ISSN No:-2456-2165

Mechanism of Hydrogen Embrittlement by Volumetric Expansion and Transmutation by Cold Fusion

(Request for the Transmutation Experiment with H_2 Gas to Prove the Mechsnism of Cold Fusion and of Hydrogen Embrittlement.)

Noriyuki Kodama
Techno Gateway Co. Ltd.
4-4-7 Hachiman-dai, Kisarazu-city, Chiba prefecture, Japan 292-0814

Abstract:- New mechanism of hydrogen embrittlement (HE) of metals based on my cold fusion mechanism is proposed. Low temperature HE is caused by the volumetric expansion at grain boundary based on the conventional theory and based on cold fusion that hydrogen negative ion can occupy expandable T site. High temperature HE is caused by vacancy generation by transmutation with femto-hydrogens generated by Cold Fusion. Because hydrogen can be positive(proton) if the metal is positive voltage, and the T site center is negatively charged because of the electronegativity of metal. On the grain boundary surface, metal lattice is imperfect and T-site vertex atom can have no bond to the adjacent lattice and it can move easily to have hydrogen negative ion with larger size than original T site space. I call this T site, expandable T-site. Thus, hydrogen can turn to negative ions with very large size by electrons at the expandable T site, which cause very large stress at grain boundary by volumetric expansion by hydrogen negative ions. Hydrogen environmental Embrittlement(HEE) is caused by the transmutation of metal atoms by femto-H_2 created by the compression of covalent bond of hydrogen molecule at the expanded T site because of H^+ joins to H^- to be H_2 at expanded T site. This mechanism to generate femto-hydrogen molecule is based on the electron deep orbit theory, which has been verified theoretically. Transmutation generates vacancies and interstitial atoms in metal, and the large number of vacancies aggregate into void which causes HEE at high temperature. The transmutation experiments by Cold Fusion with D_2 gas verified that atomic number increases by 4. Because generated femto-D_2 by compression of D_2 at expandable T site can shield the coulomb repulsive force shielding to cause Cold Fusion. Although the number of femto-D2 seems to be very small due to the fusion consume D2 molecule. Transmutation experiment uses femto-D_2 during Cold Fusion and transmutation is caused by the addition of two deuteron (d) to the target metal nucleus. Because experiments show clearly that increase of atomic number after transmutation is 4, therefore 2d=4 and d must have two charge, therefore, d must be constituted by 2 two protons and one internal electron, d is not constituted by proton and neutron. Thus, the nucleus is constituted only by proton and internal electron, and "neutron" is a pair of proton and electron in the tight bound state, which is the theory before the introduction of neutron. Because this finding has enormous impact on science, I would like to request researchers and institutions who study HE to study transmutation with femto-H_2 to verify that cold fusion is caused by femto-D_2 and hydrogen environmental embrittlement is caused by Cold Fusion, which will show that current nucleus model and neutron model are incorrect.

Keywords:- *Hydrogen Embrittlement; Cold Fusion; Electron Deep Orbit; Hydrogen Environmental Embrittlement; Neutron Nucleus Model.*

I. INTRODUCTION

Research on hydrogen embrittlement (HE) has continued for a long time because of its importance, however, we have neither common understanding nor standard theory. Existing theories are just a hypothesis, which are not reasonable physically. Therefore, now is the time to have totally different approach on HE theory.

High temperature Hydrogen environmental embrittlement (HEE) should have a mechanism similar to cold fusion, because they are similar in that hydrogen causes embrittlement and deuterium causes cold fusion. I presume that HEE is caused by vacancy generation by femto-H2 molecule based on Cold Fusion theory.

I found that some types of hydrogen embrittlement are caused by cold fusion, and some types of HE can be explained by the extension of conventional HE theory.

Therefore First, I will explain the Cold Fusion and its mechanism, and current transmutation experiment with D_2, gas which should probe the mechanism of Cold Fusion is inconsistent with nuclear physics and particle physics.

ISSN No:-2456-2165

II. HISTORY OF COLD FUSION

On March 23, 1989, Martin Fleischmann of the University of Southampton, UK, and Stanley Pons of the University of Utah, USA, announced to the media that they had discovered a phenomenon in which nuclear fusion occurs at room temperature, and the term of cold fusion was coined. It became widely known to the world. Fleischmann and Pons placed a palladium rod and a platinum plate electrode in a test tube filled with heavy water as is shown in Fig.1, they left them for several days under deuterium absorption condition. A part of Rod was melted due to the very high temperature.

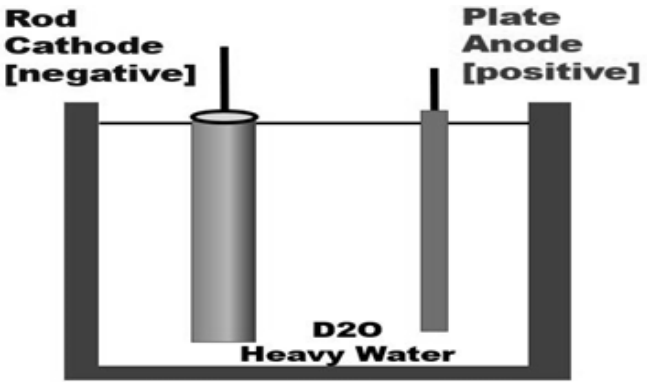

Fig 1 Experimental set-up of FPE

However, in this experiment as in Fig.1, Cold fusion was triggered by chance at the stage of loading deuterium in the Rod Cathode, which is now called FPE (Fleischmann and Pons Effect). The mechanism of FPE and Cold Fusion is explained in ref [1].

