–	–	–	–	–
59	β-Pr(111)[b]	3.2[z]	–	–	–	–	–	–
59	β-Pr(112)[b]	3.5[z]	–	–	–	–	–	–
59	α-Pr(poly)[f]	2.83 ± 0.11	–	–	–	–	2.7	–
60	α-Nd(0001)[hc]	3.2 ± 0.1[x]	–	–	–	–	–	–
60	β-Nd(100)[b]	3.6[z]	–	–	–	–	–	–
60	β-Nd(110)[b]	4.2[z]	–	–	–	–	–	–
60	β-Nd(111)[b]	3.5[z]	–	–	–	–	–	–
60	β-Nd(112)[b]	3.9[z]	–	–	–	–	–	–
60	α-Nd(poly)[hc]	<u>3.14 ± 0.08</u>	–	–	3.2 [304]	3.2 [304]	3.2	–
61	α-Pm(0001)[hc]	3.1[z]	–	–	–	–	–	–
61	β-Pm(100)[f]	3.7[z]	–	–	–	–	–	–
61	β-Pm(110)[f]	3.5[z]	–	–	–	–	–	–
61	β-Pm(111)[f]	4.0[z]	–	–	–	–	–	–
61	α-Pm(poly)[hc]	3.09 ± 0.08[y]	–	–	–	–	–	–
62	β-Sm(100)[b]	3.2[z]	–	–	–	–	–	–
62	β-Sm(110)[b]	3.8[z]	–	–	–	–	–	–
62	β-Sm(111)[b]	3.1[z]	–	–	–	–	–	–
62	β-Sm(112)[b]	3.4[z]	–	–	–	–	–	–
62	α-Sm(poly)[rh]	<u>2.81 ± 0.10</u>	–	–	2.7 [304]	2.7 [304]	2.7	–
63	Eu(100)[b]	3.3[z]	–	–	–	–	–	–
63	Eu(110)[b]	2.9 ± 0.6[y]	–	–	–	–	–	–
63	Eu(111)[b]	3.1[z]	–	–	–	–	–	–
63	Eu(112)[b]	3.5[z]	–	–	–	–	–	–
63	Eu(poly)[b]	2.74 ± 0.12	–	–	2.5 [304]	2.5 [304]	–	–
64	α-Gd(0001)[hc]	<u>3.27 ± 0.03</u>	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
64	α-Gd(1010)[hc]	4.3[z]	–	–	–	–	–	–
64	α-Gd(1124)[hc]	3.8[z]	–	–	–	–	–	–
64	β-Gd(100)[b]	3.2 ± 0.3[x]	–	–	–	–	–	–
64	β-Gd(110)[b]	4.1[z]	–	–	–	–	–	–
64	β-Gd(111)[b]	3.4[z]	–	–	–	–	–	–
64	β-Gd(112)[b]	3.8[z]	–	–	–	–	–	–
64	α-Gd(poly)[hc]	<u>3.09 ± 0.04</u>	–	–	2.90 [2943]	3.1 [304]	3.1	–
65	α-Tb(0001)[hc]	4.4 ± 0.5[y]	–	–	–	–	–	–
65	α-Tb(1010)[hc]	4.7[z]	–	–	–	–	–	–
65	α-Tb(1124)[hc]	4.1[z]	–	–	–	–	–	–
65	β-Tb(100)[b]	3.9[z]	–	–	–	–	–	–
65	β-Tb(110)[b]	4.5[z]	–	–	–	–	–	–
65	β-Tb(111)[b]	3.7[z]	–	–	–	–	–	–
65	β-Tb(112)[b]	4.1[z]	–	–	–	–	–	–
65	α-Tb(poly)[hc]	<u>3.14 ± 0.09</u>	–	–	3.0 [2716]	3.0 [2716]	3.15	–
66	α-Dy(0001)[hc]	4.2 ± 0.8[x]	–	–	–	–	–	–
66	α-Dy(1010)[hc]	4.8[z]	–	–	–	–	–	–
66	α-Dy(1124)[hc]	4.2[z]	–	–	–	–	–	–
66	α-Dy(poly)[hc]	<u>3.18 ± 0.08</u>	–	–	–	–	3.25	–
67	α-Ho(0001)[hc]	3.9 ± 0.5[x]	–	–	–	–	–	–
67	α-Ho(1010)[hc]	4.2[z]	–	–	–	–	–	–
67	α-Ho(1124)[hc]	3.7[z]	–	–	–	–	–	–
67	Ho(poly)[hc]	<u>3.05 ± 0.05</u>	–	–	–	–	3.22	–
68	Er(0001)[hc]	3.8 ± 04[y]	–	–	–	–	–	–
68	Er(1010)[hc]	4.3[z]	–	–	–	–	–	–
68	Er(1124)[hc]	3.8[z]	–	–	–	–	–	–
68	Er(poly)[hc]	<u>3.14 ± 0.08</u>	–	–	–	–	3.25	–
69	α-Tm(0001)[hc]	4.0 ± 0.5[x]	–	–	–	–	–	–
69	α-Tm(1010)[hc]	4.3[z]	–	–	–	–	–	–
69	α-Tm(1124)[hc]	3.8[z]	–	–	–	–	–	–
69	α-Tm(poly)[hc]	<u>3.12 ± 0.07</u>	–	–	–	–	3.10	–
70	α-Yb(100)[f]	4.2[z]	–	–	–	–	–	–
70	α-Yb(110)[f]	3.9[z]	–	–	–	–	–	–
70	α-Yb(111)[f]	3.5 ± 1.0[x]	–	–	–	–	–	–
70	β-Yb(100)[b]	3.6[z]	–	–	–	–	–	–
70	β-Yb(110)[b]	3.3 ± 0.8[x]	–	–	–	–	–	–
70	β-Yb(111)[b]	3.4[z]	–	–	–	–	–	–
70	β-Yb(112)[b]	3.8[z]	–	–	–	–	–	–
70	α-Yb(poly)[f]	<u>2.91 ± 0.09</u>	–	–	–	–	–	–
71	α-Lu(0001)[hc]	3.9 ± 0.4[y]	–	–	–	–	–	–
71	α-Lu(1010)[hc]	4.3[z]	–	–	–	–	–	–
71	α-Lu(1124)[hc]	3.8[z]	–	–	–	–	–	–
71	β-Lu(100)[b]	3.5[z]	–	–	–	–	–	–
71	β-Lu(110)[b]	4.1[z]	–	–	–	–	–	–
71	β-Lu(111)[b]	3.4[z]	–	–	–	–	–	–
71	β-Lu(112)[b]	3.8[z]	–	–	–	–	–	–
71	α-Lu(poly)[hc]	<u>3.17 ± 0.09</u>	–	–	3.3 [2603]	3.3 [2603]	–	–
72	α-Hf(0001)[hc]	4.2 ± 0.1[y]	–	–	–	–	–	–
72	α-Hf(1010)[hc]	4.4 ± 0.8[x]	–	–	–	–	–	–
72	α-Hf(1124)[hc]	4.6[z]	–	–	–	–	–	–
72	β-Hf(100)[b]	4.2 ± 0.1[y]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
72	β-Hf(110)[b]	5.0[z]	–	–	–	–	–	–
72	β-Hf(111)[b]	4.1[z]	–	–	–	–	–	–
72	β-Hf(112)[b]	4.6[z]	–	–	–	–	–	–
72	α-Hf(poly)[hc]	3.64 ± 0.06	–	–	3.9 [304]	3.9 [304]	3.53	–
73	Ta(100)[b]	4.15 ± 0.05	4.2[z]	–	4.15 [127]	4.15 [127]	–	4.17 ± 0.09
73	Ta(110)[b]	4.82 ± 0.06	4.84 ± 0.02[y]	4.89 ± 0.03[x]	4.80 [127]	4.80 [127]	–	4.81 ± 0.05
73	Ta(111)[b]	4.01 ± 0.04	4.00 ± 0.05[x]	–	4.00 [127]	4.00 [127]	–	4.00 ± 0.04
73	Ta(112)[b]	4.36 ± 0.04	–	–	–	–	–	4.37 ± 0.03
73	Ta(114)[b]	4.0[z]	–	–	–	–	–	–
73	Ta(116)[b]	3.92 ± 0.02[y]	–	–	–	–	–	–
73	Ta(123)[b]	4.0[z]	–	–	–	–	–	–
73	Ta(130)[b]	4.2 ± 0.2[y]	–	–	–	–	–	–
73	Ta(233)[b]	4.0[z]	–	–	–	–	–	–
74	Ta(poly)[b]	4.20 ± 0.03	4.95 ± 0.20	4.17 ± 0.13[y]	4.25 [124]	4.25 [124]	4.12	4.25 ± 0.05
74	W(100)[b]	4.65 ± 0.02	4.62 ± 0.05	4.54 ± 0.01[x]	4.63 [358]	4.63 [358]	4.65 ± 0.10[#(2)]	4.57 ± 0.03
74	W(110)[b]	5.32 ± 0.02	5.28 ± 0.11	–	5.22 [3802]	5.25 [358]	5.20 ± 0.10[#]	5.31 ± 0.05
74	W(111)[b]	4.45 ± 0.03	4.45 ± 0.04	–	4.45 [819]	4.47 [358]	4.40 ± 0.05[#]	4.38 ± 0.04
74	W(112)[b]	4.78 ± 0.03	4.70 ± 0.01[y]	–	–	–	4.85 ± 0.10[#]	4.83 ± 0.20
74	W(113)[b]	4.43 ± 0.09	–	–	4.46 [819]	4.18 [195]	4.50 ± 0.10[#]	4.55 ± 0.06
74	W(114)[b]	4.40 ± 0.03	–	–	–	–	–	4.40 ± 0.05
74	W(115)[b]	4.39 ± 0.06[y]	–	–	–	–	–	–
74	W(116)[b]	4.30 ± 0.04	–	–	4.32 [819]	4.30 [372]	4.26 ± 0.10[#]	4.32 ± 0.20
74	W(119)[b]	4.6[z]	–	–	–	–	–	–
74	W(120)[b]	4.38 ± 0.05	–	–	–	–	–	4.38 ± 0.06
74	W(122)[b]	4.34 ± 0.05	–	–	–	–	–	–
74	W(123)[b]	4.50 ± 0.05	–	–	–	–	–	4.49 ± 0.04
74	W(124)[b]	4.33 ± 0.03	–	–	–	–	–	–
74	W(130)[b]	4.32 ± 0.04	–	–	–	–	4.31 ± 0.10[#]	4.32 ± 0.04
74	W(133)[b]	4.7[z]	–	–	–	–	–	–
74	W(134)[b]	4.7[z]	–	–	–	–	–	–
74	W(144)[b]	5.2 ± 0.1[x]	–	–	–	–	–	–
74	W(150)[b]	4.4[z]	–	–	–	–	–	–
74	W(160)[b]	4.40 ± 0.06[y]	–	–	–	–	–	–
74	W(223)[b]	4.7[z]	–	–	–	–	–	–
74	W(227)[b]	4.4[z]	–	–	–	–	–	–
74	W(229)[b]	4.3[z]	–	–	–	–	–	–
74	W(230)[b]	4.33 ± 0.05	–	–	–	–	–	–
74	W(233)[b]	4.38 ± 0.06	–	–	–	–	–	–
74	W(235)[b]	4.5 ± 0.2[x]	–	–	–	–	–	–
74	W(250)[b]	4.6[z]	–	–	–	–	–	–
74	W(257)[b]	4.9 ± 0.1[x]	–	–	–	–	–	–
74	W(334)[b]	4.4 ± 0.2[x]	–	–	–	–	–	–
74	W(650)[b]	4.4 ± 0.1[y]	–	–	–	–	–	–
74	W(poly)[b]	4.56 ± 0.03	5.17 ± 0.05	4.51 ± 0.03	4.55 [828]	4.55 [828]	4.54 4.50[#]	4.55 ± 0.04
75	Re(0001)[hc]	5.30 ± 0.21	5.15 ± <0.34	–	–	–	–	5.13 ± 0.16
75	Re(1010)[hc]	5.12 ± 0.05	–	–	–	–	–	–
75	Re(1011)[hc]	5.26 ± 0.13	–	–	–	5.75 [363]	–	–
75	Re(1120)[hc]	4.95 ± 0.11	–	–	–	–	–	–
75	Re(1121)[hc]	4.82 ± 0.14	–	–	–	–	–	–
75	Re(1122)[hc]	5.03 ± 0.18	–	–	–	–	–	–
75	Re(1123)[hc]	4.7 ± 0.2[y]	–	–	–	–	–	–
75	Re(1124)[hc]	4.8 ± 0.1[x]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
75	Re(1130)[hc]	4.6 ± 0.1[x]	–	–	–	–	–	–
75	Re(2130)[hc]	4.6 ± 0.1[x]	–	–	–	–	–	–
75	Re(3140)[hc]	4.7 ± 0.1[x]	–	–	–	–	–	–
75	Re(poly)[hc]	4.96 ± 0.05	5.41 ± 0.04	5.00 ± 0.06[y]	4.72 [832]	4.96 [124]	5.0	4.95 ± 0.03
76	Os(0001)[hc]	5.6 ± 0.2	–	–	–	–	–	–
76	Os(1010)[hc]	5.3 ± 0.3[y]	–	–	–	–	–	–
76	Os(0111)[hc]	5.4 ± 0.1[x]	–	–	–	–	–	–
76	Os(0112)[hc]	5.0 ± 0.1[x]	–	–	–	–	–	–
76	Os(0113)[hc]	4.8 ± 0.1[x]	–	–	–	–	–	–
76	Os(1121)[hc]	4.8 ± 0.1[x]	–	–	–	–	–	–
76	Os(1122)[hc]	5.1 ± 0.1[x]	–	–	–	–	–	–
76	Os(1123)[hc]	4.9 ± 0.1[x]	–	–	–	–	–	–
76	Os(1124)[hc]	5.1[z]	–	–	–	–	–	–
76	Os(2130)[hc]	5.0 ± 0.1[x]	–	–	–	–	–	–
76	Os(3140)[hc]	4.9 ± 0.1[x]	–	–	–	–	–	–
76	Os(poly)[hc]	4.97 ± 0.17	–	–	5.93 [3322]	4.83 [124]	4.7	4.84 ± 0.07
77	Ir(100)[f]	5.60 ± 0.06	–	–	5.67 [414][(12)]	5.67 [414]	–	5.72 ± 0.27
77	Ir(110)[f]	5.23 ± 0.19	–	–	5.42 [358][(12)]	5.42 [358]	–	–
77	Ir(111)[f]	5.75 ± 0.06	5.76 ± 0.04	–	5.76 [358][(12)]	5.76 [358]	–	5.77 ± 0.03
77	Ir(210)[f]	5.05 ± 0.05[x]	–	–	5.00 [414][(12)]	5.00 [414]	–	–
77	Ir(211)[f]	5.2 ± 0.1[x]	–	–	–	–	–	–
77	Ir(311)[f]	5.2[x]	–	–	–	–	–	–
77	Ir(321)[f]	5.2 ± 0.1[x]	–	–	–	–	–	–
77	Ir(331)[f]	5.3 ± 0.1[x]	–	–	–	–	–	–
77	Ir(731)[f]	4.9[z]	–	–	–	–	–	–
77	Ir(poly)[f]	5.28 ± 0.04	5.75 ± 0.04	–	–	5.27 [124]	4.7	5.27 ± 0.02
78	Pt(100)[f]	5.75 ± 0.06	–	–	5.84* [428][(5)]	–	–	5.82 ± 0.07
78	Pt(110)[f]	5.54 ± 0.07	–	–	–	–	–	5.61 ± 0.13
78	Pt(111)[f]	5.84 ± 0.05	5.80 ± 0.06	–	5.93 [428]	5.7** [616][(6)]	–	5.86 ± 0.06
78	Pt(210)[f]	5.18 ± 0.04	–	–	–	–	–	–
78	Pt(211)[f]	5.7 ± 0.1[y]	–	–	–	–	–	–
78	Pt(221)[f]	5.76 ± 0.01[y]	–	–	–	–	–	–
78	Pt(310)[f]	5.4 ± 0.1[x]	–	–	–	–	–	–
78	Pt(311)[f]	5.4 ± 0.1[x]	–	–	–	–	–	–
78	Pt(320)[f]	5.19 ± 0.03[y]	–	–	5.22 [428]	–	–	–
78	Pt(321)[f]	5.3 ± 0.1[x]	–	–	–	–	–	–
78	Pt(331)[f]	5.4 ± 0.2[y]	–	–	5.12 [428]	–	–	–
78	Pt(410)[f]	5.5[z]	–	–	–	–	–	–
78	Pt(430)[f]	5.2[z]	–	–	–	–	–	–
78	Pt(520)[f]	5.3[z]	–	–	–	–	–	–
78	Pt(533)[f]	5.9[x]	–	–	–	–	–	–
78	Pt(741)[f]	5.2[z]	–	–	–	–	–	–
78	Pt(997)[f]	5.8[z]	–	–	–	–	–	–
78	Pt(poly)[f]	5.30 ± 0.07	5.58 ± 0.11	–	5.64 [435]	5.65 [304]	5.32	5.27 ± 0.08
79	Au(100)[f]	5.39 ± 0.07	–	–	5.47 [959]	5.47 [959]	–	5.41 ± 0.12
79	Au(110)[f]	5.33 ± 0.09	–	–	5.37 [959]	5.37 [959]	–	5.31 ± 0.11
79	Au(111)[f]	5.46 ± 0.07	–	–	5.31 [959]	5.31 [959]	–	5.29 ± 0.02
79	Au(112)[f]	5.1[z]	–	–	–	–	–	–
79	Au(113)[f]	5.2[z]	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
79	Au(210)[f]	5.0[z]	–	–	–	–	–	–
79	Au(532)[f]	5.0[z]	–	–	–	–	–	–
79	Au(poly)[f]	5.30 ± 0.04	5.7[z]	–	–	5.1 [304]	4.30	5.31 ± 0.07
80	Hg(liquid)	4.50 ± 0.02	–	–	4.475 [2770]	4.49 [2470]	4.52	–
80	α-Hg(poly)[rh]	4.52 ± 0.05	–	–	–	–	–	–
81	α-Tl(0001)[hc]	4.2 ± 0.3[x]	–	–	–	–	–	–
81	α-Tl(1010)[hc]	4.1 ± 0.2[x]	–	–	–	–	–	–
81	α-Tl(1124)[hc]	3.8[z]	–	–	–	–	–	–
81	β-Tl(100)[b]	3.5[z]	–	–	–	–	–	–
81	β-Tl(110)[b]	4.1[z]	–	–	–	–	–	–
81	β-Tl(111)[b]	3.4[z]	–	–	–	–	–	–
81	β-Tl(112)[b]	3.8[z]	–	–	–	–	–	–
81	α-Tl(poly)[hc]	3.82 ± 0.05	–	–	3.84 [2297]	3.84 [2297]	3.7	–
81	Tl(liquid)	3.7 ± 0.1[x]	–	–	–	–	–	–
82	Pb(100)[f]	3.96 ± 0.11	–	–	–	–	–	–
82	Pb(110)[f]	3.84 ± 0.09	–	–	–	–	–	–
82	Pb(111)[f]	4.14 ± 0.09	–	–	–	–	–	–
82	Pb(poly)[f]	4.07 ± 0.05	–	–	4.25 [613]	4.25 [613]	4.0	–
82	Pb(liquid)	4.00 ± 0.05[x]	–	–	–	–	–	–
83	Bi(0001)[tr]	4.5 ± 0.2[y]	–	–	–	–	–	–
83	Bi(1011)[tr]	4.3[z]	–	–	–	–	–	–
83	Bi(poly)[tr]	4.28 ± 0.05	–	–	4.34 [2349][(13)]	4.22 [3052]	4.4	–
83	Bi(liquid)	4.34 ± 0.07[y]	–	–	–	–	–	–
84	α-Po(poly)[c]	4.8 ± 0.2[y]	–	–	–	–	–	–
85	At	5.3[z]	–	–	–	–	–	–
87	Fr(111)[b]	2.1[z]	–	–	–	–	–	–
87	Fr(poly)[b]	2.0 ± 0.1	–	–	–	–	–	–
88	Ra(110)[b]	2.3[z]	–	–	–	–	–	–
88	Ra(111)[b]	2.0[z]	–	–	–	–	–	–
88	Ra(poly)[b]	2.4 ± 0.3	–	–	–	–	–	–
89	Ac(111)[f]	3.4[z]	–	–	–	–	–	–
89	Ac(poly)[f]	3.2 ± 0.3[y]	–	–	–	–	–	–
90	α-Th(100)[f]	3.5 ± 0.1[x]	–	–	–	–	–	–
90	α-Th(110)[f]	3.4[z]	–	–	–	–	–	–
90	α-Th(111)[f]	3.6 ± 0.2[x]	–	–	–	–	–	–
90	α-Th(poly)[f]	3.37 ± 0.04	3.4 ± 0.1[x]	3.5 ± 0.1[y]	3.4 [1854]	3.4 [1854]	3.30	–
91	Pa(111)[c]	3.8[z]	–	–	–	–	–	–
91	Pa(poly)[c]	3.4 ± 0.1[y]	–	–	–	–	–	–
92	γ-U(100)[b]	3.7 ± 0.1[y]	–	–	–	–	–	–
92	γ-U(110)[b]	4.1[z]	–	–	–	–	–	–
92	γ-U(111)[b]	3.3[z]	–	–	–	–	–	–
92	γ-U(112)[b]	3.7[z]	–	–	–	–	–	–
92	α-U(poly)[r]	3.64 ± 0.04	–	–	3.63 [2103]	3.63 [2103]	3.3	–
92	β-U(poly)[t]	3.58 ± 0.04	–	–	–	–	–	–
92	γ-U(poly)[b]	3.42 ± 0.05	–	–	–	–	–	–

Table 2 (*continued*)

No.	Surface	ϕ^e (eV) [Here]	ϕ^+ (eV) [Here]	ϕ^- (eV) [Here]	ϕ^e (eV) [1358]	ϕ^e (eV) [1045]	ϕ^e (eV) [12,1354]	ϕ^e (eV) [1351]
93	Np(111)^c	4.0^z	–	–	–	–	–	–
93	Np(poly)^c	3.4 ± 0.5^x	–	–	–	–	–	–
94	α-Pu(020)^m	3.6 ± 0.1^x	–	–	–	–	–	–
94	δ-Pu(100)^f	3.3 ± 0.2	–	–	–	–	–	–
94	δ-Pu(110)^f	3.0^z	–	–	–	–	–	–
94	δ-Pu(111)^f	3.8 ± 0.3	–	–	–	–	–	–
94	α-Pu(poly)^m	3.3^z	–	–	–	–	–	–
94	δ-Pu(poly)^f	3.6 ± 0.3^y	–	–	–	–	–	–
95	α-Am(0001)^{dhc}	3.6 ± 0.7^x	–	–	–	–	–	–
95	α-Am(1010)^{dhc}	4.2^z	–	–	–	–	–	–
95	α-Am(1124)^{dhc}	3.7^z	–	–	–	–	–	–
95	β-Am(100)^f	2.9^z	–	–	–	–	–	–
95	β-Am(110)^f	2.9^z	–	–	–	–	–	–
95	β-Am(111)^f	3.1^z	–	–	–	–	–	–
95	α-Am(poly)^{hc}	3.4 ± 0.1^y	–	–	–	–	–	–
96	Cm(poly)^{hc}	3.5 ± 0.2^y	–	–	–	–	–	–
97	Bk(poly)^{hc}	3.5 ± 0.2^y	–	–	–	–	–	–
98	Cf(poly)^{hc}	3.5 ± 0.2^y	–	–	–	–	–	–
99	Es(poly)^{hc}	3.1 ± 0.2^x	–	–	–	–	–	–
	Total element species (N_e)	88	14	6	60	63	66	18
	Total surface species (N_s)	609	39	9	103	114	66	72

(1) The superscripts (b–tr) in the 2nd column are the abbreviations indicating the crystal structures as follows.
b body-centered cubic
c cubic
d diamond
dhc double hexagonal closed packing
f face-centered cubic
h hexagonal
hc hexagonal closed packing
m monoclinic
p pseudocubic
r rhombic
rh rhombohedral
t tetragonal
tr trigonal
(2) The values with the superscript (#) for tungsten in the last 2nd column are estimated as the probable ones from many published data on tungsten by Collins and Blott [1664,1665,3964] instead of Fomenko [12,1354].
(3) The values with double and single underlines in the 3rd–5th columns may be reliable to within the errors of ±0.05 and ±0.1 eV, respectively, whilst the others in the columns may have a possible error of up to ∼0.1 eV or more.
(4) The superscripts (x and y) in the 3rd–5th columns indicate that the numbers of the work function data available for estimating these values with x and y are 2 and 3–5, respectively, whilst the value with the superscript (z) originates from a single datum alone. Consequently, many of the values (x, y or z attached) may probably be less reliable compared with those based on much abundant data (up to about 400 in total number, typically, for each of Cs and W).
(5) Regarding the plane of Pt in the CRC handbooks [11,1358,1359], "(110)" should be read "(100)" partly because any of these references (1)–(3) [13,1045,1312] cited in the handbooks does not include Pt(110) and mainly because 5.84 eV by FE corresponds exactly to Pt(100) [428] alone among the four planes of Pt tabulated in Ref. (1) [1312] and also in the original data source [428]. This is the reason why 5.84* for Pt(100) in Column 6 here is accompanied with an asterisk.
(6) The value of ϕ^e = 5.7** eV for Pt(111) [1045] in 7th column originates from Demuth's paper [616] instead of his another [1799], because the latter cited as reference 45 by Michaelson [1045] includes the datum of 5.6 eV for Pd(111) alone and does not 5.7 eV for Pt(111).
(7) The m-Co(100)^b indicates the metastable bcc–phase–Co(100) on GaAs(110) [4023,4028]. For further information, see Footnotes 428–430 in Table 1.
(8) Among the many surface species listed herein, Columns (6) [1358] and (7) [1045] for each species are found to have the same value originating from a common article selected by Michaelson [1045], while each value [1358] different from that [1045] comes from that done by Rivière [13] or Hölzl [1312]. In any cases, all of the values in the columns, in addition to those recommended by Fomenko in Column (8), are based on those data published before ∼1980.
(9) The value of 4.22 eV for Cd(poly) [349] is reported by Hopkins and Rivière after correcting the original one of 4.08 eV [1380] (see Footnote 214 in Table 1).
(10) Regarding 4.65 eV for Cu(poly), [3319] corresponding to Ref. 9 [1045] should be read [304] doing to Ref. 8 [1045] because the former [3319] includes 4.08 eV for In(poly) alone in contrast to the latter [304] including 4.65 eV for Cu(poly).

(11) In respect of Na(poly), 2.75 eV (PE, 77 K, film on quartz) [3424] and both 2.36 eV (PE, 293 K, film on Mo) [3337] and 2.35 eV [1354] are considerably larger and smaller than 2.54 eV [Here], respectively, thereby suggesting that the valid reason for such a large gap (~0.2 eV) should be found by further investigations.

(12) CRC Handbooks (78–98th Eds., 1997–2017) [1358, etc.] indicate that all of the data on Ir(100)–Ir(210) [[358] or [414]] are obtained by PE. But, PE should be read FE, just as indicated in a CRC Handbook (77th Ed., 1996) [4137] and a review [1045].

(13) On the basis of Ref. 1 [1312], CRC Handbooks (78–98 Eds., 1997–2017) [1358, etc.] recommend 4.34 eV at 300 °C by PE [2349] for Bi(poly). But, it should be read Bi(liq) measured at 573 K above T_m [2349] (see Table 1), although the value may be acceptable because the work function difference ($\Delta\phi_{LS}^e$) between the two phases is as small as 0.03 eV (see Table 12).

(14) The work function of 3.63 eV for Zn(mono) [2601] is recommended as that for Zn(poly) in CRC Handbooks (78–98 Eds., 1997–2017) [1358, etc.], while it is taken as that for Zn(0001) [475] although not clearly done so [1312,2601]. On the other hand, 4.9 eV [1508] is recommended for Zn(0001) in a CRC Handbook (77th Ed., 1996) [4137] and in a review [1045]. However, 3.63 and 4.9 eV are respectively much smaller and larger than our most probable values of 4.22 and 4.35 eV recommended for Zn(poly) and Zn(0001) in Table 2 and also than many others listed in Table 1 for the respective surfaces, thereby suggesting that any of the former values may be acceptable today as a reliable work function value for neither Zn(poly) nor Zn(0001).

(15) The value of 5.10 eV [358] recommended for Cu(100) in CRC Handbooks (78–98th Eds., 1997–2017) [1358, etc.] is extremely larger than any others (4.57–4.59 eV) [Here, 1045,1351] recommended for Cu(100) herein and also considerably larger than those (4.91–4.94 eV) done for Cu(111) having the largest among all of the copper monocrystals (see Tables 2 and 10). On the other hand, a CRC Handbook (77th Ed., 1996) [4137] as well as a review [1045] adopts 4.59 ± 0.03 eV [953,2006], which is the same with ours (4.58 ± 0.06 eV) for Cu(100).

(16) The m-Fe(100)^f grown epitaxially on Cu(100) represents the metastable fcc-Fe(100) (see Footnote 114 in Table 1 and also Sections 7.1 and 8.2).

(17) Metastable fcc-films of Co and Co(100) grown epitaxially on Cu(100) are much different in physical property from the two allotropes of bulk cobalt (see Section 8.2).

3.1. Estimation of the most probable values

On the basis of the theoretical and experimental data compiled in Table 1, the most probable values of the effective work functions (ϕ^+, ϕ^e and ϕ^-) for each of the essentially clean surface species will be estimated according to the fundamental aspects and policies as follows.

(1) In the case of thermal electron emission (TE) studied usually in relatively low vacuum conditions ($P_r \approx 10^{-7}$–10^{-9} Torr) as may be found frequently in the 4th column in Table 1, we should not overlook the important point whether or not the temperature or its range (Column 5) selected for work function measurements is high enough to keep the surface essentially clean. Typically, $T \geq 1800$ K for Re [65] and Ir [104] and also above 1900 K for W [69] may be acceptable as the normal condition even in such a low vacuum as mentioned above.

(2) Similarly in thermal positive (or negative) ion emission (PSI or NSI), T should be selected to be so high that the surface may be kept substantially clean even during the probing beam (or vapor) incidence. How to select T is readily understandable from such typical examples as Figs. 3 [58], 17 [104] and 28 [571] shown in Ref. [1351].

(3) Since other methods such as field emission (FE), photoelectric effect (PE) and contact potential difference (CPD) are usually adopted at $T \leq 300$ K, a very high vacuum below ~10^{-10} Torr should be maintained in general to insure the surface cleanness. It should be noted that adsorption lifetime of impinging residual gasses generally becomes longer with a decrease in T and hence that the surface coverage of foreign atoms and molecules (degree of surface contamination) becomes larger with decreasing temperature.

(4) With respect to a sample layers/substrate system (A/B) usually investigated around room temperature, it should be examined whether the layer(s) is adequately equilibrated (smoothed) by annealing at T_a (or $T_d) \geq T_m/3$) so as to correspond to its *bulk* sample (see Section 2.5 and Footnote 363 in Table 1) and also whether ultrahigh vacuum during work function measurements is maintained so as to keep the layer(s) substantially free from any effect owing to residual gas adsorption.

(5) Strictly speaking, all of ϕ^+, ϕ^e and ϕ^- are dependent upon surface temperature with the coefficient (α) of ~$\pm 10^{-4}$–10^{-5} eV/K (see both Section 5 and Table 6 in Ref. [1351]), which yields the work function differences of about ± 0.05–0.005 eV and of ± 0.2–0.02 eV according to the temperature differences by ~500 K (e.g., ~100–600 K, usually adopted in FE, PE or CPD) and by ~2000 K (~2300–300 K, extrapolated to room temperature in TE, PSI or NSI), respectively. However, such differences are tentatively disregarded here because of the reasons to be outlined as follows. (i) As may be seen in Table 1, the work function of any surface species changes by up to ~0.5 eV or much more from specimen to specimen or worker to worker, even in a common temperature range. Typically, ϕ^+ and ϕ^e for W(100) by PSI and TE are scattered widely in the ranges of mainly ~4.5–5.1 and ~4.4–5.0 eV, respectively, in a usual range (~1800–2300 K) among different experimental workers. Much wider scattering ($\phi^e \approx 3.7$–7.8 eV) is found for W(100) among different theoretical ones (see Table 1). All of the scattering widths (0.6–4.1 eV) are much larger than these differences (0.005–0.2 eV) due to the temperature difference mentioned just above. (ii) Such a fact as mentioned just above (i) indicates that the work function data based on both theoretical and experimental methods available today are usually not so convergent (or concentrated) enough to determine accurately the absolute value at a specified temperature (e.g., ~300 K) for any surface species to within the uncertainty of about ± 0.1 eV or so and, hence, that the estimated range of work function change (~0.005–0.2 eV) due to the actual difference in temperature may be considered to be much more narrower than the range (~0.6–4.1 eV) owing to the difference among various specimens or workers. (iii) This is the main reason why the present author has tried to estimate the most probable values of work function here without considering its temperature dependence, quite similarly as many other authors do so in handbooks and reviews [10–13,1045,1352–1355,1358]. Of course, it is needless to say that work function dependence upon surface temperature inherent in any crystal must be taken into consideration whenever the *net* work function change due to physical transition alone at a critical temperature (e.g., Curie point) is to be determined accurately (see Sections 7–10).

(6) In addition, all the data obtained for each surface species listed in Table 1 are critically analyzed from the viewpoints of (i) the reproducibility of the data reported, (ii) the surface cleanness (subject to dependence upon P_r and T), (iii) the correctness

of the reference work function adopted for CPD, etc., (iv) both method and condition selected for sample preparation, and (v) the measurement procedure employed.

(7) As will be shown typically for W in Sections 4.2–4.4, (i) ϕ^e of the "polycrystals" having the largest fractional area (δ_m) of less than 0.5 (=50% in fraction) (e.g. W(A)–W(D)) is nearly constant at 4.52 ± 0.10 eV [2453] (see Footnote (25) in Table 6) with little dependence upon the difference in both $\delta_m = 0.336$–0.463 and $\phi_m = 5.35$–4.25 eV belonging each to δ_m correspondent to the planes of (110)–(310), but (ii) ϕ^e of the "submonocrystals" with $0.5 < \delta_m < 1$ (namely, $50 < \delta_m < 100\%$), on the other hand, changes considerably depending upon both δ_m and ϕ_m (see Sections 4.4 and 4.5) and, hence, (iii) the work function data for the latter (ii) (typically, $\phi^e = 4.87$ eV for $\delta_m = 0.80$ and $\phi_m = 5.3$ eV of W(E) [2453], see Footnote (33) in Table 6) should be eliminated whenever the most probable work function value for the usually called "polycrystal" alone is taken into consideration. In other words, any "submonocrystal" should be treated as another type (category) different from both poly- and monocrystals. This is entirely because the former has generally such an anomaly that its work function depends principally upon δ_m without having a constant and unique value characteristic of the surface species (material) itself even under the normal condition accepted generally (see Section 4.5), in contrast to the "polycrystal" ($\delta_m < 0.5$) having a unique work function value with little dependence upon δ_m (see Conclusions (4)–(7) in Section 4.4). Of course, each surface of monocrystal ($\delta_m = 1$) is generally expected to have a unique value of work function characteristic of the surface species itself when the surface is essentially clean and smooth.

According to the above aspects and policies (1)–(7), the present author has tried to examine critically the work function data for each surface species listed in Table 1. As a result, about 50% or more of the very abundant data listed for such popular surface species as Cu, Mo, W, etc. are naturally eliminated in general because of (i) the poverty in surface condition, (ii) some errors in determination and/or (iii) the anomaly of $0.5 < \delta_m < 1$ corresponding to "submonocrystals" (see Sections 4.4 and 4.5). In consequence, such elimination leads to the result that both average and standard deviation for ϕ^e or ϕ^+ are calculated mainly from these data in the middle group (usually ~30–40%) alone, without including those in lower and higher groups (usually 70–60%) for each surface species. In this way, the statistical processing is applied to almost all the surface species included in Table 1, thereby yielding the most probable values of ϕ^e and ϕ^+ listed respectively in the 3rd and 4th columns in Table 2, together with ϕ^- in the 5th one. In the last column are recorded the most probable values of ϕ^e recommended by the present author previously [1351] in the same manner as above, although they are not so abundant (only 72 surface species) as the present ones (about 600 species) in the 9th and 3rd columns, respectively.

When the available data are extremely scanty in such a typical case as less-popular surface species and/or when they are much scattered in value over a very wide range, on the other hand, it is generally very difficult to find the most probable value for each species. This is the main reason why many of the surface species are not accompanied with the recommended values in the last line for the corresponding species in Table 1. Regarding those surface species having relatively scanty and/or divergent data, however, the present author dares to estimate tentatively the probable values and also to enter all of them in Column 3 of Table 2. Here, the superscripts of x and y indicate that the total numbers of work function data listed in Table 1 are 2 and 3–5, respectively. Especially, even the value of ϕ^e based on a single datum alone is purposely added with a superscript of z in order to summarize compactly all of the surface species investigated here and also to compare ϕ^e readily among different surface species for each element. Therefore, these values with x, y or z superscripted may possibly be less reliable or accurate compared with the others that are generally based on much abundant data (by up to ~400 data on each of Cs and W as typical cases) and hence that may be convincing in general. In other words, it may be safe to say that some of them (especially those with z attached) should be taken as the values estimated roughly by the present author. For quite many surface species (x–z) other than the ten species of Nb(113)^z, Nb(116)^y, Nb(310)^z, Mo(332)^y, Sb(100)^x, Sb(amorphous)^y, Te(1010)^x, Ir(210)^x, Pt(320)^y and Pt(331)^y, however, neither selected nor recommended values are found in Columns 6–8 in Table 2. Such an unfavorable situation at present suggests that much data on these species (x–z) should be accumulated hereafter by both theoretical and experimental studies.

3.2. Comparison with previously recommended values

In order to examine the important problem whether our most probable values estimated for ϕ^e as well as the previous ones [1351] are rational from the standpoint of scientific objectivity, the typical values of ϕ^e selected formerly by other authors [1045,1358] and also those recommended by another [12,1354] are listed in the 6–8th columns in Table 2. As known very well, these publications [12,1045,1354,1358] together with others [13,1312,1352,1355] have long been consulted as reliable and convenient data sources by many workers still to date. Especially, many of the values selected by Michaelson [1045] are adopted in CRC handbooks [11,1358,1359,4137, etc.], as may readily be understood from the fact that Columns 6 and 7 are often found to have the same value originating from the same reference selected for each surface species by the author [1045]. Typically, $\phi^e = 5.22, 5.04$, and 5.35 eV for Ni(100), Ni(110) and Ni(111) originating from Ref. [314], respectively, are found in both Columns 6 and 7, and all the values of which come from the selection by Michaelson [1045]. In addition, Ref. [1045] has long been widely cited to date by about 2000 groups of workers, as already mentioned in Section 1. Similarly, a handbook compiled by Fomenko [1354] has constantly been consulted especially in Russian and previous USSR countries. However, the total numbers (N_e and N_s) of the species (element and surface) covered by them [1045,1354,1358] in Table 2 are much smaller ($N_e = 60, 63$ and 66 species and $N_s = 103, 114$ and 66 species, respectively) compared with the present ones ($N_e = 88$ and $N_s = 609$ species, see the last two lines in Table 2). In addition, even CRC handbook (97th Ed.) [1358] published in 2016 is based entirely on the references [13,1045,1312], all of which were published more than ~40 years ago (1969–1979). Therefore, it may be necessary to examine the question whether all of the data listed in the above publications are fully accurate or reliable enough to be still acceptable even today.

From the above point of view, let's try to compare the recommended data [1045,1354,1358] with ours [Here] according to the typical forty examples listed below, where the figures are given as in the form of (A), {B}, [C] and (D/E). Namely, A is our

most probable value of ϕ^e (in eV) recommended in the 3rd column in Table 2, *B* is the experimental data on ϕ^e (in eV) which is achieved originally by the corresponding author [C] and also which is recommended in the 6–8th columns by one or two of the authors [1045,1354,1358], *D* is the difference (in eV) equal to $\Delta \equiv B - A$, and *E* is the percent of Δ/A. For the examinations (1)–(40) below, our value (*A*) is tentatively employed as the reference to examine the degree of difference or discrepancy (*E*) between our and other values (*A* and *B*) recommended in Table 2.

(1) α-Be(poly); (4.28 ± 0.13) // {4.98 ± 0.10} [2009] // (0.70 ± 0.16/16 ± 4)#.
(2) C(poly); (4.63 ± 0.06) // {5.0 ± 0.1} [299] // (0.37 ± 0.12/8 ± 3).
(3) Na(poly); (2.54 ± 0.03) // {2.35 ± ?} [1354] // (−0.19 ± 0.03/−7 ± 1).
(4) Na(poly); (2.54 ± 0.03) // {2.36 ± 0.02} [3337] // (−0.18 ± 0.04/−7 ± 2).
(5) Si(111); (4.86 ± 0.09) // {4.60 ± 0.13} [118] // (−0.26 ± 0.16/−5 ± 3).
(6) α-Ti(poly); (3.87 ± 0.05) // {4.33 ± 0.1} [304] // (0.46 ± 0.11/12 ± 3)#.
(7) α-Fe(poly); (4.55 ± 0.05) // {4.31 ± ?} [1354] // (−0.24 ± 0.05/−5 ± 1).
(8) α-Co(poly); (4.71 ± 0.03) // {4.41 ± ?} [1354] // (−0.30 ± 0.03/−6 ± 1).
(9) α-Co(poly); (4.71 ± 0.03) // {5.0 ± 0.1} [304] // (0.29 ± 0.1/6 ± 2).
(10) Cu(100); (4.58 ± 0.06) // {5.10 ± 0.05} [358] // (0.52 ± 0.08/11 ± 2)#.
(11) Zn(poly); (4.22 ± 0.11) // {3.63 ± ?} [2601] // (−0.59 ± 0.11/−14 ± 3)#.
(12) Ga(poly); (4.27 ± 0.06) // {3.96 ± ?} [1354] // (−0.31 ± 0.06/−7 ± 2).
(13) Ge(poly); (4.76 ± 0.05) // {5.0 ± ?} [1520] // (0.24 ± 0.05/5 ± 1).
(14) Se(poly); (5.27 ± 0.18) // {4.72 ± ?} [1354] // (−0.55 ± 0.18/−10 ± 4)#.
(15) Se(poly); (5.27 ± 0.18) // {5.9 ± ?} [3429] // (0.63 ± 0.18/12 ± 4)#.
(16) α-Sr(poly); (2.71 ± 0.08) // {2.35 ± ?} [1354] // (−0.36 ± 0.08/−13 ± 3)#.
(17) Nb(111); (3.95 ± 0.09) // {4.36 ± 0.06} [779] // (0.41 ± 0.11/10 ± 3)#.
(18) Nb(112); (4.33 ± 0.10) // {4.63 ± 0.06} [779] // (0.30 ± 0.12/7 ± 3).
(19) Mo(100); (4.38 ± 0.03) // {4.53 ± 0.02} [325] // (0.15 ± 0.04/3 ± 1).
(20) Mo(111); (4.29 ± 0.03) // {4.55 ± 0.02} [325] // (0.26 ± 0.04/6 ± 1).
(21) Mo(poly); (4.31 ± 0.02) // {4.6 ± 0.15} [304] // (0.29 ± 0.15/7 ± 3).
(22) Pd(poly); (5.17 ± 0.06) // {4.8 ± ?} [1354] // (−0.37 ± 0.06/−7 ± 1).
(23) In(poly); (4.05 ± 0.06) // {3.8 ± ?} [1354] // (−0.25 ± 0.06/−6 ± 2).
(24) Sb(poly); (4.45 ± 0.09) // {4.08 ± ?} [1354] // (−0.37 ± 0.09/−8 ± 3).
(25) Cs(poly); (2.05 ± 0.05) // {1.81 ± ?} [1354] // (−0.24 ± 0.05/−12 ± 2)#.
(26) α-La(poly); (3.27 ± 0.04) // {3.5 ± 0.2} [304] // (0.23 ± 0.20/7 ± 6).
(27) β-Ce(poly); (2.89 ± 0.07) // {2.7 ± ?} [1354] // (−0.19 ± 0.07/−7 ± 3).
(28) Eu(poly); (2.74 ± 0.12) // {2.5 ± 0.3} [304] // (−0.24 ± 0.32/−9 ± 11).
(29) α-Hf(poly); (3.64 ± 0.06) // {3.9 ± 0.1} [304] // (0.26 ± 0.12/7 ± 3).
(30) Re(1011); (5.26 ± 0.13) // {5.75 ± ?} [363] // (0.49 ± 0.13/9 ± 3).
(31) Re(poly); (4.96 ± 0.05) // {4.72 ± ?} [832] // (−0.24 ± 0.05/−5 ± 1).
(32) Os(poly); (4.97 ± 0.17) // {4.7 ± ?} [1354] // (−0.27 ± 0.17/−5 ± 4).
(33) Os(poly); (4.97 ± 0.17) // {5.93 ± 0.05} [3322] // (0.96 ± 0.18/19 ± 4)#.
(34) Ir(poly); (5.28 ± 0.04) // {4.7 ± ?} [1354] // (−0.58 ± 0.04/−11 ± 1)#.
(35) Pt(poly); (5.30 ± 0.07) // {5.64 ± ?} [435] // (0.34 ± 0.07/6 ± 2).
(36) Pt(poly); (5.30 ± 0.07) // {5.65 ± ?} [304] // (0.35 ± 0.07/7 ± 2).
(37) Au(poly); (5.30 ± 0.04) // {4.30 ± ?} [1354] // (−1.00 ± 0.04/−19 ± 1)#.
(38) Au(poly); (5.30 ± 0.04) // {5.1 ± 0.1} [304] // (−0.20 ± 0.11/−4 ± 2).
(39) Pb(poly); (4.07 ± 0.05) // {4.25 ± 0.05} [613] // (0.18 ± 0.07/4 ± 2).
(40) α-U(poly); (3.64 ± 0.04) // {3.3 ± ?} [1354] // (−0.34 ± 0.04/−9 ± 1).

As shown above, the difference of $|D| \equiv |B - A| \equiv |\Delta|$ has a wide range of 0.15–1.00 eV corresponding to $|E| \equiv |\Delta/A| = 3$–19%. In a typical case (11), we have $\Delta = -0.59$ eV and $\Delta/A = -14\%$ for Zn [2601]. The value of 3.63 eV [2601] is recommended for Zn(poly) in the CRC Handbook [1358], but it is treated as Zn(0001) [475]. Even in the latter, however, $B = 3.63$ eV for Zn(0001) yields $\Delta = -0.72 \pm 0.28$ eV and $\Delta/A = -17 \pm 6\%$ because our most probable value for Zn(0001) is 4.35 ± 0.28 eV (see Table 2). In another case (17), $B = 4.36 \pm 0.06$ eV for Nb(111) [779] is much larger than $A = 3.95 \pm 0.09$ eV for Nb(111) [Here] and not smaller than 4.02 ± 0.06 eV for Nb(100) [779], thereby leading to such a result that the triple set [779] of 4.87, 4.02 and 4.36 eV (see Table 2) does not perfectly follow the Smoluchowski rule of $\phi^e(110) > \phi^e(100) > \phi^e(111)$ to be expected generally for bcc-surfaces (for full detail, see Section 5.2 and 41–Nb–[779] in Table 9 and also Conclusion (8) in Section 5.4). In other words, it may be concluded that 4.36 eV for Nb(111) should be replaced with another to be less than 4.02 eV for Nb(100), such a typical value as 3.84 eV [774], 3.88 eV [726,775,960] or 3.95 eV [Here] (see Table 1).

Among the typical examinations (1)–(40) listed above, particularly those with # attached show that each of the value (*B*) recommended by one or two of the authors [1045,1354,1358] has a very large deviation ($|\Delta| \equiv |B - A| > 0.2$ eV and also $|\Delta/A| > 10\%$) from ours (*A*). Namely, they correspond to the examples of (1), (6), (10), (11), (15), (17) and (33) in CRC [1358], those of (1), (6), (15) and (17) in Michaelson [1045] and those of (14), (16), (25), (34) and (37) in Fomenko [1354]. The recommended values (*B*) with # attached, together with many others (*B*) included in the above forty examples, have long been consulted widely by a

great many workers. However, it does not seem to the present author that those with # may be very accurate or reliable enough to be straight or undoubtedly acceptable today, although any of our most probable values (*A*) employed as the reference for estimating the deviation or discrepancy (*Δ*) is not yet insured generally to be fully acceptable at present.

In the next step, let's examine the distribution of the work function difference ($D \equiv B - A$) for all of the recommended data (*B*) including the above forty examples.

Among our 609 surface species having the data on ϕ^e listed in the 3rd column in Table 2, it is only 134 species that can be compared with the other values of $\phi^e \equiv B$ (at least one or up to four values for each species) recommended previously in the 6–9th columns [1045,1351,1354,1358]. The difference ($|\Delta|$) between ϕ^e [Here] and each ϕ^e [1045,1354,1358] or [1351] has a wide distribution from 0.00 to 1.00 eV, which may be divided into the eleven categories as shown in Table 3; (1) good agreement of $|\Delta| \leq 0.05$ eV, (2) fair agreement of $|\Delta| = 0.06$–0.10 eV, (3) less-fair agreement of $|\Delta| = 0.11$–0.20 eV, and so on up to (11) wide gap of $|\Delta| = 0.91$–1.00 eV. The number (N_c) of those species contained in each category is different among the four references. The percentage (N_c/N_t) of the data corresponding to each category is also shown in Table 3, where N_t is the total number of the surface species contained in each of the four references (see the last line in Table 3).

Table 3
Distribution of the work function difference ($|\Delta|$) of ϕ^e between the most probable value [Here] and each one recommended by others [12,1045,1351,1354,1358] in Table 2. Here, N_t is the total number of ϕ^e–data listed in the last line and N_c is that corresponding to each category.

Category	Difference $|\Delta|$ (eV)	Ref. [1358]		Ref. [1045]		Refs. [12,1354]		Ref. [1351]	
		N_c	N_c/N_t (%)	N_c	N_c/N_t (%)	N_c	N_c/N_t (%)	N_c	N_c/N_t (%)
1	≤0.05	45	44	44	39	22	33	44	61
2	0.06–0.10	16	16	16	14	8	12	13	18
3	0.11–0.20	23	22	33	29	18	27	14	19
4	0.21–0.30	10	10	12	11	7	11	0	0
5	0.31–0.40	2	2	2	2	6	11	1	1
6	0.41–0.50	2	3	3	3	0	0	0	0
7	0.51–0.60	4	4	3	3	4	6	0	0
8	0.61–0.70	1	1	1	1	0	0	0	0
9	0.71–0.80	0	0	0	0	0	0	0	0
10	0.81–0.90	0	0	0	0	0	0	0	0
11	0.91–1.00	0	0	0	0	1	2	0	0
N_t	–	103	–	114	–	66	–	72	–

The essential points of Table 3 in addition to Table 2 may be summarized as follows.

(1) In the first category, many of our most probable values of ϕ^e [Here] in the 3rd column in Table 2 show a good agreement ($|\Delta| \leq 0.05$ eV) with about 44% ($N_c = 45$ species) of the values [1358], 39% ($N_c = 44$) of those [1045], 33% ($N_c = 22$) [12,1354] and 61% ($N_c = 44$) [1351] of the selected or recommended ones in the four references in the 6–9th columns in Table 2 (except those# for tungsten inserted with sharp in Column 8), respectively. Regarding the above "good agreement", each of the four references has the highest percentage ($N_c/N_t = 44, 39, 33$ or 61%) among the eleven categories. Especially, the following species satisfy the best agreement ($|\Delta| \leq 0.05$ eV) between each of our present values (Column 3 in Table 2) and more than two values referred for the same species in Columns 6–9 in Table 2. Namely, Li(poly); Mg(poly); Al(110), Al(111) and Al(poly); K(poly); α-Ca(poly); $\alpha-\beta$-Mn(poly); α-Fe(100); Ni(100) and Ni(111); Cu(100), Cu(110), Cu(111) and Cu(112); Rb(poly); Nb(100); Mo(110) and Mo(poly); Ru(poly); Pd(111) and Pd(poly); Cd(poly); Ba(poly); β-Ce(poly); Gd(poly); Ta(100), Ta(110), Ta(111) and Ta(poly); W(100), W(111), W(116) and W(poly); Re(poly); Ir(111) and Ir(poly); Au(110); Hg(liquid); α-Tl(poly); α-Th(poly) and α-U(poly). The recommended value of ϕ^e [Here] for each surface species mentioned just above may be fitly concluded to have a higher reliability or accuracy in comparison with that for any other species having $|\Delta| > 0.05$ eV.

(2) In the 2nd category, rather small percentages ($N_c/N_t = 12$–18% of $N_c = 8$–16 species) of the values recommended in the four references [1358, etc.] correspond to a fair agreement ($|\Delta| = 0.06 - 0.10$ eV) with our most probable value estimated for a common surface species [Here]. Among the four references, usually more than two are found to satisfy a fair agreement with the following species: Al(100); Si(100); Ni(110); Ga(poly); α-Y(poly); Nb(110); Ag(111); In(poly); β-Sn(poly); Cs(poly); α-Nd(poly); W(110) and W(113); Ir(100); Pt(100); Au(100) and Bi(poly). Our most probable values for the above species in Column 3 in Table 2 may probably be accepted to be considerably reliable in contrast to the others with $|\Delta| > 0.10$ eV.

(3) In the 3rd category, a less-fair agreement ($|\Delta| = 0.11 - 0.20$ eV) between the present and other four values is not small in percentage ($N_c/N_t = 22, 29, 27$ and 19% for $N_c = 23, 33, 18$ and 14 species, respectively). The following species belong to this category: Na(poly); Si(poly); α-Sc(poly); V(poly); Cr(poly); α-Fe(poly); Ni(poly); Cu(poly); Zn(poly); α-Sr(poly); α-Zr(poly); Nb(116) and Nb(poly); Mo(100), Mo(112) and Mo(114); Rh(poly); Ag(100) and Ag(poly); Sb(100) and Sb(amorphous); Te(1010); Sm(poly); α-Tb(poly); Lu(poly); Os(poly); Ir(110); Pt(111); Au(111) and Pb(poly). For each species, more than two values in Columns 6−9 in Table 2 correspond to $|\Delta| = 0.11 - 0.20$ eV. The present values [Here] as well as the others [1045,1351,1354,1358] for the above species may possibly be needed to be examined after accumulating much more data of ϕ^e achieved by both experiment and theory. Among the forty examinations listed above, these (3) and (4) Na(poly) [1354,3337], (19) Mo(100) [325], (27) β-Ce(poly) [1354] and (39) Pb(poly) [613] belong to the 3rd category, whilst the other thirty five ones ($|\Delta| = 0.21 - 1.00$ eV) do to those 4th–11th ones.

(4) In the 4th category, a considerable percentage of $N_c/N_t \approx 10\%$ ($N_c = 10, 12$ and 7 corresponding to Refs. [1045,1358] and [1354], respectively), in contrast to $N_c/N_t = 0\%$ [1351], is still found to have $|\Delta| = 0.21 - 0.30$ eV, being little agreeable to ϕ^e in the present and previous studies [Here, 1351]. The following surface species belong to this category; Si(111); α-Co(poly); Ge(poly); Nb(112); Mo(111) and Mo(332); Ag(110); α-La(poly); and α-Hf(poly). Much further study about these nine species may probably be needed to find the accurate or reliable value of ϕ^e so as to be convincing in general.

(5) In the 5–8th categories, a considerable discrepancy ($|\Delta| = 0.31 - 0.70$ eV) is found for the seven species of α-Be(poly); C(poly); α-Ti(poly); α-Fe(111); Se(poly); Nb(111); and Pt(poly). Typically, a marked discrepancy of $|\Delta| = |5.27 - 5.9| \approx 0.6$ eV is observed for Se(poly) between Column 3 [Here] and Columns 6 and 7 [1045,1358] in Table 2. The value of $\phi^e = 5.9$ eV by PE originating from Ref. [3429] is extraordinarily larger than any others except both 5.9 eV by TC [298] and 6.3 eV by FE [1677] listed in Table 1. In addition, 4.72 eV for Se(poly) [12,1354] corresponding to $|\Delta| = 0.55$ eV (Category 7) is exceedingly smaller than 4.8–5.8 eV (except 4.42 and 4.62 eV and also 5.9 and 6.3 eV above) among about 30 data obtained by various methods in Table 1. Therefore, none of the above values (5.9 and 4.72 eV) recommended for Se(poly) seems to be reliable enough to be acceptable today. With respect to the above seven species, it may be necessary to accumulate much data reliable enough to settle the question which value of ϕ^e for each species is nearer to the true or most probable one among those recommended by present or other authors.

(6) In the 11th category for $|\Delta| = 0.91 - 1.00$ eV, a wide gap of $|\Delta| = |5.30 - 4.30| = 1.00$ eV for Au(poly) exists between the present [Here] and the other [10,12,1354]. The latter (4.30 eV) seems to be affected strongly by the data obtained by using mercury diffusion pump systems which were very popular until ~1970. Table 1 includes many data determined for Au to be $\phi^e < 4.8$ eV, most of which were reported before ~1980. It should be noted that Au is subject to surface reaction (amalgamation) with Hg [1071–1073] having $\phi^e = 4.475$–4.52 eV (see Table 2). Typically, $\phi^e = 5.22$ eV for Au is reduced by ~0.45 eV by intentional admission of Hg-vapor [1071]. Several topics on Au may be added as follows: (i) Remove of Hg adsorbed on Au and Ag can be done readily by baking above 520 K [1893]. Typically, 5.25 ± 0.01 eV is observed for Au/W(110) after annealing at 750 K at $P_r = 5 \times 10^{-10}$ Torr attained by using a mercury pumping system [1670,1673], and similarly 5.24–5.27 eV is found for an Au ribbon after baking around 1070 K [2473]. Similarly at $P_r < 10^{-9}$ Torr (2×10^{-10} Torr as the partial pressure of Hg), ϕ^e of an Au-ribbon is increased from 4.89 ± 0.06 eV to 5.20 ± 0.05 eV by flashing at 1170 K [1072]. (ii) Further information about the mercury contamination of Au may be obtained from Section 4.2.3 in Ref. [1351]. (iii) Instead of 4.30 eV [10,12,1354], either 5.30 ± 0.04 eV [Here] or 5.31 ± 0.07 eV [1351] for Au may be recommended to be the most probable value of ϕ^e according to those data achieved in Hg-free systems. Employment of the latter makes it possible to establish much better the linear relationship between ϕ^e and X (see Fig. 1 [1955] and Fig 4.1 [1312]) expressed by Eq. (7). (iv) Regarding amorphous gold film on glass, on the other hand, ϕ^e is considered to be 4.7 eV [4113], which is currently interpreted on the basis of plasmon-assisted multiphoton emission [4369,4370]. (v) According to another study about Au-nanoparticles grown on a Si-wafer covered with a monolayer of alkyl chain, ϕ^e is found to change from ~3.5 to 3.8 eV as the particle radius increases from ~20 to 80 Å [4368] (see Footnote 478 in Table 1). The above typical examples suggest that some of the Au-layers having $\phi^e < 4.7$ eV (see Table 1) measured in an Hg-free atmosphere may possibly consist of fine crystallites.

(7) In order to list up compactly all of the surface species studied for their work functions in this article and also to demonstrate the present state how scanty the work function data are for a variety of less-common or unfamiliar surface species, the probable values of ϕ^e, ϕ^+ and ϕ^- with superscript (x, y or z) are also included in Table 2. Here, each of the values is estimated from the scanty data whose total numbers available in Table 1 are 2 and 3–5 for x and y, respectively, and only one for z. Consequently, any of them may possibly be less accurate or reliable than the others estimated from much abundant data (e.g., ~400 in number for each of Cs and W) listed in Table 1. With the eleven exceptions of As(111), Nb(113), Nb(116), Nb(310), Mo(332), Sb(100), Sb(amorphous), Te(1010), Ir(210), Pt(320) and Pt(331), many (97%) of our data on ϕ^e with x, y or z (387 surface species in total) in Column 3 (Table 2) can not be compared with any others in Columns 6–8 in Table 2.

(8) Accumulation of many new data on ϕ^e is generally expected particularly for the species attached with a superscript (x, y or z) as follows: α-Sc(1010); α-Ti(1010) and β-Ti(100)–(112); α-Co(1010)–(1124); Zn(1010); Ga(100)–(111); α-Y(1010) and β-Y(100)–(112); α-Zr(1010) and β-Zr(100)–(112); Cd(1010); In(100)–(111); Sb(111); β-La(100)–(112); β- and γ-Ce(100)–(112); α-Pr(0001) and β-Pr(100)–(112); β-Nd(100)–(112); Sm(100)–(112); Eu(100)–(112); α-Gd(1010) and (1124) and also β-Gd(100)–(112); α-Tb(1010) and (1124) and also β-Tb(100)–(112); α-Dy(1010) and (1124); α-Ho(1010) and (1124); α-Er(1010) and (1024); α-Tm(0001), (1010) and (1124); α- and β-Yb(100)–(112); α-Lu(0001), (1010) and (1124) and also β-Lu(100)–(112); α-Hf(0001), (1010) and (1124) and also β-Hf(100)–(112); Os(1010)–(1124); Au(112); α-Tl(0001)–(1124); Bi(0001) and (1011); Th(100)–(111); γ-U(100)–(112); and so on. Many of the above species may be interested in some workers active in the fields of pure and applied physics. Addition of new reliable data on the above species is strongly expected to fill out such great blanks as found in Columns 6–8th in Table 2.

(9) The most probable values of ϕ^e without any of x–z attached are estimated for 213 surface species in the 3rd column in Table 2, whilst their large part (36%, 77 species) is not covered in the 6–8th columns by any of the other authors [1045,1354,1358]. Namely, any of the 77 species has long been left without ϕ^e recommended in spite of the fact that a considerable number (≥ 6) of data on ϕ^e have already been published for each species. Of our all data (about 600 surface species including those with x–z attached), such a high percentage as ~80% (about 480 surface species) is not covered in any data list compiled by other authors, as may readily be understandable from the great blank in the three columns in Table 2. In other words, not only the best estimates but also even preferable ones of ϕ^e have not yet been reported for the latter 480 species by any other authors. Consequently, much further work is needed to accumulate many reliable data on ϕ^e particularly for those less-common species with x–z attached.

(10) To the best of the present author's knowledge, any other authors have not yet published the most probable values (or recommended data) of both ϕ^+ and ϕ^-, and hence of the thermionic contrasts ($\Delta\phi^*$ and $\Delta\phi^{**}$) for any surface species (see Section 4).

(11) Our values of ϕ^e with double underlines in the 3rd column (93 kinds of surface species, only 15% of the total 609 ones including those with x–z attached) in Table 2 may probably be acceptable at present as the most reliable values of ϕ^e with a possible

uncertainty of less than ± 0.05 eV for each of the surface species. In addition, our data with a single underline (73 species, 12% of the total ones) may be usable as considerably reliable values of ϕ^e with a possible uncertainty of less than ± 0.1 eV.

(12) Citation of these data on ϕ^e having no underline (443 species, 73% of the total ones) may be accompanied with a possible uncertainty of up to ~0.1 eV or much more. Namely, more than half of the total 606 surface species surveyed comprehensively from 4461 literatures cannot yield us any convincing estimates of ϕ^e within possible uncertainty of less than ± 0.1 eV, in contrast to the above 166 species of underlined data mentioned in Point (11). This is mainly because the work function data available for the species without any underline attached are very small in number less than 6 or partly because the data themselves are scattered in value in a wide range of up to 1 eV or more. Typically, the five data on α-Sc(0001) largely range from 2.1 to 4.81 eV (see Table 1).

(13) Disappointingly, no data are found for quite many surface species such as $C_{60}(100)$, Al(112), P(100), α-Ca(112), Zn(1011), As(100), Sc(0001), α-Y(1011), α-Zr(1011), Pd(112), Ag(112), Cd(1011), In(112), Sb(110), Te(0001), α-La(1010), α-Pr(1010), α-Nd(1010), α-Gd(1011), α-Tb(1011), α-Dy(1011), α-Ho(1011), α-Tm(1011), α-Lu(1011), α-Hf(1011), α-Tl(1011), Pb(112) and Bi(1010), although they may be interested in some of the workers active in various fields of physics and chemistry. As may be seen in Column 3 of Table 2, the work function data on high-Miller index surfaces are reported for several species alone (e.g., Cu, W and Pt). Such data are generally expected for many other metals and metalloids, too.

(14) The actual situation exemplified in Points (7)–(9) and (13) indubitably indicates that accumulation of work function data for great many surface species is quite poor still to date and hence that much further survey or study is needed to establish more reliable estimates of ϕ^e (within the uncertainty of ± 0.1 eV) for quite many surface species mentioned partly in Points (3)–(5) in addition to those listed typically in Points (7), (8) and (13).

With respect to the "Electron Work Function of the Elements" in CRC handbooks (78th−98th Editions published in 1997−2017), it seems to the present author that Pt(110) should be read Pt(100) because any of the references (1)–(3) [13,1045,1312] has no datum on Pt(110), whilst 5.84 eV cited from Ref. [1312] in the handbooks originates from Ref. [428], accurately corresponding not to Pt(110) but to Pt(100) studied by FE (see also Footnote # in Table 2 in Ref. [1351]). Consequently, it may be reasonable to suggest that "5.84 eV" cited by Logovoi et al. [2543] as ϕ^e for "Pt(110)" from the CRC Handbook (78th Ed.) [4318], for example, should be replaced with "5.54 $\pm$ 0.07 eV" recommended for Pt(110) by us (see Table 2). If so replaced, then, the theoretical value of 5.52 eV [2543] as well as 5.54 eV [1931] calculated for Pt(110) (see Table II in Ref. [2543]) agrees exactly with ours cited just above without having the "unreasonable discrepancy of 0.32 eV" against the "literature value of 5.84 eV for Pt(110)".

4. Peculiarity of polycrystalline work function

In contrast to monocrystals, polycrystals have generally the different work functions of ϕ^+ and ϕ^e, as already shown in Tables 1 and 2. This peculiarity brings about the "thermionic contrast" of $\Delta\phi^* \equiv \phi^+ - \phi^e > 0$ and, hence, it poses very interesting problems and new information about work function. After analyzing the data on $\Delta\phi^*$, an exhaustive discussion is devoted to the peculiarity of polycrystals ($\delta_m < 0.5$) and also to the anomaly of submonocrystals ($0.5 < \delta_m < 1$) in this section, where δ_m is focused as the *key* factor governing both ϕ^+ and ϕ^e as well as $\Delta\phi^*$.

4.1. Polycrystalline thermionic contrast ($\Delta\phi^*$) between ϕ^+ and ϕ^e

Positive surface ionization (PSI), often called thermal positive ion emission, has long been utilized by great many workers in a variety of fields of both science and technology in order to (1) generate positive ion beams of various species of atoms (M) having relatively low ionization energy ($I < 6$ eV), (2) detect neutral beams (or vapor) of atoms (M) or molecules (MX), (3) analyze a microsize of materials including M or MX, (4) investigate both surface reactions and phenomena related with work function, its change and so on [2,5,15–22]. For these purposes, almost all the workers have employed polycrystals and, hence, they are inevitably required to employ reliable values of ϕ^+ instead of ϕ^e for either analyzing or predicting correctly the positive ion emission data to be obtained in a given experiment under a specified experimental condition. In other words, the accuracy of the analyzed result to be achieved is generally affected by that of the value of ϕ^+ or $\phi^e + \Delta\phi^*$, strongly dependent upon the size of $\Delta\phi^*$.

Nevertheless, the thermionic contrast ($\Delta\phi^* \equiv \phi^+ - \phi^e$) has long been overlooked or disregarded often by many groups of workers in spite of the fact that $\Delta\phi^* = 0$ holds for a clean and smooth monocrystalline surface alone, as already mentioned in Section 1 and also explained in Section 4.4 in Ref. [1351]. In addition, these data on ϕ^+ and $\Delta\phi^*$ are hardly found in many handbooks available today. The latter may be largely responsible for such a present status that the emission predominance peculiar to polycrystalline surfaces ($\phi^+ > \phi^a > \phi^e = \phi^- = \phi$) has not yet fully been recognized to date. Without considering or examining the surface homogeneity in work function of the various specimens (usually polycrystals) under study, ϕ^e instead of ϕ^+ is employed to analyze these data on the positive ion emission from the specimens under study by many groups of workers [3–9,14,16,17,20,98,99,120,132,137,160,228,232,323,416,490–494,522,611,804,823,924,932–934,946, 954,961,965,966,979,1003,1004,1252,1320–1350,3823–3829,3832,3834–3839,3849–3854,3869–3871,3884,3907]. Without being recognized or perceived by each of the corresponding workers themselves, of course, some of the above specimens may have possibly been changed already from polycrystals into nearly monocrystals owing to previous or preliminary aging for a very long time at high temperatures. When the specimen under study is almost monocrystallized ($\delta_m \approx 1$) by high temperature aging prior to work function measurements, of course, ϕ^e may generally be employable as the equivalence to ϕ^+ with safety.

Needless to say, even refractory metals are subject to recrystallization according to heating at high temperatures (usually above ~2000 K) for very long hours, thereby generally leading to such a change as follows:

Polycrystal ($\delta_m < 0.5$) → "Submonocrystal" ($0.5 < \delta_m < 1$) → Monocrystal ($\delta_m = 1$).

According to the above change in surface structure, work function also changes considerably in general. The peculiarity of polycrystal and the anomaly of submonocrystal will be outlined later in Sections 4.3–4.5.

In a typical case of W [3834], ϕ^+ and ϕ^e are determined to be 4.65 and 4.56 eV by PSI of Ba and by TE, respectively (see Table 1), thereby yielding that $\Delta\phi^* = 4.65 - 4.56 = 0.09$ eV is much smaller than the most probable value of $\Delta\phi^* = 0.61 \pm 0.06$ eV usually expected for polycrystalline tungsten specimens with $\delta_m < 0.5$ (see Tables 4 and 5 to be shown later). This discrepancy (0.09 vs. 0.61 eV) may be reasonably explained by considering that the specimen [3834] having subjected up to ~2900 K prior to measurements consists probably almost ($\delta_m > 0.9$) of the W(100) face developed after thermal recrystallization without being sufficiently recognized by the worker [3834], like as the specimen of W(F) with $\delta_m = 0.95$–(100) oriented [3414] having (43) $\Delta\phi^* = 4.70 \pm 0.04 - 4.61 \pm 0.04 = 0.09 \pm 0.05$ eV [2453] (to be shown later in Table 6). Both of the tungsten specimens [3414,3834] are the typical examples of submonocrystal ($0.5 < \delta_m < 1$ and $\Delta\phi^* > 0$ eV).

Table 4
Thermionic contrast ($\Delta\phi^* \equiv \phi^+ - \phi^e$) determined for the *same* specimen under substantially the same condition in each study.

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
				6. Highly Oriented Pyrolytic Graphite				
C(HOPG)	?	Cs	Cs$^+$	4.51 ± 0.15	4.58 ± 0.02	-0.07 ± 0.15	PSI, TE	[1049]
C(HOPG)	?	Cs	Cs$^+$	4.60 ± 0.11	4.58 ± 0.02	0.02 ± 0.11	PSI, TE	[112,524,1049]
C(HOPG)	?	Cs	Cs$^+$	4.62 ± 0.17	4.58 ± 0.02	0.04 ± 0.17	PSI, TE	[1049]
C(HOPG)	?	Cs	Cs$^+$	4.69 ± 0.19	4.58 ± 0.02	0.11 ± 0.19	PSI, TE	[1049]
C(HOPG)	?	Cs	Cs$^+$	4.82 ± 0.14	4.58 ± 0.02	0.24 ± 0.14	PSI, TE	[1049]
Mean	–	–	–	–	–	**0.07 ± 0.10**	PSI, TE	–
M.P.V.	–	–	–	4.65 ± 0.12	4.66 ± 0.05	**−0.01 ± 0.13**	various	Table 2
				6. Graphitic Carbon Film				
C/Ir	?	Cs	Cs$^+$	4.2 ± 0.1	4.5 ± 0.1	-0.3 ± 0.14	PSI, TE	[1290]
C/Re(1010)	?	Na	Na$^+$	4.30 ± 0.05	4.30 ± 0.05	0.00 ± 0.07	PSI, TE	[4458]
C/Ir(111)	?	Ba	Ba$^+$	4.5	4.5	0.0	PSI, TE	[168]
C/Ir(111)	?	In	In$^+$	4.5	4.5	0.0	PSI, TE	[168]
C/Pt–W(8%)	?	K	K$^+$	4.50 ± 0.05	4.50 ± 0.02	0.00 ± 0.05	PSI, TE	[108]
C/Pt–W(8%)	?	K	K$^+$	4.55 ± 0.07	4.63 ± 0.06	-0.08 ± 0.09	PSI, TE	[108]
C/Pt–W(8%)	?	Na	Na$^+$	4.58 ± 0.03	4.54 ± 0.06	0.04 ± 0.07	PSI, TE	[676]
C/Ir	?	K	K$^+$	4.6 ± 0.1	4.4	0.2 ± 0.1	PSI, TE	[107]
C/Ir(111)	?	Cs	Cs$^+$	4.8	4.8	0.0	PSI, TE	[103]
C/Ir(111)	?	In	In$^+$	4.8	4.8	0.0	PSI, TE	[103]
Mean	–	–	–	–	–	**−0.02 ± 0.12**	PSI, TE	–
M.P.V.	–	–	–	4.50 ± 0.04	4.47 ± 0.05	**0.03 ± 0.06**	various	Table 2
				13. Polycrystalline Aluminium				
Al/Si(111)	?	Cs, Li	Cs$^+$	4.8[a]	4.23 ± 0.06[b]	$0.6 \pm >0.06$	CPD, various	[1342]
Al	?	Cs	Cs$^+$	4.96[a]	4.23 ± 0.06[b]	$0.73 \pm >0.06$	CPD, various	[611]
Mean	–	–	–	–	–	**0.66 ± >0.06**	CPD, various	–
M.P.V.	–	–	–	4.9 ± 0.1	4.26 ± 0.03	**0.6 ± 0.1**	various	Table 2
				14. Monocrystalline Silicon				
Si(100)[n]	~100	K	K$^+$	4.54 ± 0.2	4.53 ± 0.1	0.01 ± 0.2	PSI, TE	[74]
Si(100)[n]	~100	Li	Li$^+$	4.60 ± 0.03	4.53 ± 0.1	0.07 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	Na	Na$^+$	4.70 ± 0.02	4.53 ± 0.1	0.17 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	Li	Li$^+$	4.74 ± 0.05	4.53 ± 0.1	0.21 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	Tl	Tl$^+$	4.81 ± 0.03	4.53 ± 0.1	0.28 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	Tl	Tl$^+$	4.81 ± 0.07	4.53 ± 0.1	0.28 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	Na	Na$^+$	4.84 ± 0.03	4.53 ± 0.1	0.31 ± 0.1	PSI, TE	[74]
Si(100)[n]	~100	K	K$^+$	≥ 4.84	4.53 ± 0.1	$\geq 0.31 \pm 0.1$	PSI, TE	[74]
Mean	–	–	–	–	–	**0.20 ± 0.10**[g]	PSI, TE	–
M.P.V.	–	–	–	4.72 ± 0.10	4.82 ± 0.10	**−0.10 ± 0.14**	various	Table 2
Si(110)[p]	~100	Na	Na$^+$	3.32	3.40	-0.08	PSI, TE	[1472]
Si(110)[p]	~100	K	K$^+$	3.32	3.40	-0.08	PSI, TE	[1472]
Si(110)[p]	~100	Na	Na$^+$	4.31	4.31	0.00	PSI, TE	[1472]
Si(110)[p]	~100	K	K$^+$	4.31	4.31	0.00	PSI, TE	[1472]
Si(110)[p]	~100	Na	Na$^+$	4.38 ± 0.01	4.69 ± 0.01	-0.31 ± 0.01	PSI, TE	[1472]

Table 4 (*continued*)

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Si(110)[p]	~100	K	K$^+$	4.38 ± 0.01	4.69 ± 0.01	−0.31 ± 0.01	PSI, TE	[1472]
Mean	–	–	–	–	–	**−0.13 ± 0.13**	PSI, TE	–
Mean (revised)[c]	–	–	–	–	–	**−0.04 ± 0.04**	PSI, TE	–
M.P.V.	–	–	–	4.36 ± 0.03	4.44 ± 0.24	**−0.08 ± 0.24**	various	Table 2
Si(111)[n]	~100	K	K$^+$	4.44 ± 0.1	4.55 ± 0.1	−0.11 ± 0.14	PSI, TE	[74]
Si(111)[n]	~100	Na	Na$^+$	4.63 ± 0.05	4.59 ± 0.05	0.04 ± 0.07	PSI, TE	[75]
Si(111)[n]	~100	K	K$^+$	4.69 ± 0.1	4.55 ± 0.1	0.14 ± 0.14	PSI, TE	[74]
Si(111)[n]	~100	Li	Li$^+$	4.75 ± 0.03	4.55 ± 0.1	0.20 ± 0.10	PSI, TE	[74]
Si(111)[p]	~100	Na	Na$^+$	4.76 ± 0.05	4.58 ± 0.05	0.18 ± 0.07	PSI, TE	[75]
Si(111)[n]	~100	Na	Na$^+$	4.78 ± 0.05	4.59 ± 0.05	0.19 ± 0.07	PSI, TE	[75]
Si(111)[n]	~100	Tl	Tl$^+$	4.79 ± 0.03	4.55 ± 0.1	0.24 ± 0.10	PSI, TE	[74]
Si(111)[p]	~100	K	K$^+$	4.80	4.1 ± 0.1	0.7 ± >0.1	PSI, TE	[272]
Si(111)[n]	~100	Na	Na$^+$	4.80 ± 0.04	4.55 ± 0.1	0.25 ± 0.11	PSI, TE	[74]
Si(111)[n]	~100	Na	Na$^+$	4.81 ± 0.02	4.55 ± 0.1	0.26 ± 0.10	PSI, TE	[74]
Si(111)	~100	Na	Na$^+$	4.81 ± 0.05	4.55 ± 0.05	0.26 ± 0.07	PSI, TE	[75]
Si(111)[n]	~100	Li	Li$^+$	4.84 ± 0.03	4.55 ± 0.1	0.29 ± 0.10	PSI, TE	[74]
Si(111)[p]	~100	Cs	Cs$^+$	4.85 ± 0.08	4.07 ± 0.05	0.78 ± 0.09	PSI, TE	[73]
Si(111)[p]	~100	Cs	Cs$^+$	4.85 ± 0.08	4.83 ± 0.04[d]	0.02 ± 0.09	PSI, TE	[73]
Si(111)[p]	~100	Cs	Cs$^+$	4.85 ± 0.08	4.86 ± 0.11	−0.01 ± 0.14	PSI, CPD	[73]
Si(111)[n]	~100	Li	Li$^+$	4.86 ± 0.07	4.04 ± 0.05	0.82 ± 0.09	PSI, TE	[72]
Si(111)[n]	~100	Li	Li$^+$	4.86 ± 0.07	4.80 ± 0.04[d]	0.06 ± 0.08	PSI, TE	[72]
Si(111)[n]	~100	Na	Na$^+$	4.87 ± 0.03	4.04 ± 0.05	0.83 ± 0.06	PSI, TE	[72]
Si(111)[n]	~100	Na	Na$^+$	4.87 ± 0.03	4.80 ± 0.04[d]	0.07 ± 0.05	PSI, TE	[72]
Si(111)[p]	~100	Cs	Cs$^+$	4.88 ± 0.10	4.07 ± 0.05	0.81 ± 0.11	PSI, TE	[73]
Si(111)[p]	~100	Cs	Cs$^+$	4.88 ± 0.10	4.83 ± 0.04[d]	0.05 ± 0.11	PSI, TE	[73]
Si(111)[p]	~100	Cs	Cs$^+$	4.88 ± 0.10	4.84 ± 0.14	0.04 ± 0.17	PSI, CPD	[73]
Si(111)[n]	~100	In	In$^+$	4.90 ± 0.10	4.04 ± 0.05	0.86 ± 0.11	PSI, TE	[72]
Si(111)[n]	~100	In	In$^+$	4.90 ± 0.10	4.80 ± 0.04[d]	0.10 ± 0.11	PSI, TE	[72]
Si(111)[n]	~100	Tl	Tl$^+$	4.99 ± 0.05	4.55 ± 0.1	0.44 ± 0.11	PSI, TE	[74]
Si(111)	~100	Na	Na$^+$	5.00 ± 0.05	4.51	0.49 ± >0.05	PSI, TE	[75]
Si(111)[p]	~100	Na	Na$^+$	5.05	4.1 ± 0.1	0.95 ± >0.1	PSI, TE	[272]
Si(111)[p]	~100	Na	Na$^+$	5.06	4.1 ± 0.1	0.96 ± >0.1	PSI, TE	[272]
Si(111)	~100	Li	Li$^+$	5.23 ± 0.05	4.51 ± 0.05	0.72 ± 0.07	PSI, TE	[75]
Mean	–	–	–	–	–	**0.35 ± 0.33**	PSI, SIE, TE	–
Mean (revised)[e]	–	–	–	–	–	**0.05 ± 0.03**	PSI, CPD, Eq. (8)	–
M.P.V.	–	–	–	4.83 ± 0.07	4.86 ± 0.09	**−0.03 ± 0.11**	various	Table 2

14. Polycrystalline Silicon

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Si	?	Cs	Cs$^+$	5.14[a]	4.6 ± 0.1[b]	0.5 ± >0.1	CPD, various	[611]

41. Monocrystalline Niobium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Nb(100)	~100	Cs	Cs$^+$	4.04	3.90	0.14	PSI, TE	[739]
M.P.V.	–	–	–	4.04	4.02 ± 0.05	**0.02 ± >0.05**	various	Table 2
Nb(110)	~100	Cs	Cs$^+$	4.64	4.80	−0.16	PSI, TE	[739]
Nb(110)	~100	Na	Na$^+$	4.84 ± 0.05	4.80	0.04 ± >0.05	PSI, TE	[726]
Mean	–	–	–	–	–	**−0.06 ± 0.10**	PSI, TE	–
M.P.V.	–	–	–	4.74 ± 0.10	4.77 ± 0.05	**−0.03 ± 0.11**	various	Table 2
Nb(111)	~100	Cs	Cs$^+$	3.78	3.88	−0.10	PSI, TE	[739]
Nb(111)	~100	Na	Na$^+$	3.90	3.88	0.02	PSI, TE	[726]
Mean	–	–	–	–	–	**−0.04 ± 0.06**	PSI, TE	–
M.P.V.	–	–	–	3.84 ± 0.06	3.95 ± 0.09	**−0.11 ± 0.11**	various	Table 2
Nb(112)	~100	Cs	Cs$^+$	4.44	4.45 ± 0.05	−0.01 ± >0.05	PSI, TE	[739]
M.P.V.	–	–	–	4.44	4.33 ± 0.10	**0.11 ± >0.1**	various	Table 2

41. Polycrystalline Niobium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Nb–(100)[f]	68	–	–	4.39 ± 0.08	4.02 ± 0.07	0.37 ± 0.11	TC	[803]
Nb	?	RbI	Rb$^+$	4.76 ± 0.03	4.02 ± 0.05	0.74 ± 0.06	PSI, TE	[23]
Nb	?	RbBr	Rb$^+$	4.87 ± 0.06	4.02 ± 0.05	0.85 ± 0.08	PSI, TE	[23]
Nb	?	RbCl	Rb$^+$	4.88 ± 0.06	4.02 ± 0.05	0.86 ± 0.08	PSI, TE	[23]
Mean	–	–	–	–	–	**0.70 ± 0.12**	TC, PSI, TE	–
M.P.V.	–	–	–	4.81 ± 0.05	4.11 ± 0.05	**0.70 ± 0.07**	various	Table 2

Table 4 (*continued*)

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
				42. Monocrystalline Molybdenum				
Mo(100)	~100	Na	Na$^+$	4.44 ± 0.03	4.40 ± 0.03	0.04 ± 0.04	PSI, TE	[727,3103]
Mo(100)	~100	Na	Na$^+$	4.45	4.45	0.00	PSI, TE	[278]
Mo(100)	~100	K	K$^+$	4.45	4.45	0.00	PSI, TE	[278]
Mean	–	–	–	–	–	**0.01 ± 0.01**	PSI, TE	–
M.P.V.	–	–	–	4.38 ± 0.08	4.38 ± 0.03	**0.00 ± 0.09**	various	Table 2
Mo(110)	~100	Na	Na$^+$	5.13 ± 0.03	5.10 ± 0.03	0.03 ± 0.04	PSI, TE	[727]
M.P.V.	–	–	–	5.1	4.98 ± 0.03	**0.1 ± >0.03**	various	Table 2
Mo(111)	~100	Li	Li$^+$	4.10 ± 0.03	4.10 ± 0.03	0.00 ± 0.04	PSI, TE	[786]
Mo(111)	~100	Na	Na$^+$	4.13 ± 0.03	4.10 ± 0.03	0.03 ± 0.04	PSI, TE	[727,3103]
Mean	–	–	–	–	–	**0.02 ± 0.04**	PSI, TE	–
M.P.V.	–	–	–	4.17 ± 0.09	4.29 ± 0.03	**−0.12 ± 0.09**	various	Table 2
Mo(112)	~100	Na	Na$^+$	4.63 ± 0.03	4.60 ± 0.03	0.03 ± 0.04	PSI, TE	[727,2210]
M.P.V.	–	–	–	4.6	4.51 ± 0.03	**0.1 ± >0.03**	various	Table 2
				42. Polycrystalline Molybdenum				
Mo(porous)	?	Cs	Cs$^+$	4.15	3.8	0.35	PSI, TE	[3762]
Mo	?	K	K$^+$	4.23 ± 0.10	4.41 ± 0.01	−0.18 ± 0.10	PSI, TE	[645]
Mo	?	–	Mo$^+$	4.3 ± 0.1	4.20 ± 0.02	0.1 ± 0.1	PSI, TE	[132]
Mo	?	–	Mo$^+$	4.5 ± 0.1	4.19 ± 0.02	0.3 ± 0.1	PSI, TE	[954]
Mo	?	–	Mo$^+$	4.50	4.17	0.33	PSI, TE	[131]
Mo	?	–	Mo$^+$	4.6 ± 0.1	4.37 ± 0.02	0.2 ± 0.1	PSI, TE	[132]
Mo	?	–	Mo$^+$	4.7 ± 0.1	4.19 ± 0.02	0.5 ± 0.1	PSI, TE	[954]
Mo	?	KBr	K$^+$	4.90 ± 0.06	4.39 ± 0.05	0.51 ± 0.08	PSI, TE	[23,39]
Mo	?	Bi	Bi$^+$	4.96 ± 0.01	4.41 ± 0.02	0.55 ± 0.02	PSI, TE	[78]
Mo	?	In	In$^+$	5.02 ± 0.05	4.33 ± 0.07	0.69 ± 0.09	PSI, TE	[76,77]
Mo	?	–	Mo$^+$	5.1 ± 0.1	4.20 ± 0.02	0.9 ± 0.1	PSI, TE	[132]
Mo	?	–	Mo$^+$	5.1 ± 0.4	4.33 ± 0.07	0.8 ± 0.41	PSI, TE	[77]
Mo	?	KCl	K$^+$	5.10 ± 0.07	4.39 ± 0.05	0.71 ± 0.09	PSI, TE	[23,39]
Mo	?	–	Mo$^+$	5.4 ± 0.1	4.37 ± 0.02	1.0 ± 0.1	PSI, TE	[132]
Mean	–	–	–	–	–	**0.48 ± 0.31**	PSI, TE	–
M.P.V.	–	–	–	5.03 ± 0.06	4.31 ± 0.02	**0.72 ± 0.06**	various	Table 2
				73. Monocrystalline Tantalum				
Ta(100)	~100	Na	Na$^+$	4.20 ± 0.04	4.17 ± 0.04	0.03 ± 0.06	PSI, TE	[797]
M.P.V.	–	–	–	4.2	4.15 ± 0.05	**0.05 ± >0.05**	various	Table 2
Ta(110)	~100	Li	Li$^+$	4.8	4.80 ± 0.03	0.0 ± >0.03	PSI, TE	[786]
Ta(110)	~100	Na	Na$^+$	4.84 ± 0.04	4.82 ± 0.04	0.02 ± 0.06	PSI, TE	[797]
Ta(110)	~100	Na	Na$^+$	4.85 ± 0.05	4.81	0.04 ± >0.05	PSI, TE	[726]
Ta(110)	~100	L^h	L$^+$	4.85 ± 0.06	4.85	0.00 ± >0.05	PSI, TE	[279]
Mean	–	–	–	–	–	**0.02 ± 0.01**	PSI, TE	–
M.P.V.	–	–	–	4.84 ± 0.02	4.82 ± 0.06	**0.02 ± 0.06**	various	Table 2
Ta(111)	~100	Na	Na$^+$	4.00 ± 0.04	4.02 ± 0.04	−0.02 ± 0.06	PSI, TE	[797]
Ta(111)	~100	Na	Na$^+$	4.00 ± 0.05	3.98 ± 0.05	0.02 ± 0.07	PSI, TE	[726]
Mean	–	–	–	–	–	**0.00 ± 0.02**	PSI, TE	–
M.P.V.	–	–	–	4.00 ± 0.05	4.01 ± 0.04	**−0.01 ± 0.06**	various	Table 2
Ta(112)	~100	K	K$^+$	4.8	4.8 ± 0.05	0.0 ± >0.05	PSI, TE	[79]
				73. Polycrystalline Tantalum				
Ta(porous)	?	Cs	Cs$^+$	4.2	4.1	0.1	PSI, TE	[3762]
Ta–(112)^i	82	–	–	4.49 ± 0.04	4.34 ± 0.03	0.15 ± 0.05	TC	[803]
Ta	?	Na	Na$^+$	4.64 ± 0.03	4.30 ± 0.02	0.34 ± 0.04	PSI, TE	[81]
Ta	?	In	In$^+$	4.88 ± 0.05	4.33 ± 0.03	0.55 ± 0.06	PSI, TE	[76,77]
Ta	?	–	Ta$^+$	5.0 ± 0.5	4.33 ± 0.03	0.7 ± 0.5	PSI, TE	[77]
Ta	?	KCl	K$^+$	5.10 ± 0.01	4.27 ± 0.04	0.83 ± 0.04	PSI, TE	[23,2422]

Table 4 (*continued*)

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Ta	?	RbBr	Rb$^+$	5.13 ± 0.03	4.27 ± 0.04	0.86 ± 0.05	PSI, TE	[23,67]
Ta	?	RbCl	Rb$^+$	5.19 ± 0.03	4.27 ± 0.04	0.92 ± 0.05	PSI, TE	[23,67]
Mean	–	–	–	–	–	**0.56 ± 0.30**	TC, PSI, TE	–
M.P.V.	–	–	–	4.95 ± 0.20	4.20 ± 0.03	**0.75 ± 0.20**	various	Table 2

74. Monocrystalline Tungsten

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
W(100)	~100	K	K$^+$	4.54 ± 0.02	4.59 ± 0.03	−0.05 ± 0.04	PSI, TE	[82,261]
W(100)	~100	Ba	Ba$^+$	4.55 ± 0.03	4.52 ± 0.07	0.03 ± 0.08	PSI, TE	[92]
W(100)	~100	Sm	Sm$^+$	4.6	4.6	0.0	PSI, TE	[271]
W(100)	~100	Ba	Ba$^+$	4.6 ± 0.1	4.6 ± 0.1	0.0 ± 0.1	PSI, TE	[15,649]
W(100)	~100	K	K$^+$	4.6 ± 0.1	4.6 ± 0.1	0.0 ± 0.1	PSI, TE	[1659]
W(100)	~100	In	In$^+$	4.60	4.55	0.05	PSI, TE	[83]
W(100)	96	–	–	4.60 ± 0.04	4.59 ± 0.04	0.01 ± 0.06	TC	[630]
W(100)	~100	Cs	Cs$^+$	4.61 ± 0.07	4.65 ± 0.02	−0.04 ± 0.07	PSI, TE	[266]
W(100)	~100	Bi	Bi$^+$	4.62 ± 0.06	4.59 ± 0.05	0.03 ± 0.08	PSI, TE	[84]
W(100)	~100	Na	Na$^+$	4.66 ± 0.03	4.60 ± 0.03	0.06 ± 0.04	PSI, TE	[3103]
W(100)	~100	Cs	Cs$^+$	4.66 ± 0.11	4.60 ± 0.06	0.06 ± 0.13	PSI, TE	[280]
W(100)	95	–	–	4.69 ± 0.05	4.57 ± 0.00	0.12 ± 0.05	TC	[803]
W(100)	95	–	–	4.70 ± 0.04	4.61 ± 0.04	0.09 ± 0.06	TC	[2453]
Mean	–	–	–	–	–	**0.03 ± 0.05**	TC, PSI, TE	–
M.P.V.	–	–	–	4.62 ± 0.05	4.65 ± 0.02	**−0.03 ± 0.05**	various	Table 2
W(110)	~100	Ba	Ba$^+$	4.82 ± 0.06	5.04	−0.22 ± >0.06	PSI, TE	[87]
W(110)	~100	Cs	Cs$^+$	5.11	5.33 ± 0.04	−0.22 ± >0.04	PSI, TE	[2314]
W(110)	~100	Na	Na$^+$	5.14	5.04 ± 0.06	0.10 ± >0.06	PSI, TE	[87]
W(110)	~100	Na	Na$^+$	5.14	4.8 ± 0.1	0.34 ± >0.1	PSI, TE	[85]
W(110)	~100	Na	Na$^+$	5.14 ± 0.03	5.30 ± 0.03	−0.16 ± 0.04	PSI, TE	[3103]
W(110)	~100	Na	Na$^+$	5.2	5.2	0.0	PSI, TE	[2773]
W(110)	~100	Na	Na$^+$	5.25	5.27	−0.02	PSI, TE	[86,90]
W(110)	80	–	–	5.25 ± 0.02	4.90 ± 0.05	0.35 ± 0.05	TC	[630]
W(110)	>90	Na	Na$^+$	5.25 ± 0.05	5.25 ± 0.05	0.00 ± 0.07	PSI, TE	[86,90]
W(110)	~100	Li	Li$^+$	5.28 ± 0.03	5.30 ± 0.03	−0.02 ± 0.04	PSI, TE	[88]
W(110)	~100	Li	Li$^+$	5.30 ± 0.03	5.30 ± 0.03	0.00 ± 0.04	PSI, TE	[814]
Mean	–	–	–	–	–	**0.01 ± 0.11**	TC, PSI, TE	–
M.P.V.	–	–	–	5.28 ± 0.11	5.32 ± 0.02	**−0.04 ± 0.11**	various	Table 2
W(111)	~100	Na	Na$^+$	4.42 ± 0.03	4.40 ± 0.03	0.02 ± 0.04	PSI, TE	[3103]
W(111)	~100	Na	Na$^+$	4.44 ± 0.03	4.40 ± 0.03	0.04 ± 0.04	PSI, TE	[817]
W(111)	~100	Li	Li$^+$	4.44 ± 0.03	4.40 ± 0.03	0.04 ± 0.04	PSI, TE	[3103]
W(111)	~100	Li	Li$^+$	4.50 ± 0.03	4.40 ± 0.02	0.10 ± 0.04	PSI, TE	[88]
Mean	–	–	–	–	–	**0.05 ± 0.03**	PSI, TE	–
M.P.V.	–	–	–	4.45 ± 0.04	4.45 ± 0.03	**0.00 ± 0.05**	various	Table 2
W(112)	~100	Gd	Gd$^+$	4.70 ± 0.02	4.85 ± 0.07	−0.15 ± 0.07	PSI, TE	[91]
W(112)	~100	Er	Er$^+$	4.70 ± 0.02	4.85 ± 0.07	−0.15 ± 0.07	PSI, TE	[91]
W(112)	~100	Er	Er$^+$	4.72 ± 0.06	4.85 ± 0.07	−0.13 ± 0.09	PSI, TE	[91]
Mean	–	–	–	–	–	**−0.15 ± 0.07**	PSI, TE	–
M.P.V.	–	–	–	4.70 ± 0.01	4.78 ± 0.03	**−0.08 ± 0.03**	various	Table 2

74. Polycrystalline Tungsten

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
W	?	–	W$^+$	4.8 ± 0.6	4.58 ± 0.03	0.2 ± 0.6	PSI, TE	[77]
W	?	Na	Na$^+$	4.95 ± 0.05	4.61	0.34 ± >0.05	PSI, TE	[85]
W–(310)^f	46.3	–	–	4.96 ± 0.03	4.34 ± 0.05	0.62 ± 0.06	TC	[630]
W–(100)	46	–	–	4.99 ± 0.05	4.56 ± 0.01	0.43 ± 0.05	TC	[803]
W–(310)	46.3	–	–	4.99 ± 0.06	4.38 ± 0.05	0.61 ± 0.08	TC	[2453]
W–(100)	46	–	–	5.00 ± 0.05	4.56 ± 0.01	0.44 ± 0.05	TC	[2453]
W	?	In	In$^+$	5.05 ± 0.05	4.58 ± 0.05	0.47 ± 0.07	PSI, TE	[94]
W	?	KCl	K$^+$	5.09 ± 0.02	4.42 ± 0.02	0.67 ± 0.03	PSI, TE	[36]
W	?	KCl	K$^+$	5.09 ± 0.06	4.48 ± 0.06	0.61 ± 0.08	PSI, TE	[23]
W–(110)	<35	–	–	5.09 ± 0.10	4.52 ± 0.12	0.57 ± 0.16	TC	[283]
W	?	In	In$^+$	5.10	4.58 ± 0.05	0.52 ± >0.05	PSI, TE	[94]
W–(110)	25	–	–	5.12	4.46	0.66	TC	[3844]
W	?	KF	K$^+$	5.12 ± 0.02	4.48 ± 0.06	0.64 ± 0.06	PSI, TE	[23]
W–(112)	33.6	–	–	5.13 ± 0.04	4.62 ± 0.02	0.51 ± 0.04	TC	[630]
W	?	In	In$^+$	5.14 ± 0.03	4.58 ± 0.03	0.56 ± 0.04	PSI, TE	[76,77]
W	?	Bi	Bi$^+$	5.14 ± 0.05	4.60 ± 0.04	0.54 ± 0.06	PSI, TE	[84,93]

(*continued on next page*)

Table 4 (*continued*)

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
W–(110)	35.2	–	–	5.15 ± 0.03	4.63 ± 0.01	0.52 ± 0.03	TC	[281]
W	?	LiI	Li$^+$	5.16 ± 0.05	4.61 ± 0.03	0.55 ± 0.06	PSI, TE	[281]
W	?	LiCl	Li$^+$	5.18 ± 0.03	4.57 ± 0.04	0.61 ± 0.05	PSI, TE	[281]
W–(110)	35	–	–	5.18 ± 0.03	4.61 ± 0.03	0.57 ± 0.04	PSI, TE	[630]
W	?	LiCl	Li$^+$	5.19 ± 0.03	4.48 ± 0.06	0.71 ± 0.07	PSI, TE	[23]
W	?	LiF	Li$^+$	5.19 ± 0.05	4.60 ± 0.05	0.59 ± 0.07	PSI, TE	[281]
W	?	NaBr	Na$^+$	5.20 ± 0.02	4.48 ± 0.06	0.72 ± 0.06	PSI, TE	[23]
W	?	LiCl	Li$^+$	5.20 ± 0.02	4.47 ± 0.04	0.73 ± 0.04	PSI, TE	[37]
W	?	LiBr	Li$^+$	5.20 ± 0.04	4.60 ± 0.05	0.60 ± 0.06	PSI, TE	[281]
W	?	NaCl	Na$^+$	5.21 ± 0.02	4.48 ± 0.06	0.73 ± 0.06	PSI, TE	[23]
W	?	RbCl	Rb$^+$	5.21 ± 0.06	4.48 ± 0.06	0.73 ± 0.08	PSI, TE	[23]
W	?	NaCl	Na$^+$	5.22 ± 0.02	4.47 ± 0.04	0.75 ± 0.04	PSI, TE	[37]
W	?	LiF	Li$^+$	5.22 ± 0.07	4.48 ± 0.06	0.74 ± 0.09	PSI, TE	[23]
W	?	NaCl	Na$^+$	5.23 ± 0.01	4.42 ± 0.02	0.81 ± 0.02	PSI, TE	[36]
W	?	NaI	Na$^+$	5.23 ± 0.02	4.48 ± 0.06	0.75 ± 0.06	PSI, TE	[23]
W	?	LiBr	Li$^+$	5.23 ± 0.02	4.48 ± 0.06	0.75 ± 0.06	PSI, TE	[23,37]
W–(110)	80	–	–	5.25 ± 0.02	4.90 ± 0.05	0.35 ± 0.05	TC	[630]
W–(110)	80	–	–	5.26 ± 0.02	4.87 ± 0.05	0.39 ± 0.06	TC	[2453]
W	?	LiI	Li$^+$	5.26 ± 0.02	4.48 ± 0.06	0.78 ± 0.06	PSI, TE	[23]
W	?	LiI	Li$^+$	5.27 ± 0.01	4.47 ± 0.04	0.80 ± 0.04	PSI, TE	[37]
Mean	–	–	–	–	–	**0.60 ± 0.13**	TC, PSI, TE	–
M.P.V.	–	–	–	5.17 ± 0.05	4.56 ± 0.03	**0.61 ± 0.06**	various	Table 2

75. Monocrystalline Rhenium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Re(0001)	~100	La	La$^+$	5.15 ± 0.21	5.15 ± 0.10	0.00 ± 0.23	PSI, TE	[96]
Re(0001)	~100	Ce	Ce$^+$	5.15 ± 0.21	5.15 ± 0.10	0.00 ± 0.23	PSI, TE	[96]
Re(0001)	~100	Er	Er$^+$	5.15 ± 0.21	5.15 ± 0.10	0.00 ± 0.23	PSI, TE	[96]
Re(0001)	~100	Gd	Gd$^+$	5.15 ± 0.34	5.15 ± 0.10	0.00 ± 0.35	PSI, TE	[96]
Re(0001)	~100	Tm	Tm$^+$	5.15 ± 0.34	5.15 ± 0.10	0.00 ± 0.35	PSI, TE	[96]
Mean	–	–	–	–	–	**0.00 ± 0.28**	PSI, TE	–
M.P.V.	–	–	–	5.15 ± <0.34	5.30 ± 0.21	**−0.15 ± <0.40**	various	Table 2

75. Polycrystalline Rhenium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Re	?	NaI	Na$^+$	5.01	5.0 ± 0.1	0.0 ± >0.1	PSI, TE	[99]
Re	?	Na	Na$^+$	5.06	5.0 ± 0.1	0.1 ± >0.1	PSI, TE	[99]
Re	?	NaCl	Na$^+$	5.06	5.0 ± 0.1	0.1 ± >0.1	PSI, TE	[99]
Re	?	NaBr	Na$^+$	5.11	5.0 ± 0.1	0.1 ± >0.1	PSI, TE	[99]
Re	?	Na	Na$^+$	5.14	4.93 ± 0.04	0.21 ± >0.04	PSI, TE	[53]
Re	?	NaCl	Na$^+$	5.14	4.93 ± 0.04	0.21 ± >0.04	PSI, TE	[53]
Re	?	Li	Li$^+$	5.21 ± 0.01	4.98 ± 0.03	0.23 ± 0.03	PSI, TE	[54]
Re	?	In	In$^+$	5.31 ± 0.03	4.93 ± 0.04	0.38 ± 0.05	PSI, TE	[97]
Re	?	Li	Li$^+$	5.34	4.93 ± 0.04	0.41 ± >0.04	PSI, TE	[53]
Re	?	LiCl	Li$^+$	5.34	4.93 ± 0.04	0.41 ± >0.04	PSI, TE	[53]
Re	?	Bi	Bi$^+$	5.35 ± 0.05	4.85 ± 0.05	0.50 ± 0.07	PSI, TE	[100]
Re	?	In	In$^+$	5.38 ± 0.03	4.93 ± 0.04	0.45 ± 0.05	PSI, TE	[97]
Re	?	Ca	Ca$^+$	5.38 ± 0.03	4.93 ± 0.04	0.45 ± 0.05	PSI, TE	[97]
Re	?	In	In$^+$	5.39 ± 0.05	4.99 ± 0.05	0.40 ± 0.07	PSI, TE	[94]
Re	?	–	Re$^+$	5.4 ± 0.6	4.93 ± 0.04	0.5 ± 0.6	PSI, TE	[77]
Re	?	In	In$^+$	5.40	4.99 ± 0.05	0.41 ± >0.05	PSI, TE	[94]
Re	?	Mg	Mg$^+$	5.40 ± 0.05	4.93 ± 0.04	0.47 ± 0.06	PSI, TE	[97]
Re	?	NaI	Na$^+$	5.41 ± 0.05	4.95 ± 0.05	0.46 ± 0.07	PSI, TE	[23]
Re	?	NaCl	Na$^+$	5.42	4.93	0.49	PSI, TE	[23]
Re	?	NaCl	Na$^+$	5.42	4.97	0.45	PSI, TE	[23]
Re	?	NaCl	Na$^+$	5.42 ± 0.02	4.95 ± 0.05	0.47 ± 0.05	PSI, TE	[23]
Re	?	NaI	Na$^+$	5.43 ± 0.01	4.93 ± 0.02	0.50 ± 0.02	PSI, TE	[23]
Re	?	NaI	Na$^+$	5.43 ± 0.01	4.95 ± 0.01	0.48 ± 0.01	PSI, TE	[23]
Re	?	Ag	Ag$^+$	5.43 ± 0.02	4.93 ± 0.04	0.50 ± 0.04	PSI, TE	[97]
Re	?	Ca	Ca$^+$	5.43 ± 0.02	4.93 ± 0.04	0.50 ± 0.04	PSI, TE	[76,77]
Re	?	NaCl	Na$^+$	5.43 ± 0.04	4.96 ± 0.05	0.47 ± 0.06	PSI, TE	[23]
Re	?	Ca	Ca$^+$	5.44 ± 0.03	4.93 ± 0.04	0.51 ± 0.05	PSI, TE	[97]
Re	?	NaI	Na$^+$	5.45	4.97	0.48	PSI, TE	[23]
Re	?	NaI	Na$^+$	5.45	4.94	0.51	PSI, TE	[23]
Re	?	Ca	Ca$^+$	5.46 ± 0.02	4.93 ± 0.04	0.53 ± 0.04	PSI, TE	[97]
Re	?	LiBr	Li$^+$	5.48 ± 0.02	4.95 ± 0.05	0.53 ± 0.05	PSI, TE	[23]
Re	?	LiI	Li$^+$	5.49 ± 0.02	4.95 ± 0.05	0.54 ± 0.05	PSI, TE	[23,38]
Re	?	LiCl	Li$^+$	5.53 ± 0.02	4.95 ± 0.05	0.58 ± 0.05	PSI, TE	[23]
Re	?	LiI	Li$^+$	5.53 ± 0.02	5.00 ± 0.01	0.53 ± 0.02	PSI, TE	[101]

Table 4 (*continued*)

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Re	?	NaCl	Na$^+$	5.58	5.18	0.40	PSI, TE	[23]
Re	?	NaCl	Na$^+$	5.70	5.36	0.34	PSI, TE	[23]
Re	?	NaI	Na$^+$	5.76	5.37	0.39	PSI, TE	[23]
Re	?	NaI	Na$^+$	5.81	5.41	0.40	PSI, TE	[23]
Mean	–	–	–	–	–	**0.41 ± 0.14**	PSI, TE	–
M.P.V.	–	–	–	5.41 ± 0.04	4.96 ± 0.05	**0.45 ± 0.06**	various	Table 2

77. Monocrystalline Iridium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Ir(111)	~100	Bi	Bi$^+$	5.75 ± 0.05	5.75 ± 0.05	0.00 ± 0.07	PSI, TE	[105,409]
Ir(111)	~100	Yb	Yb$^+$	5.75 ± 0.10	5.75 ± 0.10	0.00 ± 0.14	PSI, TE	[104]
Ir(111)	~100	Bi	Bi$^+$	5.79 ± 0.03	5.74 ± 0.06	0.05 ± 0.07	PSI, TE	[102,410]
Ir(111)	~100	Tl	Tl$^+$	5.79 ± 0.03	5.74 ± 0.06	0.05 ± 0.07	PSI, TE	[102,410]
Ir(111)	~100	K	K$^+$	5.8	5.75 ± 0.05	0.05 ± >0.05	PSI, TE	[252,411]
Ir(111)	~100	Ba	Ba$^+$	5.8	5.80 ± 0.05	0.0 ± >0.05	PSI, TE	[649]
Ir(111)	~100	In	In$^+$	5.80 ± 0.03	5.80 ± 0.03	0.00 ± 0.04	PSI, TE	[103]
Mean	–	–	–	–	–	**0.02 ± 0.02**	PSI, TE	–
M.P.V.	–	–	–	5.76 ± 0.04	5.75 ± 0.06	**0.01 ± 0.07**	various	Table 2

77. Polycrystalline Iridium

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Ir	?	NaBr	Na$^+$	5.72 ± 0.03	5.15 ± 0.03	0.57 ± 0.04	PSI, TE	[68]
Ir–(111)	81	–	–	5.73 ± 0.01	5.36 ± 0.07	0.37 ± 0.07	TC	[803]
Ir	?	NaCl	Na$^+$	5.73 ± 0.02	5.15 ± 0.03	0.58 ± 0.04	PSI, TE	[68]
Ir	?	Bi	Bi$^+$	5.80 ± 0.05	5.40 ± 0.05	0.40 ± 0.07	PSI, TE	[106,667]
Mean	–	–	–	–	–	**0.48 ± 0.10**	TC, PSI, TE	–
M.P.V.	–	–	–	5.75 ± 0.04	5.28 ± 0.04	**0.47 ± 0.06**	various	Table 2

78. Monocrystalline Platinum

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Pt(111)	~100	Li	Li$^+$	5.75 ± 0.02	5.86 ± 0.06[b]	−0.11 ± 0.06	PSI, various	[167]
Pt(111)	~100	Li	Li$^+$	5.76 ± 0.02	5.86 ± 0.06[b]	−0.10 ± 0.06	PSI, various	[167]
Pt(111)	~100	Li	Li$^+$	5.77 ± 0.02	5.86 ± 0.06[b]	−0.09 ± 0.06	PSI, various	[167]
Pt(111)	~100	Li	Li$^+$	5.80 ± 0.02	5.86 ± 0.06[b]	−0.06 ± 0.06	PSI, various	[167]
Pt(111)	~100	Li	Li$^+$	5.91 ± 0.02	5.86 ± 0.06[b]	0.05 ± 0.06	PSI, various	[167]
Mean	–	–	–	–	–	**−0.06 ± 0.06**	PSI, various	–
M.P.V.	–	–	–	5.80 ± 0.06	5.84 ± 0.05	**−0.04 ± 0.08**	various	Table 2

78. Polycrystalline Platinum

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Pt	?	Na	Na$^+$	5.44	5.27 ± 0.08[b]	0.17 ± >0.08	PSI, various	[3336]
Pt	?	Na	Na$^+$	5.49 ± 0.01	5.27 ± 0.08[b]	0.22 ± 0.08	PSI, various	[50]
Pt	?	Cs	Cs$^+$	5.5	5.45 ± 0.05	0.05 ± >0.05	PSI, TE	[98]
Pt	?	K	K$^+$	5.52 ± 0.05	5.41 ± 0.05	0.11 ± >0.07	PSI, TE	[282]
Pt	?	NaNO$_3$	Na$^+$	5.54 ± 0.07	5.27 ± 0.08[b]	0.27 ± 0.11	PSI, various	[178]
Pt	?	NaNO$_3$	Na$^+$	5.56	5.27 ± 0.08[b]	0.29 ± >0.08	PSI, various	[178]
Pt	?	Na	Na$^+$	5.6 ± 0.1	5.27 ± 0.08[b]	0.3 ± 0.13	PSI, various	[75]
Pt	?	NaBr	Na$^+$	5.66	5.27 ± 0.08[b]	0.39 ± >0.08	PSI, various	[58]
Pt	?	Bi	Bi$^+$	5.77 ± 0.05	5.13 ± 0.05	0.64 ± 0.07	PSI, TE	[106,667]
Mean	–	–	–	–	–	**0.27 ± 0.16**	PSI, various	–
M.P.V.	–	–	–	5.58 ± 0.11	5.30 ± 0.07	**0.28 ± 0.13**	various	Table 2

79. Polycrystalline Gold

Surface	δ_m (%)	Beam	Ion	ϕ^+ (eV)	ϕ^e (eV)	$\Delta\phi^*$ (eV)	Meths.	Refs.
Au/Si(111)	?	Cs, Li	Cs$^+$	5.7[a]	5.31 ± 0.07[b]	0.4 ± >0.07	CPD, various	[1342]
M.P.V.	–	–	–	5.7	5.30 ± 0.04	**0.4 ± >0.04**	various	Table 2

[a]Each of the values of ϕ^+ (e.g., 4.8 eV for Al and 5.7 eV for Au) is calculated by the present author using each of the data included in the corresponding reference.

[b]Each value (ϕ^e) is taken tentatively from the most probable value listed in Table 2 [1351] because each of the corresponding references [611,1342,1342,3336, etc.] has no data on ϕ^e for the specimen itself (Al, Si, Pt or Au) under study.

[c]The mean (revised) for Si(110)^p is obtained after disregarding the last two data [1472], which correspond to the composite surface covered partially with the reaction products between Na (or K) and Si (see Footnote 434 in Table 1).