III. PROPERTIES OF HYDROGEN IN METALS

It is important to understand the nature of hydrogen in metal for both Cold Fusion and HE.

Several semi-empirical methods have been proposed for the property of hydrogen in metal[2]. Among them is a geometric model based on the size of the space in the metal lattice by Westlake. Although this is a very simple method, it is effective as a first approximation. About the electronic state of hydrogen in metal, we had two hypos.

- *A proton model in which a hydrogen atom completely releases an electron and becomes* H^+ .
- *On the contrary, an anion model in which one extra electron is taken in and the state becomes* H^-.

Changes in electrical resistance, magnetic susceptibility, and electron specific heat due to hydrogen absorption have been explained by model of (1) or (2) that is more convenient.

However, recent theoretical calculations of the electronic state of metal hydrides, founded by Switendick, have shown that both of the above two models turned out to be only one side of the truth.

Thus I hypothesized that hydrogen in metal has the possibiliy of both positive and negative ion properties simultaneously, and both electronic state in metal and geometry of space and size of hydrogen determin wether it is H^+, H^-or H0 at Space. I started my cold fusion study from this hypo that both D^+ and D^- can exist at the same time to be D_2 in the metal which might cause fusion.

IV. MECHANISM OF OF COLD FUSION

➢ *Nano-Structure on the Metal Surface*

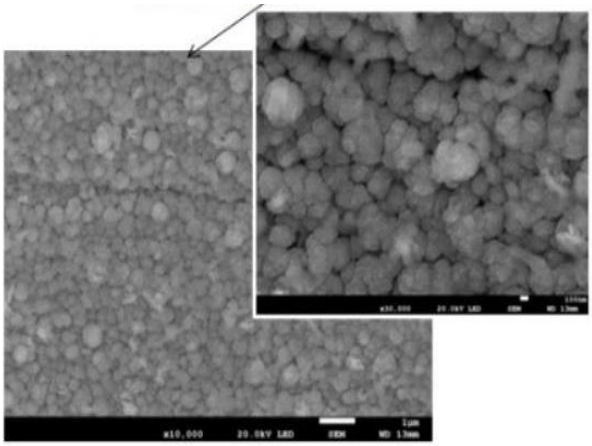
Fig 2 SEM Micrograph of the Nickel Surface After Cold Fusion

Cold Fusion occurs on the metal surface with nano-roughness (nano-structure).

➢ *Lattice Structure for Cold Fusion*

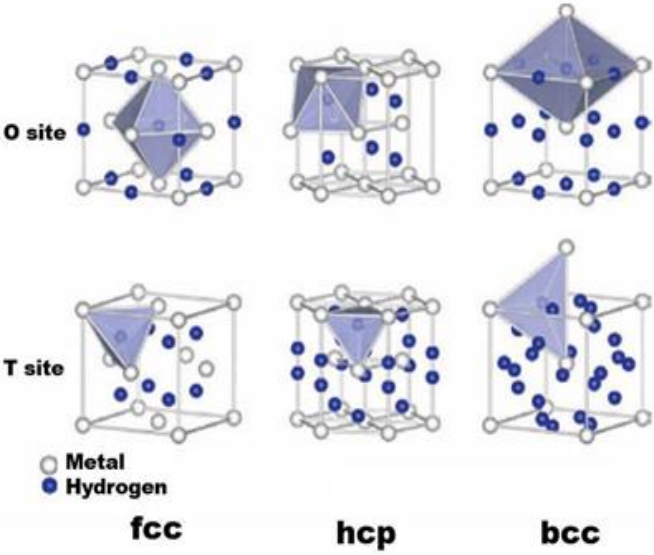

Fig 3 Types of Metal Lattices (O: Octahedral Sire, T: Tetrahedral Site)

A surprising fact that almost all Cold fusion phenomenon has been observed in fcc (and hcp) transition-metal hydrides and deuterides is mentioned in [3]. Because fcc and hcp have the closest packed structures shown in Fig.

3 and the size difference between O site and T site suggests that the Cold fusion could occur at the surface T site because this feature indicates that cold fusion is caused by the very narrow space. I thought that the compression of molecules(D_2) on the metal surface cause Cold Fusion of my first hypothesis.

The Close-packed structure of FCC can cause very high compressing stress at T site, which internal space is narrower than the size of atomic hydrogen to bring ds into contact.