[d]The values of ϕ^e = 4.83 and 4.80 eV for Si(111)^p [73] and Si(111)^n [72] are corrected from those of 4.07 and 4.04 eV, respectively, by using Eq. (8) (see Footnote 66 in Table 1). It should be noted that the former (4.83 ± 0.04 eV) is essentially equal to 4.86 ± 0.11 eV determined directly for the same specimen by CPD [73]. For further information about the data on Si(100)–Si(111) [72–75, etc.], see Footnotes 63–70 in Table 1.

[e]The mean (revised) for Si(111) is based on these data alone whose ϕ^e is determined by CPD or calculated from Eq. (8).

[f]The expression such as W–(310) denotes that the surface consists mainly (δ_m = 46.3%) of the (310) face of W [630]. For further information about the surface, see W(D) [489] in Table 6. On the other hand, Nb–(100) consists mainly (68%) of the (100) plane (see Table 2 in Ref. [803]).

[g]The authors [74] suggest that the discrepancy of $\phi^+ - \phi^e \neq 0$ eV would be accounted by surface contamination of Si(100)[n] (see Footnotes 63 and also 64 in Table 1).

[h]L represents lanthanides for measuring ϕ^+ of Ta(110) by PSI [279] (see Footnote 466 in Table 1).

[i]Ta–(112) designates that its surface consists mainly of the (112) face with $\delta_m = 82\%$ [803], similarly as in other cases of Nb and W (see Footnote f).

Table 5
Summary of the thermionic contrast ($\Delta\phi^*$) determined by the two methods of the "mean" originating from each common pair of ϕ^+ and ϕ^e measured for the same specimen under virtually the same condition and of the "most probable value" due to heterogeneous pairs measured separately for various specimens under different conditions by a variety of workers (see Table 4 and also the values in Table 1).

No.	Surface	$\Delta\phi^*$ (eV) (mono)			$\Delta\phi^*$ (eV) (poly)		
		Mean	M.P.V.	[1351]	Mean	M.P.V.	[1351]
6	C(HOPG)	0.07 ± 0.10	−0.01 ± 0.13	–	–	–	–
6	C(film)[a]	−0.02 ± 0.12	0.03 ± 0.06	–	–	–	–
13	Al(poly)	–	–	–	0.66 ± >0.06	0.6 ± 0.1	0.6
14	Si(100)	–[b]	−0.10 ± 0.14	0.02 ± 0.19	–	–	–
14	Si(110)	−0.04 ± 0.04	−0.08 ± 0.24	–	–	–	–
14	Si(111)	0.05 ± 0.03	−0.03 ± 0.11	0.03 ± 0.12	–	–	–
14	Si(poly)	–	–	–	0.5 ± >0.1	–	–
41	Nb(100)	0.14[c]	0.02 ± >0.05	–	–	–	–
41	Nb(110)	−0.06 ± 0.10	−0.03 ± 0.11	0.04 ± 0.05	–	–	–
41	Nb(111)	−0.04 ± 0.06	−0.11 ± 0.11	0.02 ± 0.05	–	–	–
41	Nb(112)	−0.01 ± >0.05	0.11 ± >0.1	–	–	–	–
41	Nb(poly)	–	–	–	0.70 ± 0.12	0.70 ± 0.07	0.78 ± 0.11
42	Mo(100)	0.01 ± 0.01	0.00 ± 0.09	−0.03 ± 0.08	–	–	–
42	Mo(110)	0.03 ± 0.04	0.1 ± >0.03	0.03 ± 0.30	–	–	–
42	Mo(111)	0.02 ± 0.04	−0.12 ± 0.09	−0.02 ± 0.15	–	–	–
42	Mo(112)	0.03 ± 0.04	0.1 ± >0.03	0.03 ± 0.30	–	–	–
42	Mo(poly)	–	–	–	0.48 ± 0.31	0.72 ± 0.06	0.66 ± 0.07
73	Ta(100)	0.03 ± 0.06	0.05 ± >0.05	0.03 ± 0.06	–	–	–
73	Ta(110)	0.02 ± 0.01	0.02 ± 0.06	0.04 ± 0.07	–	–	–
73	Ta(111)	0.00 ± 0.02	−0.01 ± 0.06	0.00 ± 0.06	–	–	–
73	Ta(poly)	–	–	–	0.56 ± 0.30	0.75 ± 0.20	0.71 ± 0.23
74	W(100)	0.03 ± 0.05	−0.03 ± 0.05	0.03 ± 0.06	–	–	–
74	W(110)	0.01 ± 0.11	−0.04 ± 0.11	−0.02 ± 0.09	–	–	–
74	W(111)	0.05 ± 0.03	0.00 ± 0.05	0.07 ± 0.06	–	–	–
74	W(112)	−0.15 ± 0.07	−0.08 ± 0.03	0.07 ± 0.32	–	–	–
74	W(poly)	–	–	–	0.60 ± 0.13	0.61 ± 0.06	0.59 ± 0.06
75	Re(0001)	0.00 ± 0.28	−0.15 ± <0.40	0.02 ± 0.19	–	–	–
75	Re(poly)	–	–	–	0.41 ± 0.14	0.45 ± 0.06	0.45 ± 0.05
77	Ir(111)	0.02 ± 0.02	0.01 ± 0.07	−0.01 ± 0.05	–	–	–
77	Ir(poly)	–	–	–	0.48 ± 0.10	0.47 ± 0.06	0.48 ± 0.04
78	Pt(111)	−0.06 ± 0.06	−0.04 ± 0.08	−0.06 ± 0.08	–	–	–
78	Pt(poly)	–	–	–	0.27 ± 0.16	0.28 ± 0.13	0.34 ± 0.14
79	Au(poly)	–	–	–	0.4 ± >0.07	0.4 ± >0.04	0.4
	Average[d]	**0.00 ± 0.06**	**−0.02 ± 0.07**	**0.02 ± 0.03**	–	–	–
	Range[e]	–	–	–	**~0.3–0.7**	**~0.3–0.7**	**~0.3–0.8**

[a]The value of $\Delta\phi^* = -0.02$ or $0.03 \approx 0.0$ eV for C(film) is substantially equal to that (0.07 or $-0.01 \approx 0.0$ eV) for C(HOPG), thereby showing that the graphitic film formed on a foreign substrate (typically, Mo, Re or Pt) has usually the same thermionic property with monocrystalline graphite. In other words, carbon is subject to forming a two-dimensional film with the graphitic monocrystalline structure under some conditions such as ~1700 K on Ir(111) ($\phi^+ = \phi^e = 4.5$ eV) [168] and ~1500 K on Pt–W(8%) ($\phi^+ = \phi^e = 4.50$ eV) [108]. For further information about the chemico-physical peculiarity of the graphitic film in contrast to a carbidic one, see Section 4.2.4 in Ref. [1351].

[b]The mean of $\Delta\phi^* = 0.20 \pm 0.10$ eV evaluated for Si(100) from the data in Ref. [74] alone is disregarded because of the reason outlined in Footnote g in Table 4.

[c]This value of 0.14 eV for Nb(100) may be disregarded in statistical examination of $\Delta\phi^*$ because it is based on a single datum alone.

[d]As may be seen in the last 2 line, the overall average for monocrystalline surfaces has $\Delta\phi^* = 0.00, -0.02$ or $0.02 \approx 0.0$ eV as a whole covering the 21, 23 or 18 surface species, just as predicted by theory.

[e]As shown in the last line, on the other hand, $\Delta\phi^*$ for any polycrystalline surfaces studied here is much larger than 0.0 eV for any species, ranging from ~0.3 to ~0.8 eV, just as expected from Eqs. (1) and (2).

In addition, we may cite such an example that a Mo-specimen [125,129,572] is assigned later to have the (100) plane arranged naturally by recrystallization of the Mo ribbon through thermal annealing for very long hours above ~2200 K [573], where $\phi^+ = 4.28 \pm 0.05$ [129,572,573] or 4.38 ± 0.01 eV [125] (see Footnote 167 in Table 1) is in good agreement with our best estimates of $\phi^+ = 4.38 \pm 0.08$ eV and also $\phi^e = 4.38 \pm 0.03$ eV for Mo(100) (see Table 2). Consequently, the annealed specimen may be assigned to be Mo(100) ($\delta_m = 1$ and $\Delta\phi^* = 0$ eV). A persuasive example may be added for a nanocrystalline Ni [4142]. Namely, ϕ^e is found to increase from 3.92 ± 0.05 eV to 4.40 ± 0.05 eV as the specific grain boundary length (per grain size of 1 μm^2) decreases from ~12 to 0.3 μm according to the recrystallization due to annealing from ~300 up to 773 K [4142]. About such a thermal instability in surface crystal structure mentioned just above, further information may be obtained from Section 4.5 in Ref. [1351].

As may be seen in the 6th column on many lines much below W(650) in Table 1, the data on $\phi^+ \approx 4.5$–4.7 eV $\approx \phi^e$ (=4.5–4.6 eV accepted today for W) are reported for many "polycrystalline" tungsten specimens, which have typically $\phi^+ = 4.49$ and $\phi^e = 4.59$ eV [823] (see Footnotes 170 and 296 in Table 1), 4.65 and 4.56 eV [3834] and 4.67 and 4.57 eV [3055]. They may possibly consist predominantly ($\delta_m > 0.9$) of W(100) without each worker's recognition if the data on both ϕ^+ and ϕ^e are free from systematic errors. In consequence, such data may possibly afford to many workers the incorrect apprehension or conclusion that $\Delta\phi^*$ of W is always negligibly small to be less than ~0.1 eV instead of ~0.6 ± 0.1 eV (see Table 5) to be expected usually.

If the various specimens mentioned above [[3–9], etc., ranging to [3907]] consist of mainly ($\delta_m > 0.9$) monocrystalline surfaces owing to thermal recrystallization, then, such analysis as taking ϕ^e instead of ϕ^+ may hardly yield unreasonable results from the data on positive ion emission from apparent polycrystals. If not or little so, on the other hand, any analytical results obtained by employment of ϕ^e may be affected by systematic errors according to the degree of inhomogeneity in work function and hence to the size of $\Delta\phi^*$ up to ~0.6 eV.

In a typical case [3863], the ionization efficiency (β^+) of Na emitted as Na^+ from a Pt surface heated to 1200 or 1500 K is theoretically calculated from Eq. (5) to be respectively 0.94 or 0.89 by taking $\phi^+ = 5.5$ eV [98], which is nearly the same with the most probable value of 5.6 ± 0.1 eV [1351, Here]. Employment of $\phi^e = 5.3$ eV [12,1351,1354, Here], on the other hand, would yield $\beta^+ = 0.70$ or 0.63, thereby decreasing by 26 or 29% in comparison with the former, according to $\Delta\phi^* = 0.2$ eV. In another case of Na^+ from W ($\Delta\phi^* = 0.61$ eV, see Table 5) at the same temperatures just above, on the other hand, employment of $\phi^e = 4.56$ eV (see the 3rd column for W(poly) in Table 2) would afford a very small value of $\beta^+ = 0.002$ or 0.006, whilst that of $\phi^+ = 5.17$ eV (see 4th column for W(poly) in Table 2) would yield such a much larger value as $\beta^+ = 0.40$ or 0.39, thus demonstrating that the neglect of $\Delta\phi^*$ is subject to committing a large systematic error to the analytical results of positive ion emission from polycrystals.

The importance of $\Delta\phi^*$ is concerned also with the Schottky equation [251]:

$$\phi + E^+ = E^0 + I, \tag{9}$$

where E^+ is the desorption energy of positive ion (M^+), E^0 is that of neutral atom (M), and I is the ionization energy of M (see Fig. 25 [256] in Ref. [1351]). Here, E^+ and E^0 are determinable from the data either on adsorption lifetimes (τ^+ and τ^0) according to Frenckel's equation [14,15,86,178,260], on desorption rate constants (k^+ and k^0) [98,282,397] or on the slope of an Arrhenius plot of $\ln i^+ T^n$ vs. $1/T$ [77]. Here, i^+ is the ion current of M^+, and n = 1/2 [77]. Generally, E^0 can be determined from a similar plot (n = 1) mentioned just above after converting M into M^+ by electron impact of M [77]. In the case of self-surface ionization (SSI, see Section 2.3), E^0 can be calculated from the data on the standard heat of formation in thermochemical tables [26–28]. Unless the surface under study is substantially both clean and monocrystalline, ϕ^+ instead of ϕ^e should be employed as ϕ in Eq. (9). Otherwise, the energy cycle of $\Delta E^* \equiv (\phi^e + E^+) - (E_0 + I)$ yields $-\Delta\phi^* \neq 0$ even if the other three terms are free from errors. Such failure in closing the cycle ($\Delta E^* \neq 0$) is reported by several authors [132,137,804,924,3869–3871], where SSI on polycrystalline metals (Mo, Ta, W) is studied together with the emissions of neutral atom and electron, but where ϕ^+ itself (or $\Delta\phi^*$) is neither considered nor measured. Typically, the data on Ta [137] yields $\Delta E^* \equiv (\phi^e + E^+) - (E^0 + I) = (4.19 \pm 0.02 + 10.0 \pm 0.3) - (7.97 \pm 0.03 + 7.3 \pm 0.3) = -1.1 \pm 0.4$ eV, falling to close the cycle by 1.1 eV. There is still lacking -0.4 eV even for the limit values [137]. This is mainly because ϕ^e is taken as ϕ in Eq. (9) and partly because the other values are not so accurate as ϕ^e. Here, $\phi^e = 4.19 \pm 0.02$ eV [137] is equal to 4.20 ± 0.03 eV (see Table 2) but much smaller than $\phi^+ = 4.95 \pm 0.20$ eV recommended for Ta (Table 2). Citation of the latter (ϕ^+) could reduce ΔE^* from -1.1 to about -0.3 eV, which covers amply the above limit (-0.4 eV). Similarly, the data on E^+, E^0 and ϕ^e for Re [76,77] yield such an unreasonable result that $\Delta E^* = (4.93 + 10.2) - (7.7 + 7.87) = -0.44$ eV $\neq 0$ when $\phi^e = 4.93 \pm 0.04$ eV [77] (see Table 1) is employed as ϕ in Eq. (9).

On the other hand, adoption of $\phi^+ = 5.43$ eV (larger than $\phi^e = 4.93$ eV by $\Delta\phi^* = 0.50$ eV for Re) [76,77] (see Table 1) affords a reasonable result of $\Delta E^* = 0.06$ eV ≈ 0.0 eV. Similarly to Mo [76,77], employment of $\phi^+ = 5.02 \pm 0.05$ eV as ϕ yields $\Delta E^* = -0.08$ eV ≈ 0.0 eV, in contrast to $\Delta E^* = -0.77$ eV $\neq 0$ owing to $\phi^e = 4.33 \pm 0.07$ eV. In the latter case, $\Delta E^* = -0.77$ eV is nearly equal to $-\Delta\phi^* \equiv \phi^e - \phi^+ = -0.69 \pm 0.09$ eV, where the difference of -0.08 eV between -0.77 and -0.69 eV is mainly due to the errors in E^+ and/or E^0 because $\Delta\phi^* = 0.69 \pm 0.09$ eV well accords with our most probable value (M.P.V.) of 0.72 ± 0.06 eV for Mo (see Table 5). These examples indicate that employment of ϕ^e instead of ϕ^+ falls to close the Schottky cycle by $\Delta\phi^*$ even if the other data (E^+, E^0 and I) themselves are essentially free from any error.

Let's consider another case of PSI on a monocrystalline surface instead of the polycrystalline ones exemplified above. When Cs^+ and Cs are desorbed from a substantially clean surface of W(100) with $\phi^e = 4.65 \pm 0.02$ eV [266], we find $\Delta E^* = (4.65 \pm 0.02 + 2.05 \pm 0.05) - (2.77 \pm 0.05 + 3.89) = 0.04 \pm 0.07 \approx 0.0$ eV, showing clearly that even adoption of ϕ^e affords the reasonable result in a monocrystalline surface system. Of course, adoption of $\phi^+ = 4.61 \pm 0.07$ eV [266] yields $\Delta E^* = 0.00 \pm 0.10$ eV, just closed exactly. This is because W(100) has the most probable values of $\phi^e = 4.65 \pm 0.02$ and $\phi^+ = 4.62 \pm 0.06$ eV (see Table 2), essentially equivalent between the two within the error of 0.03 ± 0.06 eV. An interesting information about the dependence of E^+ upon ϕ^+ may be acquired from Table 9 and Section 7.1 in Ref. [1351].

As described above by citing some of the typical examples, consideration of $\Delta\phi^* \neq 0$ inherent in polycrystalline surfaces is always necessary to avoid systematic errors in quantitative analysis of experimental data on PSI on any polycrystals, which have long been employed widely as useful and convenient ionizing materials in many fields of both physics and chemistry.

In addition, both theoretical and experimental studies of $\Delta\phi^*$ afford us a clue to the very important problem how the effective work functions of ϕ^e and ϕ^+ for polycrystals depend upon the surface components (F_i and ϕ_i) and particularly upon both $\delta_m (\equiv F_m)$ and ϕ_m, as will be discussed next together with those of the "submonocrystals" in Sections 4.2–4.5.

From the viewpoint mentioned above, all of the data on $\Delta\phi^*$ surveyed by the present author are listed in Table 4, where each of the data on ϕ^+ is achieved at the temperatures high enough to keep the ionizing surface essentially clean even during sample

beam incidence (see Section 2.2 in Ref. [1351]). In the first column in Table 4, a typical example of W–(310) [630] means that the polycrystalline surface of W consists mainly ($\delta_m = 46.3\% = 0.463$ in fractional surface area) of the (310) plane.

Similarly as in Table 1, the "Beam" and "Ion" in the 3rd and 4th columns in Table 4, respectively, show the species of probing atom (or molecule) impinging upon the surface under investigation and that of ion produced from the atom (or molecule) usually by PSI. Thus, the value of ϕ^+ in the 5th column is either determined by experiment usually according to a semi-Saha–Langmuir plot (see Section 4.2.1 in Ref. [1351]) or calculated by theory using Eq. (1).

Each value of ϕ^e in the 6th column is determined usually by TE according to the Richardson equation in a separate experiment, where nearly the same surface condition during TE and PSI on the same specimen is maintained by selection of suitable experimental conditions (namely, P_r, T and incident beam intensity), irrespective of the beam incidence (see Section 4.1 in Ref. [1351]). Needless to say, ϕ^e as well as ϕ^+ is determined in the temperature range high enough to avoid sample adsorption effect upon the surface under study (see Fig. 17 [104] in Ref. [1351]). Theoretical calculation (TC) of both ϕ^+ and ϕ^e is made, of course, for the same specimen by using the published data on F_i's and ϕ_i's (see Section 4.2).

The values of $\Delta\phi^*$ ($\equiv \phi^+ - \phi^e$) thus determined experimentally or theoretically for various surfaces by many workers are given in the 7th column in Table 4. The 2nd line above the last for each surface species shows the mean value (Mean) of $\Delta\phi^*$ based on the data (ϕ^+ and ϕ^e) obtained for the *same* specimen listed therein. On the other hand, the last line for each species shows the most probable value (M.P.V.) of $\Delta\phi^*$ evaluated from those data on both ϕ^e and ϕ^+ listed in the 3rd and 4th columns in Table 2. In contrast to the former, the latter is based on those much more data which are based on a variety of *distinct* specimens by different workers using various methods under a variety of conditions (see Table 1). Consequently, comparison between the two values of $\Delta\phi^*$ (Mean and M.P.V.) is helpful for examining the objective accuracy or reliability of each $\Delta\phi^*$. In Table 5, the two types of the best estimates (Mean and M.P.V.) originating from the data in Table 4 are summarized compactly together with another estimate achieved previously [1351] so that the values of $\Delta\phi^*$ may readily be compared between mono- and polycrystals and also among different surface species investigated by the present author.

Speaking in general about the monocrystals in Table 5, almost all the means of $\Delta\phi^*$ are found to be Mean ≈ 0.0 eV, exactly following to Eqs. (1) and (2). Regarding such an unreasonable result as M.P.V. $= -0.15$ eV against Mean $= 0.00$ eV for Re(0001), further studies are needed to find a valid reason for the discrepancy between the two. On the contrary to the monocrystals, all of the polycrystals have $\Delta\phi^* > 0$, just as predicted by our theoretical model. Namely, $\Delta\phi^*$ has a range from ~0.3 eV (Pt) to ~0.7 eV (Nb), which satisfies the fundamental condition of $\Delta\phi^* < \phi_{max} - \phi_{min} \approx 0.8$–1 eV (see Section 4.3 and Fig. 1). It is worthwhile to note that C(film) has $\Delta\phi^* = -0.02$ or $0.03 \approx 0.0$ eV, quite similarly to C(HOPG) with 0.07 or $-0.01 \approx 0.0$ eV, as shown in Table 5.

Carbonaceous overlayers grown on transition metal surfaces generally consist of the two types of carbidic and graphitic carbon [3939]. Compared with the latter, the former is usually stable at lower temperatures alone ($T < 600$ K), higher in work function ($\phi^e > 5$ eV) and more active as a catalyst. On the contrary, the latter has a very *anomalous* insensitivity to PSI of incident alkali halide molecules (MX), for example, because the degree of dissociation (MX $\to$ M + X) reduces to ~$10^{-3} \approx 0$ (and hence $\beta^+ \approx 0$ for producing M$^+$ from MX) compared with a normal detection sensitivity ($\beta^+ > 0$) to alkali atoms (M) incident upon a graphitized metal surface. Such a notable difference in detection sensitivity between the two surfaces affords us a very convenient technique of the "differential surface ionization" [222,223,226,737], by which the currents of M$^+$ originating from M alone and of M$^+$ from a mixture of M and MX are distinctively measurable without using mass spectrometry (for further information, see Sections 4.2.4 and 6.4 in Ref. [1351]).

Regarding graphitic film formation, a typical example is shown in Fig. 18 [103] in Ref. [1351], thus indicating that both ϕ^+ and ϕ^e of Ir(111) change from 5.8 to 4.8 eV according to graphitic film formation ($\theta = 1$ ML) at 1685 K [103] (see Table 1). About carbonaceous overlayers, both preparation methods and conditions and also chemico-physical properties are comprehensively reviewed by Gall' et al. [450] and Oshima et al. [695] and also outlined in Section 4.2.4 in Ref. [1351].

The work function of C$_{60}$/metal system ($\theta = 1$) is found experimentally to depend upon the metal species, showing that $\phi^e = 4.53, 5.06, 5.07$ and 5.19 eV on the substrates of Au(111), Cu(100), Cu(111) and Ag(111), respectively [4449]. Such a substrate dependence is reported also for other systems (Cu, Ag and Au) having a range of 4.39–4.72 eV [2198] (see Table 1).

In contrast to free-standing graphene ($\phi^e = 4.48$ eV) [4174,4284], adsorbed graphene is calculated to have 3.66, 4.03 and 4.87 eV on the substrates of Ni(111), Pd(111) and Pt(111) [4174,4284], the dependence of which may be supported by the experimental data of 3.9, 4.3 and 4.8 eV [695], respectively. Such a substrate dependence is caused by the formation of an interface dipole and the electron transfer between the metal and graphene levels driven by the work function difference, as well as the chemical interaction between graphene and the substrate metal [4174,4282,4284]. Since many of the carbon film systems are not clearly described for their surface structure, tentatively, Table 1 lists their work function data separately in the two groups of the "graphitic carbon films" and "graphene". But, some of the former of graphite/metal systems ($\phi^e = 3.32$–6.3 eV) seem to belong probably to the graphene/metal ones (4.03–4.96 eV). Such a large divergence in ϕ^e seems to support the above conclusion [4174,4284] that the work function of adsorbed graphene depends upon the substrate species. Similar dependence by up to 0.15 eV is observed [4435,4436].

Interestingly, highly ordered graphene films are epitaxially grown by thermal desorption of silicon from silicon carbide by high-temperature annealing (~1300–1900 K) in vacuum or under an argon atmosphere [4455–4457]. Typically, the variation in work function is as small as 12 meV over the single layer surface [4455], and the difference is only 139 ± 9 meV between single and bilayers thus prepared [4456].

The chief points of Tables 4 and 5 may be summarized as follows.

(1) As shown in Columns 3–5 in Table 5, the experimental determination for an essentially clean surface of W(100), for example, indicates that $\Delta\phi^* = 0.03$ or -0.03 eV ≈ 0.0 eV [Here, 1351], just as predicted by theory. On the other hand, a non-clean

monocrystalline surface such as an oxygenated W(100) face is observed to have $\phi^+ = 6.50 \pm 0.05$ eV and $\phi^e \approx 5.8$ eV [84,833], thereby giving $\Delta\phi^* \approx 0.7$ eV (see Table 1 in Ref. [1351]). This is near to $0.59-0.61$ eV determined for many polycrystalline W specimens (see Table 5), but considerably smaller than $\Delta\phi^* = 6.75 \pm 0.01 - 5.75 \pm 0.05 = 1.00 \pm 0.05$ eV found for an oxygenated polycrystalline W face [84,93,824,833] (Table 1 in Ref. [1351]).

(2) With the two exceptions of 0.14 and -0.15 eV for Nb(100) and W(112), respectively, almost all the species show that Mean is inside the range of -0.06 to 0.07 eV. Consideration of all the species affords Average $= 0.00 \pm 0.06$ eV, as shown on the 2nd line above the bottom in Table 5. In addition, quite many species have M.P.V. $= -0.10-0.10$ eV, but the average of all the species yields M.P.V. $= -0.02 \pm 0.07$ eV. In our previous study [1351], it is found to be 0.02 ± 0.03 eV. Consequently, essentially clean monocrystalline surfaces may be concluded to have $\Delta\phi^* = 0.0$ eV, just as expected by theory.

(3) Even when we try to analyze quantitatively these data on positive ionization and related phenomena on an essentially clean monocrystalline surface, therefore, our employment of ϕ^e instead of ϕ^+ of the surface may be generally expected to be substantially free from a systematic error.

(4) For any of the clean polycrystalline surfaces, on the other hand, $\Delta\phi^*$ is found to be considerably higher than 0.0 eV. Typically, Ir has Mean $= 0.48 \pm 0.10$ eV and M.P.V. $= 0.47 \pm 0.06$ eV [Here], both of which are equal to 0.48 ± 0.04 eV estimated in the previous review [1351] (see Table 5). Similarly, Nb has 0.70 ± 0.12 or 0.70 ± 0.07 eV [Here], nearly equal to 0.78 ± 0.11 eV [1351]. The last line in Table 5 indicates that $\Delta\phi^*$ has Range of $\sim 0.3-0.7 > 0.0$ eV, largely depending upon the surface species.

(5) Consequently, employment of ϕ^e instead of ϕ^+ always results in a systematic error depending upon the size of $\Delta\phi^*$ (up to ~ 0.7 eV) whenever we try to analyze these data on positive ionization phenomena on any polycrystalline surface. From this point of view, such data on $\Delta\phi^*$ as listed in Tables 4 and 5 may be very useful for better understanding the thermionic peculiarity of polycrystal ($\Delta\phi^* \geq 0.3$ eV), in contrast to monocrystal ($\Delta\phi^* = 0.0$ eV).

(6) Regarding a typical case of W, the dependence of $\Delta\phi^*$ upon the surface compositions of both F_i and ϕ_i is thoroughly studied for not imaginary but actual specimens [2453]. For instance, it is clearly shown for W that the theoretical values of $\Delta\phi^* = 0.62$ eV [630] and 0.57 eV [283] for $\delta_m = 0.46$ and 0.34, respectively, are in good agreement with these experimental data on 0.61 eV [23] and 0.56 eV [76,77]. The quantitative relation between δ_m and $\Delta\phi^*$ will be discussed for W in Section 4.3.

(7) It should be emphasized here that theoretical analysis of such data on $\Delta\phi^*$ as exemplified in Tables 4–6 affords us a promising clue to the long-pending problem how the polycrystalline work function is decided by the surface components of F_i and ϕ_i [4406], as will be discussed in Sections 4.4 and 4.5.

Disappointedly, the present author can find neither the best estimates nor the most probable values recommended statistically from abundant data on $\Delta\phi^*$ for any surface species by other authors in any literatures published to date. Consequently, any of our values on $\Delta\phi^*$ in Table 5 cannot be examined objectively by comparison with those to be recommended possibly by others.

4.2. Theoretical evaluation of the contrast ($\Delta\phi^*$)

Eqs. (1) and (2) indicate that $\Delta\phi^* \equiv \phi^+ - \phi^e$ can be evaluated theoretically when the data on both ϕ_i and F_i for a given specimen are available from literatures. The present author has already published the values of $\Delta\phi^*$ calculated for actual specimens of Ni [283,630], of Nb, Mo, Ta and Ir [803], and also of W [281,283,630,803,2453]. Typically for the seven specimens (A)–(G) of W having different values of $\delta_m = 0.336-0.96$, the data on $\Delta\phi^*$ evaluated from Eqs. (1) and (2) are summarized in Table 6, together with experimental data available on ϕ^e to be compared with the theoretical ones for the *same* specimen under study. Typically, the specimen of W(G) is found to have Footnote (59) $\phi^e = 4.59 \pm 0.04$ eV as Mean by theory [2453] and Footnote (60) 4.52 ± 0.07 eV as the actual data on the same specimen by experiment [124,3414], both of which well agree with each other, thereby strongly supporting the validity of the above equations symbolic of our theoretical model.

Table 6
Typical data on the fractional surface area (F_i), the local work function (ϕ_i) reported for tungsten specimens (A–G, Q, R and U) having different values of the degree of monocrystallization (δ_m), and also the thermionic contrast ($\Delta\phi^*$) calculated from the data on both F_i and ϕ_i listed herein, thereby yielding Fig. 1.

Specimen	δ_m	Footnote	Fractional surface area, Local work function, and Thermionic contrast						Refs.
W(A)	0.336	(1)	Plane	(111)	(100)	(112)	(110)		[488]
		(2)	F_i	0.062	0.331	0.336	0.271		[488]
		(3)	ϕ_i (eV)	4.35	4.56	4.69	5.35		[488]
		(4)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.13 \pm 0.04 - 4.62 \pm 0.02 = \mathbf{0.52 \pm 0.04}}$				ϕ^a (eV) = 4.80		[2453]
W(B)	0.352	(5)	Plane	(111)	(100)	(112)	(110)		[488]
		(6)	F_i	0.089	0.254	0.343	0.352		[488]
		(7)	ϕ_i (eV)	4.35	4.56	4.69	5.35		[488]
		(8)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.18 \pm 0.03 - 4.61 \pm 0.03 = \mathbf{0.57 \pm 0.04}}$				ϕ^a (eV) = 5.04		[2453]
W(C)	0.46	(9)	Plane	(011)	(001)	(112)	(013)	(222)	(123)	[825]
		(10)	F_i	0.16	0.46	0.09	0.06	0.22	0.01	[825]
		(11)	ϕ_i (eV)	5.25	4.63	5.12	4.34	4.45	4.50	[825]

(continued on next page)

Table 6 (*continued*)

Specimen	δ_m	Footnote	Fractional surface area, Local work function, and Thermionic contrast						Refs.
		(12)	ϕ_i (eV)	5.31	4.63	4.83	4.32	4.45	4.49	[825,1351]
		(13)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.98 \pm 0.05 - 4.56 \pm 0.01 = 0.42 \pm 0.05$				ϕ^a (eV) = 4.72		[2453]
		(14)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 5.01 \pm 0.05 - 4.56 \pm 0.01 = 0.45 \pm 0.05$				ϕ^a (eV) = 4.70		[2453]
		(15)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.00 \pm 0.05 - 4.56 \pm 0.01} = \mathbf{0.44 \pm 0.05}$ (Mean of 13 and 14)						[2453]
W(D)	0.463	(16)	Plane	(310)	(111)	(100)	(112)	(110)	[489]
		(17)	F_i	0.463	0.054	0.140	0.155	0.189	[489]
		(18)	ϕ_i (eV)	4.25	4.47	4.65	4.76	5.25	[489]
		(19)	ϕ_i (eV)	4.32	4.38	4.57	4.83	5.31	[1351]
		(20)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.96 \pm 0.03 - 4.37 \pm 0.02 = 0.59 \pm 0.04$				ϕ^a (eV) = 4.59 [489]		[2453]
		(21)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 5.02 \pm 0.07 - 4.42 \pm 0.01 = 0.60 \pm 0.07$				ϕ^a (eV) = 4.63		[2453]
		(22)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{4.99 \pm 0.06 - 4.38 \pm 0.05} = \mathbf{0.61 \pm 0.08}$ (Mean of 20 and 21)						[2453]
		(23)	ϕ^e (eV) = 4.38 ± 0.05 (Mean by calculation)						[2453]
		(24)	ϕ^e (eV) = 4.8 ± 0.05 (by experiment)						[489]
W(A)–(D)	<0.5	(25)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.05 \pm 0.09 - 4.52 \pm 0.10} = \mathbf{0.53 \pm 0.09}$ (Mean of 4, 8, 15 and 22)						[2453]
W(P)	<0.5	(26)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.14 \pm 0.05 - 4.55 \pm 0.04} = \mathbf{0.59 \pm 0.06}$ (M.P.V. by experiment)						[1351]
W(E)	0.80	(27)	Plane	(110)	(112)	(100)	(111)		[162]
		(28)	F_i	0.80	0.05	0.14	0.01		[162]
		(29)	ϕ_i (eV)	5.3	4.8	4.66	4.35		[162]
		(30)	ϕ_i (eV)	5.31	4.83	4.57	4.38		[1351]
		(31)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 5.25 \pm 0.02 - 4.90 \pm 0.05 = 0.35 \pm 0.05$				ϕ^a (eV) = 5.18		[2453]
		(32)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 5.27 \pm 0.01 - 4.85 \pm 0.05 = 0.42 \pm 0.05$				ϕ^a (eV) = 5.17		[2453]
		(33)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.26 \pm 0.02 - 4.87 \pm 0.06} = \mathbf{0.39 \pm 0.06}$ (Mean of 31 and 32)						[2453]
W(F)	0.95	(34)	Plane	(100)	(110)	(111)	(112)	(116)	[3414]
		(35)	F_i	0.95	0.01	<0.01	0.02	–	[3414]
		(36)	F_i	0.95	0.01	<0.01	0.02	0.01	[2453]
		(37)	ϕ_i (eV)	4.65	5.25	4.47	4.67	4.32	[489,1351]
		(38)	ϕ_i (eV)	4.57	5.31	4.38	4.83	4.32	[1351]
		(39)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.70 \pm 0.03 - 4.65 \pm 0.00 = 0.05 \pm 0.03$				ϕ^a (eV) = 4.61		[2453]
		(40)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.70 \pm 0.03 - 4.64 \pm 0.00 = 0.06 \pm 0.03$				ϕ^a (eV) = 4.65		[2453]
		(41)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.69 \pm 0.05 - 4.57 \pm 0.00 = 0.12 \pm 0.05$				ϕ^a (eV) = 4.54		[2453]
		(42)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.69 \pm 0.05 - 4.56 \pm 0.01 = 0.12 \pm 0.05$				ϕ^a (eV) = 4.58		[2453]
		(43)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{4.70 \pm 0.04 - 4.61 \pm 0.04} = \mathbf{0.09 \pm 0.05}$ (Mean of 39–42)						[2453]
		(44)	ϕ^e (eV) = 4.61 ± 0.04 (Mean by calculation)						[2453]
		(45)	ϕ^e (eV) = 4.52 ± 0.07 (by experiment)						[124,3414]
W(G)	0.96	(46)	Plane	(100)	(111)				[124]
		(47)	F_i	0.96	0.04				[124]
		(48)	ϕ_i (eV)	4.65	4.47				[489]
		(49)	ϕ_i (eV)	4.66	4.35				[162]
		(50)	ϕ_i (eV)	4.60	4.40				[144]
		(51)	ϕ_i (eV)	4.55	4.42				[143]
		(52)	ϕ_i (eV)	4.57	4.38				[1351]
		(53)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.64 \pm 0.01 - 4.64 \pm 0.00 = 0.00 \pm 0.01$				ϕ^a (eV) = 4.64		[2453]
		(54)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.65 \pm 0.01 - 4.63 \pm 0.01 = 0.02 \pm 0.01$				ϕ^a (eV) = 4.65		[2453]
		(55)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.59 \pm 0.00 - 4.58 \pm 0.00 = 0.01 \pm 0.00$				ϕ^a (eV) = 4.59		[2453]
		(56)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.54 \pm 0.00 - 4.53 \pm 0.00 = 0.01 \pm 0.00$				ϕ^a (eV) = 4.54		[2453]
		(57)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = 4.56 \pm 0.01 - 4.55 \pm 0.01 = 0.01 \pm 0.01$				ϕ^a (eV) = 4.56		[2453]
		(58)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{4.60 \pm 0.04 - 4.59 \pm 0.04} = \mathbf{0.01 \pm 0.01}$ (Mean of 53–57)						[2453]
		(59)	ϕ^e (eV) = 4.59 ± 0.04 (Mean by calculation)						[2453]
		(60)	ϕ^e (eV) = 4.52 ± 0.07 (by experiment)						[124,3414]
W(Q)	1.00	(61)	Plane	(100)					[1351]
		(62)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{4.60 \pm 0.05 - 4.57 \pm 0.03} = \mathbf{0.03 \pm 0.06}$ (M.P.V.)						[1351]
W(R)	1.00	(63)	Plane	(110)					[1351]
		(64)	$\Delta\phi^*$ (eV) $\equiv \phi^+ - \phi^e = \underline{5.29 \pm 0.08 - 5.31 \pm 0.05} = \mathbf{-0.02 \pm 0.09}$ (M.P.V.)						[1351]
W(U)	–	(65)	$\phi_{max} - \phi_{min} \simeq 1.0{-}0.8$ eV $> \phi^+ - \phi^e \equiv \Delta\phi^* \simeq 0.6{-}0.0$ eV						[2453]

(1)–(4) From the experimental data (1)–(3) [488], the values (4) are theoretically obtained from Eqs. (1), (2) and (4) [2453].

(5)–(8) Similarly as above, the data (5)–(7) [488] yield the theoretical values (8) [2453].

(9)–(15) By using the data of (11) ϕ_i and (12) ϕ_i together with (10) F_i for the specimen of W(C) (9), we obtain the results of (13) $\Delta\phi^*$ and (14) $\Delta\phi^*$, respectively, thereby yielding the mean value of (15) $\Delta\phi^*$.

(16)–(22) Similarly, the local work function sets (18) and (19) together with the set (17) afford the results (20) and (21), respectively, which give the mean value (22).

(23)–(24) The theoretical value (23) based on the mean (22) is found to be poor in agreement with the experimental one (24) determined with the specimen of W(D) by the corresponding workers [489]. For this reason, see Chief point (4) in Section 4.2.

(25) The contrast (25) is the mean value for the four specimens of (A)–(D) having the values of $\delta_m < 0.5$.

(26) The contrast (26) is the most probable value determined from quite many specimens of polycrystalline tungsten (see Table 2 in Ref. [1351]).

(27)–(33) The sets (29) and (30) together with the set (28) afford the contrasts (31) and (32), respectively, which give the mean of (33) $\Delta\phi^*$.

(34)–(45) Combinations of (35)–(37), (35)–(38), (36)–(37) and (36)–(38) give the four values of (39)–(42), respectively, which yield Mean (43). The mean of (44) $\phi^e = 4.61 \pm 0.04$ eV thus calculated is in fair agreement with (45) $\phi^e = 4.52 \pm 0.07$ eV determined experimentally for the specimen of W(F) by the corresponding worker [124,3414].

(46)–(60) Employment of ϕ_i (48)–ϕ_i (52) yields $\Delta\phi^*$ (53)–$\Delta\phi^*$ (57), respectively, which afford the mean (58). Our calculated value of ϕ^e (59) = 4.59 $\pm$ 0.04 eV well agrees with the experimental data of ϕ^e (60) = 4.52 $\pm$ 0.07 eV determined with W(G) by the worker [124,3414].

(61)–(62) The contrast (62) is the most probable value determined from quite many specimens of W(100) (see Table 2 in Ref. [1351]).

(63)–(64) Similarly, the value (64) for W(110) is cited from Ref. [1351].

(65) The range (1.0–0.8 eV) is generally estimated for bcc metals such as W, Ta and Mo [2453]. Polycrystalline tungsten exemplified as W(U) consists generally of various faces, among which W(110) and W(116) seem to have the largest and smallest values of $\phi_{max} \approx 5.3$ eV and $\phi_{min} \approx 4.3$ eV, respectively (see Table 2). The range (0.6–0.0 eV) is determinable also from the data on (22) and (62) of $\Delta\phi^* = 0.61$ and 0.0 eV, respectively, contained above [Here].

The main points of Table 6 may be summarized below, where the numbers of (1)–(65) regarding various items (e.g., plane, F_i and ϕ_i) correspond to those of Footnote in Column 3.

(1) Regarding the specimen of W(A) consisting of the four planes (1) of (111)–(110) with $\delta_m = F(112) = 0.336$ [488], substitution of both Footnote (2) $F_i = 0.062$–0.271 and that (3) $\phi_i = 4.35$–5.35 eV into Eqs. (1) and (2) yields the result (4) of $\phi^+ = 5.13 \pm 0.04$ and $\phi^e = 4.62 \pm 0.02$ eV and, hence, $\Delta\phi^* = 0.52 \pm 0.04$ eV. Each of the three values is very close to that listed as the most probable value (M.P.V.) for the generally called "polycrystalline" tungsten ($\delta_m < 0.5$, usually considered) in Table 4, which shows $\phi^+ = 5.17 \pm 0.05$ eV, $\phi^e = 4.56 \pm 0.03$ eV and $\Delta\phi^* = 0.61 \pm 0.06$ eV as M.P.V. for polycrystalline W. In addition, the result (4) [2453] shows that the sequence of $\phi^+ = 5.13$ eV $> \phi^a = 4.80$ eV $> \phi^e = 4.62$ eV holds just as predicted by theory in Section 1 (see Eqs. (1), (2) and (4)).

(2) With regard to W(B) having $\delta_m = F(110) = 0.352$ [488], the data on (6) F_i and (7) ϕ_i afford theoretically the result (8) of $\phi^+ = 5.18 \pm 0.03$ and $\phi^e = 4.61 \pm 0.03$ eV and, hence, $\Delta\phi^* = 0.57 \pm 0.04$ eV. With respect to W(A) and W(B), both (3) ϕ_i and (7) ϕ_i are common for each of the planes (1) and (5), but (2) F_i and (6) F_i are different (by up to 0.081) with each other between the two. Each of ϕ^+, ϕ^e and $\Delta\phi^*$, however, is essentially the same (within 0.05 eV gapped) between the results of (4) and (8) [2453], in spite of the fact that $\phi^a = 4.80$ eV for W(A) is very different (by 0.24 eV) from $\phi^a = 5.04$ eV for W(B). In addition, $\phi^a = 5.04$ eV is quite different from both $\phi^+ = 5.18 \pm 0.03$ and $\phi^e = 4.61 \pm 0.03$ eV for W(B). Such difference among the three is observed also for W(C)–W(E) to be mentioned below. These results indicate that employment of ϕ^a as ϕ^e or ϕ^+ is not very reasonable for any polycrystals, as already mentioned in Section 1.

(3) About W(C) with $\delta_m = F(001) = 0.46$ [825], adoption of the two sets (11) and (12) of ϕ_i's gives the results (13) and (14), respectively. Each of the three values of ϕ^+, ϕ^e and $\Delta\phi^*$ is essentially the same between the results of (13) and (14), irrespective of the difference in ϕ_i by up to 0.29 eV between the two sets of (11) and (12) for ϕ_i. They lead to the mean (15). Again, $\phi^a = 4.71 \pm 0.01$ eV is different from both $\phi^+ = 5.00 \pm 0.05$ and $\phi^e = 4.56 \pm 0.01$ eV by 0.29 $\pm$ 0.05 and 0.15 $\pm$ 0.01 eV, respectively, showing again $\phi^+ > \phi^a > \phi^e$. On the other hand, the authors [825] report that $\phi^a = 4.72$ eV differs from $\phi^+ = 4.61 \pm 0.05$ eV determined by PSI of Li and Eu on W(C). The difference itself is quite natural, but the result of $\phi^+ = 4.61$ eV $< \phi^a = 4.72$ eV does not accord with ours of $\phi^+ = 5.00$ eV $> \phi^a = 4.71 \pm 0.01$ eV.

(4) With respect to W(D) having $\delta_m \equiv F_m = F(310) = 0.463$ [489], the two sets (18) and (19) of ϕ_i's together with (17) F_i afford the two results of (20) and (21), respectively. Again, each of ϕ^+, ϕ^e and $\Delta\phi^*$ is almost the same (gap ≤ 0.06 eV) between the results of (20) and (21), nearly independent of the considerable difference (by up to 0.09 eV) between the two ϕ_i sets of (18) and (19). Of course, each of $\phi^a = 4.59$ and 4.63 eV is intermediate between $\phi^+ = 4.99$ eV and $\phi^e = 4.38$ eV, as shown in the mean (22)). On the other hand, the corresponding workers [489] conclude that the data (24) of $\phi^e = 4.8$ eV measured for W(D) by FE is in good agreement with the calculated value (20) of $\phi^a = 4.59 \approx 4.6$ eV. This conclusion, however, does not seem very reasonable, mainly because $\phi^e = \phi^a$ or $\phi^e > \phi^a$ does not hold in principle for any polycrystalline surface and also because $\phi^e = 4.8$ eV is much larger than the most probable value (26) of $\phi^e = 4.55 \pm 0.04$ eV [1351] and also than such values of 4.56 $\pm$ 0.03 eV [Here], 4.55 eV [1045,1358] and 4.54 eV [1354] as generally accepted today for the usually called "polycrystalline" tungsten (see Table 2).

(5) About the four specimens of W(A)–W(D) having $\delta_m < 0.5$ [488,489,825], we obtain Mean (25) from the results (4), (8), (15) and (22). Namely, $\phi^+ = 5.05 \pm 0.09$, $\phi^e = 4.52 \pm 0.10$ eV and $\Delta\phi^* = 0.53 \pm 0.09$ eV, each of which is comparable with each of the means for W(A)–W(D) in spite of the fact that both δ_m and ϕ^a are considerably different by up to 0.127 and to 0.45 eV, respectively, among the four specimens.

(6) The result (26) for W(P) is achieved by various experimental methods (FE, PE, CPD, TE, PSI, etc.) for a variety of specimens of the generally called "polycrystalline" tungsten (usually $\delta_m < 0.5$). Namely, the data (26) $\phi^+ = 5.14 \pm 0.05$ (or 5.17 $\pm$ 0.05) eV, $\phi^e = 4.55 \pm 0.04$ (or 4.56 $\pm$ 0.03) eV and $\Delta\phi^* = 0.59 \pm 0.06$ (or 0.61 $\pm$ 0.06) eV are cited as the most probable values from Table 2 in Ref. [1351] or as those (given in each parentheses) from M.P.V. in Table 4. Comparison between the theoretical results (25) and the experimental ones (26) shows that each of the three values is in fair agreement between the two to within 0.09 eV gapped. Especially, ϕ^e is substantially the same (only 0.03 eV gapped) between theory and experiment, irrespective of the fact that ϕ^a has a wide gap (0.45 eV in the range of 4.59–5.04 eV) among the four specimens of W(A)–W(D). Again, this result indicates that ϕ^a is quite different in both nature and value from both ϕ^e and ϕ^+ for polycrystalline surfaces, in contrast to the treatment ($\phi^a \approx \phi^e$) [489] mentioned in Point (4) above.

(7) Regarding W(E) with $\delta_m = F(110) = 0.80$ [162], calculation using the two different sets (29) and (30) of ϕ_i's [162,1351] together with F_i (28) [162] yields results (31) and (32), respectively, and also does their Mean (33). Compared with W(A)–W(D)

having $\delta_m < 0.5$, W(E) has a larger value of $\delta_m = 0.80$ (submonocrystal), considerably near to ~1 for the monocrystal ($\Delta\phi^* = 0$) of W(110). In consequence, it is quite natural that $\Delta\phi^*$ decreases from 0.53 eV (25) to 0.39 eV (33), becoming nearer to zero.

(8) In the case of W(F) having $\delta_m = F(100) = 0.95$ [3414], the two combinations of F_i (35) and ϕ_i (37) and of F_i (35) and ϕ_i (38) afford the results (39) and (41), respectively, while those of F_i (36) and ϕ_i (37) and of F_i (36) and ϕ_i (38) yield the respective results (40) and (42). These results indicate that each of ϕ^+, ϕ^e, $\Delta\phi^*$ and ϕ^a is nearly identical (within 0.09 eV gapped) in spite of the difference in the sets of F_i's and ϕ_i's among those (39)–(42). In addition, Mean (43) shows that $\Delta\phi^* = 0.09 \pm 0.05$ eV is much smaller than Mean (33) of $\Delta\phi^* = 0.39 \pm 0.06$ eV for W(E) according as δ_m becomes larger from 0.80 to 0.95 and, hence, as it does nearer to unity for the monocrystalline tungsten ($\delta_m = 1$) of W(100). Mean (44) of $\phi^e = 4.61 \pm 0.04$ eV by calculation [2453] is in fair agreement with the experimental data (45) on $\phi^e = 4.52 \pm 0.07$ eV determined directly for W(F) itself by TE (Richardson plots) [124,3414].

(9) With respect to W(G) having $\delta_m = F(100) = 0.96$ [124], the five sets (48)–(52) of ϕ_i's combined with the set (47) of F_i yield the results of (53)–(57), respectively, from which Mean (58) is obtained. Again, Mean (59) of $\phi^e = 4.59 \pm 0.04$ eV yielded by theory [2453] well agrees with the data (60) of $\phi^e = 4.52 \pm 0.07$ eV done for W(G) by TE [124,3414]. The mean of the five values (53)–(57) for $\phi^a = 4.59 \pm 0.04$ eV coincides exactly with Mean (59) of $\phi^e = 4.59 \pm 0.04$ eV. This is quite natural because W(G) is essentially equivalent in electrophysical property to W(100) listed as (61) W(Q). Namely, each of the three averages (58) of $\phi^+ = 4.60 \pm 0.04$ eV, $\phi^e = 4.59 \pm 0.04$ eV and $\Delta\phi^* = 0.01 \pm 0.01 \approx 0.00$ eV is essentially the same (within 0.02 eV gapped) with each of the most probable values (62) of $\phi^+ = 4.60 \pm 0.05$ eV and $\phi^e = 4.57 \pm 0.03$ eV and $\Delta\phi^* = 0.03 \pm 0.06$ eV based on those data achieved for W(100) by a great many workers (see Table 2 in Ref. [1351]). These results of $\phi^+ = \phi^e = \phi^a = 4.59 \pm 0.04$ eV and also $\Delta\phi^* = 0.0$ eV indicate that W(G) with $\delta_m = F(100) = 0.96$ is substantially equivalent in work function to W(100) with $\delta_m = 1$. This is one of the important outcomes that can be deduced theoretically by our simple model leading to Eqs. (1), (2) and (4).

(10) As partly mentioned above, each of the three values (58) calculated for W(G) are essentially equal to each of those (62) determined by using various experimental methods, thus giving an additional evidence to support the validity of our theoretical model.

(11) With respect to W(110) listed as (63) W(R), the most probable values (64) of ϕ^+ and ϕ^e are determined from a good many data listed in Table 1 [1351], giving $\Delta\phi^* = -0.02 \pm 0.09 \approx 0.0$ eV (see Table 2 [1351] and Table 5 [Here]), just as predicted by theory.

(12) Regarding the "polycrystalline" tungsten expressed as (65) W(U), its maximum and minimum local work function values (ϕ_{max} and ϕ_{min}) seem to correspond to $\phi^e(110) \approx 5.3$ eV and $\phi^e(116) \approx 4.3$ eV (see Table 2), respectively. Compared with the difference of $\phi_{max} - \phi_{min} \approx 1.0$ eV, our value of $\Delta\phi^* \approx 0.6 - 0.0$ eV for W(A)–W(G) [2453] is reasonably smaller, just as expected on principle.

(13) Quite similarly for W as exemplified in Points (6) and (10) above, a fair agreement of ϕ^e between theory and experiment is observed also for Ni [283,630] and for Nb, Mo, Ta and Ir [803]. Typically, we have the results of (i) Nb($\delta_m = 0.68$) as ($4.02 \pm 0.07/4.1$–4.19), (ii) Mo(0.72) as ($4.38 \pm 0.03/4.0$–4.4), (iii) Ta(0.82) as ($4.34 \pm 0.03/4.25 \pm 0.05$) and (iv) Ir(0.81) as ($5.36 \pm 0.07/5.27 \pm 0.05$ or 5.35 ± 0.05). Here, the figures of numerator and denominator in the second parentheses correspond to the values of ϕ^e (in eV) calculated by the present author [803] and measured directly for each specimen by Wilson [124,169,3414], respectively. These specimens ($\delta_m = 0.68$–0.82) correspond to the "submonocrystals", the anomaly of which is outlined in Sections 4.4 and 4.5.

(14) Such an agreement between theory and experiment is generally expected to hold for ϕ^-, too, because both ϕ^e and ϕ^- are given theoretically by the same equations of Eqs. (2) and (3) (see Section 1), and also $\Delta\phi^{**} \equiv \phi^- - \phi^e = 0.0$ eV is found experimentally for W together with other species of polycrystals such as C, Mo and Ta, too (see Table 7).

The results summarized in the above points (1)–(14) give an additional evidence to support that our theoretical model is very reasonable and useful, although it is very simple and plain and also may seem crude and coarse apparently.

4.3. Quantitative relation between the contrast ($\Delta\phi^*$) and the degree of monocrystallization (δ_m)

As may be seen in Table 6, δ_m corresponds simply to the largest (F_m) among the fractional surface areas (F_i's) for each specimen. Apparently, therefore, δ_m itself may seem to be neither chief nor basic (key) factor decisive actually of the work functions (ϕ^+ and ϕ^e) of the specimen under study. The points (1)–(9) in Section 4.2, however, suggests it by δ_m that $\Delta\phi^*$ is governed substantially. Such a suggestion leads to the idea that δ_m may be taken as an indicator representative of the two types of $\Delta\phi^*$. Namely, $\Delta\phi^*$ is nearly constant with little dependence upon δ_m so long as δ_m is below 0.5. At $\delta_m > 0.5$, on the contrary, $\Delta\phi^*$ decreases gradually with increasing δ_m, generally converging to zero as $\delta_m \to 1$. To find the quantitative relation between the two, the data on $\Delta\phi^*$ in Table 6 are plotted against δ_m, as shown in Fig. 1 [2453]. Here, the solid circles of (A)–(G) correspond to the theoretical values of $\Delta\phi^*$ for the seven specimens of W(A)–W(G) in Table 6, respectively, while the horizontal line crossed with a vertical arrow (A–D) shows Mean (25) of $\Delta\phi^* = 0.53 \pm 0.09$ eV at $\delta_m < 0.5$ for the four specimens of W(A)–W(D). Here, the number of (25) corresponds to that of Footnote in Table 6, quite similarly as above in Section 4.2. The horizontal line with arrow (P) at $\delta_m < 0.5$ corresponds to W(P) of M.P.V. (26) having $\Delta\phi^* = 0.59 \pm 0.06$ eV [1351] based on the data achieved experimentally by a great many workers applying different methods and processes to a variety of polycrystalline tungsten specimens under various conditions. The open circles of (Q) and (R) at $\delta_m = 1.00$ correspond to W(Q) and W(R), originating from the experimental data ($\Delta\phi^* = 0.03 \pm 0.06$ and -0.02 ± 0.09 eV) [1351] on the monocrystals of W(100) and W(110), respectively (see M.P.V.'s (62) and (64) in Table 6). Consideration of both Fig. 1 and the above points (1)–(9) in Section 4.2 leads to the conclusion that the quantitative relation between the two is given by the empirical formulae [2453] as follows:

$$\Delta\phi^* = c \quad \text{for } 0 < \delta_m < 0.5 \text{ (polycrystal)}. \tag{10}$$

Fig. 1. Dependence of the thermionic contrast ($\Delta\phi^*$) upon the degree of monocrystallization (δ_m) of tungsten [2453]. Each of the data (A)–(G) as well as those (P)–(R) is cited from Table 6 [Here].

$$\Delta\phi^* = 4c\delta_m(1 - \delta_m) \quad \text{for } 0.5 < \delta_m < 1 \text{ ("submonocrystal").} \tag{11}$$

$$\Delta\phi^* = 0 \quad \text{for } \delta_m = 1 \text{ (monocrystal).} \tag{12}$$

From the data on $\Delta\phi^*$ at $\delta_m < 0.5$ for W, the constant of c is evaluated theoretically to be 0.53 ± 0.09 eV (Mean (25) [2453] in Table 6), as shown by the horizontal line crossed with vertical arrow (A–D). This value is substantially equal to 0.59 ± 0.06 eV (M.P.V. (26) [1351] in Table 6), which is shown by the horizontal line with the arrow (P) originating from the experimental data obtained by many workers (see Tables 1 and 2 in Ref. [1351]). At $\delta_m > 0.5$, on the other hand, the theoretical values of $\Delta\phi^* = 0.39 \pm 0.06$, 0.09 ± 0.05 and 0.01 ± 0.01 eV (Means (33), (43) and (58) evaluated respectively for (E)–(G) in Table 6) are well expressed by a parabolic curve according to Eq. (11), as may be seen in Fig. 1. These results indicate that the so-called "polycrystal" should be divided into the two different categories of the usually called "polycrystal" ($\delta_m < 0.5$, corresponding to Eq. (10)) and the tentatively named "submonocrystal" ($0.5 < \delta_m < 1$, doing to Eq. (11)) because the dependence of ϕ^+, ϕ^e and $\Delta\phi^*$ upon δ_m is quite different between the two, as will be discussed in Sections 4.4 and 4.5.

In the present case of W, ϕ_{max} and ϕ_{min} may be estimated to be $\phi(110) \approx 5.3$ eV and $\phi(116) \approx \phi(013) \approx 4.3$ eV (see Table 2), respectively, which are partly included as ϕ_i in the present calculation of $\Delta\phi^*$ for almost all the seven specimens of W(A)–W(G) in Table 6. At $\delta_m < 1$, the sequence of $\phi_{max} > \phi^+ > \phi^a > \phi^e > \phi_{min}$ holds for tungsten polycrystals [1351] and, hence, we have the relation of $\Delta\phi^* \equiv \phi^+ - \phi^e < \phi_{max} - \phi_{min} \approx 5.3 - 4.3 = 1.0$ or ≈ 0.9 eV [3965]. In other words, the actual value of $\Delta\phi^*$ is strongly governed by both ϕ_{max} and ϕ_{min} included in ϕ_i's that are considered for either calculation or measurement of $\Delta\phi^*$. In respect of W(G), ϕ_{max} and ϕ_{min} correspond to $\phi(100) \approx 4.6$ eV for $F(100) = 0.96$ and to $\phi(111) \approx 4.4$ eV for $F(111) = 0.04$, respectively. Even in this case for $\delta_m \approx 1$, of course, $\Delta\phi^* = 0.01 \pm 0.01$ eV (see Mean (58) in Table 6) fully satisfies the above condition of $\Delta\phi^* < \phi_{max} - \phi_{min} \approx 1.0$ eV. In a typical case of bcc-metals (e.g., Nb, Mo, Ta and W), the difference of $\phi_{max} - \phi_{min}$ is generally estimated to have a range of ~ 0.9–1.0 [127] or ~ 0.8–1.0 eV [1351], the latter of which is inserted as dotted horizontal lines (U) in Fig. 1. Even at $\delta_m < 0.5$ having the largest values of $\Delta\phi^*$, the present value of $\Delta\phi^* = c$ is limited to 0.44–0.65 eV (see the probable ranges indicated with two arrows of (A–D) and (P) in Fig. 1) and, hence, our values of $\Delta\phi^*$ are always (at any value of δ_m) much smaller than the upper limit of 0.8–1.0 eV mentioned just above. Consequently, the theoretical result about W satisfies perfectly the essential condition of $\Delta\phi^* \leq c < \phi_{max} - \phi_{min}$ for any value of δ_m. For additional examples of fcc-polycrystals, Ir and Pt are estimated from Table 2 to have $\phi_{max} - \phi_{min} \approx 0.9$ and 0.7 eV, respectively, which are much larger than $\Delta\phi^* \approx 0.5$ and 0.3 eV (see Table 5), respectively. For hcp-Re, the former (~ 0.7 eV) is also larger than the latter (~ 0.4 eV), quite similarly for the bcc-metals mentioned just above (~ 0.8–1.0 eV $> \sim 0.6$–0.7 eV, see Tables 2 and 5).

In the range of $\delta_m \approx 0.5$–1.0 for "submonocrystals", $\Delta\phi^*$ is given by Eq. (11), where c for W is theoretically evaluated to be 0.53 ± 0.09 eV by the present author [2453] (Mean (25) in Table 6). This is in good agreement with $\Delta\phi^* = 0.59 \pm 0.06$ eV [1351] (M.P.V. (26) in Table 6) and also with both 0.60 ± 0.13 and 0.61 ± 0.06 eV (Mean and M.P.V., respectively, in Tables 4 and 5) determined by the present author according to the abundant data on both ϕ^+ and ϕ^e achieved for W mainly by experiment by a great many workers (see Table 1). Eq. (11) may be expected to be available to other metals, too. According to a preliminary study about Ir, for instance, the constant (c) may be estimated to be 0.60 ± 0.13 eV [2453], which is consistent with $\Delta\phi^* = 0.48 \pm 0.10$ eV (Mean) and 0.47 ± 0.06 eV (M.P.V.) based on much data by experiment (see Table 5). However, it needs much further work to confirm the general applicability of Eq. (11) to any other metals.

4.4. Effect of the degree of monocrystallization (δ_{m}) upon both ϕ^{e} and ϕ^+ for polycrystal ($\delta_{\mathrm{m}} < 50\%$) and also submonocrystal ($50 < \delta_{\mathrm{m}} < 100\%$)

Considerations of the analytical results in Section 4.3 and of the data in Table 6 may lead to the conclusions as follows:

(1) Substitution of a probable combination of F_i and ϕ_i into Eqs. (1) and (2) affords the theoretical values of ϕ^+ and ϕ^{e} and also of $\Delta\phi^*$, each of which is usually expected to agree well or fairly with each value to be determined by experiment within the error of ± 0.1 eV. Namely, our model is useful for estimating theoretically the effective work functions (ϕ^+ and ϕ^{e}) of any polycrystalline surfaces probably within the uncertainty of less than ± 0.1 eV if the reliable data on F_i and ϕ_i are available for the surface under study.

(2) Typically for the four specimens (W(A)–W(D)) of polycrystalline tungsten ($\delta_{\mathrm{m}} = 0.336$–$0.463 < 0.5$) having a large difference in surface components (F_i's and ϕ_i's), all of the theoretical values of ϕ^+, ϕ^{e} and $\Delta\phi^*$ are in good agreement with the respective ones determined by experiment to within the discrepancy of ± 0.09 eV, as may readily be understandable from the comparison between the two data in Table 6. Typically, our theoretical value of (25) $\phi^{\mathrm{e}} = 4.52$ eV for the four actual specimens ($\delta_{\mathrm{m}} < 0.5$) well agrees with the experimental data on (26) $\phi^{\mathrm{e}} = 4.55$ eV [1351] and also with those on 4.50[#] eV [1665], 4.54 eV [1354] and 4.55 eV [1045,1358] recommended for polycrystalline W by other authors in Table 2. This agreement suggests such new information that the work function data on polycrystals listed in Table 2 may usually correspond to the surfaces of $\delta_{\mathrm{m}} < 0.5$.

(3) The above agreement between theory and experiment indicates that each of the three values (ϕ^+, ϕ^{e} and $\Delta\phi^*$) is generally common and nearly constant with little dependence upon the difference in specimen and hence in surface components (F_i's and ϕ_i's, changing considerably from specimen to specimen even of the same species) so long as $\delta_{\mathrm{m}} < 0.5$ corresponding to Eq. (10).

(4) The agreement and constancy found for W just above suggest that any species of the so called "polycrystals" may have a nearly constant value of ϕ^{e} among a variety of distinct specimens. This suggestion is strongly supported by the fact that every polycrystal ($\delta_{\mathrm{m}} < 0.5$ estimated in general) is found to have an essentially constant value characteristic of its surface species (see Column (3) in Table 2). In other wards, each polycrystal has the universal constancy in ϕ^{e} unique of the surface material (element) itself so long as $\delta_{\mathrm{m}} < 0.5$, thus giving a definite answer to the long pending problem why every "polycrystal" as well as every monocrystal is generally recognized to have a constant value of work function (ϕ^{e}) characteristic of its species. Quite similarly to ϕ^{e}, such a universal constancy for any polycrystal may be concluded also for both ϕ^+ and $\Delta\phi^*$ from the theoretical result (25) in Table 6. In addition, the constancy may be done also from the experimental data on ϕ^+ in Column (4) in Table 2 and from those on $\Delta\phi^*$ in Columns (6)–(8) in Table 5.

(5) Thus, our model leading to Eqs. (1), (2) and (10) furnishes a new and sound basis for supporting theoretically the experimental fact that every polycrystal ($\delta_{\mathrm{m}} < 0.5$ in general) has a nearly constant value (with the uncertainty of less than about ± 0.1 eV) of work function under the normal condition accepted in general, irrespective of a considerable difference in surface components (F_i's and ϕ_i's) among various specimens so long as $\delta_{\mathrm{m}} \equiv F_{\mathrm{m}} < 0.5$. In other words, it may be reasonable to interpret that the so-called "polycrystal" appearing in many publications is implicitly recognized to correspond to $\delta_{\mathrm{m}} < 0.5$ alone, instead of $\delta_{\mathrm{m}} < 1$ including the "submonocrystal". The above theoretical support may be considered a new contribution of our model to the work function studies developed to date.

(6) As described in (1)–(5) above, δ_{m} has such a strong governance as to keep each of ϕ^+, ϕ^{e} and $\Delta\phi^*$ to be nearly constant representatively of the surface species itself so long as $\delta_{\mathrm{m}} < 0.5$. On the contrary, ϕ_{m} belonging to δ_{m} does not possess such an impartial effect upon all of the work functions. Typically for W(A) of mainly W(112) and W(B) of mainly W(110) with $\delta_{\mathrm{m}} < 0.5$, their values of $\phi_{\mathrm{m}} = 4.69$ and 5.35 eV have a considerable effect upon the determination of $\phi^{\mathrm{e}} = 4.62$ eV and $\phi^+ = 5.18$ eV, respectively, but have little to do with $\phi^+ = 5.13$ eV and $\phi^{\mathrm{e}} = 4.61$ eV, respectively (see Footnotes (1)–(8) in Table 6). This differential effect originates in the emission predominance emphasized in Section 1. Namely, ϕ_{m} has less effect upon ϕ^{e} and ϕ^+ when ϕ_{m} is relatively higher and lower among ϕ_i's, respectively. In conclusion, it is not ϕ_{m} but δ_{m} that substantially governs all of ϕ^+, ϕ^{e} and $\Delta\phi^*$ under the condition of $\delta_{\mathrm{m}} < 0.5$, as shown in Footnote (25) in Table 6. Here, each of the three values is found to be nearly constant to within ± 0.1 eV, irrespective of the large difference in ϕ_{m} ranging from 4.25 to 5.35 eV among the four different specimens of W(A)–W(D). It should be emphasized here again that our theoretical results thus achieved (Footnote (25)) are strongly supported by the experimental data shown in Footnote (26) in Table 6.

(7) In the case of the "submonocrystal" ($0.5 < \delta_{\mathrm{m}} < 1$) corresponding to Eq. (11), on the contrary to any polycrystal ($\delta_{\mathrm{m}} < 0.5$) mentioned just above, ϕ^{e} as well as $\Delta\phi^*$ depends upon δ_{m}. Typically, W(E) of mainly W(110) ($\delta_{\mathrm{m}} = 0.80$) has $\phi^{\mathrm{e}} = 4.87 \pm 0.06$ eV, which is very different from $\phi^{\mathrm{e}} = 4.61 \pm 0.04$ eV for W(F) of mainly W(100) ($\delta_{\mathrm{m}} = 0.95$) (see Table 6). In addition, each of them is considerably or somewhat different from 4.56 ± 0.03 eV for W(poly) ($\delta_{\mathrm{m}} < 0.5$) and also largely or slightly different from 5.32 ± 0.02 eV for W(110) ($\delta_{\mathrm{m}} = 1.0$) or 4.65 ± 0.02 eV for W(100) ($\delta_{\mathrm{m}} = 1.0$) (see Column (3) in Table 2). Namely, any "submonocrystal" ($0.5 < \delta_{\mathrm{m}} < 1$) has such an anomaly that ϕ^{e} is not independent of δ_{m}, changing considerably according to the surface compositions (F_i's and ϕ_i's) without having a universal constancy unique of the surface material itself. With regard to such a work function dependence upon δ_{m} as certified theoretically for W-submonocrystals above, we can find many other examples here and there in Table 1. Typically, $\phi^{\mathrm{e}} = 4.80$ eV for Ni(100) ($\delta_{\mathrm{m}} = 0.95$) [283] and 4.68 eV for Ni(111) (0.89) [283] are radically different from any of 5.06 eV for Ni(poly) ($\delta_{\mathrm{m}} < 0.5$), 5.19 eV for Ni(100) ($\delta_{\mathrm{m}} = 1$) and 5.32 eV for Ni(111) ($\delta_{\mathrm{m}} = 1$) (see Table 2). About the work function for any element, therefore, submonocrystal ($0.5 < \delta_{\mathrm{m}} < 1$) should be treated *separately* as another type (category) different from both polycrystal ($\delta_{\mathrm{m}} < 0.5$) and monocrystal ($\delta_{\mathrm{m}} = 1$), as already pointed out in Aspect and Policy (7) in Section 3.1. For a given specimen, of course, the work function value of any submonocrystal becomes nearer to the unique value characteristic of the poly- or monocrystalline surface itself as δ_{m} approaches to 0.5 or 1. It should be emphasized here again that δ_{m} is the key factor governing mainly the work function at a different mode between poly- and submonocrystal according to the conditions of $\delta_{\mathrm{m}} < 0.5$

and $0.5 < \delta_m < 1$, respectively. Our new findings of both the "key factor" (δ_m) and the anomaly of "submonocrystal" ($0.5 < \delta_m < 1$) outlined above originate entirely from our simple model leading to Eqs. (1)–(3) and (10)–(12), and they may be considered as an additional contribution to the work function studies developed to date [4406].

(8) Regarding submonocrystals, theoretical studies are made for other metals, too. Typically for Ir(111) ($\delta_m = 0.81$) [169], ϕ^e is theoretically evaluated to be 5.36 eV [803], which is in good agreement with 5.35 eV [169] determined experimentally for the same specimen. However, they are different from both 5.75 eV for Ir(111) ($\delta_m = 1$) and 5.28 eV for Ir(poly) ($\delta_m < 0.5$) (Table 2), thus showing again the anomaly of submonocrystal. In addition, our theoretical value of $\Delta\phi^* \equiv \phi^+ - \phi^e = 5.73 \pm 0.01 - 5.36 \pm 0.07$ eV $= 0.37 \pm 0.07$ eV [803] is smaller than $\Delta\phi^* = 0.48$ and 0.47 eV for Ir(poly) (see Columns 6–8 in Table 5). This difference is quite natural because $\delta_m = 0.81$ for Ir (submonocrystal) [3414] is larger than that ($\delta_m < 0.5$) of the generally called "polycrystal". Namely, the former is near to the "monocrystal" ($\delta_m = 1$) having $\Delta\phi^* = 0.0$ eV (see Average at the bottom of Table 5). The tendency of $\Delta\phi^* \rightarrow 0$ as $\delta_m \rightarrow 1$ is typically shown for W in Fig. 1.

(9) So long as $\delta_m < 1$, therefore, distinction between ϕ^+ and ϕ^e is very important to avoid the systematic errors due to $\Delta\phi^*$, although $\Delta\phi^*$ itself has long been overlooked or ignored by many workers without considering or examining the homogeneity of work function over the surface under study. Such errors due to $\Delta\phi^*$ inherent in any polycrystals and submonocrystals are accompanied typically with the evaluation of β^+ from Eq. (5) and of E^+ or E^0 from Eq. (9), as already exemplified in Section 4.1.

(10) In a typical case of $\delta_m \approx 1.0$ such as W(G) with $\delta_m = 0.96$ for the (100) plane, of course, all of ϕ^+, ϕ^a and ϕ^e have a substantially common value ($\phi_m \approx 4.6$ eV) characteristic of the main surface components ($F(100) = 0.96$ and $\phi(100) = 4.60$ eV), as may be seen in Footnote (58) in Table 6. Namely, our theoretical values of $\phi^+ = 4.60$ eV and $\phi^e = 4.59$ eV are essentially equal to $\phi^+ = 4.60$ eV and $\phi^e = 4.57$ eV [1351] (see Footnote (62)) and also to $\phi^+ = 4.62$ eV and $\phi^e = 4.65$ eV (Table 2) recommended for W(100) according mainly to the experimental data.

(11) Our model leads to the conclusion that the sequence of $\phi^+ > \phi^a > \phi^e$ holds always for $\delta_m < 1$ independent of the species of both poly- and submonocrystal. For W(F) alone among W(A)–W(G), for example, it may seem to be the "exceptions" that Footnote (39) $\phi^a = 4.61$ eV $< \phi^e = 4.65$ eV and also that (41) $\phi^a = 4.54$ eV $< \phi^e = 4.57$ eV. Both of them, however, are concluded to be not real but only apparent, being entirely due to the disregard of $F(116) = 0.01$ in Footnote (35). This conclusion may readily be understandable from the comparison with the results that (40) $\phi^a = 4.65$ eV $> \phi^e = 4.64$ eV and that (42) $\phi^a = 4.58$ eV $> \phi^e = 4.56$ eV. For the calculated values of these (40) and (42), $F(116) = 0.01$ in Footnote (36) is tentatively taken into consideration by the present author so that the total of $\Sigma F(hkl)$ may be exactly equal to 1.00 in contrast to 0.99 due to the above disregard (35). Such a treatment is entirely because it is for the four planes of (100)–(112) alone that the data on (35) $F_i = 0.95$–0.02 are specified by the corresponding author [3414].

(12) As δ_m increases from ~ 0.5 up to ~ 1, $\Delta\phi^*$ converges gradually to zero, closely approaching to the usually called "monocrystalline" surface ($\phi^+ = \phi^a = \phi^e = \phi$ and $\Delta\phi^* = 0$), just as concluded by both theory and experiment (see Table 5). Here, ϕ is the "work function" generally used without distinction among ϕ^+, ϕ^a and ϕ^e. Of course, any monocrystal with $\delta_m = 1$ is generally expected to have the unique work function value characteristic of the surface species itself within the uncertainty of about ± 0.1 eV under the normal condition (see Table 2).

4.5. Anomaly of submonocrystal work functions (ϕ^+ and ϕ^e)

The conclusions (7) and (8) described in Section 4.4 open a novel aspect as follows. In terms of work function, elemental crystals should be classified into the three different types as follows.

(1) Polycrystal ($\delta_m < 0.5$) having a nearly constant value (within ± 0.1 eV in fluctuation) of each ϕ^e and ϕ^+ ($\Delta\phi^* > 0$) characteristic of its elemental species in spite of a considerable difference in the surface components (ϕ_i and F_i) among different specimens.

(2) Submonocrystal ($0.5 < \delta_m < 1$) having such an anomaly that both ϕ^e and ϕ^+($\Delta\phi^* > 0$) are strongly dependent upon δ_m and hence any of them doesn't possess the constant value unique of its elemental species.

(3) Monocrystal ($\delta_m = 1$) with $\phi^e = \phi^+ = $ constant and $\Delta\phi^* = 0$ characteristic of its surface species.

For better understanding the anomaly of the submonocrystal work functions together with the key factor of δ_m, let's consider the work function change in two different solid systems. As may be known very well, every binary alloy changes in ϕ^e depending upon its alloy component (γ_c) [2626,2634,4251,4253]. Typically, the alloy of Ag–Yb shows that its ϕ^e decreases nonlinearly from 4.5 eV (Ag) to 2.7 eV (Yb) as γ_c of Yb increases from 0 to 1 in mole fraction [4251]. Typically, ϕ^e is found to be about 3.5 and 2.9 eV at γ_c (Yb) $= 0.3$ and 0.8, respectively. Namely, ϕ^e of the alloy is not constant but variable with a strong dependence upon γ_c in the range of between 0 and 1, while $\gamma_c = 0$ and 1 alone yield the constant values of ϕ^e unique of the surface species of polycrystalline Ag and Yb, respectively. Comparison of the effect on the work function between the surface component (δ_m) and the alloy one (γ_c) indicates that the dependence of ϕ^e on δ_m (>0.5, but $\neq 1$) resembles strongly that on γ_c ($\neq 0$ and $\neq 1$). The anomaly of submonocrystal (cf. Conclusion (7) in Section 4.4) may readily be understood by consideration of the resemblance that δ_m (surface component) corresponds closely to γ_c (alloy component) in terms of the governance of work function in the two different solid systems [4406].

It should be emphasized here again that the work functions (ϕ^e and ϕ^+) of polycrystal ($\delta_m < 0.5$) remain nearly constant (within ± 0.1 eV in fluctuation) independently of the difference in both ϕ_i and F_i among various specimens of the same species, but that both ϕ^e and ϕ^+ of submonocrystal ($0.5 < \delta_m < 1$) are governed differentially by the ϕ_i's values lower and higher than the others according to the principle of emission predominance (see Section 1). Namely, δ_m functions as the key factor having the critical point of 0.5, above which any of ϕ^e, ϕ^+ and $\Delta\phi^*$ of submonocrystal has no longer the independency of δ_m ($0.5 < \delta_m < 1$) and also the constancy characteristic of its elemental species, quite similarly to the case of a binary alloy ($0 < \gamma_c < 1$) exemplified just above.

4.6. Contrast ($\Delta\phi^{**}$) between ϕ^- and ϕ^e

Comparison between Eqs. (2) and (3) predicts that $\Delta\phi^{**} \equiv \phi^- - \phi^e$ should be zero without depending upon the heterogeneity in work function over the entire surface because both negative ions and electrons are emitted predominantly from lower work function sites, on the contrary to positive ions to be done so from higher ones. To confirm the prediction of $\Delta\phi^{**} = 0$ eV, the present author has tried to find the experimental data on both ϕ^- and ϕ^e measured usually by NSI and TE, respectively, for the *same* specimen under substantially the same condition. In NSI as well as PSI, the working temperatures are selected to be high enough to avoid the surface contamination due to the incident sample beam or vapor, as already mentioned in Section 2.7.

Table 7
Thermionic contrast ($\Delta\phi^{**} \equiv \phi^- - \phi^e$) determined for the same surface specimen under substantially the same condition in each study.

No.	Surface	Beam	Ion	ϕ^- (eV)	ϕ^e (eV)	$\Delta\phi^{**}$ (eV)	Meths.	Refs.
				A. Monocrystalline Surface				
6	C(111)	I_2	I_2^-	5.4	5.4 ± 0.5^d	$0.0 \pm >0.5$	NSI, various	[3771, Here]
42	Mo(100)	CsI	I^-	4.29 ± 0.02	4.38 ± 0.04^d	-0.09 ± 0.04	NSI, various	[572, Here]
42	Mo(100)	I_2	I^-	4.36 ± 0.05	4.35 ± 0.05	0.01 ± 0.07	NSI, TE	[571]
42	Mo(100)	Br_2	Br^-	4.36 ± 0.06	4.35 ± 0.05	0.01 ± 0.08	NSI, TE	[925]
73	Ta(110)	F^+	F^-	4.86 ± 0.1	4.82 ± 0.06^d	0.04 ± 0.12	NSI, various	[604, Here]
73	Ta(110)	Cl^+	Cl^-	4.92 ± 0.1	4.82 ± 0.06^d	0.10 ± 0.12	NSI, various	[604, Here]
74	W(100)	Br_2	Br^-	4.53 ± 0.05	4.65 ± 0.02^d	-0.12 ± 0.05	NSI, various	[1658, Here]
74	W(100)	I_2	I_2^-	4.55 ± 0.05	4.53 ± 0.05	0.02 ± 0.07	NSI, TE	[571]
Mean	–	–	–	–	–	**-0.04 ± 0.02^e**	–	–
				B. Polycrystalline Surface				
6	C/Pt	UF_6	UF_6^-	4.4	4.4	0.0	NSI, TE	[675]
6	C/Pt–W(8%)	UF_6	UF_6^-	4.4	4.4	0.0	NSI, TF	[675]
6	C(ribbon)	N_2^+	CN^-	4.6 ± 0.2	4.63 ± 0.06^d	0.0 ± 0.2	NSI, various	[617, Here]
42	Mo	Ag	Ag^-	$(1.38 \pm 0.10)^a$	$(1.30)^b$	$0.08 \pm >0.10^c$	NSI, TE	[569,1351]
42	Mo	Au	Au^-	$(2.34 \pm 0.10)^a$	$(2.31)^b$	$0.03 \pm >0.10^c$	NSI, TE	[569,1351]
42	Mo	KI	I^-	$(3.08 \pm 0.07)^a$	$(3.06)^b$	$0.02 \pm >0.07^c$	NSI, TE	[569,1351]
73	Ta	Br^+	Br^-	4.22	4.37 ± 0.1	$-0.15 \pm >0.1$	NSI, TE	[600,641]
73	Ta	I^+	I^-	4.23	4.37 ± 0.1	$-0.14 \pm >0.1$	NSI, TE	[600,641]
73	Ta	Cl^+	Cl^-	4.28	4.37 ± 0.1	$-0.09 \pm >0.1$	NSI, TE	[600,641]
74	W	CsCl	Cl^-	4.46	4.56 ± 0.03^d	$-0.10 \pm >0.03$	NSI, various	[574, Here]
74	W	KCl	Cl^-	4.49	4.56 ± 0.03^d	$-0.07 \pm >0.03$	NSI, various	[574, Here]
74	W	KI	I^-	4.49	4.56 ± 0.03^d	$-0.07 \pm >0.03$	NSI, various	[574, Here]
74	W	I	I^-	4.49	4.51	-0.02	NSI, TE	[827]
74	W	–	W^-	4.5	4.56 ± 0.03^d	$-0.06 \pm >0.03$	NSI, various	[966, Here]
74	W	RbCl	Cl^-	4.51	4.56 ± 0.03^d	$-0.05 \pm >0.03$	NSI, various	[574, Here]
74	W	I_2	I^-	4.51	4.51	0.00	NSI, TE	[827]
74	W	SF_6	SF_6^-	4.54	4.56 ± 0.03^d	$-0.02 \pm >0.03$	NSI, various	[586, Here]
74	W	KBr	Br^-	4.58	4.56 ± 0.03^d	$0.02 \pm >0.03$	NSI, various	[574, Here]
74	W	H_2	H^-	$(0.8 \pm 0.1)^a$	$(0.75)^b$	$0.05 \pm >0.1^c$	NSI, TE	[587,1351]
74	W	Cl_2	Cl^-	$(3.72 \pm 0.04)^a$	$(3.62)^b$	$0.10 \pm >0.04^c$	NSI, TE	[588,1351]
74	W	$SnCl_4$	Cl^-	$(3.72 \pm 0.04)^a$	$(3.62)^b$	$0.10 \pm >0.04^c$	NSI, TE	[588,1351]
74	W	Br_2	Br^-	$(3.49 \pm 0.02)^a$	$(3.36)^b$	$0.13 \pm >0.02^c$	NSI, TE	[589,1351]
74	W	KI	I^-	$(3.08 \pm 0.07)^a$	$(3.06)^b$	$0.02 \pm >0.07^c$	NSI, TE	[569,1351]
74	W	I_2	I^-	$(3.1)^a$	$(3.06)^b$	0.04^c	NSI, TE	[591,1351]
74	W	I_2	I^-	$(3.14 \pm 0.07)^a$	$(3.06)^b$	$0.08 \pm >0.07^c$	NSI, TE	[590,1351]
74	W	Ag	Ag^-	$(1.38 \pm 0.10)^a$	$(1.30)^b$	$0.08 \pm >0.10^c$	NSI, TE	[569,1351]
74	W	Au	Au^-	$(2.34 \pm 0.10)^a$	$(2.31)^b$	$0.03 \pm >0.10^c$	NSI, TE	[569,1351]
90	Th	I_2	I^-	3.58	3.46	0.12	NSI, TE	[827]
90	Th	I	I^-	3.60	3.46	0.14	NSI, TE	[827]
Mean	–	–	–	–	–	**0.01 ± 0.07^e**	–	–

[a] Each value in parentheses is not ϕ^- but electron affinity (E) determined for a probing atom (Ag, Au, I, etc.) by the corresponding author(s).

[b] Each value in parentheses is not ϕ^e but the electron affinity (E^*) accepted today as the most probable value [577,578,972,973].

[c] Each of the contrasts is estimated from the difference ($\Delta\phi^{**} = E - E^*$) as the possible error due to the assumption that ϕ^- is equal to ϕ^e (see Table 12 in Ref. [1351]).

[d] Each value (e.g., $\phi^e = 4.38 \pm 0.03$ eV for Mo(100)) is cited tentatively from the most probable value in Table 2 [Here] because each of the corresponding references (e.g. [572]) has no data on ϕ^e characteristic of the surface specimen itself (e.g., Mo(100)) under study.

[e] Just as predicted theoretically by Eqs. (2) and (3), polycrystals as well as monocrystals are verified experimentally to have $\Delta\phi^{**} \approx 0.0$ eV in contrast to $\Delta\phi^* \approx 0.0$ eV for clean and smooth monocrystals alone and also to $\Delta\phi^* > 0.0$ eV for any polycrystals (see Table 5).

The results thus achieved for $\Delta\phi^{**}$ is summarized in Table 7. Here, the total data are much scanty, disappointingly, compared with those on $\Delta\phi^* \equiv \phi^+ - \phi^e$ summarized in Table 4. From the data in Table 7, however, we may draw the conclusions as follows.

Table 8 (*continued*)

Surface	D_s (atoms/10^{14} cm^2)	ϕ^e (eV)	ϕ^e (eV)	ϕ^e (eV)	ϕ^e (eV)	ϕ^e (eV)	ϕ^e (eV)
				Re. hcp[d]			
Re(0001)	15.1	5.26 ± 0.05	5.30 ± 0.21	5.53	5.59 ± 0.05	–	–
Re(1011)	14.3	–	5.26 ± 0.13	–	5.37 ± 0.03	5.55 ± 0.03	5.69 ± 0.06
Re(1010)	8.1	–	5.12 ± 0.05	5.20	5.15 ± 0.02	5.95 ± 0.15	5.52 ± 0.03
Meth.	–	CPD	various	TC	TE	FE	PE
Refs.	[340]	[3378]	[Here][a]	[1159,1980]	[402,3416]	[730]	[403]

[a] The data on ϕ^e [Here] are cited from the most probable values in Table 2.

[b] Its unit for Al is atoms/10^{18} cm^2.

[c] Regarding the triple set investigated for Al by the same worker(s) under the common condition, the present author has not yet found any data by CPD, FE, etc. other than PE and TC.

[d] To the best of the present author's knowledge, it is by TE alone that the complete set for Re is studied under the same condition and method.

As exemplified in Table 8, the data on W of the bcc-type show the normal trend that ϕ^e(hkl) decreases monotonically with decreasing D_s(hkl), irrespective of the difference in determination method, except PE having single datum alone [1273]. About the fcc-type of Ni, all the methods except FE [1898] affords the general trend well accordant to D_s(hkl). With respect to the hcp-type of Re(hkil), a similar tendency may be expectable, although the available data are much scanty than those of W and Ni and also they include one exception by FE [730] against the above trend.

Regarding the listed data on Al of fcc-type, in contrast to Ni, only two examples [556,612] follow the sequence of ϕ^e(111) > ϕ^e(100) > ϕ^e(110) with a decrease in D_s(hkl), in contrast to the four other examples [239,241], Here, [718] determined mainly by PE or TC. To the best of the present author's knowledge, the triple set of ϕ^e(hkl) determined by the same worker(s) using CPD, FE or TE has not yet been reported for Al. According to the examples shown in Table 8, the data on Al alone seem to be anomalous frequently to the corresponding sequence, in contrast to the others to be so rather seldom.

The above result strongly suggests it very interesting to examine carefully the problem whether the sequences of ϕ^e(110) > ϕ^e(100) > ϕ^e(111) for bcc-metals and also of ϕ^e(111) > ϕ^e(100) > ϕ^e(110) for fcc-ones in accordance with the decrease in D_s(hkl) may hold surely for many metals listed in Table 1. Many results to be thus examined will be discussed below in Sections 5.2–5.4. In addition, let's examine other anisotropic sequences of surface energy (ε) and melting point (T_m) in Section 5.5, where the quantitative relations between ε and ϕ^e and also between T_m and ϕ^e will be summarized briefly.

5.2. Examination of the anisotropic work function sequence for bcc-metals

From the above viewpoint, the present author has tried to examine the sequence of ϕ^e(110) > ϕ^e(100) > ϕ^e(111) for various bcc-metals by citing many triple sets of work function data from Table 1, where each set is investigated by the same worker(s) employing either the identical method under the same condition or the same theoretical model. The results thus obtained are summarized in Table 9, which shows the examination of the sequence found for 32 species of bcc-metals ranging from Li to U. Here, "Yes" and "No" mean that the sequence of ϕ^e(110) > ϕ^e(100) > ϕ^e(111) holds exactly and never, respectively. Especially, each triple sequence with double underlines for each metal species originates from the most probable values estimated by the present author using much data achieved by many groups of workers adopting various methods (see Table 2), and the sequence with a single underline comes from the data recommended previously in Table 2 in Ref. [1351]. Therefore, both of the two may be expected probably to be more accurate or reliable than any of the others based on a single method (or model) employed by an individual group of workers, although the data available for each metal in the latter [1351] are generally not so abundant as those in the former [Here].

Table 9

Examination of the work function sequence of ϕ^e(110) > ϕ^e(100) > ϕ^e(111) for the three principal planes of bcc metals.

No.	Metal.	ϕ^e(110) (eV)		ϕ^e(100) (eV)		ϕ^e(111) (eV)	Seq.	Meth.	Refs.
3	Li	2.40	=	2.40	>	2.30	No	TC	[475]
3	Li	2.78	>	2.61	>	2.58	Yes	TC	[1980]
3	Li	3.00	=	3.00	>	2.90	No	TC	[1095]
3	Li	3.09	>	2.92	>	2.90	Yes	TC	[231]
3	Li	3.18	>	3.11	>	2.96	Yes	TC	[711]
3	Li	3.221	>	2.986	>	2.746	Yes	TC	[4091]
3	Li	3.27	>	3.03	>	2.93	Yes	TC	[553]
3	Li	3.31	>	3.25	>	3.12	Yes	TC	[476,711]
3	Li	3.31	>	3.26	>	3.12	Yes	TC	[711]
3	Li	3.32	>	3.04	>	2.94	Yes	TC	[3467]
3	Li	3.37 ± 0.05	>	3.12 ± 0.03	>	3.04 ± 0.08	Yes	TC	[Here][a]
3	Li	3.40	>	3.36	<	3.44	No	TC	[637]
3	Li	3.43	>	3.03	<	3.12	No	TC	[637,2418]

Table 9 (*continued*)

No.	Metal.	$\phi^e(110)$ (eV)		$\phi^e(100)$ (eV)		$\phi^e(111)$ (eV)	Seq.	Meth.	Refs.
3	Li	3.43	>	3.28	>	3.15	Yes	TC	[3814]
3	Li	3.44	>	3.39	>	3.26	Yes	TC	[476]
3	Li	3.46	>	3.06	<	3.09	No	TC	[637,2418]
3	Li	3.5	>	3.4	>	3.2	Yes	TC	[1088]
3	Li	3.54	>	3.27	>	3.13	Yes	TC	[1237]
3	Li	3.55	>	3.30	>	3.25	Yes	TC	[475]
3	Li	3.55	>	3.32	>	3.13	Yes	TC	[556]
3	Li	3.58	>	3.30	>	3.16	Yes	TC	[1030]
3	Li	3.61	>	3.10	>	2.97	Yes	TC	[321]
3	Li	3.63	>	3.32	>	3.19	Yes	TC	[555]
3	Li	3.77	>	3.56	>	3.42	Yes	TC	[472]
3	Li	3.87	>	3.47	>	3.20	Yes	TC	[1030]
Conformity $(N_{yes}/N_{total})^d$				–		–	**80%**	–	–
11	Na	2.52	>	2.40	>	2.39	Yes	TC	[1159]
11	Na	2.75	>	2.58	>	2.54	Yes	TC	[231]
11	Na	2.76	>	2.60	>	2.57	Yes	TC	[3467]
11	Na	2.839	>	2.638	>	2.585	Yes	TC	[4091]
11	Na	2.86	>	2.69	>	2.63	Yes	TC	[4222]
11	Na	2.87	>	2.66	>	2.26	Yes	TC	[3477]
11	Na	2.88	>	2.66	>	2.59	Yes	TC	[553]
11	Na	2.9	>	2.7	>	2.6	Yes	TC	[2851]
11	Na	2.91	>	2.77	>	2.56	Yes	TC	[711]
11	Na	2.98	>	2.80	>	2.79	Yes	TC	[4398]
11	Na	2.99	>	2.80	>	2.77	Yes	TC	[4398]
11	Na	3.00	>	2.86	>	2.71	Yes	TC	[473]
11	Na	3.00	>	2.83	>	2.48	Yes	TC	[3477]
11	Na	3.00	>	2.80	>	2.79	Yes	TC	[721]
11	Na	3.04	>	2.89	>	2.72	Yes	TC	[3814]
11	Na	3.05 ± 0.04	>	2.80 ± 0.04	>	2.68 ± 0.06	Yes	TC	[Here]^a
11	Na	3.06	>	2.93	>	2.73	Yes	TC	[476,711]
11	Na	3.08	>	2.88	>	2.75	Yes	TC	[1030]
11	Na	3.1	>	2.9	>	2.8	Yes	TC	[1088]
11	Na	3.10	>	2.75	>	2.65	Yes	TC	[475]
11	Na	3.11	>	2.88	>	2.76	Yes	TC	[555]
11	Na	3.13	>	2.84	>	2.76	Yes	TC	[556]
11	Na	3.16	>	3.04	>	2.85	Yes	TC	[476]
11	Na	3.22	>	3.03	>	2.82	Yes	TC	[472,554]
11	Na	3.3	>	3.0	>	2.7	Yes	TC	[1088]
11	Na	3.33	>	3.07	>	2.79	Yes	TC	[1030]
11	Na	3.44	>	2.95	>	2.83	Yes	TC	[321]
11	Na	3.62	>	3.27	>	3.17	Yes	TC	[1095]
Conformity $(N_{yes}/N_{total})^d$				–		–	**100%**	–	–
19	K	2.35	>	2.25	>	2.24	Yes	TC	[1159,3067]
19	K	2.37	>	2.21	>	2.17	Yes	TC	[231]
19	K	2.372	>	2.24	>	2.18	Yes	TC	[4091]
19	K	2.43	>	2.26	>	2.21	Yes	TC	[3467]
19	K	2.44	>	2.27	>	2.19	Yes	TC	[553]
19	K	2.58	>	2.43	>	2.21	Yes	TC	[711]
19	K	2.72	>	2.51	>	2.39	Yes	TC	[1030]
19	K	2.74 ± 0.04	>	2.47 ± 0.04	>	2.39 ± 0.02	Yes	TC	[Here]^a
19	K	2.75	>	2.60	>	2.38	Yes	TC	[476,711]
19	K	2.75	>	2.40	>	2.35	Yes	TC	[475]
19	K	2.76	>	2.59	>	2.42	Yes	TC	[472]
19	K	2.82	>	2.68	>	2.48	Yes	TC	[476]
19	K	2.9	>	2.7	>	2.5	Yes	TC	[55,1088]
19	K	2.90	>	2.49	>	2.39	Yes	TC	[321]
19	K	2.96	>	2.55	>	2.40	Yes	TC	[3814]
19	K	3.01	>	2.71	>	2.45	Yes	TC	[1030]
19	K	3.15	>	2.80	>	2.75	Yes	TC	[1095]
Conformity $(N_{yes}/N_{total})^d$				–		–	**100%**	–	–
20	γ-Ca	4.09	>	3.52	>	3.37	Yes	TC	[321]
22	β-Ti	4.57	>	3.94	>	3.76	Yes	TC	[321]
22	β-Ti	$a_0 + 0.3673$	>	a_0	>	$a_0 - 0.3982$	Yes	TC	[4259]^f
23	V	4.52	>	3.88	>	3.72	Yes	TC	[321]

Table 9 (*continued*)

No.	Metal.	$\phi^e(110)$ (eV)		$\phi^e(100)$ (eV)		$\phi^e(111)$ (eV)	Seq.	Meth.	Refs.
23	V	4.96	>	4.29	>	4.10	Yes	TC	[2548]
23	V	4.97	>	4.28	>	4.11	Yes	TC	[1980,3067]
23	V	5.00	>	4.46	>	4.19	Yes	TE	[3695]
23	V	5.04 ± 0.07	>	4.27 ± 0.05	>	4.13 ± 0.04	Yes	various	[Here][a]
23	V	$b_0 + 0.3735$	>	b_0	>	$b_0 - 0.4237$	Yes	TC	[4259][f]
Conformity $(N_{yes}/N_{total})^d$				–		–	**100%**	–	–
24	Cr	4.44	>	4.27	>	3.78	Yes	TC	[4034]
24	Cr	4.53	>	3.90	>	3.72	Yes	TC	[321]
24	Cr	4.70	>	3.88	=	3.88	No	TC	[2818]
24	Cr	4.99 ± 0.19	>	4.43 ± 0.14	>	3.8 ± 0.1	Yes	various	[Here][a]
24	Cr	$c_0 + 0.4143$	>	c_0	>	$c_0 - 0.4319$	Yes	TC	[4259][f]
Conformity $(N_{yes}/N_{total})^d$				–		–	**80%**	–	–
25	δ-Mn	4.97	>	4.27	>	4.09	Yes	TC	[321]
25	δ-Mn	5.3 ± 0.3	>	4.8 ± 0.4	>	4.1	Yes	TC	[Here][a]
26	α-Fe	4.75	>	3.87	<	3.89	No	TC	[1625]
26	α-Fe	4.76	>	3.91	<	3.95	No	TC	[1625]
26	α-Fe	4.81	>	3.86	<	3.90	No	TC	[1619]
26	α-Fe	4.82	>	3.91	=	3.91	No	TC	[1619]
26	α-Fe	4.99 ± 0.04	>	4.64 ± 0.05	>	4.4 ± 0.3	Yes	various	[Here][a]
26	α-Fe	5.07 ± 0.04	>	4.60 ± 0.33	<	4.81 ± 0.29	No	various	[4088]
26	α-Fe	5.12	>	3.85	>	3.81	Yes	TC	[4222]
26	α-Fe	5.30	>	4.55	>	4.35	Yes	TC	[321]
Conformity $(N_{yes}/N_{total})^d$				–		–	**38%**	–	–
37	Rb	2.20	>	2.10	>	2.05	Yes	TC	[475]
37	Rb	2.243	>	2.115	>	2.096	Yes	TC	[4091]
37	Rb	2.28	>	2.12	>	2.08	Yes	TC	[231]
37	Rb	2.33	>	2.15	>	2.09	Yes	TC	[3467]
37	Rb	2.33	>	2.17	>	2.12	Yes	TC	[553]
37	Rb	2.40	=	2.40	>	2.22	No	TC	[472]
37	Rb	2.46	>	2.28	>	2.06	Yes	TC	[711]
37	Rb	2.49	>	2.36	>	2.26	Yes	TC	[1030]
37	Rb	2.56	>	2.41	>	2.25	Yes	TC	[3814]
37	Rb	2.57	>	2.47	>	2.42	Yes	TC	[1095]
37	Rb	2.63	>	2.45	>	2.23	Yes	TC	[476,711]
37	Rb	2.65	>	2.35	>	2.30	Yes	TC	[475]
37	Rb	2.65 ± 0.05	>	2.31 ± 0.08	>	2.21 ± 0.09	Yes	TC	[Here][a]
37	Rb	2.70	>	2.53	>	2.32	Yes	TC	[476]
37	Rb	2.72	>	2.54	>	2.28	Yes	TC	[1030,1089]
37	Rb	2.79	>	2.40	>	2.30	Yes	TC	[321]
37	Rb	2.9	>	2.6	>	2.3	Yes	TC	[1088]
Conformity $(N_{yes}/N_{total})^d$				–		–	**94%**	–	–
38	γ-Sr	2.63	<	2.71	<	2.80	No	TC	[1159]
38	γ-Sr	3.2 ± 0.6	>	3.0 ± 0.3	=	3.0 ± 0.2	No	TC	[Here][a]
38	γ-Sr	3.81	>	3.27	>	3.13	Yes	TC	[321]
39	β-Y	4.28	>	3.67	>	3.52	Yes	TC	[321]
39	β-Y	$d_0 + 0.303$	>	d_0	>	$d_0 - 0.355$	Yes	TC	[4246][f]
40	β-Zr	4.57	>	3.94	>	3.76	Yes	TC	[321]
40	β-Zr	$e_0 + 0.367$	>	e_0	>	$e_0 - 0.407$	Yes	TC	[4246][f]
41	Nb	4.488	>	3.552	<	3.775	No	TC	[4091]
41	Nb	4.51 ± 0.02	>	3.97 ± 0.02	<	4.08 ± 0.02	No	PE	[336]
41	Nb	4.61	>	3.96	>	3.80	Yes	TC	[321]
41	Nb	4.63 ± 0.17	>	4.08 ± 0.17	<	4.37 ± 0.19	No	various	[4088]
41	Nb	4.64^{+e}	>	4.04^+	>	3.78^+	Yes	PSI	[739]
41	Nb	4.74	>	4.06	>	3.93	Yes	TC	[2548]
41	Nb	$4.74 \pm 0.10^+$	>	4.04^+	>	$3.84 \pm 0.06^+$	Yes	PSI	[Here][a]
41	Nb	4.75	>	4.07	>	3.94	Yes	TC	[1159]
41	Nb	4.77 ± 0.05	>	4.02 ± 0.05	>	3.95 ± 0.09	Yes	various	[Here][a]
41	Nb	4.80	>	3.90	>	3.88	Yes	TE	[739]
41	Nb	4.80 ± 0.05	>	3.95 ± 0.03	>	3.88 ± 0.03	Yes	TE	[775,2811]

(*continued on next page*)

Table 9 (*continued*)

No.	Metal.	ϕ^e(110) (eV)		ϕ^e(100) (eV)		ϕ^e(111) (eV)	Seq.	Meth.	Refs.
41	Nb	4.83 ± 0.05	>	3.95 ± 0.05	>	3.86 ± 0.03	Yes	various	[1351][b]
41	Nb	4.87 ± 0.07	>	4.02 ± 0.06	<	4.36 ± 0.06	No	TE	[779]
41	Nb	4.90 ± 0.05	>	3.86 ± 0.05	>	3.84 ± 0.05	Yes	TE	[774]
41	Nb	$f_0 + 0.443$	>	f_0	>	$f_0 - 0.435$	Yes	TC	[4246][f]
41	Nb	$p_0 + 0.56$	>	p_0	>	$p_0 - 0.07$	Yes	TC	[4078][g]
Conformity (N_{yes}/N_{total})[d]				–		–	**75%**	–	–
42	Mo	4.32 ± 0.07	>	4.1 ± 0.1	<	4.33 ± 0.01	No	TE	[643]
42	Mo	4.510	>	3.842	<	3.940	No	TC	[4091]
42	Mo	4.59	>	4.01	>	4.00	Yes	TC	[4057]
42	Mo	4.64	>	4.06	>	3.86	Yes	TC	[4057]
42	Mo	4.7 ± 0.04	>	4.5 ± 0.04	<	4.8 ± 0.04	No	TE	[3344]
42	Mo	4.77	>	4.10	>	3.93	Yes	TC	[321]
42	Mo	4.81 ± 0.09	>	4.35 ± 0.02	>	4.00 ± 0.08	Yes	FE	[3691]
42	Mo	4.82	>	4.28	>	4.23	Yes	TC	[3224]
42	Mo	4.83	>	4.26	>	4.06	Yes	FE	[648]
42	Mo	4.84	>	4.28	<	4.30	No	TC	[1624]
42	Mo	4.85	>	4.20	<	4.27	No	TC	[639]
42	Mo	4.85 ± 0.05	>	4.40 ± 0.05	>	4.15 ± 0.05	Yes	TE	[323]
42	Mo	4.88	>	4.03	<	4.32	No	TC	[639]
42	Mo	4.90 ± 0.04	>	4.60 ± 0.04	>	4.35 ± 0.04	Yes	TE	[2244]
42	Mo	4.90 ± 0.05	>	4.43 ± 0.05	>	4.10 ± 0.05	Yes	TE	[781]
42	Mo	4.92 ± 0.05	>	4.46 ± 0.11	>	4.37 ± 0.24	Yes	various	[4088]
42	Mo	4.94	>	4.58	>	4.55	Yes	TC	[3224]
42	Mo	4.95 ± 0.02	>	4.53 ± 0.02	<	4.55 ± 0.02	No	PE	[325]
42	Mo	4.95 ± 0.05	>	4.43 ± 0.05	>	4.10 ± 0.05	Yes	TE	[739,1407]
42	Mo	4.96 ± 0.06	>	4.40 ± 0.03	>	4.09 ± 0.07	Yes	various	[1351][b]
42	Mo	4.98 ± 0.03	>	4.38 ± 0.03	>	4.29 ± 0.03	Yes	various	[Here][a]
42	Mo	5.00	>	4.45	>	4.20	Yes	FE	[1416]
42	Mo	5.00 ± 0.05	>	4.40 ± 0.02	>	4.10 ± 0.02	Yes	TE	[127,144]
42	Mo	5.1^+	>	$4.38 \pm 0.08^+$	>	$4.17 \pm 0.09^+$	Yes	PSI	[Here][a]
42	Mo	5.1	>	4.5	>	4.2	Yes	TE	[2339]
42	Mo	5.10 ± 0.03	>	4.40 ± 0.03	>	4.10 ± 0.03	Yes	TE	[727,3103]
42	Mo	5.10 ± 0.05	>	4.40 ± 0.05	>	4.15 ± 0.05	Yes	TE	[323]
42	Mo	5.10 ± 0.15	>	4.26 ± 0.03	>	3.94 ± 0.05	Yes	FE	[999]
42	Mo	5.11 ± 0.07	>	4.28 ± 0.01	>	3.99 ± 0.02	Yes	FE	[999,1668]
42	Mo	5.13	>	4.37	>	4.07	Yes	TC	[4034]
42	Mo	$5.13 \pm 0.03^+$	>	$4.37 \pm 0.07^+$	>	$4.07 \pm 0.13^+$	Yes	PSI	[1351][b]
42	Mo	$5.13 \pm 0.03^{+e}$	>	$4.44 \pm 0.03^+$	>	$4.13 \pm 0.03^+$	Yes	PSI	[727,3103]
42	Mo	5.23	>	4.43	>	4.25	Yes	TC	[2548]
42	Mo	5.23	>	4.44	>	4.27	Yes	TC	[1980]
42	Mo	5.4 ± 0.2	>	4.5 ± 0.1	>	4.3 ± 0.1	Yes	TE	[335,1650]
42	Mo	5.90	>	4.36	>	4.23	Yes	TC	[3224]
42	Mo	$q_0 + 0.43$	>	q_0	>	$q_0 - 0.22$	Yes	TC	[4078][g]
42	Mo	$g_0 + 0.470$	>	g_0	>	$g_0 - 0.453$	Yes	TC	[4246][f]
Conformity (N_{yes}/N_{total})[d]				–		–	**82%**	–	–
50	α-Sn	4.77	>	3.47	<	4.01	No	TC	[3211]
55	Cs	2.073	>	1.974	>	1.971	Yes	TC	[4091]
55	Cs	2.17	>	2.01	>	1.97	Yes	TC	[231]
55	Cs	2.19	>	2.04	>	2.01	Yes	TC	[553,2427]
55	Cs	2.21	>	2.03	>	1.98	Yes	TC	[3467]
55	Cs	2.23	>	2.14	=	2.14	No	TC	[1159]
55	Cs	2.25	>	1.90	>	1.80	Yes	TC	[475]
55	Cs	2.34	>	2.14	>	1.93	Yes	TC	[711]
55	Cs	2.35	>	2.23	>	2.14	Yes	TC	[1030]
55	Cs	2.44	>	2.28	>	2.14	Yes	TC	[3814]
55	Cs	2.51	>	2.31	>	2.10	Yes	TC	[476,711]
55	Cs	2.54 ± 0.07	>	2.24 ± 0.06	>	2.09 ± 0.08	Yes	TC	[Here][a]
55	Cs	2.56	>	2.40	>	2.14	Yes	TC	[1030,1089]
55	Cs	2.57	>	2.39	>	2.19	Yes	TC	[476]
55	Cs	2.59	>	2.24	>	2.14	Yes	TC	[1095]
55	Cs	2.60	>	2.24	>	2.14	Yes	TC	[321]
55	Cs	2.60	>	2.30	>	2.20	Yes	TC	[475]
55	Cs	2.62	>	2.36	>	2.24	Yes	TC	[555]
55	Cs	2.8	>	2.3	>	2.2	Yes	TC	[1086,1088]
Conformity (N_{yes}/N_{total})[d]				–		–	**94%**	–	–

Table 9 (*continued*)

No.	Metal.	ϕ^e(110) (eV)		ϕ^e(100) (eV)		ϕ^e(111) (eV)	Seq.	Meth.	Refs.
56	Ba	2.384	>	2.31	>	2.293	Yes	TC	[4091]
56	Ba	2.71	>	2.50	>	2.48	Yes	TC	[1159]
56	Ba	2.83	>	2.67	<	2.73	No	TC	[231]
56	Ba	2.88	>	2.68	<	2.72	No	TC	[3467]
56	Ba	3.21	>	3.15	>	2.85	Yes	TC	[476]
56	Ba	3.32	>	3.26	>	2.96	Yes	TC	[476]
56	Ba	3.46 ± 0.14	>	3.07 ± 0.06	>	2.81 ± 0.06	Yes	TC	[Here][a]
56	Ba	3.49	>	3.00	>	2.87	Yes	TC	[321]
56	Ba	3.56	>	3.06	>	2.86	Yes	TC	[1030]
56	Ba	3.58	>	3.42	>	2.85	Yes	TC	[1030]
Conformity $(N_{yes}/N_{total})^d$				–		–	**80%**	–	–
57	γ-La	3.76	>	3.23	>	3.09	Yes	TC	[321]
57	γ-La	$h_0 + 0.281$	>	h_0	>	$h_0 - 0.334$	Yes	TC	[4246][f]
58	γ-Ce	4.63	>	3.98	>	3.81	Yes	TC	[321]
59	β-Pr	3.86	>	3.32	>	3.17	Yes	TC	[321]
60	β-Nd	4.23	>	3.63	>	3.48	Yes	TC	[321]
62	Sm	3.76	>	3.23	>	3.09	Yes	TC	[321]
63	Eu	3.80	>	3.26	>	3.12	Yes	TC	[321]
64	β-Gd	4.13	>	3.55	>	3.40	Yes	TC	[321]
65	β-Tb	4.52	>	3.88	>	3.72	Yes	TC	[321]
71	β-Lu	4.13	>	3.54	>	3.39	Yes	TC	[321]
72	β-Hf	5.03	>	4.32	>	4.13	Yes	TC	[321]
72	β-Hf	4.31	>	3.30	<	3.35	No	TC	[4057]
72	β-Hf	4.31	>	3.30	<	3.39	No	TC	[4057]
72	β-Hf	$i_0 + 0.358$	>	i_0	>	$i_0 - 0.4177$	Yes	TC	[4246][f]
73	Ta	4.74	>	4.07	>	3.93	Yes	TC	[2548]
73	Ta	4.74 ± 0.09	>	4.10 ± 0.25	>	3.50 ± 0.21	Yes	various	[4088]
73	Ta	4.75	>	4.08	>	3.94	Yes	TC	[1980]
73	Ta	4.77	>	3.83	<	3.93	No	TC	[1200]
73	Ta	4.78	>	3.83	<	3.96	No	TC	[1200]
73	Ta	4.80 ± 0.02	>	4.15 ± 0.02	>	4.00 ± 0.02	Yes	TE	[127,144]
73	Ta	4.81 ± 0.05	>	4.17 ± 0.09	>	4.00 ± 0.04	Yes	various	[1351][b]
73	Ta	4.82 ± 0.06	>	4.15 ± 0.05	>	4.01 ± 0.04	Yes	various	[Here][a]
73	Ta	4.83 ± 0.05	>	4.12 ± 0.05	>	3.98 ± 0.05	Yes	TE	[739,798]
73	Ta	$4.84 \pm 0.02^+$	>	4.20^+	>	$4.00 \pm 0.05^+$	Yes	PSI	[Here][a]
73	Ta	$4.84 \pm 0.04^+$	>	$4.20 \pm 0.04^+$	>	$4.00 \pm 0.04^+$	Yes	PSI	[797]
73	Ta	$4.85 \pm 0.05^+$	>	$4.20 \pm 0.04^+$	>	$4.00 \pm 0.05^+$	Yes	PSI	[1351][b]
73	Ta	4.86	>	4.04	>	3.51	Yes	TC	[1200]
73	Ta	4.87	>	4.11	>	3.50	Yes	CT	[1200]
73	Ta	4.95	>	4.10	>	3.95	Yes	FE	[796]
73	Ta	4.964	>	4.096	<	4.201	No	TC	[4091]
73	Ta	5.16	>	4.44	>	4.25	Yes	TC	[321]
73	Ta	$r_0 + 0.29$	>	r_0	>	$r_0 - 0.36$	Yes	TC	[4078][g]
73	Ta	$j_0 + 0.499$	>	j_0	>	$j_0 - 0.491$	Yes	TC	[4246][f]
Conformity $(N_{yes}/N_{total})^d$				–		–	**84%**	–	–
74	W	4.58	>	4.52	>	4.38	Yes	TE	[150]
74	W	4.6	>	4.54	<	5.3	No	FE	[2714]
74	W	4.65	>	4.53	>	4.38	Yes	TE	[2706]
74	W	4.65 ± 0.02	>	4.56 ± 0.02	>	4.35 ± 0.02	Yes	TE	[149]
74	W	4.66 (4.58)	>	4.52	>	4.38 ± 0.02	Yes	TE	[150]
74	W	4.67 ± 0.05	>	4.55 ± 0.05	>	4.26 ± 0.05	Yes	TE	[1663,2012]
74	W	4.758	>	4.090	<	4.240	No	TC	[4091]
74	W	4.9	>	4.6	>	4.4	Yes	FE	[1463]
74	W	4.92	>	4.48	>	4.45	Yes	TE	[352]
74	W	5.0 ± 0.2	>	4.6 ± 0.1	>	4.4 ± 0.1	Yes	TE	[335,1650]
74	W	5.02 ± 0.03	>	4.59 ± 0.02	>	4.49 ± 0.02	Yes	FE	[502]
74	W	5.025	>	4.37	<	4.381	No	TC	[4189]

Table 9 (*continued*)

No.	Metal.	ϕ^e(110) (eV)		ϕ^e(100) (eV)		ϕ^e(111) (eV)	Seq.	Meth.	Refs.
74	W	5.09	>	4.40	>	4.35	Yes	TE	[141]
74	W	5.11	>	4.46	>	4.41	Yes	TC	[3224]
74	W	5.11 ± 0.02	>	4.65 ± 0.04	>	4.45	Yes	CPD	[1056]
74	W	5.13	>	4.50	>	4.44	Yes	TC	[4405]
74	W	5.13 ± 0.02	>	4.65 ± 0.02	>	4.60 ± 0.02	Yes	CPD	[582]
74	W	5.14 ± 0.03[+e]	>	4.66 ± 0.03[+]	>	4.42 ± 0.03[+]	Yes	PSI	[3103]
74	W	5.15	>	4.54	>	4.49	Yes	TC	[3224]
74	W	5.15 ± 0.02	>	4.65 ± 0.02	>	4.45 ± 0.02	Yes	CPD	[3088]
74	W	5.17 ± 0.01	>	4.54 ± 0.01	>	4.44 ± 0.02	Yes	TE	[3349]
74	W	5.18	>	4.64	>	4.61[c]	Yes	TE	[212]
74	W	5.18	>	4.64	<	4.67[c]	No	TE	[212]
74	W	5.18	>	4.58	<	4.60	No	TC	[531]
74	W	5.2	>	4.64	>	4.6	Yes	TE	[212]
74	W	5.2	>	4.6	>	4.2	Yes	TE	[1958]
74	W	5.20	>	4.963	>	4.562	Yes	TC	[365]
74	W	5.20	>	4.56	>	4.50	Yes	TC	[3224]
74	W	5.22 ± 0.01	>	4.54 ± 0.01	=	4.54 ± 0.01	No	TE	[1053]
74	W	5.24 ± 0.03	>	4.62 ± 0.03	>	4.59 ± 0.03	Yes	TE	[1793]
74	W	5.25	>	4.65	>	4.47	Yes	FE	[489]
74	W	5.25 ± 0.02	>	4.63 ± 0.02	>	4.47 ± 0.02	Yes	FE	[358,3092]
74	W	5.26	>	4.52	>	4.38	Yes	TE	[150]
74	W	5.26	>	4.56	>	4.44	Yes	TC	[1271]
74	W	5.26	>	4.69	>	4.43	Yes	TE	[2187,3664]
74	W	5.269	>	4.979	>	4.500	Yes	TC	[365]
74	W	5.28 ± 0.11[+]	>	4.62 ± 0.06[+]	>	4.45 ± 0.04[+]	Yes	PSI	[Here][a]
74	W	5.29 ± 0.08[+]	>	4.60 ± 0.05[+]	>	4.45 ± 0.05[+]	Yes	PSI	[1351][b]
74	W	5.3	>	4.5	>	4.4	Yes	CPD	[259]
74	W	5.3	>	4.60	>	4.40	Yes	TE	[3096]
74	W	5.30	>	4.60	>	4.45	Yes	FE	[3508]
74	W	5.30 ± 0.03	>	4.60 ± 0.03	>	4.40 ± 0.03	Yes	TE	[3103]
74	W	5.30 ± 0.05	>	4.61 ± 0.05	>	4.40 ± 0.05	Yes	TE	[2214,2217]
74	W	5.31 ± 0.05	>	4.57 ± 0.03	>	4.38 ± 0.04	Yes	various	[1351][b]
74	W	5.32	>	4.59	>	4.51	Yes	CPD	[1274]
74	W	5.32 ± 0.02	>	4.65 ± 0.02	>	4.45 ± 0.03	Yes	various	[Here][a]
74	W	5.32 ± 0.10	>	4.93 ± 0.06	>	4.45 ± 0.05	Yes	FE	[819]
74	W	5.33 ± 0.03	>	4.76 ± 0.05	>	4.40 ± 0.03	Yes	TE	[372,3064]
74	W	5.345	>	5.009	>	4.500	Yes	TC	[365]
74	W	5.35 ± 0.05	>	4.60 ± 0.05	>	4.40 ± 0.02	Yes	TE	[127]
74	W	5.40 ± 0.05	>	4.55 ± 0.05	>	4.42 ± 0.03	Yes	TE	[143]
74	W	5.44	>	4.63	>	4.55	Yes	TC	[357]
74	W	5.44 ± 0.14	>	4.70 ± 0.06	>	4.44 ± 0.03	Yes	various	[4088]
74	W	5.5 ± 0.2	>	4.6 ± 0.1	>	4.2 ± 0.1	Yes	FE	[3033]
74	W	5.50	>	4.65	>	4.46	Yes	TC	[2548]
74	W	5.50	>	4.66	>	4.47	Yes	TC	[1980]
74	W	5.54	>	4.60	>	4.54	Yes	TE	[2187,3664]
74	W	5.54	>	4.50	<	5.60	No	TC	[4117]
74	W	5.6	>	4.6	>	3.9	Yes	FE	[1964]
74	W	5.66 ± 0.03	>	4.83 ± 0.02	>	4.47 ± 0.03	Yes	FE	[999]
74	W	5.70	>	4.70	>	4.54	Yes	FE	[812]
74	W	5.73	>	4.67	>	4.59	Yes	TC	[3224]
74	W	5.75	>	4.49	>	4.38	Yes	TC	[4405]
74	W	5.75 ± 0.03	>	4.83 ± 0.02	>	4.47 ± 0.03	Yes	FE	[999]
74	W	5.75 ± 0.15	>	4.6	=	4.6	No	FE	[3079]
74	W	5.79	>	4.78	>	4.35	Yes	FE	[373]
74	W	5.79	>	4.47	<	4.49	No	FE	[378]
74	W	5.8	>	4.9	>	4.6	Yes	FE	[3438]
74	W	5.8 ± 0.3	>	4.93 ± 0.06	>	4.45 ± 0.05	Yes	FE	[819]
74	W	5.80 ± 0.05	>	4.90 ± 0.03	>	4.60 ± 0.05	Yes	FE	[813]
74	W	5.83	>	4.89	>	4.68	Yes	FE	[653]
74	W	5.85	>	4.82	>	4.41	Yes	FE	[267]
74	W	5.9	>	4.82	>	4.41	Yes	FE	[2324]
74	W	5.93	>	4.77	>	4.4	Yes	FE	[2766]
74	W	6.0	>	4.70	>	4.43	Yes	FE	[809]
74	W	6.00	>	4.65	>	4.40	Yes	FE	[1276]
74	W	6.28 ± 0.08	>	4.93 ± 0.06	>	4.45 ± 0.05	Yes	FE	[819]
74	W	6.35	>	4.98	>	4.57	Yes	FE	[1057]
74	W	6.5	>	4.54	<	5.3	No	FE	[2714]
74	W	$s_0 + 0.52$	>	s_0	>	$s_0 - 0.31$	Yes	TC	[4078][g]
74	W	$k_0 + 0.538$	>	k_0	>	$k_0 - 0.520$	Yes	TC	[4246][f]

(continued on next page)

Table 9 (*continued*)

No.	Metal.	ϕ^e(110) (eV)		ϕ^e(100) (eV)		ϕ^e(111) (eV)	Seq.	Meth.	Refs.
Conformity (N_{yes}/N_{total})[d]				–		–	**89%**	–	–
81	β-Tl	4.10	>	3.52	>	3.36	Yes	TC	[321]
92	γ-U	4.07	>	3.49	>	3.33	Yes	TC	[321]

[a] Each of the work function data with double underlines is cited from the most probable value listed in Table 2 [Here].

[b] Similarly, each of the data with a single underline is cited from the value recommended in Table 2 in the previous review [1351].

[c] The values of ϕ^e(111) = 4.61 and 4.67 eV for W(111) [212] are determined at $P(O_2) = 5 \times 10^{-10}$ Torr and $T = 1900$ K and done at 5×10^{-8} Torr and 2200 K, respectively, thereby yielding the result that the sequence changes from Yes to No in accordance with the work function increase by 0.06 eV due to the oxygen gas pressure increase. Both of the above values, however, are considerably larger than 4.45 eV recommended in Table 2, although 4.64 eV for W(100) [212] well agrees with 4.65 eV [Here].

[d] In the last line for each metal with $N_{total} \geq 5$, the conformity ($C_Y \equiv N_{yes}/N_{total}$) of the listed triple sets to the Smoluchowski rule is entered, where N_{yes} and N_{total} are the number of the sequence corresponding to Yes and that including both Yes and No, respectively. As may be seen above, many of the metals have very high values of $C_Y \approx$ 80–100%.

[e] These work function values such as ϕ(110) = 4.64$^+$ eV for Nb(110) [739], 5.13 ± 0.03$^+$ eV for Mo(110) [727,3103] and 5.14 ± 0.03$^+$ eV for W(110) [3103] are not ϕ^e but ϕ^+ determined by positive surface ionization of Cs [739] or Na [727,3103].

[f] The absolute values of a_0–c_0 [4259] and d_0–k_0 [4246] are not listed anywhere in the tables [4246,4259].

[g] None of the absolute valves (p_0–s_0) is given in the table [4078].

On the last line for each metal, the conformity ($C_Y \equiv N_{yes}/N_{total}$) of the listed triple sets following the Smoluchowski rule [1040] is entered, where N_{yes} and N_{total} are the numbers of the sequence corresponding to Yes and of that including both Yes and No, respectively. However, C_Y is omitted for any of the metals with N_{total} less than three.

In Table 9, "Yes" is found for all of the sequences (C_Y = 100%) listed for Na, K and V ($N_{total} \geq 6$) and also for γ-Ca, β-Ti, δ-Mn, β-Y, β-Zr, γ-La, γ-Ce, β-Pr, β-Nd, Sm, Eu, β-Gd, β-Tb, β-Lu, β-Tl and γ-U ($N_{total} \leq 2$). In addition, very high percentages of "Yes" (C_Y = 75–94%) are found for Li, Rb, Nb, Mo, Cs, Ba, Ta and W (N_{total} = 10–81) as well as Cr (C_Y = 80%, N_t = 5). Quite similarly in the former cases (Na–V), all of our present sequences [Here] originating from the most probable values in Table 2 have "Yes", of course, together with the latter cases (Li–W and Cr), too. On the other hand, α-Fe, γ-Sr and β-Hf are found to have a very small value of C_Y = 38, 33 and 50%, respectively, while α-Sn (N_{total} = 1) has C_Y = 0% [3211]. These results are probably due to the poverty in set size (N_{total} = 8, 3, 4 or 1 alone) and, hence, they may be less reliable than the others (C_Y = 75–100%) based on N_{total} = 10–78. Therefore, much further study is needed to answer definitely the question whether the above four species (α-Fe, γ-Sr, α-Sn and β-Hf) do not obey inherently the Smoluchowski rule. Except the four species to be pendent, almost all the bcc-metals listed in Table 9 may be concluded to follow faithfully the sequence of ϕ^e(110) > ϕ^e(100) > ϕ^e(111). Consequently, all of the examples (except the four above) having "No" may be considered to indicate that at least one of the three values for each triple set is inaccurate or incorrect. Typically, all of ϕ^e(100) = 3.86, 3.87 and 3.91 eV by TC for α-Fe(100) [1619,1625] mentioned above to be pendent are extremely smaller than our most probable value of 4.64 ± 0.05 eV [Here] and also than the others of both 4.67 eV [1045,1358] and 4.59 eV [1351] recommended in Table 2. This is probably the main reason why the conformity is reduced to 38% from 50% or more that might be expected from the other sequences alone [Here, 321,4088,4222] except the above four [1619,1625]. In other words, the real value of C_Y for α-Fe will be improved to be much larger than ∼50% by further investigations.

As additional examples for several bcc-metals, a theoretical study yields the anomalous sequence of ϕ^e(110) > ϕ^e(100) < ϕ^e(111) for Nb, Mo, Ta and W [4091], whilst it gains the normal one of ϕ^e(110) > ϕ^e(100) > ϕ^e(111) for the five species of such alkali metals and Ba [4091]. Similarly to fcc-metals to be discussed mainly in the next section, the study [4091] yields ϕ^e(111) > ϕ^e(100) < ϕ^e(110) for fcc-metals (Ca and Sr), on the contrary to ϕ^e(111) > ϕ^e(100) > ϕ^e(110) for fcc-transition metals (typically, Ni, Cu, Rh, Pd and Ag having C_Y = 90–100%) to be shown in Table 10. These results against the above rule [1040] suggest that the theoretical calculation should be examined by further investigation.

It should be pointedly emphasized that ϕ^+(110) > ϕ^+(100) > ϕ^+(111) based on PSI also holds for the bcc-metals of Nb [739, Here], Mo [727,1351,3103, Here], Ta [797,1351, Here] and W [1351,3103, Here], quite similarly to each of their sequences of ϕ^e(hkl). The former is our new finding reported here first, and also it does support strongly our theoretical model that ϕ^+(hkl) is equivalent to ϕ^e(hkl) for clean monocrystalline samples, just as concluded directly from Eqs. (1) and (2).

5.3. Examination of the anisotropic work function sequence for fcc-metals

Quite similarly as above, many triple sets for fcc-metals are cited from Table 1 in order to examine the sequence of ϕ^e(111) > ϕ^e(100) > ϕ^e(110) corresponding to D_s(111) > D_s(100) > D_s(110). As shown in Table 10, "Yes" is found entirely ($C_Y \equiv N_{yes}/N_{total}$ = 100%) for β-Sc, γ-Mn, γ-Fe, β-Co, Ni and Rh (N_{total} = 1–17), while "No" is done seldom ($I_N \equiv N_{no}/N_{total} \leq 10$%) for Cu, Pd, and Ag ($N_{total}$ = 12–44). Here, I_N is the inconformity, while N_{no} and N_{total} are the numbers of the sequence having "No" and of the total one including both "No" and "Yes", respectively. Regarding the above eight species (γ-Mn to Rh and Cu to Ag, $C_Y \geq 90$%), "Yes" is observed also for all of our sequences [Here] based on the most probable values in Table 2. Quite similarly as in the cases of bcc-metals mentioned in Section 5.2, the sequence of ϕ^+(111) > ϕ^+(100) > ϕ^+(110) determined by PSI is found to hold for the

fcc-metal of Ni, too [Here, 283,630]. Again, this is the interesting and important finding reported here first, as already mentioned in Section 5.2 just above.

Table 10
Examination of the work function sequence of $\phi^e(111) > \phi^e(100) > \phi^e(110)$ for the three principal planes of <u>fcc</u> metals.

No.	Metal	$\phi^e(111)$ (eV)		$\phi^e(100)$ (eV)		$\phi^e(110)$ (eV)	Seq.	Meth.	Refs.
13	Al	3.11 ± 0.10	<	3.38 ± 0.07	<	3.80	No	PE	[239]
13	Al	3.13	<	3.22	>	2.83	No	TC	[2697]
13	Al	3.47	<	4.16	>	3.95	No	TC	[1030,1089]
13	Al	3.48	<	3.83	<	4.10	No	TC	[476]
13	Al	3.72	>	3.62	<	3.81	No	TC	[231]
13	Al	3.73	<	4.06	<	4.28	No	TC	[476]
13	Al	3.73	>	3.63	<	3.82	No	TC	[3467]
13	Al	3.77	>	3.71	>	3.60	Yes	TC	[473][20]
13	Al	3.86	<	3.87	<	3.88	No	TC	[3004]
13	Al	3.9	>	3.8	>	3.7	Yes	TC	[2982]
13	Al	3.92	<	4.30	>	3.89	No	TC	[1030]
13	Al	4.0	<	4.7	>	4.5	No	TC	[1088]
13	Al	4.02	<	4.30	>	4.09	No	TC	[4087,4410]
13	Al	4.05	<	4.20	>	3.65	No	TC	[475]
13	Al	4.05	<	4.27	>	4.06	No	TC	[4233]
13	Al	4.059	>	3.782	>	3.642	Yes	TC	[1626]
13	Al	4.06	<	4.24	>	4.07	No	TC	[1175]
13	Al	4.08	<	4.29	>	4.11	No	TC	[4233]
13	Al	4.09	>	3.77	>	3.59	Yes	TC	[553][20]
13	Al	4.1	=	4.1	>	3.7	No	TC	[2851]
13	Al	4.1	>	3.9	>	3.8	Yes	TC	[1088]
13	Al	4.117	>	3.805	>	3.643	Yes	TC	[1626,2914]
13	Al	4.12	>	3.92	>	3.73	Yes	TC	[1159]
13	Al	4.17	<	4.36	>	4.19	No	TC	[1943]
13	Al	4.17	<	4.27	>	3.87	No	TC	[3004]
13	Al	4.18	<	4.27	>	3.88	No	TC	[555,715]
13	Al	4.18	<	4.38	>	4.20	No	TC	[1943]
13	Al	4.181	>	3.831	>	3.643	Yes	TC	[1626]
13	Al	4.19	<	4.41	>	4.20	No	TC	[557]
13	Al	4.19	<	4.30	>	3.85	No	TC	[1435]
13	Al	4.2	>	4.1	>	3.7	Yes	TC	[2851]
13	Al	4.21	=	4.21	=	4.21	No	TC	[2548]
13	Al	4.22	<	4.46	>	4.26	No	TC	[1943]
13	Al	4.23	<	4.42	>	4.29	No	TC	[482,721,4398]
13	Al	4.24 ± 0.02	<	4.41 ± 0.03	>	4.28 ± 0.02	No	PE	[241,242]
13	Al	4.24 ± 0.04	<	4.28 ± 0.05	>	4.05 ± 0.06	No	various	[Here][a]
13	Al	4.25	<	4.38	>	4.30	No	TC	[561,721,4398]
13	Al	4.25	<	4.50	>	4.25	No	TC	[3203]
13	Al	4.25	<	4.30	>	4.17	No	TC	[723][19]
13	Al	4.26 ± 0.03	>	4.20 ± 0.03	>	4.06 ± 0.03	Yes	PE	[612]
13	Al	4.27	>	4.25	>	4.02	Yes	TC	[556]
13	Al	4.28 ± 0.04	<	4.36 ± 0.10	>	4.21 ± 0.09	No	various	[1351][b]
13	Al	4.3	<	4.4	>	4.2	No	TC	[2905]
13	Al	4.31	>	4.27	>	3.92	Yes	TC	[4401]
13	Al	4.31 ± 0.03	<	4.51 ± 0.03	>	4.32 ± 0.03	No	TC	[718]
13	Al	4.32 ± 0.06	>	4.31 ± 0.18	>	4.23 ± 0.13	Yes	various	[4088]
13	Al	4.32	>	4.00	>	3.76	Yes	TC	[321]
13	Al	4.32	<	4.56	>	4.36	No	TC	[1943]
13	Al	4.33	<	4.43	>	4.28	No	TC	[4117]
13	Al	4.60	<	4.69	>	4.30	No	TC	[2697]
13	Al	4.75	<	4.90	>	4.35	No	TC	[1095]
13	Al	4.77	<	4.86	>	4.47	No	TC	[2697]
13	Al	4.81	>	4.69	>	3.97	Yes	TC	[1563]
13	Al	4.99	>	4.85	>	4.44	Yes	TC	[3477][20]
13	Al	5.35	>	5.24	>	4.91	Yes	TC	[3477][20]
13	Al	$\phi(111)$	>	$\phi(100)$	>	$\phi(110)$	Yes	TC	[227][20]
Conformity $(N_{yes}/N_{total})^e$				–		–	**32%**	–	–
20	Ca	2.916	>	2.758	<	2.813	No	TC	[4091]
20	Ca	2.98	>	2.87	>	2.83	Yes	TC	[4222]
20	Ca	3.10	>	2.94	>	2.92	Yes	TC	[231]
20	Ca	3.14	>	2.97	>	2.92	Yes	TC	[3467]
20	Ca	3.35	<	3.38	>	3.29	No	TC	[476]
20	Ca	3.49	<	3.52	>	3.41	No	TC	[476]

Table 10 (*continued*)

No.	Metal	ϕ^e(111) (eV)		ϕ^e(100) (eV)		ϕ^e(110) (eV)	Seq.	Meth.	Refs.
20	Ca	3.5 ± 0.2	>	3.4 ± 0.4	>	3.3 ± 0.3	Yes	TC	[Here][a]
20	Ca	3.68	<	3.96	>	3.43	No	TC	[1030]
20	Ca	3.70	>	3.57	>	3.20	Yes	TC	[1030]
20	Ca	4.40	>	4.09	>	3.84	Yes	TC	[321]
Conformity (N_{yes}/N_{total})[e]				–		–	60%	–	–
21	β-Sc	4.73	>	4.39	>	4.13	Yes	TC	[321]
25	γ-Mn	5.36	>	4.97	>	4.67	Yes	TC	[321]
25	γ-Mn	5.3 ± 0.1	>	5.2 ± 0.3	>	4.7	Yes	TC	[Here][a]
26	γ-Fe	5.70	>	5.28	>	4.97	Yes	TC	[321]
26	γ-Fe	5.6 ± 0.1	>	5.3 ± 0.2	>	5.0	Yes	various	[Here][a]
27	β-Co	5.68	>	5.25	>	4.95	Yes	TC	[321]
27	β-Co	5.39 ± 0.23	>	5.25 ± 0.17	>	5.0	Yes	various	[Here][a]
27	β-Co	$a_0 + 0.1574$	>	a_0	>	$a_0 - 0.3448$	Yes	TC	[4259][h]
28	Ni	5.11	>	4.97	>	4.6	Yes	TC	[311]
28	Ni	5.22	>	4.86	>	4.69	Yes	TC	[3224]
28	Ni	5.22 ± 0.03	>	4.89 ± 0.03	>	4.64 ± 0.03	Yes	TE	[312,837]
28	Ni	5.24 ± 0.07	>	5.17 ± 0.11	>	4.72 ± 0.13	Yes	various	[4088]
28	Ni	5.28 ± 0.05	>	5.23 ± 0.10	>	4.64 ± 0.05	Yes	various	[1351][b]
28	Ni	5.3[+f]	>	5.2[+]	>	5.0[+]	Yes	PSI	[Here][a]
28	Ni	5.3 ± 0.1	>	5.1 ± 0.1	>	4.7 ± 0.1	Yes	CPD	[1110]
28	Ni	5.32 ± 0.05	>	5.19 ± 0.05	>	4.96 ± 0.10	Yes	various	[Here][a]
28	Ni	5.33 ± 0.01[+f]	>	5.21 ± 0.01[+]	>	5.03 ± 0.01[+g]	Yes	TC	[283,630]
28	Ni	5.35 ± 0.05	>	5.22 ± 0.04	>	5.04 ± 0.02	Yes	PE	[314,315]
28	Ni	5.40 ± 0.15	>	5.2 ± 0.15	>	4.85 ± 0.15	Yes	CPD	[1791]
28	Ni	5.50	>	5.31	>	4.90	Yes	TC	[1237]
28	Ni	5.56	>	5.19	>	4.84	Yes	TC	[2548]
28	Ni	5.56	>	5.20	>	4.84	Yes	TC	[1980]
28	Ni	5.6	>	5.4	>	5.1	Yes	TC	[2905]
28	Ni	$b_0 + 0.1651$	>	b_0	>	$b_0 - 0.3438$	Yes	TC	[4259][h]
28	Ni	$x_0 + 0.21$	>	x_0	>	$x_0 - 0.38$	Yes	TC	[4078][i]
Conformity (N_{yes}/N_{total})[e]				–		–	100%	–	–
29	Cu	3.90	>	3.80	>	3.55	Yes	TC	[475]
29	Cu	4.123	>	3.855	>	3.648	Yes	TC	[2914]
29	Cu	4.24	>	4.12	>	3.98	Yes	TC	[947]
29	Cu	4.381	<	4.412	>	4.408	No	TC	[1118]
29	Cu	4.50	>	4.27	>	4.23	Yes	PE	[1661]
29	Cu	4.58	>	4.30	>	4.27	Yes	TC	[4034]
29	Cu	4.632 ± 0.010	>	4.458 ± 0.010	>	4.400 ± 0.010	Yes	CPD	[948,2841]
29	Cu	4.714	>	4.506	>	4.272	Yes	TC	[4091]
29	Cu	4.79	>	4.67	>	4.33	Yes	TC	[3477]
29	Cu	4.8	>	4.5	>	4.4	Yes	PE	[1238,4210]
29	Cu	4.80	>	4.58	>	4.44	Yes	TC	[3304]
29	Cu	4.80	>	4.54	>	4.43	Yes	TC	[2917]
29	Cu	4.80	>	4.53	<	4.56	No	TC	[723][19]
29	Cu	4.85	>	4.68	>	4.48	Yes	CPD	[959]
29	Cu	4.876	>	4.753	>	4.508	Yes	TC	[1119,2989]
29	Cu	4.90 ± 0.02	>	4.73 ± 0.10	>	4.56 ± 0.10	Yes	various	[4088]
29	Cu	4.91	>	4.58	>	4.25	Yes	TC	[3477]
29	Cu	4.91	>	4.81	>	4.53	Yes	TC	[3477]
29	Cu	4.91 ± 0.03	>	4.57 ± 0.08	>	4.48 ± 0.06	Yes	various	[1351][b]
29	Cu	4.92 ± 0.05	>	4.58 ± 0.06	>	4.43 ± 0.04	Yes	various	[Here][a]
29	Cu	4.93 ± 0.03	>	4.63 ± 0.03	>	4.48 ± 0.03	Yes	PE	[2903]
29	Cu	4.94 ± 0.03	>	4.59 ± 0.03	>	4.48 ± 0.03	Yes	PE	[953,2006]
29	Cu	4.95	>	4.56	>	4.40	Yes	CPD	[952]
29	Cu	4.95	>	4.76	>	4.40	Yes	CPD	[952]
29	Cu	4.958	>	4.71	>	4.625	Yes	TC	[4189]
29	Cu	4.99	>	4.89	>	4.61	Yes	TC	[3477]
29	Cu	5.10	>	4.85	>	4.67	Yes	TC	[480]
29	Cu	5.17	>	4.88	>	4.71	Yes	TC	[1237]
29	Cu	5.19	>	4.95	>	4.9	Yes	TC	[956]
29	Cu	5.25 ± 0.1	>	4.75 ± 0.1	>	4.7 ± 0.1	Yes	CPD	[1507]
29	Cu	5.30	>	5.26	>	4.48	Yes	TC	[229,334]

Table 10 (*continued*)

No.	Metal	ϕ^e(111) (eV)		ϕ^e(100) (eV)		ϕ^e(110) (eV)	Seq.	Meth.	Refs.
29	Cu	5.31	>	5.02	>	4.81	Yes	TC	[480,4398]
29	Cu	5.32	>	5.05	>	4.83	Yes	TC	[480,4398]
29	Cu	5.32	>	4.99	>	4.65	Yes	TC	[1980]
29	Cu	5.32	>	4.99	>	4.66	Yes	TC	[2548]
29	Cu	5.43	>	5.26	>	4.53	Yes	TC	[962]
29	Cu	5.44	>	5.31	>	4.98	Yes	TC	[962]
29	Cu	5.44	>	5.31	>	5.04	Yes	TC	[962]
29	Cu	5.54 ± 0.012	>	5.155 ± 0.054	>	4.92 ± 0.019	Yes	CPD	[963]
29	Cu	5.55	>	4.98	>	3.56	Yes	TC	[962]
29	Cu	5.55	>	5.13	>	4.94	Yes	TC	[3224]
29	Cu	5.56	>	5.03	>	4.10	Yes	TC	[962]
29	Cu	5.56	>	5.03	>	4.20	Yes	TC	[962]
29	Cu	5.57	>	5.16	>	3.85	Yes	TC	[321]
Conformity (N$_{yes}$/N$_{total}$)[e]				–		–	**95%**	–	–
31	Ga	3.79	>	3.35	<	4.08	No	TC	[3211]
38	α-Sr	2.569	>	2.473	<	2.545	No	TC	[4091]
38	α-Sr	2.94	>	2.79	>	2.75	Yes	TC	[231]
38	α-Sr	3.21	>	2.95	>	2.76	Yes	TC	[3467]
38	α-Sr	3.4 ± 0.3	>	3.3 ± 0.4	>	3.1 ± 0.3	Yes	TC	[Here][a]
38	α-Sr	3.57	<	3.82	>	3.31	No	TC	[1030]
38	α-Sr	3.61	>	3.42	>	3.05	Yes	TC	[1030]
38	α-Sr	4.10	>	3.81	>	3.57	Yes	TC	[321]
Conformity (N$_{yes}$/N$_{total}$)[e]				–		–	**71%**	–	–
45	Rh	5.105	>	5.087	>	4.615	Yes	TC	[2229,2447]
45	Rh	5.138	>	5.040	>	4.635	Yes	TC	[4091]
45	Rh	5.21	>	5.17	>	4.67	Yes	TC	[2912]
45	Rh	5.39	>	4.99	>	4.69	Yes	TC	[321]
45	Rh	5.40 ± 0.08	>	5.24 ± 0.07	>	4.75 ± 0.06	Yes	various	[Here][a]
45	Rh	5.44	>	5.25	>	4.94	Yes	TC	[320,1178]
45	Rh	5.46 ± 0.09	>	5.30 ± 0.15	>	4.86 ± 0.21	Yes	various	[4088]
45	Rh	5.50 ± 0.10	>	5.29 ± 0.07	>	4.77 ± 0.06	Yes	various	[1351][b]
45	Rh	5.56	>	5.46	>	5.07	Yes	TC	[4228]
45	Rh	5.59	>	5.45	>	5.07	Yes	TC	[4228]
45	Rh	5.66 ± 0.02	>	5.40 ± 0.02	>	5.12 ± 0.02	Yes	?	[2832]
45	Rh	5.67 ± 0.01	>	5.41 ± 0.01	>	4.86 ± 0.01	Yes	FE	[1010]
645	Rh	c_0 + 0.196	>	c_0	>	c_0 − 0.371	Yes	TC	[4246][h]
Conformity (N$_{yes}$/N$_{total}$)[e]				–		–	**100%**	–	–
46	Pd	5.18	>	5.14	>	4.90	Yes	TC	[602]
46	Pd	5.198	>	5.115	>	4.781	Yes	TC	[2229,2447]
46	Pd	5.23	>	5.080	>	4.860	Yes	TC	[4091]
46	Pd	5.25	>	5.11	>	4.87	Yes	TC	[4087,4410]
46	Pd	5.53	>	5.30	>	5.13	Yes	TC	[320,2534]
46	Pd	5.55 ± 0.07	<	5.59 ± 0.05	>	5.19 ± 0.04[c]	No	various	[1351][b]
46	Pd	5.58 ± 0.05	>	5.48 ± 0.04	>	5.12 ± 0.09	Yes	various	[Here][a]
46	Pd	5.67 ± 0.12	>	5.48 ± 0.23	>	5.07 ± 0.20	Yes	various	[4088]
46	Pd	5.90 ± <0.1	>	5.65 ± <0.1	>	5.20 ± <0.1	Yes	PE	[672]
46	Pd	5.95 ± <0.1	>	5.65 ± <0.1	>	5.20 ± <0.1	Yes	PE	[914,1026,3449]
46	Pd	6.02	>	5.56	>	5.24	Yes	TC	[321]
46	Pd	d_0 + 0.179	>	d_0	>	d_0 − 0.340	Yes	TC	[4246][h]
Conformity (N$_{yes}$/N$_{total}$)[e]				–		–	**92%**	–	–
47	Ag	3.70	>	3.55	>	3.35	Yes	TC	[475]
47	Ag	3.96	>	3.89	>	3.66	Yes	TC	[2516]
47	Ag	4.25	<	4.35	>	4.20	No	TC	[4117]
47	Ag	4.368	>	4.246	>	4.059	Yes	TC	[4091]
47	Ag	4.40	>	4.33	>	4.19	Yes	TC	[3280]
47	Ag	4.40	>	4.29	>	4.10	Yes	TC	[947]
47	Ag	4.45 ± 0.03	>	4.34 ± 0.03	>	4.25 ± 0.03	Yes	PE	[1192]
47	Ag	4.46 ± 0.02	>	4.22 ± 0.04	>	4.14 ± 0.05	Yes	PE	[625,1693]
47	Ag	4.53 ± 0.07	>	4.36 ± 0.05	>	4.10 ± 0.15	Yes	various	[4088]
47	Ag	4.56 ± 0.15	>	4.50 ± 0.10	>	4.16 ± 0.05	Yes	various	[1351][b]
47	Ag	4.64 ± 0.06	>	4.46 ± 0.05	>	4.28 ± 0.08	Yes	various	[Here][a]

Table 10 (*continued*)

No.	Metal	ϕ^e(111) (eV)		ϕ^e(100) (eV)		ϕ^e(110) (eV)	Seq.	Meth.	Refs.
47	Ag	4.65	>	4.33	>	4.30	Yes	TC	[1264]
47	Ag	4.67	>	4.43	>	4.23	Yes	TC	[320,1178]
47	Ag	4.74	>	4.45	>	4.17	Yes	TC	[1159]
47	Ag	4.74 ± 0.02	>	4.64 ± 0.02	>	4.52 ± 0.02	Yes	PE	[626,1134]
47	Ag	4.95	>	4.82	>	4.68	Yes	TC	[1237]
47	Ag	4.98	>	4.82	>	4.66	Yes	TC	[1264]
47	Ag	5.01	<	5.02	>	4.40	No	TC	[334,3179]
47	Ag	5.46	>	5.06	>	4.76	Yes	TC	[321]
47	Ag	$e_0 + 0.151$	>	e_0	>	$e_0 - 0.293$	Yes	TC	[4246][h]
Conformity (N_{yes}/N_{total})[e]				–		–	**90%**	–	–
57	β-La	4.04	>	3.74	>	3.53	Yes	TC	[321]
57	β-La	$f_0 + 0.126$	>	f_0	>	$f_0 - 0.268$	Yes	TC	[4246][h]
58	β-Ce	4.98	>	4.62	>	4.35	Yes	TC	[321]
61	Pm	4.03	>	3.73	>	3.52	Yes	TC	[321]
70	α-Yb	4.47	>	4.15	>	3.90	Yes	TC	[321]
77	Ir	5.42	<	5.60	>	5.07	No	TC	[3243]
77	Ir	5.497	<	5.55	>	4.958	No	TC	[4091]
77	Ir	5.55	>	5.20	>	4.83	Yes	TC	[2548]
77	Ir	5.56	>	5.20	>	4.84	Yes	TC	[1980]
77	Ir	5.72	<	5.89	>	5.36	No	TC	[3243]
77	Ir	5.75 ± 0.06	>	5.60 ± 0.06	>	5.23 ± 0.19	Yes	various	[Here][a]
77	Ir	5.77 ± 0.03	>	5.72 ± 0.27	>	5.31 ± 0.35[d]	Yes	various	[1351][b]
77	Ir	5.78 ± 0.04	<	5.95 (5.97)	>	5.42 ± 0.32	No	various	[4088]
77	Ir	5.80 ± 0.05	>	5.70 ± 0.05	>	5.0	Yes	FE	[1797,1802]
77	Ir	5.86	>	5.52	>	5.37	Yes	TC	[3224]
77	Ir	5.92	=	5.92	>	5.45	No	TC	[1933]
77	Ir	6.51	>	6.03	>	5.67	Yes	TC	[321]
77	Ir	$g_0 + 0.237$	>	g_0	>	$g_0 - 0.499$	Yes	TC	[4246][h]
Conformity (N_{yes}/N_{total})[e]				–		–	**62%**	–	–
78	Pt	5.56	>	5.20	>	4.84	Yes	TC	[1980]
78	Pt	5.69	>	5.66	>	5.26	Yes	TC	[4087,4410]
78	Pt	5.702	>	5.625	>	5.223	Yes	TC	[4091]
78	Pt	5.747	>	5.711	>	5.297	Yes	TC	[3245]
78	Pt	5.817	<	5.840	>	5.441	No	TC	[2229]
78	Pt	5.84 ± 0.05	>	5.75 ± 0.06	>	5.54 ± 0.07	Yes	various	[Here][a]
78	Pt	5.86 ± 0.06	>	5.82 ± 0.27	>	5.61 ± 0.13	Yes	various	[1351][b]
78	Pt	5.91 ± 0.08	>	5.67 (5.75)	>	5.53 ± 0.13	Yes	various	[4088]
78	Pt	5.94	>	5.86	>	5.72	Yes	PE	[429]
78	Pt	6.01	>	5.67	>	5.52	Yes	TC	[3224]
78	Pt	6.1	=	6.1	>	5.7	No	TC	[2905]
78	Pt	6.12	>	6.07	>	5.74	Yes	TC	[1237]
78	Pt	6.47	>	5.99	>	5.63	Yes	TC	[321]
78	Pt	6.53	>	6.52	>	6.19	Yes	TC	[1201]
78	Pt	6.60	<	6.86	>	6.10	No	TC	[3194]
78	Pt	6.67	<	6.93	>	6.15	No	TC	[3194]
78	Pt	$h_0 + 0.218$	>	h_0	>	$h_0 - 0.414$	Yes	TC	[4246][h]
Conformity (N_{yes}/N_{total})[e]				–		–	**76%**	–	–
79	Au	3.478	>	3.318	>	3.148	Yes	TC	[2914]
79	Au	3.80	>	3.65	>	3.50	Yes	TC	[475]
79	Au	4.165	>	3.816	>	3.629	Yes	TC	[2914]
79	Au	5.1	>	5.05	>	4.93	Yes	TC	[4233]
79	Au	5.110	>	5.071	>	4.91	Yes	TC	[4091]
79	Au	5.13	>	5.04	>	4.98	Yes	TC	[4233]
79	Au	5.15	>	5.10	>	5.04	Yes	TC	[4087,4410]
79	Au	5.26 ± 0.04	>	5.22 ± 0.04	>	5.20 ± 0.04	Yes	PE	[1068]
79	Au	5.29 ± 0.02	<	5.41 ± 0.12	>	5.31 ± 0.11	No	various	[1351][b]
79	Au	5.31	<	5.47	>	5.37	No	CPD	[959]
79	Au	5.32	>	4.99	>	4.65	Yes	TC	[1980]
79	Au	5.33 ± 0.06	>	5.22 ± 0.31	>	5.16 ± 0.22	Yes	various	[4088]
79	Au	5.46 ± 0.07	>	5.39 ± 0.07	>	5.33 ± 0.09	Yes	various	[Here][a]

Table 10 (*continued*)

No.	Metal	$\phi^e(111)$ (eV)		$\phi^e(100)$ (eV)		$\phi^e(110)$ (eV)	Seq.	Meth.	Refs.
79	Au	5.63	>	5.53	>	5.41	Yes	TC	[480,4398]
79	Au	5.65	>	5.56	>	5.42	Yes	TC	[3317]
79	Au	6.01	<	6.16	>	5.40	No	TC	[334]
79	Au	6.08	<	6.23	>	5.85	No	TC	[3194]
79	Au	6.13	<	6.26	>	5.86	No	TC	[3194]
79	Au	6.65	>	6.16	>	5.80	Yes	TC	[321]
79	Au	$i_0 + 0.190$	>	i_0	>	$i_0 - 0.363$	Yes	TC	[4246][h]
Conformity $(N_{yes}/N_{total})^e$				–		–	<u>**75%**</u>	–	–
82	Pb	3.16	>	3.04	>	2.99	Yes	TC	[1159]
82	Pb	3.31	<	3.45	<	3.82	No	TC	[476]
82	Pb	3.51	<	3.67	<	4.01	No	TC	[476]
82	Pb	3.59	>	3.50	<	3.77	No	TC	[231]
82	Pb	3.65	<	3.81	<	3.84	No	TC	[1030]
82	Pb	3.7	<	3.8	<	4.4	No	TC	[1088]
82	Pb	3.76	<	3.78	>	3.65	No	TC[1]	[3521]
82	Pb	3.77	>	3.75	>	3.65	Yes	TC[2]	[3521]
82	Pb	3.78	>	3.77	>	3.64	Yes	TC[3]	[3521]
82	Pb	3.78	>	3.77	>	3.64	Yes	TC[4]	[3521]
82	Pb	3.78	<	3.79	>	3.63	No	TC[5]	[3521]
82	Pb	3.78	<	3.80	>	3.63	No	TC[6]	[3521]
82	Pb	3.78	<	3.80	>	3.66	No	TC[7]	[3521]
82	Pb	3.78	<	3.83	>	3.63	No	TC[8]	[3521]
82	Pb	3.78 ± 0.01	<	3.79 ± 0.02	>	3.64 ± 0.01	No	TC[9]	[3521]
82	Pb	3.79	=	3.79	<	3.80	No	TC	[3004]
82	Pb	3.85	<	3.95	>	3.80	No	TC	[475]
82	Pb	3.9	<	4.0	>	3.8	No	TC	[1088]
82	Pb	3.90	>	3.57	>	3.46	Yes	TC	[553]
82	Pb	4.07	>	4.06	>	3.92	Yes	TC[10]	[3521]
82	Pb	4.07	>	4.06	>	3.93	Yes	TC[11]	[3521]
82	Pb	4.07	=	4.07	>	3.92	No	TC[12]	[3521]
82	Pb	4.07	=	4.07	>	3.92	No	TC[13]	[3521]
82	Pb	4.08	>	4.07	>	3.92	Yes	TC[14]	[3521]
82	Pb	4.08	>	4.07	>	3.93	Yes	TC[15]	[3521]
82	Pb	4.09	>	4.07	>	3.92	Yes	TC[16]	[3521]
82	Pb	4.09	>	4.07	>	3.93	Yes	TC[17]	[3521]
82	Pb	4.08 ± 0.01	>	4.07 ± 0.01	>	3.92 ± 0.01	Yes	TC[18]	[3521]
82	Pb	4.11	>	4.07	>	3.84	Yes	TC	[3004]
82	Pb	4.14	>	4.12	>	3.73	Yes	TC	[2516]
82	Pb	<u>4.14 ± 0.09</u>	>	<u>3.96 ± 0.11</u>	>	<u>3.84 ± 0.09</u>	Yes	various	[Here][a]
82	Pb	4.15	<	4.50	>	3.80	No	TC	[475]
82	Pb	4.30	<	4.31	>	3.98	No	TC	[555]
82	Pb	4.34	>	3.76	>	3.51	Yes	TC	[3467]
82	Pb	4.55	<	4.65	>	4.50	No	TC	[1095]
82	Pb	4.79	>	3.48	<	3.89	No	TC	[3211]
82	Pb	5.23	>	3.88	<	4.08	No	TC	[1030]
82	Pb	5.35	>	4.95	>	4.66	Yes	TC	[321]
Conformity $(N_{yes}/N_{total})^e$				–		–	<u>**45%**</u>	–	–
90	Th	3.75	>	3.57	>	3.38	Yes	TC	[1980]
94	δ-Pu	3.4	>	3.11	>	2.99	Yes	TC	[2069]
95	β-Am	3.06	>	2.93	>	2.86	Yes	TC	[2071,2076]

[a]<u>Each of the work function data</u> with double underlines is cited from the most probable value recommended in Table 2 [Here].

[b]Similarly, <u>each of the data</u> with a single underline is cited from the value recommended in Table 2 in the previous review [1351].

[c]This is obtained by correction of 5.08 ± 0.13 eV for Pd (110) in Table 2 [1351].

[d]This is tentatively evaluated from the three data on Ir(110) listed in Table 1 [1351].

[e]The conformity shows the percentage for each metal whose triple sets have "Yes" among the whole listed here (see Footnote d in Table 9).

[f]These work function values such as $\phi(111) = 5.3^+$ eV for Ni(111) [Here][a] and $5.33 \pm 0.01^+$ eV for Ni(111) [283,630] are not ϕ^e but ϕ^+ determined by PSI.

[g]This triple set is tentatively listed to examine the conformity of $\phi^+(hkl)$ for Ni although δ_m for each surface is slightly less than unity [283,630].

[h]No table includes the absolute values of $a_0 - b_0$ [4259] and $c_0 - i_0$ [4246].

[i]The absolute value of x_0 for Ni(100) is not given in the table [4078].

[1–9]By using different values for several parameters in a model of local density approximation for lead, the work function values calculated theoretically afford the averages.[9] Depending upon the parameters, the sequences[1–8] change from Yes to No, and vice versa. For a full detail, see Ref. [3521].

[10–18] The theoretical values for lead[10–17] based on a generalized gradient approximation model yield the averages.[18] Similarly as above[1–8], the sequences[10–17] vary also between Yes and No according to the parametric values employed for calculating ϕ^e (see Ref. [3521] for further information).

[19] Each of the three values for Al or Cu is the average calculated by the authors [723] from published experimental data.

[20] Theoretical study of the face-dependent work function yields the conclusion that Smoluchowski rule holds with Al(111)–Al(110) without showing numerical data [227]. Some typical data supporting the conclusion are found in their later publications [473,553,3477] as listed in this table.

On the contrary, the sequences of Al show "No" frequently ($I_N = 68\%$) among the 56 examples reported by many authors, and "No" is found also for our present and previous ones [Here, 1351] listed with double and single underline, respectively, in Table 10. In addition, Al is experimentally found to have the differences of $\Delta \equiv \phi^e(100) - \phi^e(111) = 0.220 \pm 0.050$ eV [4267] and 0.17 ± 0.04 eV [241,1045]. Both correspond to "No", in contrast to $\Delta = -0.06$ eV [1358]. Interestingly, a theoretical investigation for Al yields that atomically flat surfaces follow exactly the Smoluchowski rule ($4.31 > 4.27 > 3.92$ eV) but that rough surfaces have the direct opposite sequence (typically, $4.03 < 4.19 < 4.23$ eV) [4401]. Here, both $\phi^e(111)$ and $\phi^e(100)$ decrease from 4.31 and 4.27 eV to 4.03 and 4.19 eV, respectively, the result of which is consistent with the general tendency that ϕ^e reduces with an increase in surface roughness (see Footnotes 177, 331 and 332 in Table 1 and also Section 4.2.5 in Ref. [1351]). On the contrary, $\phi^e(110)$ alone increases irregularly from 3.92 to 4.23 eV with increasing roughness, the basic reason for which is naturally expected to be ascertained clearly.

Similarly to Al exemplified just above, Pb also indicates frequently "No" ($I_N = 55\%$ of $N_{total} = 38$), although our sequence [Here] has "Yes". These inconformity percentages ($I_N = 68$ and 55%) for the two metals are much larger than those (e.g., $I_N = 38, 24$ and 25% of $N_{total} = 13, 17$ and 20) for other fcc-metals (e.g., Ir, Pt and Au, respectively) and also extremely higher than those (typically, $I_N = 0, 0$ and 5% of $N_{total} = 17, 13$ and 44) found for others (namely, Ni, Rh and Cu, respectively).

5.4. Concluding remarks on the work function sequences

The data on work function sequences exemplified for many metals in Tables 9 and 10 and also the above consideration may lead to the conclusions as follows.

(1) Following well the sequence of $D_s(110) > D_s(100) > D_s(111)$, both of $\phi^e(110) > \phi^e(100) > \phi^e(111)$ and $\phi^+(110) > \phi^+(100) > \phi^+(111)$ hold generally for bcc-metals. Typically, the percentage of "Yes" for the sequence of ϕ^e is actually found to be $C_Y = 100\%$ for both Na and K and also 94% for both Rb and Cs according to the data obtained wholly by TC, while 89% for W, 82% for Mo and 75% for Nb by various methods. The sequences with double underlines [Here] coming from our most probable values in Table 2 show "Yes" for all the bcc-metals, with only one exception of γ-Sr by TC. This exception, however, can hardly be frankly acceptable, because each of the three values for γ-Sr(hkl) with double underlines [Here] is estimated from only two or three data sources [321,334,1159] (see Table 1) and also because any surface species with the same orientation has a very wide gap of 0.33–1.42 eV among the two or three different groups of workers [321,334,1159]. For making the accurate determination of either "Yes" or "No", much further work is needed to accumulate abundant data on γ-Sr(hkl).

(2) The sequence of $\phi^e(111) > \phi^e(100) > \phi^e(110)$ holds for many fcc-metals, and also $\phi^+(111) > \phi^+(100) > \phi^+(110)$ does so for Ni [Here], as shown in Table 10. The percentages of "Yes" for the former (ϕ^e) are found to be very high such as $C_Y = 100\%$ for both Ni and Rh, 95% for Cu, 92% for Pd, 90% for Ag and 71% for α-Sr, where N_t ranges from 7 up to 44. The sequences with double underlines [Here] originating from Table 2 have "Yes" for almost all the fcc-metals including Pb ($I_N = 55\%$), too, while our sequence [Here] for Al has "No" similarly together with many other sequences for Al ($I_N = 68\%$).

(3) With the two exceptions of Al ($C_Y = 32\%$) and Pb (45%), many of the bcc- and fcc-metals examined here have such sequences as follow strictly the Smoluchowski rule [1040]. Namely, $\phi^e(hkl)$ decreases as $D_s(hkl)$ reduces and hence as the surface becomes more open. In addition, both $\phi^e(hkl)$ and $\phi^+(hkl)$ have the same sequence in each case, thereby giving an additional evidence to support strongly our theoretical model that $\phi^+(hkl)$ is identically equivalent to $\phi^e(hkl)$ for essentially clean monocrystalline surfaces ($\delta_m = 1.0$ and $\Delta\phi^* = 0.0$ eV).

(4) In both cases of bcc- and fcc-metals with the two exceptions (Al and Pb), each triple set with "Yes" indicates that the *relative* values among the three are generally reasonable, but does not insure that the *absolute* value of each in the set is always accurate or correct enough to be acceptable today. Typically, the sequence of $5.12 > 3.85 > 3.81$ eV for α-Fe [4222] has "Yes", but both $\phi^e(100)$ and $\phi^e(111)$ alone are much smaller than ours ($4.99 > 4.64 > 4.4$ eV), as may be seen in Table 9. The above indications are quite natural because "Yes" exactly fulfills the *necessary* condition but does not always satisfy the *sufficient* one for insuring the accuracy or acceptability of each $\phi^e(hkl)$ among the three in the set under study.

(5) Except the cases of Al and Pb, each triple set with "No" generally indicates that at least one of the three values among $\phi^e(100)$–$\phi^e(111)$ is inaccurate either due to some errors in the experimental measurements and/or analyses performed, or due to those in the model itself and/or parameters selected for theoretical calculations for each set (see Footnotes 1–9 and 10–18 for Pb in Table 10).

(6) Consequently, such an examination as "Yes" or "No" exemplified in Tables 9 and 10 is very useful for answering quickly the question whether the three values in the set under study are partly inaccurate or unreliable. If "No", then, either the experimental and analytical procedures or the theoretical model and parameters employed should be improved until yielding "Yes", although "Yes" itself does not always insure that all of the improved values in the new set to be thus achieved are absolutely correct (see Conclusion (4) above).

(7) The triple set of Cu(100)–Cu(111) in 6th column [1358] (see Footnote (15) in Table 2) does not completely follow the Smoluchowski rule [1040], in contrast to that in the 7th column [1045] where $\phi^e(111) = 4.94$ eV $> \phi^e(100) = 4.59$ eV $> \phi^e(110) = 4.48$ eV [953] holds similarly to the most (95%) of the 44 sequences [475–321] in Table 10. On the basis of Conclusion (6) above, therefore, it may be advised that $\phi^e(100) = 5.10$ eV [358] adopted in CRC Handbooks (78–98th Eds., 1997–2017)

[1358, etc.] should be returned to 4.59 eV [953] which was once selected in the 77th Ed. (1996) [4137]. If done so, the revised triple set becomes reasonable similarly to those three sets in the 3rd, 7th and 9th columns for Cu(100)–Cu(111) in Table 2.

(8) Quite similarly to Conclusion (7) just above, the triple set of Nb(hkl) [779] recommended by both CRC and Michaelson in Table 2 also does not follow the above rule. If 4.36 eV for Nb(111) [779] is replaced typically with 3.95 eV [Here], then, the normal sequence of 4.87 eV [779] (or 4.77 eV [Here]) > 4.02 eV [779, Here] > 3.95 eV [Here] holds clearly, as already mentioned in Section 3.2 (see Examination (17)).

(9) In addition, the set of 4.95 > 4.53 < 4.55 eV [325] recommended in Table 2 for bcc-Mo(hkl) by both CRC [1358] and Michaelson [1045] also seems to be partly incorrect, although $\phi(110) = 4.95$ eV alone agrees well with ours (4.98 eV). Namely, both of $\phi(111) = 4.55$ eV and $\phi(100) = 4.53$ eV [325] are considerably larger than ours of 4.29 and 4.38 eV, respectively, and also than many others (see Table 1). Therefore, both seem to need a suitable correction (see Examinations (19) and (20) in Section 3.2).

(10) Interestingly, Al (fcc) is found to have an extremely high percentage ($I_N = 68\%$ among $N_{total} = 56$ sequences) of "No" including also the two sequences of our most probable values [Here, 1351], in contrast to many other fcc-metals having very low percentages of the inconformity; such as Ni and Rh ($I_N = 0\%$, both $N_{total} \geq 13$), Cu ($I_n = 5\%$, $N_{total} = 44$), and Ag ($I_N = 10\%$, $N_{total} = 20$).

(11) Several workers [227,241,721] have tried to examine the applicability of the Smoluchowski rule [1040] to the work function sequence of the three low-index planes of Al. Typically, it is stated to be difficult [227] to understand such *anomalous* behavior as $\phi^e(111) = 4.24 < \phi^e(100) = 4.41 > \phi^e(110) = 4.28$ eV observed for Al by PE [241,242] since other fcc-metals (e.g., Cu by PE [953,2006] and Ni by TE [312,837], see Table 10) behave correctly, regarding the above rule [1040]. On the other hand, Fall et al. [721] arrive at the conclusion that the *anomaly* in the anisotropy of Al against the rule (such as 4.23 < 4.42 > 4.29 eV [482,721] and 4.25 < 4.38 > 4.30 eV [561,721] by TC) originates from the increased *p*-atomic-like character of the density of the states at the Fermi energy, in comparison with most other fcc-metals.

(12) According to theoretical studies published recently (2017) by Perdew et al. [4312], all of the five different models (LDA, PBE, etc.) applied to Pd and Ag (both fcc) yields $\phi^e(111) > \phi^e(100) > \phi^e(110)$. Typically, 5.66 > 5.54 > 5.32 eV for Pd and 4.97 > 4.64 > 4.61 eV for Ag (both calculated by LDA) are listed together with those data by other models in Table 3 [4312]. These results with $C_Y = 100\%$ found by the five models are well accordant to many ($C_Y \geq 90\%$) of other examples of Pd and Ag in Table 10 [Here], which does not include any of the "latest" data listed in Table 3 [4312]. On the contrary, all of the five models afford $\phi^e(111) < \phi^e(100) > \phi^e(110)$ for Al alone among the eight fcc-metals (Cu, Rh, Pt, Au, etc.) under study [4312]. Typically, 4.36 < 4.41 > 4.08 eV by LDA and 4.2 < 4.27 > 3.96 eV by PBE are listed for Al in Table 3 [4312]. These anomalous results against the rule support our result with very high inconformity ($I_N = 68\%$ of $N_{total} = 56$ sequences for Al, see Table 10).

(13) Quite similarly to Al mentioned above, Pb also has a high percentage ($I_N = 55\%$ of $N_{total} = 38$ sequences) of "No", whilst the sequence of our most probable values based on various methods (see Table 2) is consistent with the Smoluchowski rule. Unfortunately, the "latest" data on Pb are not included in Table 3 [4312]. The anomaly (21 examples) found for Pb by many workers is probably first reported here comprehensively. However, it should be noted that no experimental data on Pb(100) and Pb(110) are available today and also that even the four data on Pb(111) determined by PE [2228,2268] or CPD [1525,2002] are scattered in a wide range of 4.05–4.70 eV (see Table 1). Not only by theory but also by experiment, much further investigation is expected to be done in order to examine the above anomaly found almost by theoretical studies.

(14) Any of the sequences with "No" in Tables 9 and 10, tentatively with the exceptions of Al and Pb at present, may not be employed without partial or entire corrections after consulting with the most probable values in Table 2. It should be emphasized here again that many of our most probable values are generally established from much abundant database (Table 1) published to date, and also that most of ours except those with x–z attached are generally expected to be more reliable or accurate at present, compared with others recommended according to those articles published before ~1980.

5.5. Other anisotropic dependence sequences

Concerning the three main planes of bcc- and fcc-monocrystals, similar anisotropic sequences are found to hold for other chemico-physical properties such as surface energy (ε) and melting point (T_m). Some of their data available today will be outlined below, together with the quantitative relations between $\phi^e(hkl)$ and $\varepsilon(hkl)$ and also between $\phi^e(hkl)$ and $T_m(hkl)$.

5.5.1. Anisotropy of surface energy

A theoretical study of ε [320] on fcc-Pd, for example, yields the sequence of $\varepsilon(111) = 0.68 < \varepsilon(100) = 0.89 < \varepsilon(110) = 1.33$ eV, thus increasing as the surface-atom density (D_s, see Table 8) decreases and, hence, as the surface becomes more open. This sequence is in diametric opposition to $\phi^e(111) = 5.53 > \phi^e(100) = 5.30 > \phi^e(110) = 5.13$ eV for Pd by TC [320]. Such opposition is found theoretically also for fcc-Rh and Ag [320,4061]. Another theoretical investigation yields the sequence of $\varepsilon(111) < \varepsilon(100) < \varepsilon(110)$ for all of the six fcc-metals (Ni, Cu, Pd, Ag, Pt and Au) [4064]. Such a normal sequence of ε is theoretically found also for fcc-Al [1175,4077] and Ir [3243], in contrast to an anomalous one of $\phi^e(111) < \phi^e(100) > \phi^e(110)$ for both Al [1175] and Ir [3243] (see Table 10).

Regarding bcc-crystals, α-Fe [4124] and both Mo and β-Hf [4057] are theoretically found to have the sequence of $\varepsilon(111) > \varepsilon(100) > \varepsilon$ (110)]. Again, this is directly opposite to that of $\phi^e(111) < \phi^e(100) < \phi^e(110)$ observed for the most (82%) of Mo crystals in Table 9, although only 38 and 50% of α-Fe and β-Hf, respectively, satisfy the latter sequence of $\phi^e(hkl)$.

Another theoretical study on 14 kinds of metals reports that fcc-metals (Ca, α-Sr, Cu, Ag and Au) and bcc-ones (Li, Na, K, Rb and Cs) have the sequences of $\varepsilon(111) < \varepsilon(100) < \varepsilon(110)$ and $\varepsilon(110) < \varepsilon(100) < \varepsilon(111)$, respectively [4085]. Both sequences are opposite

to the respective ones of ϕ^e(hkl) (see Tables 10 and 9). Such opposite sequences of ε(hkl) against ϕ^e(hkl) are derived theoretically for the fcc-metals of Pd, Pt and Au, although Al alone is found to have the anomalous sequence of ϕ^e(111) = 4.02 eV $< \phi^e$ (100) = 4.30 eV $> \phi^e$(110) = 4.09 eV [4087] (Table 10), contrary to the normal one of ε(111) = 0.30 eV $< \varepsilon$ (100) = 0.45 (or 0.44) eV $< \varepsilon$(110) = 0.70 (or 0.68) eV for Al [4087].

On the other hand, other theoretical studies on fcc-metals (e.g., Ni, Cu, Ag) yield the anomalous result of ε(111) $> \varepsilon$(100) $< \varepsilon$(110) [4070,4072], in contrast to ε(111) $< \varepsilon$(100) $< \varepsilon$(110) for fcc-Al [4070]. Similarly, bcc-metals (e.g., Nb, Mo, W) are observed theoretically to have ε(111) $< \varepsilon$(100) $> \varepsilon$(110) [4071,4072], on the contrary to ε(111) $> \varepsilon$(100) $> \varepsilon$(110) for bcc-Cr alone [4071].

As exemplified above, the sequence of ε(hkl) evaluated theoretically for a given species (e.g., Mo or Ag) is often found to be different with each other depending upon theoretical models employed by different workers, quite similarly to those of ϕ^e(hkl) done so especially for Al and Pb (see Table 10). Such a status suggests it desirable to promote much further studies on ε(hkl) as well as ϕ^e(hkl).

According to the theoretical data on surface energy calculated for 60 kinds of chemical elements, on the other hand, all of the fcc-metals (both Al and Pb included) and of bcc-ones under study are found to satisfy the normal sequences of ε(111) $< \varepsilon$(100) $< \varepsilon$(110) and ε(110) $< \varepsilon$(100) $< \varepsilon$(111), respectively [4077], both of which are directly opposite to the respective sequences of ϕ^e(hkl). Unfortunately, no experimental datum on ε(hkl) except fcc-In and Pb seems to be available today [4077], in contrast with much data on ε(poly) [4077]. Therefore, theoretical determination of ε(hkl) is vitally important [4077]. For thirteen hcp-metals (e.g., Be, Co, Zr, Re), a theoretical study is focused on the surface energy and its anisotropy [4342].

Recently (2014), another theoretical study has been made on both ε(hkl) and ϕ^e(hkl) for many elements such as five alkali metals, three alkali earth metals, four bcc-transition metals and also seven fcc-transition metals (see Tables 1–4 in Ref. [4091]), thereby yielding that many of the metals have the inverse-proportional relation between the sequences of ε(hkl) and ϕ^e(hkl) [4091].

5.5.2. Quantitative relation between surface energy and work function

After consideration of both theoretical values of ε(hkl) and experimental data on ϕ^e(hkl) for fcc-Ni and for bcc-Nb, Mo, Ta and W, Zadumkin et al. (in 1970) [4078] derive a quantitative relationship between the two on the basis of statistical–electronic theory. Namely,

$$\phi^e(\text{hkl}) + (Ba^2/z)\varepsilon(\text{hkl}) = \text{const.} \tag{13}$$

Here, a is the lattice constant, z is the number of valence electrons per atom, B is the constant depending only upon the type of crystal structure. Typically for fcc-Ni, they [4078] yield the theoretical values of the differences such as ϕ^e(100) $- \phi^e$(110) = 0.38 eV, as ϕ^e(100) $- \phi^e$(111) = -0.21 eV (see Table 10) and as ϕ^e(110) $- \phi^e$(111) = -0.55 eV. These differences calculated from Eq. (13) are in good or fair agreement with the experimental ones of 0.25, -0.33 and -0.58 eV determined by TE [312,837] (see Table 10), respectively. Namely, the gap ($|\Delta\phi|$) between the theory [4078] and the experiment [312,837] is as small as $0.03-0.13$ eV. Similarly for bcc-Nb, Mo, Ta and W, such an agreement as $|\Delta\phi| = 0.00 - 0.29$ eV is found between the theory [4078] and the experiment [144,775]. On the basis of these results, it is concluded that the facets with lower surface energy have higher work function, and vice versa [4078]. In other words, any theoretical value of ε(hkl) under study may readily be examined from Eq. (13) by substituting some experimental data on ϕ^e(hkl) for the same surface species (hkl) according to such data as listed in Table 2 [Here].

From another equation (12) derived theoretically by Zadumkin et al. [4084], ε(poly) is theoretically evaluated by using experimental data on ϕ^e(poly) for both alkali and alkali-earth metals, thereby indicating that substitution of an accurate work function value into the above equation (12) may yield a good agreement (within the gap of ~5%) between theoretical and experimental values of ε(poly) for alkalis (Na–Cs). In other words, an accurate value of ε by experiment may be applied to examining the accuracy of ϕ^e from a quite different viewpoint.

Using a modified Frenkel'–Gombas–Zadumkin theory correlating ε with ϕ^e, Shebzukhova and Aref'eva have recently calculated the allotropic work function differences for several metals [4259]. Typically for fcc-Ni, ϕ^e(111) $- \phi^e$(100) = 0.1651 eV and ϕ^e(100) $- \phi^e$(110) = 0.3438 eV by theory [4259] are in fair agreement with 0.33 and 0.25 eV by experiment [312] and also with 0.21 and 0.38 eV by the previous theoretical model [4078], respectively. Both of the theoretical results for Ni follow the normal sequence of ϕ^e(111) $> \phi^e$(100) $> \phi^e$(110), as shown in Table 10 (see Footnotes (h) and (i)). Others on bcc-metals (Nb, Mo, Ta and W) [4078] are listed in Table 9 (see Footnote (g)), normally following ϕ^e(110) $> \phi^e$ (100) $> \phi^e$(111).

A recent study by Shebzukhova et al. using Eq. (13) reports that the work function difference between theory and experiment is estimated to range from ~8 to 1% for Cd(0001), Zn(0001) and Hg(001) [4459].

By the theoretical studies on both ϕ(hkl) and ε(hkl) for six close-packed surfaces of 19 common fcc and bcc metals, Wang et al. find a roughly inverse proportional relationship between the two [4091].

5.5.3. Anisotropy of melting point

The melting point (T_m) of fcc-Cu, for example, is theoretically calculated by Chatterjee, who uses a variety of known parameters for both surface and bulk such as Debye temperature, atomic weight, mean-square amplitude of atomic vibration. Consequently, he yields the sequence of T_m(111) = 866 K $> T_m$(100) = 836 K $> T_m$(110) = 809 K for Cu [1684,4062]. This sequence is identical with that of ϕ^e(111) = 4.94 eV $> \phi^e$(100) = 4.59 eV $> \phi^e$(110) = 4.48 eV for Cu by PE [953] (see Table 10). Such an identity in anisotropic sequence is found also for fcc-metals of Ni, Ag, Pt and Pb [4062]. Typically, Pt has T_m(111) = 2023 K $> T_m$(100) = 1851 K $> T_m$(110) = 1837 K, in harmony with ϕ^e(111) = 5.84 $\pm$ 0.05 eV $> \phi^e$(100) = 5.75 $\pm$ 0.06 eV $> \phi^e$(110) = 5.54 $\pm$ 0.07 eV (see our most probable values in Table 2). Unfortunately, it seems to the present author that any data on T_m(hkl) have not yet been reported for bcc-metals by any worker.

5.5.4. Correlation between melting point and work function

By consideration of the above fact that the anisotropic sequence is identical between $T_m(hkl)$ and $\phi^e(hkl)$, Chatterjee (in 1979) yields the empirical equation as follows [1684].

$$\log[\phi^e(hkl)] = \log[T_m(hkl)^{1/4}/V^{1/6}] - 2.87 \pm 0.04. \tag{14}$$

Here, V is the atomic volume.

Application of Eq. (14) to fcc-Ag yields $\phi^e(111) = 4.85$ eV and $\phi^e(110) = 4.75$ eV [1684]. The respective values, however, are not well accordant to ours of 4.64 ± 0.06 and 4.28 ± 0.08 eV (Table 2), although the former [1684] also follows exactly the normal sequence of $\phi^e(111) > \phi^e(110)$, just as expected from the high conformity ($C_Y = 90\%$ among $N_t = 20$ examples) for Ag-sequence in Table 10. Similarly for fcc-Pb, the calculated values of 3.39 and 3.26 eV [1684] are in poor agreement with ours of 4.14 ± 0.09 and 3.84 ± 0.09 eV (Table 2) for $\phi^e(111)$ and $\phi^e(110)$, respectively, although the sequence of $\phi^e(111) > \phi^e(110)$ itself is identical again between theory and experiment, following the Smoluchowski rule [1040].

It may be worthwhile to inspect the reason why the values of $\phi^e(hkl)$ calculated from Eq. (14) are not well accordant with ours. In addition, it is fully expected to solve the problem whether the work function values to be calculated for bcc-metals from such an empirical equation as Eq. (14) are well accordant to ours in Table 2 [Here].

6. Work function dependence upon the Wigner–Seitz radius

In this section, theoretical evaluation of work function by two typical quantum models will be outlined below together with comparison between calculated values and experimental data.

6.1. Theoretical evaluation of work function by the Lang–Kohn model

The work function may be expressed fundamentally as a function of the external and internal components governed solely by the surface and bulk properties of the solid, respectively. Namely,

$$\phi = D_b - E_F. \tag{15}$$

Here, D_b is the dipole barrier against electrons' escape from the surface into vacuum, and E_F is the Fermi energy or chemical potential of electrons in the bulk.

Lang and Kohn calculate the work function (ϕ) of nine simple metals by using the uniform-positive-background model published in 1971 [475], the result of which may be summarized below in comparison with our most probable values.

As the Wigner–Seitz radius (r_s) increases from 2.0 to 6.0 bohr (1 bohr = 0.0529 nm), D_b and E_F decrease monotonically from 6.80 to 0.04 and 2.91 to -2.37 eV, respectively, thereby affording that ϕ decreases gradually from 3.89 to 2.41 eV (see Table I in Ref. [475]). Such a dependence of D_b, $-E_F$ and ϕ is shown as Curves (1)–(3), respectively, in Fig. 2. Consequently, the contribution of D_b to ϕ becomes smaller with increasing r_s. Typically, the ratio (D_b/ϕ) is (i) about 30% for Na ($r_s = 3.99$ bohr) having $\phi = D_b - E_F = 0.91 + 2.15 = 3.06$ eV, (ii) about 13% for K ($r_s = 4.96$ bohr) with $\phi = 0.36 + 2.38 = 2.74$ eV, and (iii) only about 5% for Cs ($r_s = 5.63$ bohr) with $\phi = 0.12 + 2.37 = 2.49$ eV. In other words, ϕ is governed more strongly (from ~70% for Na, to 87% for K, and further to 95% for Cs) by the bulk component (E_F) as r_s increases from 3.99 to 4.96 and moreover to 5.63 bohr, respectively.

The plot of Curve (3) for ϕ based on the theoretical values in Table II (e.g., 3.06, 2.74 and 2.49 eV for Na, K and Cs, respectively) [475] does not well overlap with that of Curve (4) for our ϕ^e in Table 2 [Here] (e.g., 2.54, 2.29 and 2.05 eV for Na, K and Cs, respectively), thus showing the mean discrepancy of $|\phi - \phi^e| = 0.38 \pm 0.15$ eV for the nine metals (Al–Cs) entered in Fig. 2. But, both plots have the same tendency, gradually lowering their positions with increasing r_s. Regarding another curve to be obtainable from the experimental values of work function (e.g., $\phi_{exp} = 2.7$ eV for Na by CPD [1992], 2.39 ± 0.01 eV for K by PE [1481] and 2.14 ± 0.02 eV for Cs by PE [1489], entirely published before 1970) cited in Table II [475], we shall find that the supposed curve of ϕ_{exp} might attain the position nearer to Curve (3) within the mean difference ($|\phi - \phi_{exp}|$) of 0.31 ± 0.14 eV. This is slightly smaller than $|\phi - \phi^e| = 0.38 \pm 0.15$ eV mentioned just above, but still showing a considerable difference between ϕ and ϕ_{exp}.

Another theoretical study [4089] evaluates E_F for 19 species of metals, and it yields typically -2.0, -2.2 and -2.2 eV for Na, K and Cs [4089], which are different (by $0.15-0.18$ eV) from -2.15, -2.38 and -2.37 eV in Table I [475], respectively. By substitution of both the former values of E_F [4089] and the literature ones of ϕ_{exp} cited in Table II [475] into Eq. (15), D_b is calculated to be 0.7, 0.2 and -0.06 eV [4089], which are similarly different (by $0.16-0.21$ eV) from 0.91, 0.36 and 0.12 eV [475] for Na, K and Cs, respectively. Such a difference may be quite natural because both of E_F and work function (ϕ or ϕ_{exp}) are different between the two studies [475,4089]. In other words, any theoretical evaluation of D_b is usually subject to the uncertainty of ± 0.1 eV or so.

For eleven polyvalent metals ($r_s < 3$ bohr) of higher electron density, the theoretical study [4089] leads to the conclusion that ϕ is stabilized very efficiently around 4.1 ± 0.4 eV by D_b, in spite of a considerable variation in E_F. In fact, our most probable values of ϕ^e for typical metals (e.g., Be, Al, Zn, Cd, In, α-Sn and Pb with r_s ranging from 1.87–2.59 bohr) are found to have 4.17 ± 0.10 eV (see Table 2). Regarding monovalent metals such as alkalis ($r_s > 3$ bohr), on the other hand, D_b becomes less contributable to ϕ because E_F becomes less variable with increasing r_s, as may be readily understandable from Fig. 2.

Quantitative relation between D_b and E_F is investigated theoretically and summarized in Fig. 1 [4054], showing that D_b tends to decrease monotonically (non-linearly) with increasing $-E_F$ [4054], quite similarly as above.
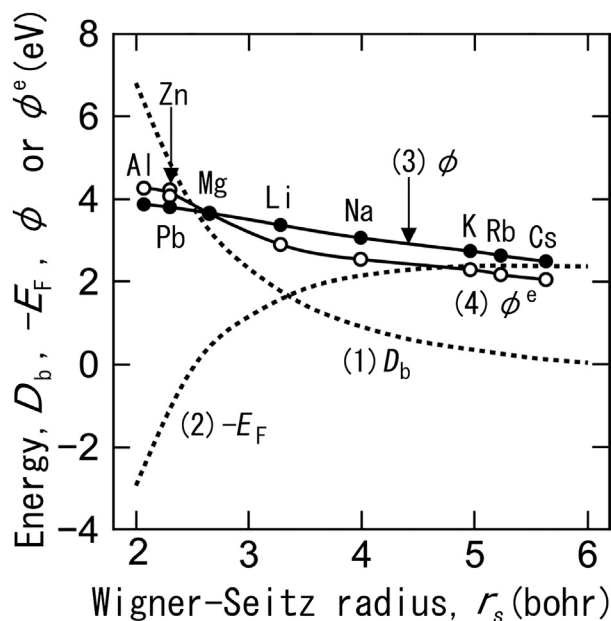
Fig. 2. Wigner–Seitz radius dependence of (1) dipole barrier (D_b), (2) Fermi energy (E_F), (3) work function (ϕ) evaluated from Eq. (15) [475], and (4) the most probable value of work function (ϕ^e) cited from Table 2 [Here].

In the above study [475] summarized in Fig. 2, it is $\phi = 3.66$ eV for Mg alone that agrees well (within 0.01 ± 0.02 eV) with our most probable value of $\phi^e = 3.65 \pm 0.05$ eV and also with other recommended values of 3.66, 3.66 and 3.64 eV in Refs. [1358], [1045] and [1354], respectively (see Table 2). Typically, another example of Na ($\phi = 3.06$ eV [475]) has the largest deviation (0.52 ± 0.03 eV) from our value ($\phi^e = 2.54 \pm 0.03$ eV in Table 2), and the former has a large discrepancy (0.31–0.71 eV) also from others (2.75–2.35 eV) recommended in Refs. [1045,1354,1358]. In other words, many of the theoretical values of ϕ calculated by the original model [475] are not yet so well accordant even to the literature values of ϕ_{exp} [1992, etc.] available at that time (~1970).

However, it should be noted that the original theory initiated in 1964 by Kohn and co-workers [475,3638,4044,4045] has made thereafter a definite contribution to better calculations of work function. As briefly mentioned in Section 2.8.5, they have constructed an epoch-making framework [1698,4395–4397], which has contributed greatly as the motive power to promote the amazing progress in precise evaluation of work function for various surface species. Namely, a variety of theoretical models have been published thereafter to evaluate ϕ^e for various mono- and polycrystalline surfaces, and many of them have achieved very accurate values of ϕ^e. Typically for W(100) reported in 1982–2004, $\phi^e = 4.6$ eV [382,1908], 4.63 eV [383,385], 4.63 eV [3452], 4.63 eV [357] and 4.65 eV [386] by quantum theory (see Table 1) agree exactly with our most probable value of 4.65 ± 0.02 eV based mainly on experiment and also do well with other recommended values of 4.63 eV [1045,1358] and 4.65 ± 0.10 eV# [1664,1665,3964] (see Table 2) and again fairly with 4.70 ± 0.06 eV recommended recently (in 2015) [4088]. Such a good agreement between a theoretical value and ours is found for many other surface species such as Al(hkl) [482,561], Cu(hkl) [3477] and Ag(hkl) [1264] (see Table 1). Regarding the comparison between theory and experiment about ϕ^e, further information is obtained from a compact review by Kiejna [2427,3901]. Recently, De Waele et al. have published the error estimates for density function theory of work function [4108], whose data are summarized in Appendices A and B added to Master's dissertation [4460].

6.2. Theoretical evaluation of work function by the Halas–Durakiewicz model

Recently (in 2010), Halas and Durakiewicz have discussed the problem whether work function is a surface or bulk property, and indicated that ϕ is derived solely from the bulk properties of both the Wigner–Seitz radius (r_s) and the Fermi energy (E_F). Namely [298,495,510,2205,3978],

$$\phi = 43.46/r_s^{3/2} E_F^{1/2}, \qquad (16)$$

which is applicable to work function changes from a clean surface to a gas-covered one and finally to gas-reacted compound one. Typically, Pd is calculated to have 5.25 eV [510,2205], which decreases gradually by hydrogen gas adsorption and finally to 3.2 eV for PdH [510,2205]. Such a gradual decrease estimated by theory is well accordant to that found by experiment [3979]. The former value (5.25 eV) for Pd agrees fairly with 5.17 ± 0.06 eV [Here], 5.22 eV [1358], 5.12 eV [1045] and 5.24 ± 0.05 eV [1351] (see Table 2). With respect to many other polycrystalline surfaces (59 species), Eq. (16) is successfully applied to the calculation of ϕ^e-values [298], many of which are found to agree well or fairly with ϕ^e recommended in a CRC-handbook (77th Ed. in 1996–1997) [4137]. There, all of the work function values are cited from those selected in 1977 by Michaelson [1045].

7. Work function change due to phase transition

This section will summarize briefly the work function changes due to allotropic transition from α to β or β to γ phase and also due to the phase change from solid to liquid, together with their experimental data available today.

7.1. Work function change due to allotropic transition

As known well, many solid elements (typically, C, Ca, Ti, Mn, Fe, Co, Sr, Y, Zr, Sn, La, Ce, Pr, Nd, Tb, Dy, Tm, Hf, U, Pu and Am) have several allotropes, each crystal structure of which changes usually at the allotropic transition temperature (T_A) characteristic of the solid species, thereby showing one of the different phases of α, β, γ, etc. with somewhat different work function values of ϕ_α^e, ϕ_β^e, ϕ_γ^e, etc. among them. The work function change due to allotropic transition may be generally expected to afford us some interesting information about chemico-physical properties characteristic of the surface and bulk under study. The experimental data reported for such a change are summarized in Table 11, where $\Delta\phi_{\beta\alpha}^e \equiv \phi_\beta^e - \phi_\alpha^e$ and $\Delta\phi_{\gamma\beta}^e \equiv \phi_\gamma^e - \phi_\beta^e$ are the work function changes corresponding to the differences between the final and initial stages of $\beta \leftarrow \alpha$ and $\gamma \leftarrow \beta$, respectively. Of course, each of the data on allotropic transition temperatures (T_A) for any metal species entered therein is scattered in a wide range dependent upon specimens or workers. Typically for Hf, nine groups of workers have reported that T_A for $\alpha \leftrightarrow \beta$ is 1583, 1970, 1990–2003, 2007–2100, 2013 $\pm$ 20, 2028, 2033, 2050 $\pm$ 5 or 2236–2266 K [2967]. Similarly, Co also has a large scatter of $T_A \approx 650$–720 K. According to Ref. [1148], $T_A = 670$ K is tentatively adopted for Co in Table 11, although 695 K [4336] is employed in Table 1.

Table 11
Work function changes due to allotropic transformation.

α-phase	β-phase	γ-phase	ϕ_α^e (eV)	$\Delta\phi_{\beta\alpha}^e$ (eV)[a]	ϕ_β^e (eV)	$\Delta\phi_{\gamma\beta}^e$ (eV)[a]	ϕ_γ^e (eV)	Meth.	Refs.
				21. Sc (α = hcp, $T < 1660$ K; β = fcc, $T > 1660$ K for bulk)					
Sc	Sc	–	3.62	−0.16	3.46	–	–	TE	[4356]
				22. Ti (α = hcp, $T < 1155$ K; β = bcc, $T > 1155$ K for bulk)					
Ti/W(100)	Ti/W(100)	–	3.88 $\pm$ 0.09	−0.23 $\pm$ 0.10	3.65 $\pm$ 0.05	–	–	FE	[1404]
Ti/W	Ti/W	–	3.95	−0.30	3.65	–	–	FE	[1522]
Ti/W(111)	Ti/W(111)	–	3.95	−0.35	3.6	–	–	FE	[2194]
Mean	–	–	–	**−0.29 $\pm$ 0.05[m]**	–	–	–	–	–
Ti	Ti	–	3.76	0.00	3.76	–	–	TE	[179]
Ti	Ti	–	4.26	−0.03	4.23	–	–	TE	[179]
Ti	Ti	–	4.36	−0.04	4.32	–	–	TE	[179]
Ti	Ti	–	3.87 $\pm$ 0.05	0.06 $\pm$ 0.17	3.93 $\pm$ 0.16	–	–	various	[Here][b]
Mean	–	–	–	**0.00 $\pm$ 0.03**	–	–	–	–	–
				26. Fe (α = bcc, $T < 1042$ K; β = bcc; γ = fcc, $T = 1179$–1674 K for bulk)[g]					
–	Fe	Fe	–	–	4.48 $\pm$ 0.06	−0.27 $\pm$ 0.08[k]	4.21 $\pm$ 0.05	TE	[310]
–	Fe	Fe	–	–	4.64 $\pm$ 0.06	0.02 $\pm$ 0.08	4.66 $\pm$ 0.05	TE	[310]
Fe	Fe	–	4.53	−0.08	4.45	–	–	TC	[3318]
Fe	Fe	–	4.65 $\pm$ 0.01	−0.03 $\pm$ 0.01	4.62 $\pm$ 0.01	–	–	PE	[305]
Fe	Fe	Fe	4.63 $\pm$ 0.01	−0.01 $\pm$ 0.01[l]	4.62 $\pm$ 0.01	0.06 $\pm$ 0.01	4.68 $\pm$ 0.01	PE	[305]
–	Fe	Fe	–	–	?	0.09	?	TE	[303]
–	Fe	Fe	–	–	4.49+	0.06	4.55+	PSI	[303][c]
–	Fe	Fe	–	–	4.77	0.00	4.77	TE	[3024]
Fe	Fe	Fe	4.55 $\pm$ 0.05	−0.03 $\pm$ 0.18	4.52 $\pm$ 0.17	0.02 $\pm$ 0.18	4.54 $\pm$ 0.05	various	[Here][b]
Mean	–	–	–	**−0.04 $\pm$ 0.03**	–	**0.04 $\pm$ 0.03**	–	–	–
				27. Co (α = hcp, $T < 670$ K; β = fcc, $T > 670$ K for bulk)					
Co(0001)	Co(111)	–	5.264	0.002	5.266	–	–	CPD	[3192]
Co	Co	–	4.923[n]	0.002	4.925[n]	–	–	CPD	[1148]
Co	Co	–	4.923	0.043	4.966	–	–	CPD	[1148]
Co	Co	–	4.960	−0.035	4.925	–	–	CPD	[1148]
Co	Co	–	4.960[n]	0.006	4.966[n]	–	–	CPD	[1148]
Co	Co	–	4.97	−0.04	4.93	–	–	CPD	[3153]
Co	Co	–	4.12 $\pm$ 0.04	0.13 $\pm$ 0.09	4.25 $\pm$ 0.08	–	–	PE	[1632]

Table 11 (*continued*)

α-phase	β-phase	γ-phase	ϕ_α^e (eV)	$\Delta\phi_{\beta\alpha}^e$ (eV)[a]	ϕ_β^e (eV)	$\Delta\phi_{\gamma\beta}^e$ (eV)[a]	ϕ_γ^e (eV)	Meth.	Refs.
Co	Co	–	4.71 ± 0.03	−0.21 ± 0.13	4.50 ± 0.13	–	–	various	[Here][b]
Mean	–	–	–	**−0.02 ± 0.10**	–	–	–	–	–
				39. Y (α = hcp, $T < 1540$ K; β = bcc, $T > 1540$ K for bulk)					
Y	Y	–	3.62	−0.18	3.44	–	–	TE	[4356]
Y	Y	–	3.27	−0.10	3.17	–	–	TE	[4356]
Y	Y	–	3.16 ± 0.06	0.01 ± 0.06	3.17	–	–	various	[Here][b]
				50. Sn (α = bcc, $T < 291$ K; β = tetragonal; γ = hexagonal, $T > 473$ K for bulk)					
–	Sn	Sn	–	–	4.39	−0.11	4.28	PE	[1135]
–	Sn	Sn	–	–	4.51	−0.13	4.38	PE	[1945–1947]
Sn	Sn	Sn	4.27 ± 0.06	0.07 ± 0.08	4.34 ± 0.06	−0.05 ± 0.08	4.29 ± 0.06	various	[Here][b]
Mean	–	–	–	**0.07 ± 0.08**	–	**−0.10 ± 0.03**	–	–	–
				65. Tb (α = hcp, $T < 1500$ K; β = bcc, $T > 1500$ K for bulk)					
Tb(0001)	Tb(???)[h]	–	3.09 ± 0.05	−0.15 ± 0.07	2.94 ± 0.05	–	–	TE	[3920]
Tb	Tb	–	3.19	−0.18	3.01	–	–	TE	[4356]
				72. Hf (α = hcp, $T < 2050$ K; β = bcc, $T > 2050$ K for bulk)[i]					
Hf(0001)	Hf(???)[h]	–	4.10 ± 0.05	−0.20 ± 0.07	3.90 ± 0.05	–	–	TE	[3921]
Hf(0001)	Hf(???)[h]	–	4.11 ± 0.05	−0.21 ± 0.07	3.90 ± 0.05	–	–	TE	[2967]
Mean	–	–	–	**−0.21 ± 0.07**	–	–	–	–	–
				92. U (α = rhombic, $T < 940$ K; β = tetragonal; γ = bcc, $T > 1050$ K for bulk)[f]					
U(foil)	U	U	3.47 ± 0.01	0.05 ± 0.01	3.52 ± 0.01	−0.13 ± 0.01	3.39 ± 0.01	PE	[1884]
U/W	U/W	U/W	3.56 ± 0.05	−0.51 ± 0.06*	3.05 ± 0.03	0.35 ± 0.20**	3.4 ± 0.2	FE	[1657]
U/W(116)	–	U/W(116)	3.57 ± 0.03	–	–	–	3.43 ± 0.03	FE	[1664]
U/W(113)	–	U/W(113)	3.60 ± 0.03	–	–	–	3.53 ± 0.03	FE	[1664]
U/W	U/W	U/W	3.60 ± 0.03	−0.07 ± 0.04	3.53 ± 0.03	−0.10 ± 0.04	3.43 ± 0.03	FE	[1654]
U/W	U/W	U/W	3.63 ± 0.01	−0.05 ± 0.01	3.58 ± 0.01	−0.05 ± 0.01	3.53 ± 0.01	CPD	[1484]
U/W(111)	U/W(111)	U/W(111)	3.64 ± 0.03	−0.28 ± 0.04*	3.36 ± 0.03	−0.05 ± 0.04	3.31 ± 0.03	FE	[1664]
U/W	U/W	U/W	3.65 ± 0.01	−0.06 ± 0.01	3.59 ± 0.01	−0.14 ± 0.01	3.45 ± 0.01	PE	[2467]
U/W(112)	U/W(112)	U/W(112)	3.70 ± 0.03	−0.06 ± 0.04	3.64 ± 0.03	−0.35 ± 0.04**	3.29 ± 0.03	FE	[1664]
U/W(100)	U/W(100)	U/W(100)	3.88 ± 0.03	−0.27 ± 0.04*	3.61 ± 0.03	0.21 ± 0.04**	3.82 ± 0.03	FE	[1664]
U/W(110)	U/W(110)	U/W(110)	4.04 ± 0.03	−0.05 ± 0.04	3.99 ± 0.03	0.01 ± 0.04	4.00 ± 0.03	FE	[1664]
U	U	U	3.64 ± 0.04	−0.06 ± 0.06	3.58 ± 0.04	−0.16 ± 0.06	3.42 ± 0.05	various	[Here][b]
Mean	–	–	–	**−0.04 ± 0.04[d]**	–	**−0.09 ± 0.06[e]**	–	–	–
Partial mean	–	–	–	**−0.03 ± 0.06[j]**	–	**−0.04 ± 0.08**	–	–	–

[a]The work function changes due to the $\alpha \to \beta$ and $\beta \to \gamma$ transformations are shown as $\Delta\phi_{\beta\alpha}^e \equiv \phi_\beta^e - \phi_\alpha^e$ and $\Delta\phi_{\gamma\beta}^e \equiv \phi_\gamma^e - \phi_\beta^e$, respectively.

[b]The work function data [Here] are cited from Table 2.

[c]The value with the superscript (+) for Fe indicates ϕ^+ instead of ϕ^e (see Footnote 112 in Table 1).

[d]This mean for U is evaluated after disregarding the three values* with an asterisk in the fifth column.

[e]Similarly, this is estimated without including these data** in the seventh column for U.

[f]The allotropic transition temperatures of U from β to α and γ to β are found to range from 918 to 948 K and from 1037 to 1053 K, respectively [3967] (see Footnote 400 in Table 1).

[g]Even at a constant temperature of ~300 K, allotropic transformation from γ-like fcc-Fe(100) to α-bcc-Fe(110) is found to occur when the Fe-layers on Cu(100) increase beyond ~10 ML [3913] (see Sections 7.1 and 8.2).

[h]Regarding β-Tb(???) and Hf(???), further investigation by both theory and experiment may be necessary to assign correctly their orientation, although both Zr and Ti are already established to have the allotropic orientation relationship of α-hcp-{0001}∥ β-bcc-{110} (see Section 7.1).

[i]The allotropic transition temperature of Hf is measured to be 2050 ± 5 K [2967], while 1997 ± 7, 2013 ± 20, 2028 and 2033 K are reported by other workers [2967]. This spread may be caused by the difference in impurity concentration of Zr.

[j]This is not overall but partial mean for $\Delta\phi_{\beta\alpha}^e$, which is evaluated from the above data on Ti, Fe, Co, Sn and U alone because the five metals seem to be somewhat different in $\Delta\phi_{\beta\alpha}^e$ from Y, Tb and Hf (see Section 7.1).

[k]This may be corrected to be $\Delta\phi_{\gamma\beta}^e = 0.02 \pm 0.08$ eV for Fe [310] by substitution of ϕ_β^e and ϕ_γ^e into Eq. (8), as listed on the next line (for details, see Section 2.8.6).

[l]This is estimated as the *net* change due to the transition alone, where both $\phi_\alpha^e = 4.70 \pm 0.01$ eV (at 300 K) and 4.65 ± 0.01 eV (870 K) for α-Fe are corrected to be 4.63 ± 0.01 eV (1125 K) by extrapolation of the linear relationship (its coefficient $\alpha = -9 \times 10^{-5}$ eV/K) between ϕ^e and T [305] (see Section 7.1). It should be noted that the other values (−0.08 eV [3318] and −0.03 eV [305]) are not corrected by the effect due to α.

[m]This value may be corrected to be 0.00 ± 0.16 eV by adoption of our most probable value ($\phi_\beta^e = 3.93 \pm 0.16$ eV for β-Ti in Table 2) instead of the experimental data (3.65–3.6 eV [1404,1522,2194] in Table 11) (see Section 7.1).

[n]The values of ϕ_α^e = 4.923 and 4.960 eV for α-Co are measured at 663 and 300 K, respectively, while ϕ_β^e = 4.966 eV at 300 K is estimated from 4.925 eV at 673 K by extrapolation of the linear relation between ϕ^e and T [1148] (see Section 7.1 for further information).

As a typical example, bulk iron possesses the four allotropic phases of α–δ having T_A = 1042, 1179 and 1674 K corresponding to the boundary temperatures between the respective adjacent phases (see Table 11). The work function change ($\Delta\phi_{\beta\alpha}^e$) for bulk Fe is evaluated to be −0.08 eV by TC [3318]. An experimental study by the Fowler method [305] yields ϕ_β^e = 4.62 eV (1125 K) and also ϕ_α^e = 4.70 eV (300 K) or 4.65 eV (870 K). By extrapolation of ϕ_α^e from both 300 and 870 K to 1125 K according to α = −0.05 eV/570 K = −9 × 10^{-5} eV/K, however, ϕ_α^e is corrected by −0.07 and −0.02 eV at 1125 K (extrapolated temperature). Consequently, the present author estimates $\Delta\phi_{\beta\alpha}^e$ = ϕ_β^e (1125 K) − ϕ_α^e (1125 K) = 4.62 − 4.63 = −0.01 eV (see Footnote (l) in Table 11), which is different from ϕ_β^e (1125 K) − ϕ_α^e (870 K) = 4.62 − 4.65 = −0.03 eV [305] (see Table 11). The former is the *net* change due to the transition alone without including the effect of the temperature coefficient of α. It should be noted that any of the other data on $\Delta\phi_{\beta\alpha}^e$ is not corrected by the temperature effect due to α. On the other hand, $\Delta\phi_{\gamma\beta}^e \equiv \phi_\gamma^e - \phi_\beta^e$ for Fe is found to have the positive values such as 0.06 eV by PE [305] and 0.02 eV by various methods [Here], in contrast to −0.27 eV by TE [310]. The latter, however, may be corrected from −0.27 to 0.02 eV because substitution of ϕ_β^e = 4.48 eV and ϕ_γ^e = 4.21 eV into Eq. (8) yields 4.64 and 4.66 eV, respectively, as already explained in Section 2.8.6 and also in Footnote (k) in Table 11. By another study on Fe [303], the transition ($\beta \to \gamma$) is observed to *increase* by $\Delta\phi_{\gamma\beta}^e$ = 0.09 eV, which is nearly equal to $\Delta\phi_{\gamma\beta}^+ \equiv \phi_\gamma^+ - \phi_\beta^+$ = 4.55 − 4.49 = 0.06 eV determined by PSI of K on Fe at 1183 K [303] (see Footnote 112 in Table 1). The result of $\Delta\phi_{\gamma\beta}^e \approx \Delta\phi_{\gamma\beta}^+$ is very interesting and also important as the first report in this research field.

According to the fine measurements by CPD [1148], α-hcp-Co has ϕ_α^e = 4.923 and 4.960 eV at 663 and 300 K, respectively, in contrast to ϕ_β^e = 4.925 eV for β-fcc-Co at 673 K. In consequence, $\Delta\phi_{\beta\alpha}^e$ may be calculated to be 0.002 or −0.035 eV if the thermal effect due to the temperature coefficient (α) is disregarded in the latter case having a larger difference in temperature (ΔT = 373 K). On the other hand, the extrapolation from 673 to 300 K yields ϕ_β^e = 4.966 eV [1148], which affords $\Delta\phi_{\beta\alpha}^e$ = 0.006 eV as the *net* change due to the phase transition alone because ϕ_α^e = 4.960 eV is measured at 300 K (ΔT = 0 K).

In the case of the Ti-film on W (mono or poly), $\Delta\phi_{\beta\alpha}^e$ determined by FE [1404,1522,2194] has Mean = −0.29 ± 0.05 eV (see Table 11), which is very different from Mean = 0.00 ± 0.03 eV for bulk Ti [179, Here]. The latter is near to Means of $\Delta\phi_{\beta\alpha}^e$ (−0.04, −0.02, 0.07 and −0.04 eV) found for bulk Fe, Co, Sn and U, respectively. According to the data on Ti/W(mono or poly) by FE [1404,1522,2194], ϕ_α^e = 3.88–3.95 eV (mean = 3.93 ± 0.03 eV) is substantially the same with our most probable value of ϕ_α^e = 3.87 ± 0.05 eV (Table 2), but ϕ_β^e = 3.6–3.65 eV [1404,1522,2194] is *smaller* by 0.30 eV than ours of 3.93 eV (Table 2). This difference is exactly corresponding to Mean = −0.29 eV mentioned just above. This fact suggests that $\Delta\phi_{\beta\alpha}^e$ may be corrected to be (3.93 ± 0.16) − (3.93 ± 0.03) = 0.00 ± 0.16 eV. This is just equal to 0.00 ± 0.03 eV found for bulk Ti (see Table 11), although the former has a very large uncertainty of ±0.16 eV. Much further work on $\Delta\phi_{\beta\alpha}^e$ for Ti, however, is needed to clarify the reasons for the large difference (∼0.3 eV) between the film [1404,1522,2194] and the bulk [179]. For example, it may be worth while to resolve the question whether the Ti-film on W is kept substantially unchanged in both surface thickness and smoothness over the temperature range covering α–β phases without depending upon either the annealing at 1300 (or 1100) K or the heating to 1100 K (see Footnotes 97–99 in Table 1).

Regarding both of the uranium bulk and film on tungsten, $\Delta\phi_{\beta\alpha}^e \equiv \phi_\beta^e - \phi_\alpha^e$ is found to have Mean = −0.04 ± 0.04 eV, while $\Delta\phi_{\gamma\beta}^e \equiv \phi_\gamma^e - \phi_\beta^e$ has Mean = −0.09 ± 0.06 eV. The former value for U (−0.04 ± 0.04 eV) is close to $\Delta\phi_{\beta\alpha}^e$ = 0.00 ± 0.03, −0.04 ± 0.03 and −0.02 ± 0.10 eV for the bulks of Ti, Fe and Co, respectively. The latter value for U ($\Delta\phi_{\gamma\beta}^e$ = −0.09 ± 0.06 eV) is essentially equal to $\Delta\phi_{\gamma\beta}^e$ = −0.10 ± 0.03 eV for bulk Sn. The above values for U are estimated tentatively by disregarding the three values of −0.51*, −0.28* and −0.27* eV for $\Delta\phi_{\beta\alpha}^e$ (see Footnote (d) in Table 11) and also by doing those of 0.35**, −0.35** and 0.21** eV for $\Delta\phi_{\gamma\beta}^e$ (see Footnote (e) in id.). The latter example of a wide divergence (−0.35 to 0.35 eV) suggests that both accurate and abundant data around each transition temperature should be accumulated by further investigations. Typically, ϕ_α^e = 3.56 ± 0.05 eV and ϕ_γ^e = 3.4 ± 0.2 eV for the U/W system [1657] are nearly equal to our most probable values of 3.64 ± 0.04 and 3.42 ± 0.05 eV (Table 2), respectively. On the contrary, ϕ_β^e = 3.05 ± 0.03 eV alone [1657] is much smaller by ∼0.5 eV than ours of 3.58 ± 0.04 eV (Table 2). This gap may be ascribed to the anomalous result that both of $\Delta\phi_{\beta\alpha}^e$ = −0.51 ± 0.06* eV and $\Delta\phi_{\gamma\beta}^e$ = 0.35 ± 0.20** eV [1657] (see Table 11) are largely different from many other respective values such as −0.05 ± 0.04 and 0.01 ± 0.04 eV [1664] and as −0.07 ± 0.04 and −0.10 ± 0.04 eV [1654]. Such a gap is the main reason why the asterisked values mentioned above are tentatively disregarded from calculating any Mean about uranium. Of course, much further work is necessary to confirm the acceptability of the above disregarding.

In general, it is very interesting to solve the problem how the monocrystal under study changes in surface orientation according to the allotropic transition, typically from α to β. An X-ray analysis indicates that α-hcp-Zr(0001) changes to β-bcc-Zr(110), which was discovered in 1934 by Burgers [4163]. Such a "Burgers orientation relationship" between $\alpha \leftrightarrow \beta$ transition has long been investigated to date for Zr [3908,3918,4170–4172], Ti [3745,3910,4164–4169], Sn [4363] and so on. Typically, the relationship of α-{0001}∥ β-{110} and α-⟨1120⟩∥β-⟨111⟩ is found to hold by experiment and theory for Ti, too [3910,4164–4169], as well as Zr [4170–4172]. In another case of Hf, α-hcp-Hf(0001) [2967] is stated to transfer to β-bcc-Hf(210) according to the description [3908]. On the other hand, α-hcp-Co(0001) is reported to transfer to β-bcc-Co(111) at T_A = 720 ± 10 K [3192]. For α-hcp-{0001} metals such as Sc, Co, Y, Gd, Tb, Hf, etc., it seems to the present author that the orientation relationship for the $\alpha \leftrightarrow \beta$ transition should be examined in more detail and also that the work function change due to the transition should be investigated precisely by both experiment and theory.

With respect to Y, $\Delta\phi^e_{\beta\alpha}$ is extremely different between the data [4356] and [Here] and, hence, we can hardly estimate correctly its probable value without addition of much data. According to Figs. 1 and 3 for Tb(0001) [4146], ϕ^e decreases from 3.09 ± 0.05 eV (at 1440 K) to 2.94 ± 0.05 eV (1450–1500 K) [3920], while Fig. 3 for Hf(0001) [2967] shows the decrease from 4.11 ± 0.05 eV ($\sim$1800−2040 K) to 3.90 ± 0.05 eV ($\sim$2050−2100 K) [2967]. Consequently, we have $\Delta\phi^e_{\beta\alpha} = -0.15 \pm 0.07$ and -0.21 ± 0.07 eV for Tb and Hf, respectively, as shown in Table 11. Both of the net values are considerably different from the partial mean of -0.03 ± 0.06 estimated for Ti, Fe, Co, Sn and U (see Footnote (j) in Table 11). Strongly, it is desirable to ascertain the reason why $\Delta\phi^e_{\beta\alpha}$ (about -0.15 and -0.21 eV) for Tb(0001) and Hf(0001) is much different from that (-0.03 eV) for the other five metals and to promote the study about the general rule how the various species of monocrystals change in crystallographic orientation according the allotropic transitions of α to β and β to γ, and also to determine the precise *net* values of $\Delta\phi^e_{\beta\alpha}$ and $\Delta\phi^e_{\gamma\beta}$ for many species of metals at the level of 10 meV or less.

With respect to Ru($11\bar{2}2$) and Ru($11\bar{2}5$), anomalous work function change is observed to drop by 0.38 and 0.55 eV, respectively, at 1510 ± 10 K, but to jump up at 1530 ± 10 K to the initial levels of 4.45 and 4.65 eV, respectively [3686]. These changes are assumed to be caused by allotropic transformations, where $\phi^e_\alpha = \phi^e_\gamma$ and $\Delta\phi^e_{\beta\alpha} = -\Delta\phi^e_{\gamma\beta}$ [3686]. Specific heat study about Ru suggests that its crystal has four different types of α ($T < 1308 \pm 5$ K), β (1308–1500 K), γ (1500–1800 K) and δ ($T > 1800$ K) [3980]. The transition temperature corresponding to $\gamma \to \beta$ phase for Ru is changed from 1530 to 1230 ± 10 K by repetition of 500 heating–cooling cycles [3919]. The latent heat of transition at 1230 K is calculated to range from 3.9 to 5.2 kJ/mol [3919], corresponding to as small as 0.040 and 0.054 eV, respectively. According to available literature data, however, the question on possible allotropic modification in Ru is still open [3919].

We may obtain general information about the temperature-dependent allotropic structures of the elements [4382], the number of allotropes of the elements [4383], both allotropic crystal transformation and transition temperatures of rare earth metals [4364, 4384] and those of many metals and several non-metals [4385].

Finally in this section, let's enjoy such interesting topics on allotropy as follows.

(1) In the case of a bulk sample, the paramagnetic γ-fcc-Fe ($\phi^e = 4.54 \pm 0.05$ eV, Table 2) is generally retained at 1179–1674 K alone, and it turns to ferromagnetic α-bcc-Fe (4.55 ± 0.05 eV) at room temperature [3980]. On the other hand, a thin layer system (usually $\theta \leq 10$ ML) of ferromagnetic fcc-Fe/Cu(100) is found to exist at room temperature [2056,3911,3912] (see Footnote 114 in Table 1). Such a *metastable* film system is found by PE to have $\phi^e = 4.59$ eV by deposition at $\sim$300 K and 4.46 eV after annealing at 400 K [2175]. The former value alone is close to 4.62 and 4.67 eV observed by PE for metastable fcc-Fe(100)/Cu(100) prepared at $\sim$300 K [2673].

(2) Such an iron film formed on Cu(100) at $\sim$300 K is found to have the phase corresponding apparently to γ-fcc-Fe(100) at the iron thickness below the critical coverage of $\theta_c \approx 10$ ML [3913]. Above θ_c, on the other hand, the metastable γ-like fcc-Fe(100) ($\phi^e = 4.59$–4.67 eV) undergoes transition to α-bcc-Fe(110) ($\phi^e = ?$ eV) [3913]. This discovery is quite interesting from the viewpoint of solid state physics because the transition of $\gamma \to \alpha$ is undergone by crossing over θ_c alone at a constant temperature ($\sim$300 K), having nothing to do with the transition temperature ($T_A = 1179$ K for γ-phase usually found for bulk Fe). In addition, the transition of γ-like fcc-Fe(100)/Cu(100) to α-bcc-Fe(110)/Cu(100) is also very interesting from the stand point of allotropic orientation relationship, as partly mentioned above. For the metastable films of such as Fe, Co and Ni grown epitaxially on Cu(100), Cu(111) and so on, their peculiarity will be summarized briefly in Section 8.2 together with the data on work function and Curie point having dependence upon film thickness.

(3) At $T_A = 670$ K, α-hcp-Co(0001) with 5.264 eV by CPD [3192] transforms to β-fcc-Co(111) [3192,3914,3916,3917] with 5.266 eV [3192] (see Table 11), but repetition of the transformation changes it into polycrystalline Co ($\phi^e = ?$) [3915].

(4) When a β-fcc-cobalt strip with $\phi^e = 4.25 \pm 0.08$ eV at 1120 K is cooled slowly to room temperature, its phase and ϕ^e are changed to α-hcp-Co and 4.12 ± 0.04 eV, respectively [1631,1632]. By sudden cooling, on the contrary, the former is retained without change in both phase and ϕ^e. This finding is also very interesting as well as the above discoveries [3913,3915] together with both of the θ_c-dependence of Fe [3913] and the polycrystallization of Co owing to repeated transformations [3915]. In addition, it may be worth while to settle the question why the above value of $\phi^e_\alpha = 4.12$ eV for α-Co(poly) [1632] is much smaller than any of the recommended values of 5.0 eV [1045,1358], 4.71 eV [Here] and 4.41 eV [1354], quite similarly to $\phi^e_\beta = 4.25$ eV [1632] being less than 4.50 eV [Here] (see Table 2).

(5) In contrast to Co-crystals existing generally in an α-hcp-phase below T_A ($\approx$ 650–720 K, already mentioned above), Co-fine particles (crystallites, $\sim$10–500 Å) supported on a foreign substrate (e.g., SiO_2, Al_2O_3 or C) have the phase of not hcp- but fcc-structure corresponding to β-phase even below T_A [4338]. Such a phenomenon is observed also for Co/W(mono) systems [364] (see Footnote 474 in Table 1).

(6) Regarding the thickness dependence of both surface structure and work function, it is reported for an Ag/H:Si(111) system at room temperature that $\theta < 5$ and > 20 ML afford $\sim$4.2 and 4.65 ± 0.15 eV, corresponding to Ag(poly) and Ag(111), respectively [1198].

7.2. Work function change due to liquefying

Among many solid elements, these of alkali metals, P, S, Ga, Se, Sn, I, In, Tl, Pb and Bi are well known to have relatively low melting points ($T_m \approx$ 300–600 K). However, it is eight elements alone except Hg (234 K) that the work function data at the liquid state are surveyed by the present author.

The work functions evaluated from Fowler plots are 3.84 ± 0.05 eV for Tl, 3.95 ± 0.05 eV for Pb and 4.25 ± 0.05 eV for Bi [3437]. No significant difference is detected for the three between the solid phase ($\sim$300 K) and liquid one ($T_m + 100$ K) [3437].

The values of ϕ^e for Na, K, Rb and Cs measured by PE are 2.38, 2.28, 2.16 and 1.95 eV, respectively [4208]. Each is the same between the states of solid (298 K) and liquid ($\sim T_m$) within the limit of experimental error [4208], which may be estimated to be ± 0.03 eV from another article [2470].

With respect to Hg, ϕ^e is determined by PE to be 4.510 ± 0.016 and 4.486 ± 0.041 eV at ~ 300 and $83{-}234$ K, respectively [2920], thus yielding $\Delta\phi^e_{LS} \equiv \phi^e_L - \phi^e_{So} = 0.024 \pm 0.044$ eV. Here, ϕ^e_{So} and ϕ^e_L are the work function values at the solid and liquid states, respectively. A thick layer of Hg on FeO at 90 K is found by PE to have $\phi^e = 4.52 \pm 0.02$ eV, which does not change even when the mercury is allowed to melt [2921].

Some experimental data on the work function change ($\Delta\phi^e_{LS}$) due to the phase transition from solid to liquid are summarized for the thirteen elements in Table 12. All of the solid species except γ-Sn show that each mean of $\Delta\phi^e_{LS}$ stays in the range of -0.05 to 0.03 eV, although the work function data available for each element are very scanty. On the other hand, the six data on γ-Sn [1135,1945–1947,3575,4139,4241, Here] are observed to range from -0.04 to -0.17 eV, resulting in the mean value of -0.10 ± 0.05 eV in contrast to any mean mentioned above. A considerable gap between γ-Sn and the other metals should be examined by further study of both theory and experiment.

Table 12
Work function change due to liquefying.

No.	Solid	Liquid	T_m (K)	ϕ^e_{So} (eV)	$\Delta\phi^e_{LS}$ (eV)[a]	ϕ^e_L (eV)	Meth.	Refs.
11	Na	Na	371	2.38	0.00	2.38	PE	[4208]
11	Na	Na	371	2.39	0.00	2.39	PE	[4241]
11	Na	Na	371	2.949	−0.025	2.924	TC	[2419]
11	Na	Na	371	2.54 ± 0.03	0.03 ± 0.26	2.57 ± 0.26	various	[Here][b]
Mean	–	–	–	–	**0.00 ± 0.01**	–	–	–
13	Al	Al	933	4.259	−0.018	4.241	TC	[2419]
19	K	K	337	2.27	0.00	2.27	PE	[4241]
19	K	K	337	2.28	0.00	2.28	PE	[4208]
19	K	K	337	2.29 ± 0.015	0.01 ± 0.02	2.30 ± 0.015	PE	[2476]
19	K	K	337	2.29 ± 0.03	0.01 ± 0.04	2.30 ± 0.03	PE	[2470]
19	K	K	337	2.29 ± 0.02	−0.01 ± 0.03	2.28 ± 0.02	various	[Here][b]
Mean	–	–	–	–	**0.00 ± 0.02**	–	–	–
31	Ga	Ga	303	4.31	0.06	4.37	PE	[4139]
31	Ga	Ga	303	4.35 ± 0.03	−0.05 ± 0.03	4.30 ± 0.01	PE	[2770]
31	Ga	Ga	303	4.36 ± 0.03	−0.06 ± 0.04	4.30 ± 0.02	PE	[2026]
31	Ga	Ga	303	4.27 ± 0.06	0.06 ± 0.07	4.33 ± 0.03	various	[Here][b]
Mean	–	–	–	–	**0.00 ± 0.06**	–	–	–
37	Rb	Rb	312	1.85	−0.05	1.80	TC	[4249]
37	Rb	Rb	312	1.99	−0.06	1.93	PE	[4139]
37	Rb	Rb	312	2.15	0.00	2.15	PE	[4241]
37	Rb	Rb	312	2.16	0.00	2.16	PE	[4208]
37	Rb	Rb	312	2.16	0.00	2.16	PE	[4297]
37	Rb	Rb	312	2.16 ± 0.03	0.01 ± 0.04	2.17 ± 0.03	PE	[2470]
37	Rb	Rb	312	2.17 ± 0.02	−0.04 ± 0.03	2.13 ± 0.02	PE	[4141]
37	Rb	Rb	312	2.17 ± 0.05	−0.02 ± 0.05	2.15 ± 0.02	various	[Here][b]
Mean	–	–	–	–	**−0.02 ± 0.03**	–	–	–
47	Ag	Ag	1234	4.32	0.00	4.32[d]	TE	[1466]
49	In	In	430	3.96	−0.03	3.93	PE	[4139]
49	In	In	430	4.00	−0.07	3.93	PE	[4241]
49	In	In	430	4.07	−0.04	4.03	PE	[4328]
49	In	In	430	4.09 ± 0.01	−0.03 ± 0.01	4.06 ± 0.01	PE	[2770]
49	In	In	430	4.05 ± 0.06	−0.05 ± 0.10	4.00 ± 0.08	various	[Here][b]
Mean	–	–	–	–	**−0.04 ± 0.02**	–	–	–
50	γ-Sn	Sn	505	4.22	−0.04	4.18	PE	[4139]
50	γ-Sn	Sn	505	4.23	−0.04	4.19	PE	[4241]
50	γ-Sn	Sn	505	4.28	−0.11	4.17	PE	[1135]
50	γ-Sn	Sn	505	4.38 ± 0.02	−0.16 ± 0.03	4.22 ± 0.02	PE	[1945–1947]
50	γ-Sn	Sn	505	?	−0.17	?	CPD	[3575]
50	γ-Sn	Sn	505	4.29 ± 0.06	−0.09 ± 0.06	4.20 ± 0.02	various	[Here][b]
Mean[c]	–	–	–	–	**−0.10 ± 0.05**	–	–	–
55	Cs	Cs	301	1.92	−0.01	1.91	PE	[4297]
55	Cs	Cs	301	1.94	0.00	1.94	PE	[4241]
55	Cs	Cs	301	1.95	0.00	1.95	PE	[4208]

Table 12 (*continued*)

No.	Solid	Liquid	T_m (K)	ϕ^e_{So} (eV)	$\Delta\phi^e_{LS}$ (eV)[a]	ϕ^e_L (eV)	Meth.	Refs.
55	Cs	Cs	301	2.241	−0.029	2.212	TC	[2419]
55	Cs	Cs	301	2.05 ± 0.05	−0.05 ± 0.13	2.00 ± 0.12	various	[Here][b]
Mean	–	–	–	–	**−0.02 ± 0.03**	–	–	–
80	α-Hg	Hg	234	4.47 ± 0.03	0.00 ± 0.03	4.475 ± 0.01	PE	[2770]
80	α-Hg	Hg	234	4.486 ± 0.041	0.024 ± 0.044	4.510 ± 0.016	PE	[2920]
80	α-Hg	Hg	234	4.49 ± 0.01	0.00 ± 0.01	4.49 ± 0.01	PE	[1669]
80	α-Hg	Hg	234	4.49 ± 0.01	0.00 ± 0.07	4.49 ± 0.05	PE	[2470]
80	α-Hg	Hg	234	4.52 ± 0.05	−0.02 ± 0.05	4.50 ± 0.02	various	[Here][b]
Mean	–	–	–	–	**0.00 ± 0.01**	–	–	–
81	α-Tl	Tl	577	3.72	−0.08	3.64	PE	[4139]
81	α-Tl	Tl	577	3.84 ± 0.05	0.00 ± 0.07	3.84 ± 0.05	PE	[3437]
81	α-Tl	Tl	577	3.82 ± 0.05	−0.08 ± 0.11	3.74 ± 0.10	various	[Here][b]
Mean	–	–	–	–	**−0.05 ± 0.04**	–	–	–
82	Pb	Pb	601	3.95 ± 0.05	0.00 ± 0.07	3.95 ± 0.05	PE	[3437]
82	Pb	Pb	601	4.11	−0.07	4.04	PE	[4139]
82	Pb	Pb	601	4.07 ± 0.05	−0.07 ± 0.07	4.00 ± 0.05	various	[Here][b]
Mean	–	–	–	–	**−0.05 ± 0.03**	–	–	–
83	Bi	Bi	544	4.25 ± 0.05	0.00 ± 0.07	4.25 ± 0.05	PE	[3437]
83	Bi	Bi	544	4.39	0.03	4.42	PE	[4139]
83	Bi	Bi	544	4.86	0.02	4.88	CPD	[1755]
83	Bi	Bi	544	4.28 ± 0.05	0.06 ± 0.09	4.34 ± 0.07	various	[Here][b]
Mean	–	–	–	–	**0.03 ± 0.02**	–	–	–
Overall mean	–	–	–	–	**−0.02 ± 0.03**	–	–	–

[a] The work function change due to liquefying is shown as $\Delta\phi^e_{LS} \equiv \phi^e_L - \phi^e_{So}$, where ϕ^e_L and ϕ^e_{So} are the work functions at liquid and solid states, respectively.

[b] The work function data [Here] are cited from Table 2.

[c] All of the six data on $\Delta\phi^e_{LS}$ for γ-Sn are found to have the mean value of −0.10 ± 0.05 eV. This is slightly different from any one (−0.05 up to 0.03 eV) for the other twelve species listed herein. As a whole for the thirteen species, we have the overall mean of $\Delta\phi^e_{LS} = -0.02 \pm 0.03$ eV. If the data for γ-Sn are disregarded, we have −0.01 ± 0.02 eV. At any rate, the work function *decrease* due to the phase change from solid to liquid may be generally concluded to be in the order of ∼10 meV or less. Much further work by both experiment and theory may be necessary to settle definitely the problem whether $\Delta\phi^e_{LS} \approx$ 0.00 eV in general.

[d] This is the value corrected from 3.86 eV measured for molten Ag by TE [1466] by the present author (see Footnote 456 in Table 1).

At any rate, the overall means of $\Delta\phi^e_{LS}$ are estimated to be −0.02 ± 0.03 and −0.01 ± 0.02 with and without including the data on γ-Sn, respectively, thus suggesting that $\Delta\phi^e_{LS}$ may generally be in the order of ±10 meV or less. In order to determine a more precise value of $\Delta\phi^e_{LS}$ for each element, however, work function measurements of both ϕ^e_S and ϕ^e_L should be done at the level of 10 meV or less in such a narrow temperature range ($\Delta T \approx 10$ K) of about −5 and +5 K sandwiching T_m so as to minimize the thermal effect due to α·ΔT.

Alchagirov et al. have developed a two-frequency photoelectric method for continuously measuring the fast changes in ϕ^e owing to adsorption, phase transition, modification of surface structure and so on, thereby showing such a typical result for In that $\Delta\phi^e_{LS}$ can be measured more precisely compared with the Fowler method [4328].

8. Work function change due to magnetic transformation

This section summarizes the work function change due to magnetic transformation at the Curie temperature (T_C) from ferro- to paramagnetic state of both bulk metals and metastable metal films together with the dependence of T_C upon film thickness.

8.1. Work function change of bulk metal at the Curie point

These metals of Fe, Co, Ni and Gd are well known to change from ferro- to paramagnetic state at the Curie points (T_C) of typically 1042, 1390, 631 and 290 K [3980, etc.], respectively. Speaking in general, however, the experimental data on T_C as well as T_A (see Section 7.1) fluctuate widely from literature to literature. For instance, the values reported for Co by the five groups of workers have a range of $T_C = 1367–1404$ K [4336]. In this section, let's treat the problem how the work function changes at T_C.

Typically, the α-bcc-Fe below $T_C = 1042$ K is ferromagnetic, but the β-bcc-Fe at 1042–1179 is paramagnetic. The γ-fcc-Fe (1179–1674 K) and δ-bcc-Fe (1674–1811 K) are paramagnetic, too [1916,2056,3980]. Work function change of $\Delta\phi^e_{PF} \equiv \phi^e_P - \phi^e_F$ due to the magnetic transition from ferro- to paramagnetic state is equivalent to that of $\Delta\phi^e_{\beta\alpha} \equiv \phi^e_\beta - \phi^e_\alpha$ since T_C is equal to T_A for the α → β transition of Fe. As already shown in Section 7.1 and Table 11, the values of $\phi^e_\alpha = 4.70$ eV (300 K) and 4.65 eV (870 K) [305] are corrected to be 4.63 eV (1125 K) by extrapolation according to $\alpha = -9 \times 10^{-5}$ eV/K and, hence, $\Delta\phi^e_{\beta\alpha}$ is concluded

to be $\phi_\beta^e - \phi_\alpha^e = 4.62 - 4.63 = -0.01$ eV instead of $4.62 - 4.70 = -0.08$ and of $4.62 - 4.65 = -0.03$ eV [305] (see Footnote (l) in Table 11).

In Table 13, all of the data available at present are summarized for Co, Ni and Gd in addition to Fe. Theoretical investigation concludes that $\Delta\phi_{PF}^e = -0.135$ eV in general [3673]. As shown in Table 13, the values of $\Delta\phi_{PF}^e$ for Ni have a range from -0.050 to 0.045 eV, thus yielding Mean = 0.01 ± 0.03 eV (see the last line for Ni). This value is very close to Mean = 0.00 ± 0.01 eV for Gd.

Table 13
Work function change due to magnetic transformation[a].

No.	Ferromag.	Paramag.	T_C (K)	ϕ_F^e (eV)[c]	$\Delta\phi_{PF}^e$ (eV)[b]	ϕ_P^e (eV)[c]	Meth.	Refs.
26	α-bcc-Fe	β-bcc-Fe	1042	4.63 (1125)[1]	-0.01	4.62 (1125)	PE	[305]
26	α-bcc-Fe	β-bcc-Fe	1042	4.65 (870)	-0.03	4.62 (1125)	PE	[305]
26	α-bcc-Fe	β-bcc-Fe	1042	4.53	-0.08	4.45	TC	[3318]
26	α-bcc-Fe	β-bcc-Fe	1042	4.55 ± 0.05 (~300)	-0.03 ± 0.18	4.52 ± 0.17 (~1100)	various	[Here][d]
Mean	–	–	–	–	$\mathbf{-0.04 \pm 0.03}$	–	–	–
27	β-fcc-Co	β-fcc-Co	1390	4.65 ± 0.22 (~1050)	-0.05 ± 0.30	4.60 ± 0.19 (~1500)	various	[Here][e]
28	fcc-Ni	fcc-Ni	631	4.645 (300)	0.045[k]	4.690 (660)	CPD[i]	[503]
28	fcc-Ni	fcc-Ni	631	4.660 (400)	0.040[k]	4.700 (740)	CPD[i]	[503]
28	fcc-Ni	fcc-Ni	631	4.660 (400)	-0.007[f]	4.653 (400)	CPD[i]	[503]
28	fcc-Ni	fcc-Ni	631	5.05 (623)	0.05	5.10 (770)	PE	[943]
28	fcc-Ni	fcc-Ni	631	? (?)	-0.050[g]	? (?)	TC	[3954]
28	fcc-Ni	fcc-Ni	631	? (?)	0.009[g]	? (?)	TC	[2358]
28	fcc-Ni(100)	fcc-Ni(100)	631	? (~600—631)	0.00	? (631–700)	CPD[i]	[3924]
28	fcc-Ni(100)	fcc-Ni(100)	631	? (413)	-0.004	? (631)	CPD[i]	[496]
Mean	–	–	–	–	$\mathbf{0.01 \pm 0.03}$[h]	–	–	–
64	hcp-Gd(0001)	hcp-Gd(0001)	290	? (220)	-0.016	? (220)[j]	CPD[i]	[3924]
64	hcp-Gd	hcp-Gd	290	3.76	0.01	3.77	TC	[2358]
Mean	–	–	–	–	$\mathbf{0.00 \pm 0.01}$	–	–	–
Overall mean[m]	–	–	–	–	$\mathbf{-0.01 \pm 0.04}$	–	–	–

[a]Theoretical study on the work function change due to para- to ferromagnetic transition yields 0.135 eV = $-\Delta\phi_{PF}^e$ in general [3673].

[b]The work function change due to ferromagnetic to paramagnetic transformation beyond the Curie point (T_C) is shown as $\Delta\phi_{PF}^e \equiv \phi_P^e - \phi_F^e$.

[c]In parentheses in the 5th or 7th column is given the temperature (in K) adopted for determining each work function value (ϕ_F^e or ϕ_P^e) corresponding to the ferro- or paramagnetic state (see Footnote 1 below).

[d]The work function data [Here][d] are cited from Table 2.

[e]The values of ϕ_F^e and ϕ_P^e for β-Co [Here][e] are estimated from these data obtained in the ranges of 720–1390 K [310,3153,3604] and of 1390–1600 K [769,2304,3604], respectively (see Table 1).

[f]The change ($\Delta\phi_{PF}^e \equiv \phi_P^e - \phi_F^e = -0.007$[f] eV) for Ni is determined at the same temperature (400 K) for both ϕ_P^e and ϕ_F^e after extrapolating the former in the range from 750–600 K to 400 K [503] (see also Footnote 132 in Table 1). This is the *net* change due to the magnetic transition alone. On the contrary, the others ($\Delta\phi_{PF}^e = 0.045$[k] and 0.040[k] eV) are tentatively estimated by the present author taking the data on ϕ_F^e and ϕ_P^e determined at respectively different temperatures (by ~350 K gapped) indicated in the parentheses beside each ϕ_F^e and ϕ_P^e. In other words, the work function change ($\Delta\phi_T^e \approx -0.05$ eV) due to the temperature decrease by ~350 K in the range covering T_C is disregarded in the latter estimation. Such a fine measurement as excluding the effect due to $\Delta\phi_T^e$ is needed for any samples, too, in order to determine precisely the *net* value of $\Delta\phi_{PF}^e$ itself in the order of 1 meV.

[g]Both of the values for Ni are cited from Ref. [503].

[h]This mean for Ni is obtained without including the data[k] (see Footnote k below).

[i]The piezoelectric driven Kelvin probe improved by Saito et al. has an accuracy of ±1 meV in work function measurements at ~100–1000 K [4065].

[j]The linear relation between T and ϕ^e at the paramagnetic state above T_C (~460–300 K) for Gd is extrapolated down to 220 K, where ϕ^e is found to be lower by 14 meV than ϕ^e at T_C, while ϕ^e at the ferromagnetic state at 220 K is higher by 2 meV than ϕ^e at T_C. Therefore, $\Delta\phi_{PF}^e \equiv \phi_P^e - \phi_F^e$ is estimated to be -16 meV at 220 K [3924].

[k]Both of the values of $\Delta\phi_{PF}^e = 0.045$ and 0.040 eV for Ni are estimated from ϕ_P^e and ϕ_F^e measured at different temperatures and, hence, any of them is not the *net* value originating from the transition alone. Consideration of the temperature coefficient (α) of ϕ^e (see Table 6 in Ref. [1351]) yields $\Delta\phi_{PF}^e = -0.007$ eV (see Footnote f above).

[1] The value of $\phi_F^e = 4.63$ eV (1125 K) for Fe is corrected from 4.70 eV (300 K) by consideration of the thermal change due to the temperature coefficient of $\alpha = -9 \times 10^{-5}$ eV/K (for detail, see Section 7.1 and Footnote 1 in Table 11).

[m]The overall mean including all of the data on the above four metals affords $\Delta\phi_{PF}^e = -0.01 \pm 0.04$ eV. Consideration of the above fine measurement for Ni [503], however, may lead to the conclusion that the work function change due to the magnetic transition is generally in the order of ~10 meV or less.

Regarding the most probable value of $\Delta\phi_{PF}^e$ for Co, it is very difficult to estimate such a minute change probably as in order of 10 meV or less because both ϕ_F^e and ϕ_P^e [Here] originating from various specimens and methods are very large in standard deviation (±0.22 and ±0.19 eV, respectively) and also in temperature difference (~450 K). For the same specimen at nearly the same temperatures sandwiching T_C, therefore, both ϕ_F^e and ϕ_P^e should be measured not intermittently and indirectly by TE (Richardson plot) but continuously and directly by another method.

The work function of Ni(100) is found to change considerably with the temperature coefficient of $\alpha = -1.83 \times 10^{-4}$ eV/K in the range from ~760 to 631 K (T_C) at paramagnetic state [496]. But, an upper deviation from the linearity starts at T_C, gradually

increasing $\Delta\phi_{PF}^{e}$ from 0 up to 4 meV in the range of 631 K down to 140 K at ferromagnetic state [496]. Namely, $\Delta\phi_{PF}^{e}$ for Ni(100) is −0.004 eV [496]. According to a previous study by the same group of workers [503], $\Delta\phi_{PF}^{e}$ for Ni(poly) is evaluated to be $\Delta\phi_{PF}^{e} \equiv \phi_{P}^{e} - \phi_{F}^{e} = 4.653 - 4.660 = -0.007$ eV at the same temperature (400 K) after extrapolation of ϕ_{P}^{e} from ~700 to 400 K. This is the *net* change due to the transition alone without including the thermal effect ($\alpha \cdot \Delta T$) upon the work function. On the other hand, $\Delta\phi_{PF}^{e} = 0.045$ eV is estimated from both $\phi_{P}^{e} = 4.690$ eV at 660 K (above $T_{C} = 631$ K) and $\phi_{F}^{e} = 4.645$ eV at 300 K, thus yielding a difference by 0.045 eV in comparison with the above (−0.007 eV). This difference estimated tentatively by the present author is caused by disregarding the temperature dependence of ϕ^{e} inherent in any metal (see Table 6 in Ref. [1351]). Namely, the comparison of ϕ_{P}^{e} and ϕ_{F}^{e} at different temperatures does never yield accurately the *net* value of $\Delta\phi_{PF}^{e}$ itself.

According to the fine measurement (at ~1 meV level) made about 10 years later for Ni(100) by the same group using a CPD method again, however, noticeable change (>1 meV at level) is not observed at T_{C} [3924].

In respect of Gd(0001) [3924], ϕ^{e} at the paramagnetic state decreases almost linearly by ~20 meV with decreasing temperature from ~400 K down to T_{C} (~290 K). Below T_{C} at the ferromagnetic state, however, ϕ^{e} shows a minimum (shallow valley) at ~280 K and does a maximum (small hump) at ~250–230 K. Then, ϕ^{e} at ~230–220 K remains nearly at a constant, which is higher by 2 meV than ϕ^{e} at T_{C} [3924]. Regarding the paramagnetic state, on the other hand, ϕ^{e} at 220 K is found to have a value lower by 14 meV than that at T_{C} after extrapolating the above linearity from T_{C} down to 220 K according to the temperature dependence of D_{b} (dipole barrier) [3924]. Consequently, the above transformation affords the work function change of $\Delta\phi_{PF}^{e} \equiv \phi_{P}^{e} - \phi_{F}^{e} = -16$ meV at 220 K (about 70 K below T_{C}).

The overall mean of the four bulk metals is estimated to be −0.01 ± 0.04 eV, as shown in Table 13. On the other hand, the results based on the *fine* measurements for the bulks of Ni(poly) [503], Ni(100) [496] and Gd(0001) [3924] studied by the same group of Saito et al. indicate that $\Delta\phi_{PF}^{e}$ is as small as −0.009 ± 0.005 eV. Therefore, such a minute value may be disregarded in a usual treatment of ϕ^{e} accompanied with an error of ±0.05 eV or more in general (see Table 2). In other words, it is very difficult to determine $\Delta\phi_{PF}^{e}$ precisely at the level of 1 meV by means of usual methods employed by many workers.

At present, $\Delta\phi_{PF}^{e}$ may be roughly estimated to be at the level of −0.01 eV or so in general, although the data themselves are very scanty and also they are scattered in a rather wide range from −0.08 to +0.05 eV even among the four metal species (see Table 13).

8.2. Both work function and Curie point of metastable metal films

In addition to the four allotropes of bulk Fe mentioned in Section 7.1, the metastable film of Fe grown epitaxially on Cu(100) has the peculiarity different from bulk Fe. Namely,

(1) α-bcc-Fe ($T_{A} = 1042$ K, ferromag., $T_{C} = 1042$ K, $\phi^{e} = 4.55 \pm 0.05$ eV).
(2) β-bcc-Fe (1042–1179 K, paramag., $\phi^{e} = 4.52 \pm 0.17$ eV).
(3) γ-fcc-Fe (1179–1674 K, paramag., $\phi^{e} = 4.54 \pm 0.05$ eV).
(4) δ-bcc-Fe (1674–1808 K, paramag., $\phi^{e} = 4.76 \pm 0.1$ eV).
(5) m-fcc-Fe (<1042 K, ferromag., $T_{C} = variable$, $\phi^{e} = 4.58 \pm 0.10$ eV).
(6) m-fcc-Fe(100) (<1042 K, ferromag., $T_{C} = variable$, $\phi^{e} = 5.38 \pm 0.22$ eV).

Here, "m" means the "metastable" and, T_{A} and T_{C} are cited from Ref. [3980], while each value of ϕ^{e} is done from the 3rd column in Table 2.

Typically for the metastable γ-like fcc-Fe(100)/Cu(100) system (6) above, already mentioned in Topics (1) and (2) in Section 7.1, ϕ^{e} is theoretically evaluated to be 4.95 or 5.00 eV [1914], 5.48 or 5.58 eV [1913,4386] and 5.6 eV [1916], some of which are well accordant to some of the experimental data on 4.62 or 4.67 eV [2673], 4.95 eV [2650], and 5.4 or 5.5 eV [1916] determined by PE at ~300 K, although the wide divergence by up to ~0.65 or 0.9 eV makes it very difficult to compare decisively the data among different authors. The value of $\phi_{F}^{e} = 4.62$ eV found for the ferromagnetic m-Fe(100) film grown at room temperature [2673] is slightly different from $\phi_{P}^{e} = 4.67$ eV for the paramagnetic one established after annealing above 500 K [2673], thereby resulting in $\Delta\phi_{PF}^{e} = 0.05$ eV. This value is somewhat different from −0.04 ± 0.03 eV for bulk Fe (see Table 13). The most provable value of 5.38 ± 0.22 eV (Table 2) for m-fcc-ferromagnetic film-Fe(100) (~300 K) seems to be near to 5.28 ± 0.19 eV for γ-fcc-paramagnetic bulk of Fe (100) (1179–1674 K), although the gap of 0.1 eV between the two is accompanied with a large standard deviation of ±0.29 eV. On the contrary, the former is certainly different from 4.64 ± 0.05 eV recommended for α-bcc-ferromagnetic bulk-Fe(100) (Table 2).

On the other hand, m-fcc-ferromagnetic film-Fe on Cu(100) listed above (5) is found to have 4.58 ± 0.10 eV (Table 2), which is very near to 4.55 ± 0.05 eV for α-bcc-ferromagnetic bulk-Fe (Table 2). In contrast to the latter with T_{C} kept constant at 1042 K, the former changes in T_{C} from 230 to 390 K as θ increases from 1 to 3–5 ML having $\phi_{F}^{e} = 4.7 \pm 0.1$ eV [2878]. In another case, the m-fcc-Fe-film is reported to have $T_{C} = 150$ and 300 K at $\theta = 5$ and 7 ML, respectively [4345]. Similarly, such an fcc-film is observed to have $T_{C} \approx 380$ and 290 K at $\theta \approx 3$ and 6–10 ML, respectively, above which the film structure is changed to bcc [3912]. In contrast, the film formed at 463 K is found to have the ferromagnetism, which disappears after keeping for 1 h or cooling to ~300 K [4386]. The film grown at ~300 K is not ferromagnetic [4386]. Regarding the m-fcc-Fe film ($\theta_{Fe} = 3$ or 7 ML) prepared on Cu-capped films ($\theta_{Cu} = 0$–5 ML) [4361], T_{C} is found to depend on θ_{Fe} and also to have an oscillatory dependence upon θ_{Cu}, showing nearly the same pattern between theory and experiment. As θ_{Cu} increases from 0 to 5 ML at $\theta_{Fe} = 3$ ML, for example, T_{C} oscillates between ~370 and 265 K (experiment) and ~530 to 480 K (theory), all of which are much below 1042 K characteristic of α-bcc-bulk Fe. For such an interesting and complicated magnetic behavior, much further work is fully expected to be done by both theory and experiment together with precise measurements of ϕ^{e} around each T_{C} changing dependently upon θ.

The metastable film of Co grown epitaxially on Cu(100) has the property different from the two allotropes of bulk cobalt. Namely,

(1) α-hcp-Co (T_A = 695 K, ϕ^e(0001) = 5.30 eV, ϕ^e = 4.71 eV).
(2) β-fcc-Co (695–1675 K, ϕ^e(100) = 5.25 eV, ϕ^e = 4.50 eV, T_C = 1390 K).
(3) m-fcc-Co (<695 K, ϕ^e(100) = 4.72 eV, $\phi^e \approx$ 4.8 eV, T_C = *variable*).

The metastable fcc-phase of ferromagnetic Co(100) film grown epitaxially on Cu(100) is found by PE to have ϕ^e = 4.72 eV [2673], which is intermediate between our values of 5.25 ± 0.17 eV for β-fcc-Co(100) and 4.50 ± 0.13 eV for β-fcc-Co (Table 2). Similarly, the metastable Co-films (1–9 ML) grown on Cu(100) at ~300–400 K exhibits the β-like fcc-structure, and they are determined by PE to have ϕ^e = 5.0 ± 0.2 eV [2879] (see Footnote 121 in Table 1) and evaluated by TC to have 5.34 eV [3654] (see id. 122).

As shown for m-fcc-Co on Cu(100) or Cu(111) in Table 1, the average of ϕ^e = 4.94 ± 0.30 eV is calculated from the twelve data achieved for the Co-films by PE or TC, while that of ϕ^e = 4.74 ± 0.23 eV done from six ones by PE alone. The average of 4.74 eV is quite near to 4.72 eV for m-Co(100) [2673] mentioned above, thereby suggesting that the Co-films [950,968,2879,3475] listed in Table 1 consist mainly of the (100) face, although the former is accompanied with a very large standard deviation (±0.23 eV) and the latter is due to a single datum alone [2673]. It may be strongly expected to accumulate much abundant data for the both films by theory and experiment.

Regarding the metastable fcc-Co-film on Cu(100), its Curie point (T_C) is reported to have a linear dependence upon Co-coverage (θ). Namely, T_C increases from ~100 to 500 K as θ increases from 1.5 to 2.5 ML, showing a bulk-like behavior (T_C = 1390 K) at $\theta \approx$ 5–6 ML [3923]. This result suggests strongly that the thick film (θ > 5 ML) is equivalent to bulk cobalt with respect to the magnetic property. Such a dependence is observed also for a Co/Cu(111) system, where T_C increases from 207 to 500 K with increasing θ from 1.0 to 1.7 ML [4355]. Interestingly, T_C is found to have the dependence upon the deposition temperature (T_{dep}), too [4394]. Typically for 2 ML, T_C increases from 170 to 325 K when T_{dep} is changed from 340 to 275 K [4394].

Similarly for Ni/Cu(100) and Ni/Cu(111) with increasing in θ from ~3 to 16 and ~2 to 17 ML, T_C increases from 210 to 540 K and 197 to 603 K, respectively [4355], both of which are lower than $T_C \approx$ 630 K accepted generally for bulk nickel.

Experimental and theoretical studies [e.g., 3743,4345–4355,4387–4394] are made on the magnetism of metastable metal films (Fe, Co, Ni, Gd, etc.) grown epitaxially on monocrystalline metal substrates (Cu, Ag, W, Au, etc.). For these systems, additional studies are strongly expected to measure finely the work function values around T_C as a function of θ.

9. Work function change due to superconductive transition

All the data available at present for the work function change due to superconductive transition are summarized in Table 14, where T_S and T_M are the temperatures correspondent to the superconductive transition and the work function measurement, respectively, while ϕ^e_C and ϕ^e_{FE} are the work functions determined for each metal film/quartz system by CPD and for each bulk metal by FE, respectively. The 7th column shows Footnote numbers of 102, etc. (see Table 1), which may be helpful for obtaining further information about each experiment.

Table 14
Work function change due to superconductive transition.

Surface	T_S (K)[a]	T_M (K)[b]	ϕ^e_C (eV)[c]	ϕ^e_{FE} (eV)[d]	$\Delta\phi^e_{SN}$ (eV)[e]	Note[f]	Ref.
Al	1.2	293	4.2 ± 0.2	–	–	102	[1686]
		135	4.2 ± 0.2	–			
		77	–	4.20			
		5	–	4.20			
		4.2	4.1 ± 0.2	–			
V	5.4	293	3.0 ± 0.2	–	0.2 ± 0.3	101	[1686]
		15	2.9 ± 0.2	–			
		4.2–15	–	3.77			
		4.2	3.1 ± 0.2	–			
Nb	9.2	293	3.9 ± 0.2	–	0.1 ± 0.3	164	[1686]
		28	3.8 ± 0.2	–			
		5	–	5.01			
		4.2	3.9 ± 0.2	–			
Ta	4.4	293	3.8 ± 0.2	–	0.3 ± 0.3	260	[1686]
		35	3.5 ± 0.2	–			
		4.2–35	–	4.16			
		4.2	3.8 ± 0.2	–			
BSCCO	85	85	4.849	–	0.004	#	[912]
		50	4.851	–			
		50 (extrap.)	4.847[g]				

[a]T_S is the superconductive transition temperature.

[b]T_M is the temperature selected for measuring each work function.

[c]ϕ_C^e is the work function determined by CPD for each metal film prepared on quartz (Al–Ta).

[d]ϕ_{FE}^e is the work function measured by FE for each bulk metal (Al–Ta).

[e]$\Delta\phi_{SN}^e \equiv \phi_S^e - \phi_N^e$ is the work function change due to the transition from the normal to superconductive state, where the change for each metal (V–Ta) is estimated by the present author. Frankly speaking, it is impossible to determine $\Delta\phi_{SN}^e$ precisely at the level of ~ 0.01 eV or less because a fine measurement of ϕ^e for any of V–Ta is not made continuously around T_C, in contrast to the below case [912] (see Footnote g below).

[f]Each of the four numbers shows the Footnote number in Table 1, whilst the mark (#) corresponds to a monocrystalline compound of $Bi_2Sr_2CaCu_2O_8$.

[g]Fig. 3 [912] shows that ϕ^e has the temperature coefficient of $d\phi^e/dT = 5.5\times$ and -5.1×10^{-5} eV/K above and below $T_C = 85$ K, respectively. Extrapolation of the former from 85 K (4.849 eV) to 50 K yields 4.847 eV, which affords $\Delta\phi_{SN}^e = 0.004$ eV because the latter is directly determined to have 4.851 eV at 50 K. Even at 0 K more below T_C, the change is still small as 0.009 eV [912].

As may be seen in Column 4 in Table 14, each of the data (ϕ_C^e) by CPD for the V–Ta films [1686] is accompanied with a large standard deviation of ± 0.2 eV. Therefore, it is very difficult to estimate finely the work function change ($\Delta\phi_{SN}^e \equiv \phi_S^e - \phi_N^e$) due to the transition between the two states, although Column 6 includes the values of $\Delta\phi_{SN}^e = 0.2 \pm 0.3$, 0.1 ± 0.3 and 0.3 ± 0.3 eV estimated tentatively by the present author for the three metals of V, Nb and Ta, respectively. Here, ϕ_S^e and ϕ_N^e correspond to the superconductive and normal states, respectively. On the other hand, the data on ϕ_{FE}^e measured for each bulk by FE (see Column 5) seem to be considerably different from those on ϕ_C^e by CPD for each film (except Al), thereby suggesting that the absolute values of both ϕ_S^e and ϕ_N^e around T_S are also different between the film and bulk for each species. According to the description in text [1686], the transition has no effect on the pattern of Fowler–Nordheim graphs. In other words, it may be considered that an appreciable change in ϕ^e is not detected around T_S, thereby leading to the tentative estimation as follows. Namely, $\Delta\phi_{SN}^e$ is as small as ± 0.01 eV or less by consideration of the data that $\phi_F^e = 3.77 \pm ?$ eV $=$ constant in the range of 4.2–15 K sandwiching $T_S = 5.4$ K for V and also that $\phi_F^e = 4.16 \pm ?$ eV $=$ constant at 4.2–35 K covering $T_S = 4.4$ K for Ta. At any rate, such a fine measurement as the level of ~ 10 meV or less may be necessary in general in order to measure a very minute change around T_S. From this point of view, let's examine the below data obtained for a chemical compound since no datum achieved by fine measurements of $\Delta\phi_{SN}^e$ for any metal is yet found by the present author.

Regarding a monocrystalline specimen of $Bi_2Sr_2CaCu_2O_8$ [912], a plot of work function vs. temperature is found to have a minimum ($\phi^e = 4.849$ eV) at the transition temperature ($T_S = 85$ K), where the temperature coefficient ($d\phi^e/dT$) changes from 5.5×10^{-5} eV/K for the normal state to -5.1×10^{-5} eV/K for the superconductive one [912]. Therefore, the latter work function (ϕ_S^e) increases up to 4.851 eV at 50 K, while the former one (ϕ_N^e) extrapolated from T_S to 50 K is estimated to be 4.847 eV. In consequence, the *net* change in work function ($\Delta\phi_{SN}^e \equiv \phi_S^e - \phi_N^e$) is determined to be 0.004 eV at 50 K or 0.009 eV at 0 K [912]. Namely, ϕ^e *increases* only by less than 0.01 eV according to the transition from the normal to superconductive state.

For another sample of $YBa_2Cu_3O_{7-x}$ ($T_S \approx 80-90$ K) [4365], the work function is found to increase by 19 or 31 meV as T decreases from ~ 80 or 89 to 30 K. Such an increase, however, is not equal to the *net* value of $\Delta\phi_{SN}^e$ itself because the former includes the change of the thermal effect ($\Delta\phi^e \equiv \alpha \cdot \Delta T$) coming from the temperature difference of $\Delta T \approx 50$ or 59 K (see Section 10).

10. Remark on work function measurements around critical temperatures

As already mentioned for the transition from ferro- to paramagnetic state in Section 8.1, the *net* change of $\Delta\phi_{PF}^e = 0.00$ or -0.004 eV is found for Ni(100) (see Table 13) by the same group of workers [496,3924] on the basis of very precise measurements at the level of ~ 1 meV. Such a minute change as below 0.01 eV can hardly be observed accurately by usual work function measurements accompanied with uncertainty of about ± 0.05 eV or more in general. In other words, the low level of ~ 0.01 eV or less is usually disregarded in the treatment of work function data in many fields of physics and chemistry. However, such fine measurements of both $\Delta\phi_{PF}^e \equiv \phi_P^e - \phi_F^e$ and $\Delta\phi_{SN}^e \equiv \phi_S^e - \phi_N^e$ owing to the magnetic and superconductive transformations [496,3924], respectively, are very interesting and important from the viewpoint of fundamental physics. In consequence, it is fully expected to investigate the changes much further by both theory and experiment, although they seem generally to be very minute (at the level of ~ 0.01 eV or less) comparably to such a thermal work function change ($\Delta\phi^e \approx 3\ kT/2 \approx 1.3 \times 10^{-4} \times 50 \approx 0.006$ eV) even in a narrow range of less than ~ 50 K at the intermediate temperatures sandwiching the magnetic or superconductive transition temperature (T_C or T_S). In other words, the temperature dependence of ϕ^e inherent in any metals (see just below for typical examples) should be taken into consideration whenever the *net* work function change due to the transition itself alone is to be measured precisely in some temperature range covering the critical point (T_C or T_S) under study. Such a precise measurement is needed around T_A and T_m, too.

With respect to the temperature dependence of work function, theoretical and experimental studies are made by many workers [495–502,3741,4122,4123, etc.], and much data on the temperature coefficient (α) are summarized in Table 6 [1351]. Usually, α is found to range largely from about $\pm 10^{-4}$ to $\pm 10^{-5}$ eV/K depending upon metal species and also to scatter widely from specimen to specimen even for the same species. Typically for W(100) and W(110), α changes in a wide range from $<+1 \times 10^{-4}$ eV/K [84] to -1.09×10^{-4} eV/K [502] and from $+(6.3 \pm 0.6) \times 10^{-5}$ eV/K [194] to -3.7×10^{-4} eV/K [1084], respectively. Similarly for Ni and Mo, it varies greatly from $-(9.9 \pm 1.7) \times 10^{-6}$ eV/K [499] to -1.0×10^{-3} eV/K [179,650] and from $+(7.86 \pm 0.04) \times 10^{-5}$ eV/K [909] to -2.21×10^{-4} eV/K [124], respectively, from worker to worker. Such situation generally makes it very difficult to measure precisely a very minute change (probably much less than ± 0.1 eV) in work function at the critical temperature of allotropic, magnetic, superconductive or solid to liquid state transition, as already summarized in Sections 7–9 and Tables 11–14.

It should be emphasized here again that the work function change due to the above transitions should be measured precisely at the level of ± 1 meV (see Footnote (i) in Table 13). In other words, we should try to determine precisely (1) the temperature coefficient

(α) in a suitable range covering the critical temperature (T_A, T_C, T_S or T_m), (2) the work function values after extrapolating the relationship (ϕ^e vs. T) to the temperatures lower or higher than the critical point under study, and (3) the *net* value of work function change due to the transition alone without including the considerable effect due to α. Regarding the work function change due to $\alpha = \pm 10^{-4}$ eV/K in a narrow range of 100 K, for instance, it is estimated to be ± 0.01 eV, which is comparable to many of the values found as the probable change (*net* value) owing to the transition alone under study (for further information, see Footnote (l) in Table 11 and also Footnotes (k) and (l) in Table 13).

In conclusion, much further work is needed for any sample to determine accurately the minute value of work function change due to transition alone at T_A, T_C, T_S or T_m.

11. Work function dependence upon the size of fine particles

In this section, a classical theory of work function about fine particles will be summarized briefly together with the comparison between the theoretical values and the experimental data on work function available for various metal particles. After outlining a quantum theory about the energetics correlating either ionization energy or electron affinity of atom with work function of bulk solid, photoelectron spectroscopic studies will be focused on a variety of metal clusters and also on the determination of bulk work function from spectroscopic data.

11.1. Classical theory for fine particles

With respect to the fine particle having a small radius (r), a classical theory about its work function based on the image-potential model affords the following equation [3442].

$$\phi^e(r) = \phi^e(\infty) + C_p e^2/r, \tag{17}$$

$$= \phi^e(\infty) + 5.40/r \text{ (Å)} \quad \text{(for } C_p = 3/8\text{)}. \tag{17'}$$

Here, $\phi^e(\infty)$ is equivalent to $\phi^e(\text{poly})$ for bulk corresponding to $r \to \infty$, and e is the elementary electric charge. By taking the coefficient of $C_p = 3/8$, $\phi^e(\infty)$ for bulk Ag is estimated from Eq. (17') to be 4.37 eV [3442] as the best fit to the experimental data on $\phi^e(r) = 4.65$, 4.57 and 4.55 eV for $r = 20$, 27 and 30 Å, respectively [3127]. The value of $\phi^e(\text{poly}) = \phi^e(r \to \infty) = 4.37$ eV thus calculated [3442] is considerably different from the experimental value of $\phi^e(\text{poly}) = 4.90$ eV determined directly by PE for the macroscopic surface [3127] (see Footnote 208 in Table 1), but the former agrees exactly with ours of 4.39 ± 0.02 eV recommended for polycrystalline Ag in Table 2.

Tentatively, the available data on both $\phi^e(\infty)$ and $r(\text{Å})$ are substituted into Eq. (17'). Then, the values of $\phi^e(r)$ thus calculated by the present author are compared with those determined experimentally by the corresponding author(s), thereby yielding the results of (1)–(13) below. Here, the values in {A}, <B> and (C/D) indicate that A is the polycrystalline work function of $\phi^e(\text{poly})$ (in eV) cited as $\phi^e(\infty)$ from Column 3 in Table 2, B is the radius of r (in Å) either reported by the corresponding author(s) or estimated by the present author (see Section 11.3), C is the work function of $\phi^e(r)$ (in eV) calculated from Eq. (17') by the present author employing $A \equiv \phi^e(\text{poly})$ and $B \equiv r(\text{Å})$, and D is $\phi^e(r)$ measured by the corresponding author(s) by means of photoelectric quantum yield of each metal particle. In the last parentheses is given the footnote number in Table 1 so as to provide further information about each data.

(1) Al {4.26 ± 0.03} // < 22 > ($4.51 \pm 0.03/?$) [2199] (449).
(2) Al {4.26 ± 0.03} // < 52.9 > ($4.36 \pm 0.03/?$) [2199] (449).
(3) Ni {5.06 ± 0.06} // < 60–100 > ($5.13 \pm 0.02/5.1$) [2667] (448).
(4) Cu {4.51 ± 0.04} // < 30 > ($4.69 \pm 0.04/4.80 \pm 0.1$) [3190] (149).
(5) Pd {5.17 ± 0.06} // < 30 > ($5.35 \pm 0.06/5.45 \pm 0.1$) [3190] (149).
(6) Ag {4.39 ± 0.02} // < 20 > ($4.66 \pm 0.02/4.65$) [3127] (208).
(7) Ag {4.39 ± 0.02} // < 27 > ($4.59 \pm 0.02/4.57$) [3127] (208).
(8) Ag {4.39 ± 0.02} // < 30 > ($4.57 \pm 0.02/4.55$) [3127] (208).
(9) Ag {4.39 ± 0.02} // < 30 > ($4.57 \pm 0.02/4.50$) [3190] (149).
(10) Ag {4.39 ± 0.02} // < 50 ± 20 > ($4.52 \pm 0.05/4.25 \pm 0.1$) [1562] (204, 208).
(11) Ag {4.39 ± 0.02} // < 50 ± 20 > ($4.52 \pm 0.05/4.65$) [1562].
(12) Au {5.30 ± 0.04} // < 30 > ($5.49 \pm 0.04/5.20 \pm 0.1$) [3190] (149).
(13) Au {5.30 ± 0.04} // < 60 ± 30 > ($5.42 \pm 0.07/5.2 \pm 0.1$) [1562].

As may be seen for the results (3)–(13) with (10)–(13) excluded, each theoretical value of $C \equiv \phi^e(r)$ is found to agree well or fairly with each experimental data on $D \equiv \phi^e(r)$. However, it should be emphasized that any value of $C \equiv \phi^e(r)$ to be calculated is strongly dependent upon $A \equiv \phi^e(\infty)$ to be cited from literatures. As typically shown in (6)–(8) for Ag [3127], the experimental value of $\phi^e(r)$ increases from $D = 4.55$ to 4.65 eV as r decreases from 30 to 20 Å, just as predicted by theory ($C = 4.57 \to 4.66$ eV). The results of (1) and (2) above are outlined in Section 11.3, but the experimental data on $\phi^e(r)$ are not described in Ref. [2199].

Fine particles of Ag (50 ± 20 Å) are formed by passing Ag-vapor through the He-gas boiling off from liquid-He, and $\phi^e(r)$ is measured to be 4.25 ± 0.1 eV [1562]. This is smaller than our calculated value of 4.52 ± 0.05 eV (see Result (10) above). In a separate experiment after purification of the particles by passing through a trap at ~77 K, however, $\phi^e(r)$ is measured to be

D = 4.65 eV [1562] (see Result (11)). This value for $r = 50 \pm 20$ Å is not smaller but larger (by 0.08−0.15 eV) than the others (D = 4.57−4.50 eV) measured for these smaller particles of Ag for 27−30 Å [3127,3190] (see Results (7)−(9)). The former for a larger particle (50 ± 20 Å) [1562] is as large as D = 4.65 eV found for a smaller particle of Ag (20 Å) (see Result (6)) [3127], thereby suggesting it necessary to examine the question whether the actual size of Ag-particle decreases from 50 ± 20 to mostly ~20 Å after the above purification.

For another result of (3) Ni [2667], fine particles (r = 60−100 Å) are produced by a spark discharge between a nickel plane and a nickel tip in He as a carrier gas, and ϕ^e(poly) = 4.9 eV is estimated from literature values (see Footnote 448 in Table 1) and also determined directly for a flat Ni surface by photothreshold [2667]. Substitution of both $\phi^e(\infty)$ = 4.9 eV and r = 80 ± 20 Å into Eq. (17′) yields the result of $C \equiv \phi^e(r)$ = 4.97 ± 0.02 eV < $A \equiv \phi^e$(poly) = 5.06 ± 0.06 eV (Table 2). On the other hand, substitution of the latter (our value of 5.06 eV) yields $C \equiv \phi^e(r)$ = 5.13 ± 0.07 eV, which is essentially equal to the experimental value of $D \equiv \phi^e(r)$ = 5.1 eV [2667], as shown in the result (3) above. On the contrary, substitution of $\phi^e(\infty)$ = 4.9 eV and $\phi^e(r)$ = 5.1 eV into Eq. (17′) yields r = 27 Å [2667]. This is smaller than r = 60−100 Å mentioned just above, thereby suggesting it necessary to examine the effective values of r and/or $\phi^e(\infty)$ under study.

As demonstrated above for six metal species (1)−(13), substitution of our most probable value of $\phi^e(\infty)$ into Eq. (17′) yields that $\phi^e(r)$ is in good or fair agreement between theory (C) and experiment (D). This result affords an additional evidence to support that many of our most probable values of ϕ^e(poly) recommend in Table 2 are reasonably accurate and reliable.

In the next step, let's examine the theoretical values of $\phi^e(r)$ calculated by Rudnitskiĭ et al. [2973,4100] exemplified below. Here, {A} and (B/C) indicate that A is the ϕ^e(poly) cited as $\phi^e(\infty)$ from Table 2, B is $\phi^e(r)$ calculated from Eq. (17′) by the present author, and C is $\phi^e(r)$ evaluated by the original theory considering both structure and shape of the small particles (typically, r = 90 Å) under study [2973].

(1) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/4.25), octahedron.
(2) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/4.36), truncated octahedron.
(3) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/4.40), cube.
(4) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/4.42), cubic octahedron.
(5) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/4.75), real sphere.
(6) W {4.56 ± 0.03} ∥ (4.62 ± 0.03/5.30), rhombododecahedron.
(7) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/4.44), rhombododecahedron.
(8) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/4.58), real sphere.
(9) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/4.72), cube.
(10) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/4.84), cubic octahedron.
(11) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/4.93), truncated octahedron.
(12) Au {5.30 ± 0.04} ∥ (5.36 ± 0.04/5.01), octahedron.

In the case of r = 90 Å for both W and Au, both of the results (1)−(6) and (7)−(12) indicate that the respective six values of $C \equiv \phi^e(r)$ owing to the original theory [2973] are different notably with each other among the six shapes and also that the values (C) differ considerably from those ($B = \phi^e(r)$ = 4.62 and 5.36 eV) calculated for W and Au, respectively, by the present author using Eq. (17′) based on the *real sphere* model. Among the respective six models, the smallest difference (0.13 eV) between B and C is found for the real sphere model (5) for W, whilst that (0.35 eV) is done for the octahedron model (12) instead of the real sphere one (8) for Au.

Interestingly, Makov et al. [4198] as well as Peterson et al. [4322] point out that Schumacher and co-workers employ the coefficient of C_p = 1/2 in their earlier paper (in 1978) [4200] but they replace it later (in 1984) by 3/8 [2383]. With a special attention added to this replacement, the present author adopts the compiled data [4198] in order to examine the relative correctness of 1/2 and 3/8, thus yielding the following results.

(1) Na {2.54 ± 0.03} ∥ ⟨3.4−7.5⟩ (2.49/2.48) [4198].
(2) K {2.29 ± 0.02} ∥ ⟨4.1−7.4⟩ (2.40/2.50) [4198].
(3) Ag {4.39 ± 0.02} ∥ ⟨20−32⟩ (4.35/4.34) [4198].

Here, the values in {A} and ⟨B⟩ indicate that A (in eV) is the work function of ϕ^e(poly) cited from Table 2 and B (in Å) is the radius (r) of the particle under study. The dual values of $\phi^e(\infty)$ (in eV) given as in the form of (C/D) are tentatively estimated by the present author using the experimental data [4148,4200] compiled as Figs. 3−5 (plots of I vs. $1/r$) [4198], where C and D correspond to C_p = 3/8 and 1/2 in Eq. (17), respectively, and I is the ionization energy of the particle under study. As shown by Results (1) and (3), the differences between C and D and between A and C are as small as 0.01 and 0.05 (or 0.04) eV, respectively, whilst Result (2) indicates that each of the differences among A, C and D is too large as 0.10 eV or more to be taken into consideration for the present purpose. These typical results suggest it not easy to solve experimentally the problem which coefficient of 3/8 or 1/2 is more correct or reasonable.

With respect to Li-clusters (n = 2−68), the local exchange–correlation potential model yields $\phi^e(\infty)$ = 2.25 eV and C_p = 0.51, whilst the local density approximation model does 3.21 eV and 0.48, respectively [4262]. Namely, C_p is found to be very close to 1/2, but both of $\phi^e(\infty)$ themselves are considerably different from ϕ^e(poly) = 2.90±0.03 eV [Here] and 2.93 eV [363] recommended in Table 2.

According to Fig. 2 [4321], where the plot of $1/r$ vs. $I - \phi^e(\infty)$ has the two straight lines corresponding to 3/8 r and 1/2 (r + 1.54), all of the values calculated theoretically for I are found to exist inside alone between the two lines, slightly nearer to the former (3/8 r) [4321].

By analysis of the experimental data on K_n (n = 30–101) [3552,4227], the coefficient (C_p) is determined to be 0.34 or 0.38, the respective values of which afford $\phi^e(\infty)$ = 2.30 and 2.29 eV for K(poly) [4244], identically equal to our most probable value of ϕ^e(poly) = 2.29 ± 0.02 eV and also to 2.29 eV [?] and 2.30 eV [3337] recommended in Table 2. Interestingly, both of C_p's are considerably smaller than 1/2 and much nearer to 3/8, similarly exemplified just above [4321]. According to the conclusion [4198], C_p = 1/2 and 3/8 account better for the experimental observations for relatively large and small clusters, respectively. Further information about the coefficient may be obtainable from Refs. [4197,4302,4323].

11.2. Quantum theory about the energetics correlating either ionization energy or electron affinity with work function

On the basis of the quantum theory about the energetics correlating ionization energy (or electron affinity) of atom with work function of bulk solid, Perdew [4101] yields,

$$I(r_s) = \phi^e(\infty) + e^2/2(r_s + d_G). \tag{18}$$

$$E(r_s) = \phi^e(\infty) - e^2/2(r_s + d_G). \tag{19}$$

Here, r_s is the Wigner–Seitz radius, and d_G is the microscopic distance from the infinite planer Gibbs surface to its image plane. Typically for Na (r_s = 3.93 bohr, $d_G(r_s)$ = 1.24 bohr and $\phi^e(\infty) = \phi^e$ = 2.75 eV cited from Ref. [1045]), Eqs. (18) and (19) afford $I(r_s)$ = 5.38 eV and $E(r_s)$ = 0.12 eV [4101]. On the contrary, our citation of ϕ^e = 2.54 eV (Table 2) yields 5.17 eV and $E(r_s)$ = −0.09 eV, which are in better and worse agreements with I = 5.14 eV and E = 0.55 eV for Na–atom, respectively. Generally, the agreement between $E(r_s)$ and E is not better than that between $I(r_s)$ and I for many of the eight elements listed in Table II [4101].

11.3. Photoelectron spectroscopy of clusters

The ionization energies of the different charge states of a spherical metal cluster are given [2199] by

$$I(Z) = \phi^e(\infty) + (Z + \rho)e^2/(r_c + \delta). \tag{20}$$

Here, r_c is the effective radius of the spherical cluster as calculated from its density and weight, Z is its charge state, ρ is the quantum correction of bulk work function for spherical cluster, and δ is the correction of the cluster radius owing to the electron spillover into vacuum. In the case of Al, ρ = 0.49 ± 0.04 is determined by experiment [2199] and δ = 0.54–1.1 Å is estimated by theory [553], in contrast to 0.42 < ρ < 0.45 calculated by quantum theory [3208] and to ρ = 0.50 and δ = 0 in the classical theory [3208].

On the basis of the experimental data on the linear relationship between $I(Z)$ and Z for Al_{2000} or $Al_{32000\pm150}$ with Z = −1 up to +5 and ρ = 0.49, Fig. 2 [2199] affords $\phi^e(\infty)$ = 4.28 ± 0.03 eV (see Footnote 60 in Table 1), where the clusters are produced by sputtering through a magnetron discharge into a stream of liquid-nitrogen-cooled rare gas. The above value of $\phi^e(\infty)$ is just equal to ϕ^e(poly) = 4.28 ± 0.01 eV determined by PE for the Al/quartz system [612,1045] and also essentially equal to ours of 4.26 ± 0.03 eV recommended for polycrystalline Al (see Table 2). By substitution of $\phi^e(\infty)$ = 4.26 ± 0.03 eV and of r_c = 22 and 52.9 Å into Eq. (17'), $\phi^e(r_c)$ = 4.51 ± 0.03 and 4.36 ± 0.03 eV are evaluated for the clusters of Al_{2000} and $Al_{32000\pm150}$, respectively (see Footnote 449 in Table 1 and also Results (1) and (2) Al [2199] compiled together with many other examples (3)–(13) in Section 11.1).

In regard to neutral clusters (M_n, typically n = 4–34 for K_n) formed in adiabatic expansions of neutral vapor from a high temperature oven [4148], photoionization mass spectrometry of M_n^+ makes it possible to measure the first ionization energy of I(n) and, hence, to determine $\phi^e(\infty)$ from the intercept (n → ∞) of a plot (I(n) vs. $n^{-1/3}$) according to Eq. (21) [2171].

$$I(n) = \phi^e(\infty) + (3e^2/8r_s)n^{-1/3}. \tag{21}$$

Some of the typical results are summarized below together with the sample size (n) under study. Regarding {A}, (B) and ⟨C⟩ below, A is our most probable value of ϕ^e(poly) (in eV) listed in Table 2, B is the experimental value of $\phi^e(\infty)$ (in eV) determined from the above plot for each cluster (M_n) by the corresponding worker(s), and C is the number (n) of the atom constituent of M_n under study.

(1) Na; {2.54 ± 0.03} // (2.52 ± 0.04) ⟨15–65⟩ [2383,4148].
(2) Na; {2.54 ± 0.03} // (2.68) ⟨2–137⟩ [2171].
(3) Na; {2.54 ± 0.03} // (2.71) ⟨3–150⟩ [4197].
(4) Al; {4.26 ± 0.03} // (4.25) ⟨3–70⟩ [4197].
(5) Al; {4.26 ± 0.03} // (4.338) ⟨32–95⟩ [4192].
(6) Al; {4.26 ± 0.03} // (4.349) ⟨32–95⟩ [4192].
(7) K; {2.29 ± 0.02} // (2.23 ± 0.04) ⟨4–34⟩ [4148].
(8) K; {2.29 ± 0.02} // (2.28) ⟨19–200⟩ [4161].
(9) K; {2.29 ± 0.02} // (2.28) ⟨70–300⟩ [4161].
(10) K; {2.29 ± 0.02} // (2.29) ⟨30–101⟩ [4227].
(11) K; {2.29 ± 0.02} // (2.30) ⟨3–110⟩ [4197].
(12) K; {2.29 ± 0.02} // (2.52) ⟨30–101⟩ [4227].
(13) Fe; {4.55 ± 0.05} // (3.81 ± 0.04) ⟨?⟩ [4148].
(14) Cu; {4.51 ± 0.04} // (4.70 ± 0.04) ⟨3–500⟩ [4197].

(15) Ag; {4.39 ± 0.02} // (4.19) ⟨3–20⟩ [4197].
(16) In; {4.05 ± 0.06} // (4.12) ⟨3–18⟩ [4197].
(17) Ce; {2.89 ± 0.07} // (2.40) ⟨2–17⟩ [4263].
(18) Pr; {2.83 ± 0.11} // (2.50) ⟨2–21⟩ [4263].
(19) Hg; {4.50 ± 0.02} // (6.88 ± 0.05) ⟨≤12⟩ [4148].
(20) Hg; {4.50 ± 0.02} // (?) ⟨1–70⟩ [4149].
(21) Hg; {4.50 ± 0.02} // (?) ⟨2–35⟩ [4162].
(22) Tl; {3.82 ± 0.05} // (3.89) ⟨3–20⟩ [4197].
(23) Pb; {4.07 ± 0.05} // (4.00 ± 0.10) ⟨?⟩ [4148].

Regarding Result (2) for Na [2171] and that (4) for Al [4197] above, further information is obtainable from Footnotes 40 and 459 in Table 1, respectively. The experimental data on $B \equiv \phi^e(\infty) = 4.338$ and 4.349 eV for Results (5) and (6) for Al [4192] are obtained at 230 and 65 K, respectively, whilst $B = 2.29$ and 2.52 eV in Results (10) and (12) for K [4227] are determined from the data on both Fowler and linear plots according to Figs. 1 and 2 [4227], respectively. The value of $B = 2.28$ eV for K in Results (8) and (9) is calculated from the experimental data on K_n^{2+} and K_n^{3+}, respectively, by using another equation [4161], in contrast to the others (1)–(7) and (10)–(23) where B comes from the data on M_n^+.

As may be seen above, some of the metals are very poor in agreement between $B \equiv \phi^e(\infty)$ and $A \equiv \phi^e(\text{poly})$. Regarding Hg, for example, it is for n > 70 alone that the extrapolation (n → ∞) of a plot (I_n vs. $n^{-1/3}$) converges linearly to $\phi^e(\infty) = 4.49$ eV [1669,4149] or equal to 4.475–4.52 eV for Hg recommended by several authors in Table 2.

Further information about clusters is obtainable from excellent reviews [3669,4138,4194,4261,4269,4301–4304], which summarize concisely or comprehensively both experimental methods and theoretical analyses and also typical data on ionization energy (I), electron affinity (E), bulk work function ($\phi^e(\infty)$) and so on for various species of clusters.

12. Overall summary and conclusions

From the greatly abundant data summarized in Tables 1–14 and Figs. 1–2 and also from the above critical analysis and discussion given in Sections 1–11, we may yield the essential points of the various contents as follows.

(1) The experimental and theoretical data mainly on ϕ^e, in addition to ϕ^+ and ϕ^-, for mono-, submono- and polycrystalline surfaces are compiled in Table 1, which includes more than ten thousands of work function data for about 600 surface species covering 88 kinds of the chemical elements. The data are based upon as much as 4461 references selected from about ten thousands of articles surveyed during the last 20 years. However, even the former seems to be merely less than a half of the literatures published for the elemental work function to date in the world. The probable lack of more than the half is mainly because it is practically difficult to thoroughly cover almost all the related literatures by the single author himself alone. About the work function data on the latter half to be properly included herein, both survey and compilation are confidently expected to be made by other authors in the near future (cf. Section 1).

(2) Owing to the above difficulty, it is only about 200 surface species alone that are found to have more than five data on ϕ^e for each surface species to be practicable for estimating its most probable value. At present, however, Table 1 may be usable as the most abundant and latest database for ϕ^e, ϕ^+ and ϕ^-, each of which is accompanied with a note about the experimental condition and measuring method and some of which are attached with 490 footnotes in total. In addition, Table 1 may also be very useful for readily grasping the outline of work function studies accumulated to date for a variety of surface species under various conditions (cf. Section 2).

(3) Many of the experimental data on ϕ^e, ϕ^+ and ϕ^- listed in Table 1 may be useful for examining the theoretical predictions according to Eqs. (1)–(3). Namely, they make it possible to solve the problems whether (i) $\phi^+ = \phi^e$ holds for a clean and smooth monocrystalline surface alone, (ii) $\phi^+ > \phi^e$ does for all of poly- and submonocrystalline surfaces and (iii) $\phi^- = \phi^e$ applies to any ones, although the data on ϕ^+ and ϕ^- tabulated therein are very scanty in surface species (less than 39) compared with those (about 600) on ϕ^e (cf. Section 4).

(4) Among the sample layer/substrate systems listed in Column 1 of Table 1, some of them are inhomogeneous (patchy, bumpy and/or lattice-defective) in surface structure over the entire area and, hence, the work function for each layer is generally *lower* than that for bulk. To prepare a smooth layer equivalent substantially to bulk, it is necessary in general to select either annealing or deposition at a temperature (T_a or T_d) higher than the working temperature (T) so as to satisfy the condition of T_a (or T_d) ≥ $T_m/3$, as expressed in (T_a) or {T_d} at the back of T (e.g., ~300) in Column 5 of Table 1 (cf. Section 2.5 and Footnote 363 in Table 1).

(5) Typically for Si, both work function and Richardson constant to be measured directly from Richardson plots are generally subject to underestimation mainly because the internal reflection coefficient (r^e) of electron is not negligibly small compared with unity. In such a case, we can estimate the correct value (ϕ_H^e) from the measured one (ϕ_r^e) by using Eq. (8) proposed by Hensley, where the measured value (A_r) corresponds to $(1 - r^e) A_R$. Many attempts made by the present author using Eq. (8) yield very reasonable results, thereby suggesting that it should be employed by many workers in various cases of thermionic emission studies (cf. Section 2.8.6).

$$\phi_H^e = \phi_r^e + kT \ln(120/A_r). \tag{8}$$

Table 1 includes many values of both ϕ_H^e and ϕ_r^e (cf. Footnotes 384–386, 431 and 456).

(6) The most probable values of ϕ^e estimated from the data in Table 1 are summarized in Column 3 in Table 2, and many of them may probably be consultable as a more useful and reliable source on ϕ^e, compared with the others in Columns 6–8 [1045,1354,1358].

This is mainly because the former is much abundant in surface species and also because it covers these newer data published after ~1980, compared with the latter based entirely on those data published more than about forty years ago (cf. Section 3.2).

(7) Regarding about 200 surface species in Table 2, the most probable values of ϕ^e are estimated from relatively abundant data (larger than 5 in number). Among the work function values, especially those with double and single underline have much smaller standard deviations of $\leq \pm 0.05$ and $\leq \pm 0.10$ eV, respectively and, hence, both of them may probably be more reliable than the others with no underline. On the other hand, the values with the superscript (x, y or z) originate from a small number (2, 3–5 or 1) of work function data in Table 1 and, hence, they may possibly be less reliable or accurate than the others based on much abundant data (up to the larger number of ~400 for Cs and W). Consequently, the former is needed to be further investigated in order to accumulate much data worth while to be consultable with confidence (cf. Section 3).

(8) In spite of the fact that work function is one of the important chemico-physical properties of solid surfaces, its data are still very scanty in total number and rather doubtful in accuracy for some of the lanthanides and actinides, in contrast to many of the alkali-, alkali earth- and transition-metals. The former species, as well as those having no data in the 6–8th columns in Table 2, are expected to be added with accurate data on ϕ^e by further investigation (cf. Section 3).

(9) In addition to ϕ^e, the most probable values of ϕ^+ and ϕ^- are listed in Columns 4 and 5 in Table 2, both of which cannot be examined objectively by comparison with any others because none of the literatures [typically, 12,1045,1354,1358] has any recommended values of ϕ^+ and ϕ^-. However, the values of ϕ^+ in Table 2 may also be usable as a convenient source when we try to analyze these data on positive ion emission from polycrystalline surfaces, although the total number of surface species investigated for ϕ^+ to date is very small (only 39 surface species) (cf. Section 3).

(10) Of the work function values (B) recommended for 66–114 surface species (see the last line in Table 2) by other authors [1045,1354,1358], those for typical 40 species have a large discrepancy ($|B - A| = 0.15$–1.00 eV and $(|B - A|)/A = 3$–19%) compared with each of our most probable values (A). This is probably because some of B are entirely based on these less-abundant and less-reliable data published more than ~40 years ago (cf. Examinations (1)–(40) in Section 3.2).

(11) Particularly, each of the values (B) recommended by the other authors for 12 surface species among the above 40 ones has a very large discrepancy ($|B - A| > 0.2$ eV and also $(|B - A|)/A > 10\%$) from ours (A) (cf. Section 3.2); namely, (1) 4.98 eV for α-Be, (6) 4.33 eV for α-Ti, (10) 5.10 eV for Cu(100), (37) 4.30 eV for Au and so on with # attached (cf. Section 3.2).

(12) Both Michaelson and Fomenko have made a valuable contribution to compiling critically the work function data published up to ~1980, and all of the values recommended have long been widely consulted still to date by a great many workers in the world (cf. Section 3.2). About 20–30% of the values, however, have a large discrepancy ranging from ~0.2 to 1.0 eV against ours, as shown in Categories (4)–(11) in Table 3 and also in the list of Examinations (1)–(40) in Section 3.2. Namely, such discrepant values don't seem to be accurate or reliable enough to be straight or undoubtedly acceptable today, as mentioned in Points (10) and (11) above. Therefore, it may be advised that at least those values with # attached in the above list should be revised tentatively after our most probable values estimated from much more abundant and reliable data published to date, although any of ours is not yet insured to be correct enough to be straight acceptable today (cf. Section 3.2).

(13) Among our 609 surface species listed for 88 elements in Table 2, about 480 surfaces of 21 elements don't find any values of work function recommended by other authors. Especially, many of the monocrystalline work function values are newly recommended here for about 70 surface species of 42 elements (e.g., alkalis, alkali earths, V, Cr, Rh, Pb), many of which are based generally on the abundant source including more than five work function data published to date. This is one of the unique merits of the present article exceeding the other publications (cf. Section 3.2).

(14) The work function values with x, y or z superscripted according to scanty data (only 2, 3–5 or 1 in total number) are tentatively added as a rough estimate for each of about 390 surface species (e.g. monocrystals of γ-Ca, γ- and δ-Mn, Tc, Cd, In, α-Sn, Eu, α- and β-Tb, α- and β-Hf, etc., and also polycrystals of P, γ- and δ-Mn, δ-Fe, β- and γ-Sr, γ-Sn, I, β-Tb, At, Ac, Cm, etc.) in Table 2. Much data should be accumulated by further investigations so that each of the values may be insured or increased in accuracy (cf. Section 3.2).

(15) Disappointedly, Table 2 does not include many important surface species such as C(110), C_{60}(100), C_{60}(110), Al(112), β- and γ-Fe(112), Ni(112), Zn(1011), Ga(112), As(100), As(110), Se(0001), α-Sr(112), α-Y(1011), α-Zr(1011), Pd(112), Ag(112), Cd(1011), In(112), Sb(110), Sb(112), Te(0001), β-Ce(112), Hf(1011), Tl(1011), Pb(112), Bi(1010) and so on, although they seem to be interested by many workers as the fundamental species in surface science. Such a present situation indicates that further investigations by both theory and experiment are needed to accumulate the reliable work function data for many surface species covering not only the above but also many others such as exemplified in Point (14) just above (cf. Section 3.2).

(16) The effective work functions (ϕ^+, ϕ^e and ϕ^-) for the emissions of positive ion, electron and negative ion by the mechanism of thermal stimulation are generally given by Eqs. (1)–(3), respectively, and their values for any patchy surface are different from ϕ^a given by Eq. (4) (cf. Sections 1 and 4).

$$\phi^+ = kT \ln[\Sigma F_i \exp(\phi_i/kT)], \tag{1}$$

$$\phi^e = -kT \ln[\Sigma F_i \exp(-\phi_i/kT)], \tag{2}$$

$$\phi^- = -kT \ln[\Sigma F_i \exp(-\phi_i/kT)], \tag{3}$$

$$\phi^a = \Sigma F_i \phi_i. \tag{4}$$

(17) By using the literature values of ϕ_i and F_i, the theoretical values of ϕ^+ and ϕ^e calculated for seven W-specimens from Eqs. (1) and (2) are generally in fair agreement with the experimental data in a wide range of the degree of monocrystallization

($\delta_m \approx 0.34 - 0.96$), which corresponds to the largest among the fractional surface areas (F_i's) for each specimen under study. Such agreement is found for other metals (Ni, Nb, Mo, Ta and Ir), too, thus supporting again our equations (cf. Section 4.2 and Table 6).

(18) Consequently, it may be safe to conclude that each of the work function values to be thus calculated theoretically is generally expected to agree well with the data to be obtained experimentally for the specimen under study. Here, the local work function (ϕ_i) may ready be citable from Table 1 or 2 according to the local face species corresponding to the area (F_i) to be cited from literatures. Of course, each of the work function values to be calculated from Eqs. (1)–(3) based on PSI, TE and NSI, respectively, is generally expected to be equivalent to that to be determined for the same species by any other methods such as FE and PE without depending upon the emission mechanisms or processes (cf. Sections 1 and 4).

(19) For any polycrystalline surface consisting of patchy faces (1–i) with the fractional area (F_i) over the entire surface and also with the local work function (ϕ_i) ranging from the maximum (ϕ_{max}) to the minimum (ϕ_{min}), there holds the inequality of $\phi_{max} > \phi^+ > \phi^a > \phi^e = \phi^- > \phi_{min}$. This is because positive ions and electrons (negative ions, too) are emitted predominantly from these faces having high and low work functions (ϕ_i's) near to ϕ_{max} and ϕ_{min}, respectively (cf. Sections 1 and 4).

(20) Therefore, each polycrystalline surface has the thermionic contrast of $\Delta\phi^* \equiv \phi^+ - \phi^e > 0$, which depends upon the surface species ranging from $\sim$0.3 eV (Pt) to 0.7 eV (Nb) (cf. Tables 4 and 5). Whenever we try to analyze quantitatively the data (β^+ or E^+) on positive ion emission from polycrystals by using Eq. (5) or (9) to be shown below or in Point (22) later, we should employ ϕ^+ instead of ϕ^e. Otherwise, the analyzed results may be accompanied with the systematic error corresponding to $\Delta\phi^*$ (cf. Section 2.6 or 4.1).

$$\alpha^+ = \beta^+/(1 - \beta^+) = \{w^+/w^0\} \exp[(\phi^+ - I)/kT]. \tag{5}$$

(21) On the other hand, each monocrystalline surface has the relation of $\phi_{max} = \phi^+ = \phi^a = \phi^e = \phi^- = \phi_{min}$ and, hence, $\Delta\phi^* \approx 0.0$ eV holds generally so long as the surface is essentially clean and smooth (cf. Table 5). If not so, $\Delta\phi^* \approx 0.0$ eV does not hold. Typically, oxygenated W(100) surface has $\Delta\phi^* = 0.7$ eV in contrast to $\sim$0.0 eV for clean and smooth W(100) (cf. Section 4.1 and also the lines for O=W(100) in Table 1 in Ref. [1351]).

(22) Similarly as mentioned in Points (20) and (21) just above, the employment of ϕ^e as ϕ in Eq. (9) is limited to PSI on substantially clean and smooth monocrystalline surfaces alone. In the case of polycrystalline surfaces, ϕ^+ should be generally adopted as ϕ instead of ϕ^e. Otherwise, the Schottky cycle does never close exactly. Namely, $\Delta E^* \equiv (\phi + E^+) - (E^0 + I) = -\Delta\phi^* \neq 0$ (cf. Section 4.1).

$$\phi + E^+ = E^0 + I. \tag{9}$$

(23) Regarding the relationship between $\Delta\phi^*$ and δ_m, there hold the following equations derived empirically by the present author.

$$\Delta\phi^* = c \quad \text{for } 0 < \delta_m < 0.5 \text{ (polycrystal).} \tag{10}$$

$$\Delta\phi^* = 4c\delta_m(1 - \delta_m) \quad \text{for } 0.5 < \delta_m < 1 \text{ ("submonocrystal").} \tag{11}$$

$$\Delta\phi^* = 0 \quad \text{for } \delta_m = 1 \text{ (monocrystal).} \tag{12}$$

Each of the values calculated from Eqs. (10)–(12) is in fair agreement with each of the experimental data on the several specimens under study, as illustrated typically for tungsten in Fig. 1 (cf. Section 4.3).

(24) At $\delta_m < 0.5$, $\Delta\phi^*$ is kept nearly constant at c, as shown for polycrystal by Eq. (10). Quite similarly, both ϕ^+ and ϕ^e are also found by theory and experiment to be little dependent upon the difference in the surface components (ϕ_i and F_i) among various specimens of the same species (cf. Table 6). This result may afford us the conclusion that each of the polycrystalline surface species, like as each monocrystalline one, is usually expected to have a nearly constant (within $\pm$0.1 eV in variation) and unique value characteristic of the species itself under the normal condition (cf. Section 4.2). Although ϕ_m itself has the "differential effect" on both ϕ^+ and ϕ^e of any patchy surface according to the "emission predominance" (cf. Section 1), each of ϕ^+, ϕ^e and $\Delta\phi^*$ remains nearly constant independently of δ_m so long as $\delta_m < 0.5$ (see Points (25) and (31) below).

(25) The above conclusion in Point (24) is strongly supported by the fact that the most probable value of ϕ^e for any polycrystalline surface species (usually $\delta_m < 0.5$) is substantially common or nearly identical among various specimens in spite of a considerable difference in the surface components (ϕ_i and F_i). Typically for polycrystalline tungsten, our theoretical value ($\phi^e = 4.52$ eV, see Footnote (25) in Table 6) is in good agreement with 4.54–4.56 eV [Here, 12,1045,1351,1354,1358] (cf. Section 3.2 and Table 2). The latter is estimated from various values scattered in a wide range (e.g., $\phi^e \approx$ 3.8–5.2 eV by experiment and 2.8–5.8 eV by theory for W, see Table 1). In addition, both ϕ^+ and $\Delta\phi^*$ as well as ϕ^e show a good agreement (within $\pm$0.1 eV in gap) between Footnotes (25) and (26), thus affording an additional evidence to support our theoretical model (cf. Table 6).

(26) The wide scattering mentioned for polycrystals just above is mainly due to the reasons of (i) the error in experimental measurement or the incompletion in theoretical calculation, (ii) the difference in various surface conditions (e.g., contamination, irregularity and heteroatom density) and/or, probably, (iii) the inclusion of these specimens of "submonocrystals" with $0.5 < \delta_m < 1$ (cf. Section 3.1).

(27) By natural elimination of these data corresponding to some of the above reasons of (i)–(iii) mentioned just above, ϕ^e may naturally be converged to a very narrow range, which brings about the result mentioned in Point (24) above, thus yielding the most probable value with the uncertainty of less than $\pm$0.1 eV for many polycrystalline species ($\delta_m < 0.5$ in general) (cf. Section 4.4).

(28) In contrast to the "polycrystal" ($\delta_{\mathrm{m}} < 0.5$) mentioned just above, the "submonocrystal" ($0.5 < \delta_{\mathrm{m}} < 1$) has such an anomaly as changes in ϕ^{e} as well as ϕ^{+} and $\varDelta\phi^{*}$ depending upon δ_{m} and, hence, the latter is neither constant nor unique in ϕ^{e} without having the work function characteristic of the surface species itself. The above anomaly may readily be understood by consideration of the analogy between the surface area component (δ_{m}) and the binary alloy component (γ_{c}), both of which are identical with each other in terms of the governance of work function according to each fractional value (cf. Section 4.5). Such a work function dependence on δ_{m} is observed for not only W but also done for other metals, too (cf. Section 4.2). Therefore, the "submonocrystal ($0.5 < \delta_{\mathrm{m}} < 1$)" should be treated as another species (category) different from the "generally called polycrystal ($\delta_{\mathrm{m}} < 0.5$)" (cf. Section 4.4).

(29) As summarized in Points (24)–(27), Eqs. (1), (2) and (10) afford a sound basis for supporting *theoretically* the *experimental* results (cf. Column 3 in Table 2) that every polycrystal ($\delta_{\mathrm{m}} < 0.5$) is usually expected to be nearly constant within the variation of ± 0.1 eV in ϕ^{e} with little dependence upon the difference in both F_{i} and ϕ_{i} among various specimens and also that it has the unique value of ϕ^{e} characteristic of its surface species so long as $\delta_{\mathrm{m}} < 0.5$ (cf. Sections 4.2 and 4.4).

(30) Consequently, the above theoretical support gives a definite answer to the long-pending problem why every "polycrystal" as well as every monocrystal is generally recognized to have a constant value of work function, irrespective of a large difference in the surface components (F_{i} and ϕ_{i}) among polycrystal specimens. In other words, it may be reasonable to interpret that the so-called "polycrystal" appearing in many publications is implicitly recognized to correspond to $\delta_{\mathrm{m}} < 0.5$ alone instead of $\delta_{\mathrm{m}} < 1$ including the "submonocrystal" (cf. Section 4.4).

(31) When ϕ_{m} belonging to δ_{m} has relatively higher and lower values among ϕ_{i}'s, ϕ_{m} gives the differential effect to ϕ^{+} and ϕ^{e}, respectively, mainly due to the emission predominance inherent in every patchy surface (cf. Section 1). For polycrystal ($\delta_{\mathrm{m}} < 0.5$), however, both ϕ^{+} and ϕ^{e} remain nearly constant independently of both δ_{m} and ϕ_{m}, whilst submonocrystal ($0.5 < \delta_{\mathrm{m}} < 1$) changes in both ϕ^{+} and ϕ^{e} depending strongly upon δ_{m} and differentially upon ϕ_{m}, thus showing that both δ_{m} and ϕ_{m} have a complicate governance of the both work functions of any patchy surface (cf. Section 4.3).

(32) As mentioned in Points (23) and (28), Eqs. (1), (2) and (11) lead to the conclusion that the "submonocrystal" ($0.5 < \delta_{\mathrm{m}} < 1$) changes in work function depending upon the surface components (F_{i} and ϕ_{i}) without having a constant value, in contrast to both poly- and monocrystalline surfaces having each a constant and unique value characteristic of the surface species itself. Interestingly, δ_{m} thus acts as the *key factor* governing strongly both ϕ^{e} and ϕ^{+} at a *different* mode between poly- and submonocrystals according to the conditions of $\delta_{\mathrm{m}} < 0.5$ and $0.5 < \delta_{\mathrm{m}} < 1$, respectively. Namely, $\delta_{\mathrm{m}} = 0.5$ functions as the critical point governing differentially the work functions between the two crystal species (cf. Sections 4.4 and 4.5).

(33) Our findings of (i) the *sound basis* marked for polycrystal ($\delta_{\mathrm{m}} < 0.5$) in Point (29), (ii) the *anomaly* outlined for submonocrystal ($0.5 < \delta_{\mathrm{m}} < 1$) in Point (28) and (iii) the *key factor* of δ_{m} governing both ϕ^{e} and ϕ^{+} (Point (32)) may be considered to add a new contribution to the work function studies developed to date, although our theoretical model is very simple and plain and also may seem crude and coarse apparently (cf. Section 4.4). Without our deep analysis made for ϕ^{+}, ϕ^{e} and $\varDelta\phi^{*}$ on the basis of Eqs. (1)–(3) and (10)–(12), any of the above new findings could not have been made successfully (cf. Table 6, Fig. 1 and Sections 4.2–4.5).

(34) Another thermionic contrast ($\varDelta\phi^{**} \equiv \phi^{-} - \phi^{\mathrm{e}}$) for negative ion emission is experimentally confirmed to be substantially zero for a given specimen of any surface species (poly-, submono- and monocrystals) under any condition, irrespective of their surface contamination and/or surface irregularity (cf. Section 4.6 and Table 7). In other words, ϕ^{e} as well as ϕ^{-} is usable in safety for analyzing the data on negative ion emission from any surfaces, as may readily be understandable from the theoretical prediction that Eq. (2) is identically equivalent to Eq. (3) (cf. Section 1).

(35) Consequently, ϕ^{e} to be measured by TE is reasonably considered to be effective for NSI, too, on the same specimen under virtually the same condition whenever we try to use Eq. (6) (cf. Section 2.6).

$$\alpha^{-} = \beta^{-}/(1 - \beta^{-}) = \{w^{-}/w^{0}\}\exp[(E - \phi^{-})/kT]. \tag{6}$$

(36) As a special case, the graphitic carbon film formed on a metal substrate has $\varDelta\phi^{*} \approx 0.0$ eV, thermionically equivalent to monocrystalline graphite like as C(HOPG) (cf. Table 5). Both of them have the same chemico-physical properties in contrast to carbidic carbon films (cf. Section 4.1).

(37) In contrast to free-standing graphene ($\phi^{\mathrm{e}} \approx 4.5$ eV), adsorbed graphene is found by both theory and experiment to have a strong dependence of its work function (by up to ~1 eV) upon the substrate species (Ni(111), Pd(111), etc.) (cf. Section 4.1).

(38) Work function values of the three low-Miller-index surfaces have a tendency to decreasing as the surface atom density (D_{s}) reduces. Typically for hcp-Re, our most probable values of ϕ^{e} in Table 2 show the sequence of $\phi^{\mathrm{e}}(0001) > \phi^{\mathrm{e}}(10\bar{1}1) > \phi^{\mathrm{e}}(10\bar{1}0)$ in good accordance with $D_{\mathrm{s}}(0001) > D_{\mathrm{s}}(10\bar{1}1) > D_{\mathrm{s}}(10\bar{1}0)$, strictly following the Smoluchowski rule (cf. Table 8). Namely, ϕ^{e} reduces as the surface becomes more open (cf. Section 5.1).

(39) Regarding bcc-metals such as Na, Rb, Nb, Mo, Cs, Ba, Ta and W, most (~75–100%) of the experimental and theoretical data on $\phi^{\mathrm{e}}(hkl)$ for each metal are found to have the sequence of $\phi^{\mathrm{e}}(110) > \phi^{\mathrm{e}}(100) > \phi^{\mathrm{e}}(111)$, just as expected from the above rule. Quite similarly, all of the data obtained by PSI of Nb, Mo, Ta and W yield $\phi^{+}(110) > \phi^{+}(100) > \phi^{+}(111)$. The latter gives an additional evidence to support strongly our theoretical model that $\phi^{+}(hkl)$ is fundamentally equivalent to $\phi^{\mathrm{e}}(hkl)$ for essentially clean and smooth monocrystalline surfaces ($\delta_{\mathrm{m}} = 1.00$ and $\varDelta\phi^{*} = 0.00$ eV) (cf. Table 9 and Section 5.2).

(40) In the case of fcc-metals (e.g., Ni, Cu, Rh, Pd, Ag, Pt and Au), most (~60–100%) of the work function data on $\phi^{\mathrm{e}}(hkl)$ are observed to have $\phi^{\mathrm{e}}(111) > \phi^{\mathrm{e}}(100) > \phi^{\mathrm{e}}(110)$, exactly following the above rule. In addition, $\phi^{+}(111) > \phi^{+}(100) > \phi^{+}(110)$ is found to hold for Ni, thereby supporting again the equivalence between $\phi^{+}(hkl)$ and $\phi^{\mathrm{e}}(hkl)$ (cf. Table 10 and Section 5.3).

(41) In another case of fcc-Al, on the contrary, 68% of the 56 sets don't obey the Smoluchowski rule, quite similarly to the result that our two sets of Al [Here] and [1351] also don't so (see those with double and single underlines, respectively, in Table 10).

Such an anomalous result against the rule is concluded by Fall et al. to originate from the increased *p*-atomic-like character of the density of states at the Fermi energy, in comparison with most other fcc-metals (cf. Section 5.4).

(42) Of the 38 triple sets of fcc-Pb, 55% don't follow the above rule, whilst our set [Here] (see that with double underlines in Table 10) has the normal sequence proving the rule. Therefore, much further investigations by both theory and experiment are necessary to find a valid reason for the above discrepancy between the former and the latter, in contrast the above case of Al (cf. Section 5.4).

(43) Irrespective of the species of bcc- and fcc-metals (except Al and Pb), each triple set with "Yes" in Tables 9 and 10 indicates that the *relative* values among the three are generally reasonable, but any set does not insure that all of the *absolute* values in the set are always accurate or correct enough to be straight acceptable today. This is naturally because "Yes" does satisfy the *necessary* condition but does not the *sufficient* one for insuring the above acceptability of each ϕ^e(hkl) among the three in the set under study (cf. Section 5.4).

(44) Except the cases of Al and Pb, each triple set with "No" generally indicates that at least one of the three values among ϕ^e(100)–ϕ^e(111) is inaccurate due to some errors either in the experimental determinations or in the theoretical calculations for each set under study (cf. Section 5.4).

(45) Therefore, such an examination as exemplified in Tables 9 and 10 is very useful for answering quickly the question whether the three values in the set under study are partly inaccurate or incorrect. If "No", then, either the experimental methods and conditions employed or the theoretical model and parameters adopted should be improved until yielding "Yes", although the new set yielded to be so does not always insure its accuracy as already mentioned in Point (43) above (cf. Section 5.4).

(46) In regard to the anomalous set of ϕ^e(110) = 4.87 eV > ϕ^e(100) = 4.02 eV < ϕ^e(111) = 4.36 eV recommended for bcc-Nb (hkl) by both CRC [1358] and Michaelson [1045] (cf. Table 2), our examination according to Point (44) suggests that ϕ^e(111) = 4.36 eV [1045,1358] should be replaced with 3.95 eV [Here], for instance, so as to follow the Smoluchowski rule. Similarly, appropriate corrections should be made for the irregular sets of Cu and Mo recommended by Michaelson and/or CRC (cf. Examinations (10), (17), (19) and (20) in Section 3.2 and also Conclusions (7)–(9) in Section 5.4).

(47) Among many empirical formulae derived to evaluate ϕ^e for various polycrystals by using the data on a variety of chemico-physical properties, especially, Eq. (7) proposed first by Gordy and Thomas has a historically important contribution to the evaluation of ϕ^e for various polycrystalline surface species including particularly these of Pm, Po and Ra, the latter of which has no experimental data still to date (cf. Section 2.8.3).

$$\phi^e = 2.27X + 0.34 \text{ (in eV).} \tag{7}$$

(48) Substitution of theoretical data on surface energy (ε) into Eq. (13) derived by Zadumkin et al. makes it possible to evaluate ϕ^e, the calculated value of which is found to be in fair or good agreement to the experimental data on ϕ^e for several metals such as fcc-Ni and bcc-Nb (cf. Section 5.5.2).

$$\phi^e(\text{hkl}) + (Ba^2/z)\varepsilon(\text{hkl}) = \text{const.} \tag{13}$$

(49) By the theoretical investigation of the quantitative relation between the melting point (T_m) and ϕ^e, Chatterjee yields Eq. (14).

$$\log[\phi^e(\text{hkl})] = \log[T_m(\text{hkl})^{1/4}/V^{1/6}] - 2.87 \pm 0.04. \tag{14}$$

Disappointingly, any of the work function values thus calculated for fcc-monocrystalline surfaces of Ag and Pb does not well agree with ours listed in Table 2. The reason for the disagreement should be clarified by further investigation (cf. Section 5.5.4).

(50) As the Wigner–Seitz radius (r_s) increases from ~2 bohr (Al) to ~6 bohr (Cs), the work function (ϕ) becomes less dependent upon its surface property (D_b) on the contrary to its bulk one (E_F), exactly according to Eq. (15).

$$\phi = D_b - E_F. \tag{15}$$

In consequence, ϕ becomes smaller from ~4 to 2 eV with increasing r_s. This tendency is identical to that of the experimental data on ϕ^e (cf. Section 6.1 and Fig. 2). After Kohn and co-workers initiated the density functional theory in 1960's, the theoretical studies on work function have greatly progressed and, hence, a better agreement between theoretical values and experimental data on work function has been achieved today for a variety of monocrystalline surface species (cf. Sections 2.8.5 and 6.1).

(51) After inquiring the problem whether work function is a surface or bulk property, Eq. (16) is theoretically derived by Halas and Durakiewicz as a function of the Wigner–Seitz radius and the Fermi energy alone.

$$\phi = 43.46/r_s^{3/2} E_F^{1/2}. \tag{16}$$

This is successfully applied to calculating also the work function change due to surface reaction of hydrogen with Pd, thus yielding such a reasonable result as $\phi = \phi^e = 5.25$ eV (Pd) and 3.2 eV (PdH) (cf. Section 6.2).

(52) The work function changes due to allotropic transitions ($\Delta\phi^e_{\beta\alpha} \equiv \phi^e_\beta - \phi^e_\alpha$ and $\Delta\phi^e_{\gamma\beta} \equiv \phi^e_\gamma - \phi^e_\beta$) are estimated to be -0.03 ± 0.06 eV for Ti, Fe, Co, Sn and U and -0.04 ± 0.08 eV for Fe, Sn and U, respectively, while $\Delta\phi^e_{\beta\alpha}$ is found to range from -0.16 to -0.21 eV for Sc, Tb and Hf. Accumulation of much data on these metals and also on other metals, however, is desired to determine more finely the above changes at the level of 1 meV in a very narrow temperature range sandwiching each transition temperature and also to settle the problem how each change depends upon metal species (cf. Table 11 and Section 7.1).

(53) As an interesting topic of allotropic transformation, β-fcc-Co with $\phi^e = 4.25$ eV is changed to α-hcp-Co with 4.12 eV by cooling slowly from ~1100 K to 300 K, but the former is kept unchanged by sudden cooling to room temperature even after passing the allotropic transition temperature (670 K) (cf. Section 7.1).

(54) Normally, α-hcp-Co(0001) with $\phi^e = 5.264$ eV transfers at 670 K to β-fcc-Co(111) with 5.266 eV (cf. Table 11). However, repetition of the transformation alters it to polycrystalline Co (cf. Section 7.1), whose work function is generally expected to have 4.71 and 4.50 eV for α- and β-Co, respectively (cf. Table 2).

(55) According to the Burgers orientation relationship between the two phases before and after allotropic transition, α-hcp-Zr(0001) changes to β-bcc-Zr(110), the relationship of which is also the case for Ti. For many monocrystalline surfaces of such as Sc, Y, Gd, Tb and Hf in addition to Ti, Co and Zr, much further studies by both theory and experiment are strongly expected to accumulate the accurate data on both the work function change and the orientation relationship due to the allotropic transition (cf. Table 11 and Section 7.1).

(56) The work function change ($\Delta\phi^e_{LS} \equiv \phi^e_L - \phi^e_{So}$) due to the phase transition between solid and liquid is found for thirteen metals to range from −0.10 to 0.03 eV, which affords the average of −0.02 ± 0.03 eV. In order to determine more precisely such a *minute* change, however, work function measurements are generally desired to be done at the level of 1 meV in such a narrow temperature range ($\Delta T \approx 10$ K) sandwiching T_m so as to minimize the thermal effect due to $\alpha \cdot \Delta T$ (cf. Table 12 and Section 7.2).

(57) The work function change ($\Delta\phi^e_{PF} \equiv \phi^e_P - \phi^e_F$) due to the transition between ferro- and paramagnetic phases is found for Fe, Co, Ni and Gd to range from −0.05 to 0.01 eV, which yields the mean of −0.01 ± 0.04 eV. Such a fine measurement (e.g., −0.007 eV for Ni at 400 K after extrapolation) as excluding the thermal effect ($\alpha \cdot \Delta T$), however, is generally expected to be done for many other metals, too, by further investigations (cf. Table 13 and Section 8.1).

(58) A metastable γ-like fcc-ferromagnetic Fe-film grown epitaxially on a Cu(100) substrate has generally $\phi^e = 4.58 \pm 0.10$ eV, which is very near to 4.55 ± 0.05 eV for α-bcc-ferromagnetic bulk-Fe (cf. Table 2). The former, however, changes in the Curie point (T_C) typically from 230 to 390 K as θ increases from 1 to 3–5 ML with $\phi^e = 4.7 \pm 0.1$ eV, in contrast to the latter having $T_C =$ constant at 1040 K (cf. Section 8.2).

(59) A metastable fcc-Co-film on a Cu(100)-substrate is ferromagnetic below T_C, which is found to increase linearly from ~100 to 500 K as θ increases from ~1.5 to 2.5 ML. At $\theta \approx$ 5–6 ML, T_C reaches to 1390 K, just corresponding to bulk cobalt. Much further work is expected to be done for various metastable systems in order to elucidate the dependence of both ϕ^e and T_C upon the film thickness (cf. Section 8.2).

(60) On the basis of the experimental data for a chemical compound ($Bi_2Sr_2CaCu_2O_8$) in Table 14, the work function change due to the transition between the normal and superconductive states may be concluded to be as small as $\Delta\phi^e_{SN} \equiv \phi^e_S - \phi^e_N = 4$ meV or so. On the other hand, the possible change due to the transition studied for the film of metals (V, Nb and Ta) is accompanied with so large a standard deviation (±0.3 eV) by CPD that the possible change can hardly be estimated accurately, while any appreciable change at the level of 0.01 eV is not observed for any of the above three metals studied by FE. Further studies by both theory and experiment are strongly expected to determine $\Delta\phi^e_{SN}$ for various metals on the level of 10 meV or less (cf. Table 14 and Section 9).

(61) For any species of metals, ϕ^e is well-known to change widely with the temperature coefficient of $\alpha \approx \pm 10^{-5} - \pm 10^{-4}$ eV/K (cf. Table 6 in Ref. [1351]). Therefore, it is emphasized here again that the work function values at the two different states (phases) should be compared at the *common* temperature (around the critical point such as T_A, T_m, T_C or T_S) after extrapolation so as to eliminate the thermal effect of $\alpha \cdot \Delta T$. Otherwise, the *net* change due to the transition alone can not be determined accurately at the level of less than 10 meV (cf. Section 10).

(62) According to a classical theory, the work function of a fine particle is given by

$$\phi^e(r) = \phi^e(\infty) + C_p e^2/r. \tag{17}$$

The value of $\phi^e(r)$ calculated therefrom is generally found to agree either well or fairly with that determined by experiment when the reliable data on $\phi^e(\infty) \equiv \phi^e(\text{poly})$ cited typically from Table 2 and on r (particle radius reported in each article) are substituted to the above equation. Here, $C_p = 3/8$ instead of 1/2 is usually adopted like as shown by Eq. (17′) (cf. Section 11.1 and also Point (65) below).

(63) Quantum theory about the energetics correlating atom with bulk solid yields:

$$I(r_s) = \phi^e(\infty) + e^2/2(r_s + d_G), \tag{18}$$

$$E(r_s) = \phi^e(\infty) - e^2/2(r_s + d_G). \tag{19}$$

Typically by adopting $\phi^e(\infty) = 2.75$ eV, $I(r_s)$ and $E(r_s)$ are evaluated to be 5.38 and 0.12 eV for Na–atom, respectively. But, our adoption of 2.54 eV yields 5.17 and −0.09 eV, which are in better and worse agreements with $I = 5.14$ and $E = 0.55$ eV. Agreement between $E(r_s)$ and E is not better than that between $I(r_s)$ and I for many of the elements studied (cf. Section 11.2).

(64) By measuring the ionization energies of such clusters (r_c in radius) as Al_{2000} and $Al_{32000\pm150}$ with several charges ($Z = -1$ up to +5), the work function of $\phi^e(\infty)$ for bulk Al is determined from

$$I(Z) = \phi^e(\infty) + (Z + \rho)e^2/(r_c + \delta). \tag{20}$$

The value of $\phi^e(\infty) = 4.28 \pm 0.03$ eV determined from the plot of $I(Z)$ vs. Z with $\rho = 0.49$ is essentially equal to our most probable value of 4.26 ± 0.03 eV for polycrystalline Al (cf. Section 11.3).

(65) In regard to neutral clusters (M_n) to be investigated generally by mass spectrometry, we have

$$I(n) = \phi^e(\infty) + (3e^2/8r_s)n^{-1/3}. \tag{21}$$

Here, $C_p = 3/8$ is replaced with $1/2$ in some cases. From the plot of $I(n)$ vs. $n^{-1/3}$ according to experimental data on the first ionization energy (I) and the number (n) of atoms constituting the cluster under study, we can determine $\phi^e(poly) = \phi^e(\infty)$ at the intercept ($n \to \infty$). Between the two, we can find a good agreement among many examples (cf. Section 11.3).

(66) Some of the experimental and theoretical studies indicate that C_p tends to be nearer to $3/8$ rather than to $1/2$, and another study concludes that $1/2$ and $3/8$ account better for the experimental observations for relatively large and small clusters, respectively. Since the linearity of the relationship between I and r^{-1} (or $n^{-1/3}$) is not so good generally as we may expect, it is not easy to verify experimentally which coefficient of $1/2$ or $3/8$ is more accurate or reasonable in general for all of the sizes and species of clusters (cf. Section 11.1).

(67) Finally as to be emphasized particularly, both experimental and theoretical studies on work function and related subjects ought to be developed much more, typically for accumulating the accurate or reliable data on the work function characteristic of each of the various surface species including minor or less-common ones in order to enrich the fundamental data important in solid state physics, although such studies themselves may possibly be no longer greatly attractive and deeply interesting at present compared with many other current topics prevailing today in surface science.

Afterword

The main purposes of this article are (1) to establish comprehensively an abundant and up-to-date database on ϕ^e as well as ϕ^+ and ϕ^- determined by theory and experiment for both mono- and polycrystalline surfaces of almost all the chemical elements under specified conditions, (2) to estimate accurately the most probable values of the three kinds of work functions of essentially clean surfaces for a variety of the both crystals, (3) to compare critically the recommended work function values between the present and other authors for examining their objective reliability, (4) to summarize compactly the steady progress in theoretical and experimental studies on work function, (5) to outline briefly the methods and techniques developed for work function measurements, (6) to introduce concisely the interesting topics about work function and related subjects, (7) to indicate concretely the important problems to be solved for work function by further investigations by theory and experiment, (8) to determine fully the validity of $\phi_{max} > \phi^+ > \phi^a > \phi^e = \phi^- > \phi_{min}$ for various polycrystals studied by theory and experiment, (9) to establish firmly the universal recognition of $\Delta\phi^* \equiv \phi^+ - \phi^e > 0$ as the peculiarity characteristic of polycrystals, (10) to demonstrate amply the strong governance of ϕ^+, ϕ^e and $\Delta\phi^*$ by δ_m working as the *key* factor with the critical point of 0.5 (50% in surface fraction), (11) to clarify theoretically the *differential* effect of ϕ_m upon ϕ^+ and ϕ^e according to the emission predominance, (12) to afford well the theoretical ground to the experimental fact that every polycrystal ($\delta_m < 0.5$) usually has a nearly constant value of ϕ^e under the normal condition in spite of a large difference in both ϕ_i and F_i among various specimens, (13) to explain exactly the fundamental difference in work function between submono- and polycrystals and, finally, (14) to examine objectively a new contribution of our simple model to the work function studies developed to date.

For the above purposes, the present author has tried to do best during the last $\sim$20 years after his retirement from Ehime University in order to search thoroughly more than ten thousands of literatures published for work function and related subjects to date in the fields of both pure and applied physics and chemistry. This trial for preparing the present article as well as the previous one [1351] has long been very laborious to him, but the results thus achieved especially as Tables 1 and 2 may be useful and convenient to many workers whenever they try to grasp easily the outline of both method and condition adopted for evaluating each work function and also to refer quickly to the most probable value of elemental work function for the mono- or polycrystalline surface under study.

This article is based on 4461 references which the present author has selected from the amazing number of literatures mentioned just above. In consideration of the fact that more than 500 articles about work function and related subjects have long been published every year [SciFinder, CAS Solution], however, the above references seem to be much less than a half of the literatures published to date for reporting originally the theoretical or experimental data on work function (ϕ^e, ϕ^+ and/or ϕ^-) of the chemical elements and also for including both criticism and discussions about work function and related subjects. But, it is practically impossible to cover the remnant half or more by a single author alone.

Unfortunately, the present author has little time and health enough (1) to enrich sufficiently both contents and explanation in text, (2) to analyze fully the large amount of experimental and theoretical data listed in Table 1, (3) to integrate comprehensively the progress and results achieved by theoretical studies about work function and related subjects, (4) to examine carefully the possibility of overlooking very important articles on work function, (5) to survey adequately these literatures published especially after $\sim$2013, (6) to check thoroughly his inadvertent errors and inattentive mistakes made probably in this article, and also (7) to improve acceptably the readability of this article writing until convincing himself. This is mainly because he has long been much suffered by disease and disorder due to advancing in age. In consequence, for example, he has little analyzed critically these work function data achieved by quantum theory for various surface species by a good many workers and also hardly discussed quite many other important subjects and problems. At least, however, Table 1 including more than ten thousands of work function data and also 490 footnotes may be helpful to many readers for inspecting a variety of work function studies made to date under various conditions and methods in many fields of both pure and applied physics and chemistry. In addition, Table 2 may be useful as an up-to-date and reliable source for quickly finding the most probable values of ϕ^e, ϕ^+ and ϕ^- with regard to both mono- and polycrystalline surfaces of most or several of the chemical elements.

In this article, a theoretical analysis is made deeply for the experimental data on thermionic contrasts ($\Delta\phi^*$) for various mono-, submono- and polycrystalline surfaces, thereby yielding the new findings that δ_m is the key factor mainly governing the effective work functions of patchy surfaces ($\delta_m < 1$) and also that submonocrystal ($0.5 < \delta_m < 1$) should be taken into consideration as

another type (category) much different in work function characteristic from both polycrystal ($\delta_\mathrm{m} < 0.5$) and monocrystal ($\delta_\mathrm{m} = 1$). Such a deep analysis, however, is little attempted here for the work function data achieved by quantum theory and also for the work function changes around various critical temperatures, mainly because of his poverty in health.

As already exemplified in Footnotes 484–486 in Table 1 and also in those 5, 6, 10, 12 and 13 in Table 2, it is generally very difficult for any authors to be perfectly free from inattentive errors in any publications. On account of the poverty in both time and health mentioned above, particularly, the present author has the strong fear that both inadvertent errors and unconscious mistakes have been made probably here and there in this article. He hopes that such probable failures and defects may be adequately corrected and improved in the future by other authors.

Finally, he strongly desires and expects that the insufficient database and inadequate analysis as tentatively compiled in this article should be much enriched and improved in both quantity and quality by next generation so as to respond adequately to a continuous progress in the fields of work function and related subjects.

Acknowledgments

Appendix. List of main symbols

a	lattice constant (cf. Section 5.5.2 and Eq. (13))
A_R	Richardson constant = 120 A/cm^2 K^2 (cf. Section 2.8.6)

A_r	apparent Richardson constant $= (1 - r^e) A_R$ (cf. Section 2.8.6 and Eq. (8))
AI	autoionization (cf. Section 2.8.1 and Table 1)
cnt	carbon nanotube (cf. Section 2.1 and Table 1)
C_p	coefficient of 1/2 or 3/8 (cf. Eq. (17) and Section 11.1)
CPD	contact potential difference (cf. Sections 2.8.1 and 2.8.2 and also Table 1)
CS	conductive spectroscopy (cf. Section 2.8.1 and Table 1)
CVD	chemical vapor deposition (cf. Table 1 and Section 2.2)
D_b	dipole barrier on a surface (cf. Eq. (15), Section 6.1 and Fig. 2)
D_s	surface-atom density (cf. Table 8 and Section 5)
d	diameter (cf. Section 2.1 and Table 1)
d_G	distance from Gibbs surface to the image surface (cf. Section 11.2 and Eqs. (18) and (19))
dhcp	double hexagonal close-packed structure
e	elementary electric charge (cf. Eqs. (17)–(21) and Section 11)
E	electron affinity (cf. Eqs. (6) and (19) and also Sections 2.3, 2.6 and 11.2)
E^+	desorption energy of positive ion (e.g., M^+) (cf. Section 4.1 and Eq. (9))
E^0	desorption energy of neutral atom (e.g., M) (cf. Section 4.1 and Eq. (9))
E_F	Fermi energy of bulk (cf. Eqs. (15) and (16), Sections 6.1 and 6.2 and also Fig. 2)
0^E	extrapolation of temperature down to 0 K in order to estimate ϕ_0^e (cf. Section 2.5 and Table 1)
F_i	fractional surface area of the patchy face (i) (cf. Sections 1 and 4 and also Eqs. (1)–(4))
FE	field emission (cf. Sections 2.8.1 and 9 and also Tables 1, 8–11 and 14)
F_m	fractional surface area largest among F_i's, corresponding to the degree of monocrystallization (δ_m) and having ϕ_m (cf. Section 4)
fp	fine particle (cf. Section 2.1 and Table 1)
HOPG	highly oriented pyrolytic graphite (cf. Section 2.1 and Tables 1, 2, 4 and 5)
I	ionization energy (cf. Eqs. (5), (9), (18), (20) and (21) and also Sections 2.6, 4.1, 11.2 and 11.3)
i^+	positive ion current (cf. Sections 2.6 and 4.1)
ins	insulator (cf. Section 2.1 and Table 1)
IP	ionization potential (cf. Sections 2.8.1 and 11.3 and also Table 1)
ITO	indium tin oxide (cf. Section 2.1 and Table 1)
k	Boltzmann constant (8.617×10^{-5} eV K^{-1}) (cf. Eqs. (1)–(3), (5), (6) and (8))
k^0	neutral desorption rate constant having the relation of $k^0 = $ (const) $\times$ exp $[-E^0/kT]$ (cf. Section 4.1)
k^+	ionic desorption rate constant correlated as $k^+ = $ (const) $\times$ exp $[-E^+/kT]$ and also done with the positive ionization coefficient (α^+) by $\alpha^+ = k^+/k^0$ (cf. Sections 2.6 and 4.1)
M	neutral atom (e.g., alkali) (cf. Section 2.6)
M^+	positive ion of M (cf. Sections 2.3 and 2.6)
M^-	negative ion of M (cf. Sections 2.3 and 2.6)
ML	monolayer (cf. Sections 2.2, 7.1 and 8.2)
MX	diatomic molecule (e.g., alkali halide) (cf. Section 2.6)
nw	nanowire (cf. Section 2.1 and Table 1)
NSI	negative surface ionization (thermal negative ion emission) (cf. Sections 2.6 and 2.8.1 and also Table 1)
O=Ti	oxygenated titanium (cf. Section 2.1 and Table 1)
P_r	residual gas pressure inside the vacuum vessel including a sample surface (cf. Section 2.4 and Table 1)
PE	photoelectric effect (cf. Section 2.8.1 and Table 1)
PSI	positive surface ionization (thermal positive ion emission) (cf. Sections 2.6, 2.8.1 and 4.1 and also Table 1)
r	radius of a fine particle (cf. Eqs. (17) and (17′) and also Section 11.1)
r_c	effective radius of a spherical cluster as calculated from its density and weight (cf. Section 11.3 and Eq. (20))
r^e	internal reflection coefficient of electron, usually treated as in the form of $(1 - r^e) A_R$ (cf. Section 2.8.6)
r_s	Wigner–Seitz radius (cf. Fig. 2, Eqs. (16), (18), (19) and (21) and also Sections 6.1, 6.2, 11.2 and 11.3)
ΔS^+	entropy change due to positive ion production of M^+ from M (cf. Section 2.6)
ΔS^-	entropy change due to negative ion production of X^- from X (cf. Section 2.6)
SP	stopping potential (cf. Section 2.8.1 and Table 1)
SSI	self surface ionization (cf. Section 2.3)
T	temperature of a sample surface adopted for work function measurement (cf. Section 2.5 and Tables 1 and 14)
T_a	annealing temperature, usually recommended to be above $T_m/3$ (cf. Section 2.5) and given in parentheses at the back of T like as ~300 (~900) in the 5th column in Table 1
T_A	allotropic transition temperature (cf. Section 7.1)
T_C	Curie temperature (cf. Section 8)
T_d	sample deposition temperature listed as in the form of $\{T_d\}$, which is usually different from that (T) selected for work function measurements (cf. Table 1 and Section 2.5)
T_m	melting point (cf. Sections 2.5, 5.5.3, 5.5.4 and 7.2 and also Eq. (14))
T_S	superconductive transition temperature (cf. Section 9)
TC	theoretical calculation (cf. Sections 2.8.1, 2.8.3–2.8.5, 4.2, 5.5.2, 5.5.4, 6.1, 6.2 and 11 and also Tables 1, 6 and 9–13, in addition to Eqs. (1)–(3), (7) and (13)–(21))
TCS	total current spectroscopy (cf. Section 2.8.1 and Table 1)
TE	thermal electron emission (cf. Section 2.8.1 and Table 1)
V	atomic volume (cf. Section 5.5.4 and Eq. (14))
w^+/w^0	statistical weight ratio of ion (M^+) to atom (M), generally equivalent to exp $[\Delta S^+/k]$ (cf. Eq. (5) and Section 2.6)
w^-/w^0	statistical weight ratio of ion (X^-) to atom (X), generally equivalent to exp $[\Delta S^-/k]$ (cf. Eq. (6) and Section 2.6)
X	neutral atom (e.g., halogen) (cf. Section 2.6)
X^-	negative ion of X (e.g., halogen) (cf. Section 2.6)
X	electronegativity (cf. Eq. (7) and Section 2.8.3)
z	number of valence electrons per atom (cf. Section 5.5.2 and Eq. (13))
Z	charge state (cf. Section 11.3 and Eq. (20))
α	temperature coefficient of the work function of a clean surface, usually treated as in the form of $\phi_T^e = \phi_0^e + \alpha T$ (cf. Sections 2.5 and 7–10)
α^+	positive ionization coefficient of sample atom (e.g., M) (cf. Eq. (5) and Section 2.6)

α^-	negative ionization coefficient of sample atom (e.g., X) (cf. Eq. (6) and Section 2.6)
β^+	positive ionization efficiency of sample atom or molecule (e.g. M or MX) (cf. Eq. (5) and Section 2.6)
β^-	negative ionization efficiency of sample molecule (e.g., X_2 or MX) (cf. Eq. (6) and Section 2.6)
γ_c	binary alloy component having the range of 0–1 = 0–100% in mole fraction (cf. Sections 2.5 and 4.5)
δ	correction of the spherical cluster radius according to the electron spillover into vacuum (cf. Section 11.3 and Eq. (20))
δ_m	degree of monocrystallization corresponding to the largest (F_m) among the fractional surface areas (F_i's) with the range of 0–1 = 0–100%, governing strongly ϕ^+, ϕ^e and $\Delta\phi^*$ in a different mode between polycrystal ($\delta_m < 0.5$) and submonocrystals ($0.5 < \delta_m < 1$) (cf. Section 4, Eqs. (10)–(12), Table 6 and Fig. 1)
ε	surface energy (cf. Sections 5.5.1 and 5.5.2 and also Eq. (13))
ρ	quantum correction of bulk work function for spherical cluster (cf. Section 11.3 and Eq. (20))
Δ	difference of ϕ^e between our most probable value and another recommended for each surface species by Ref. [1045,1358] or [1354] in Table 2 (cf. Section 3.2 and Table 3)
$\Delta\phi^*$	thermionic contrast between the effective work functions for positive-ionic and electronic emissions, equal to the difference ($\phi^+ - \phi^e > 0$ for both poly- and submonocrystal surfaces) (cf. Tables 4–6, Sections 4.1–4.4 and Fig. 1)
$\Delta\phi^{**}$	thermionic contrast between the effective work functions for negative-ionic and electronic emissions, equal to the difference ($\phi^- - \phi^e = 0$ for any surface species) (cf. Section 4.6 and Table 7)
θ	surface coverage of adsorbate (cf. Sections 2.2, 7.1 and 8.2)
θ_c	critical coverage at which the metastable film changes in both phase and Curie point (cf. Sections 7.1 and 8.2)
ϕ	so-called "work function" generally used without distinction among ϕ^e, ϕ^+ and ϕ^- (cf. Eqs. (9), (15) and (16) and also Sections 1, 4.1, 6.1 and 6.2)
ϕ_i	local work function corresponding to the patch face (i) of a poly- or submonocrystalline surface (cf. Eqs. (1)–(4), Table 6, and also Sections 1 and 4)
ϕ^a	simply averaged work function of a poly- or submonocrystalline surface, generally intermediate between ϕ^+ and ϕ^e (cf. Eq. (4), Table 6, and Sections 1 and 4)
ϕ^e	effective work function for electron emission, generally equal to ϕ^- for any surface, but different from both ϕ^+ and ϕ^a for any poly- and submonocrystals (cf. Sections 1, 2 and 4, Eq. (2) and Tables 1–4 and 6–14)
ϕ^e_0	work function at 0 K (cf. Section 2.5 and Table 1)
ϕ^e_H	work function to be evaluated from Eq. (8) (cf. Section 2.8.6)
ϕ^-	effective work function for negative ion emission, generally equal to ϕ^e for any surface species (cf. Eqs. (3) and (6), Tables 1 and 7 and also Sections 1, 2.6, 3 and 4.5)
ϕ^+	effective work function for positive ion emission, generally larger than ϕ^e for any poly- and submonocrystalline surfaces (cf. Eqs. (1) and (5), Tables 1, 2, 4, 6, 9 and 10 and Sections 1, 2.6, 3, 4 and 5.2–5.4)
ϕ_m	local work function belonging to the largest surface area (F_m) and hence to the degree of monocrystallization (δ_m) (cf. Section 4)
ϕ_{max}	maximum value among the local work functions (ϕ_i's) of various patchy faces (1–i) of poly- or submonocrystalline surface, generally having the sequence of $\phi_{max} > \phi^+ > \phi^a > \phi^e > \phi_{min}$ (cf. Fig. 1 and Section 4.3)
ϕ_{min}	minimum value among the local work functions (ϕ_i's) of various patchy faces (1–i) of poly- or submonocrystalline surface (cf. Fig. 1 and Section 4.3)
ϕ_μ	minimum value to be usually found for an A/B sample system at $\theta < 1$ ML in a plot of ϕ^e vs. θ (cf. Section 2.2)
ϕ^e_0	work function effective for electron emission at the temperature extrapolated to 0 K, corresponding to 0^E (cf. Section 2.5 and Table 1)
ϕ^e_r	work function to be found experimentally together with $A_r \neq 120$ A/cm^2 K^2 (cf. Section 2.8.6 and Eq. (8))
$\phi^e(r)$	work function of a fine particle with a radius of r (cf. Section 11.1 and Eqs. (17) and (17′))
ϕ^e_T	work function effective for electron emission at T, usually having the relation of $\phi^e_T = \phi^e_0 + \alpha T$ (cf. Section 2.5)
$\phi^e(\infty)$	work function equivalent to ϕ^e(poly) of bulk (cf. Eqs. (17)–(21) and Section 11)
τ^0	neutral atom adsorption lifetime correlated with E^o by Frenkel's equation of $\tau^0 = $ (const) $\times$ exp $[E^o/kT]$ (cf. Section 4.1)
τ^+	positive ion adsorption lifetime correlated with E^+ by Frenkel's equation of $\tau^+ = $ (const) $\times$ exp $[E^+/kT]$ (cf. Section 4.1)

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Biography
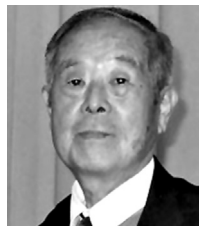
H. Kawano was born in Shimonoseki in 1934. After graduation from Hikoshima Junior High School and Shimonoseki West High School, he attained the B.Sc., M.Sc. and D.Sc. degrees at Kyoto University, Japan. He was Assistant Professor at Research Institute for Scientific Measurements, Tohoku University, Sendai, from 1962 to 1970, and was Associate Professor or Professor at Ehime University, Matsuyama until 2000, and now Professor Emeritus. He has authored or coauthored more than 200 original papers and review articles in the areas of physical chemistry and surface science, especially focused on the experimental and theoretical studies about the mechanism and processes of surface reactions emitting ions and electrons together with neutral atoms and molecules from various solid surfaces heated or electron-stimulated in vacua.