➢ *Deuterium Distribution in Nano Metal Particle*

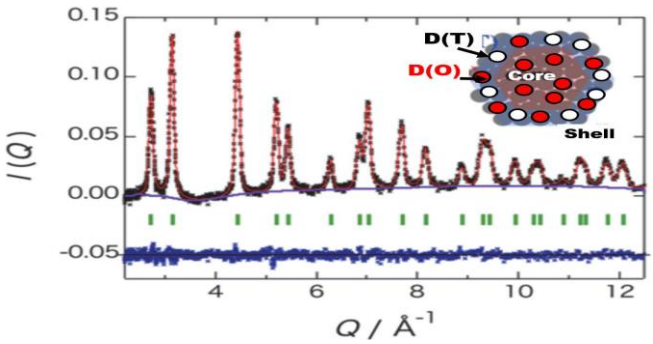

Fig 4 Powder neutron diffraction data of metal nanoparticles measured by NOVA spectrometer at J-PARC and their Rietveld analysis results [4]

I found the paper that showed the deuterium distribution in nano-metal particle, and I think that nano metal surface is similar to nano-structure surface in that they have a curvature of nm size.

Reference [4] shows that deuterium distribution in the nanometal particles by powder neutron diffraction of the same sample measured with his NOVA spectrometer at J-PARC. They conducted neutron powder diffraction experiments to investigate the structure of Pd nanoparticles and their deuterides. These analyses have been determined that D atoms occupy only the O sites in the central region and also the T sites in the near-surface regions. This is in contrast to the results for bulk metal, where deuterium occupies only O sites not T-site due to the size difference.

➢ *Expandable T site on the Metal Nanostructure*

Because I had a hypothesis that cold fusion is caused by compression of deuterium molecule(D-D covalent bond), so I investigated the characteristics of the nano-structure on the surface of this nanometal particle wether hydrogen could exist in the T-site. I will show my finding and understanding of feature of nano-structure based on my first hypo in Fig.4.

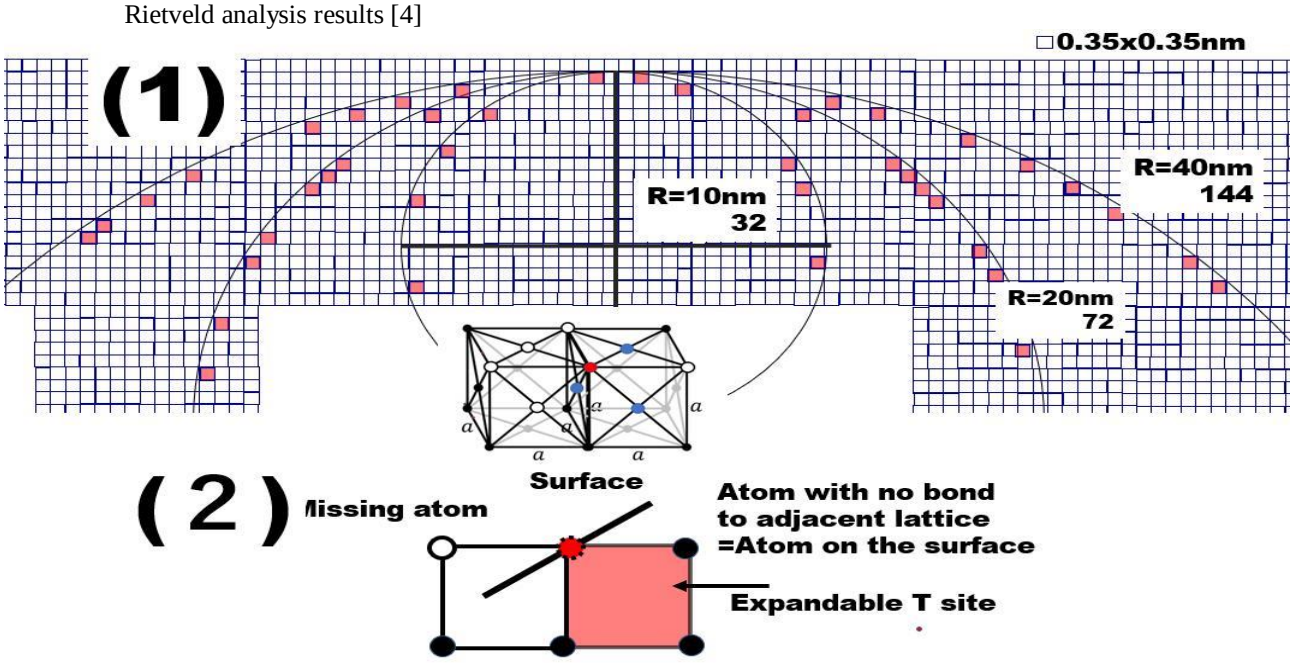

Fig 5 Expandable T site on tne Surface with Nano-Roughness

Occupying the T site by hydrogen is impossible by the geometric model of hydrogen in metal, therefore it must be the feature on the surface not in the bulk. Fig.5(1) shows the schematics of the lattice size and surface roughness at the same scale to understand the feature of the lattice on the surface. Roughness size is 10,20,40nm, and 20nm at which HE at grain boundaries is a issue. The figure shows an feature of the nano-structure on the surface. As is shown in Fig.5(2), Crystal lattice is imperfect on the surface and some T-site vertex atom(Red in Fig.5(2)) has no bond to atom of the adjacent lattice on the surface. Therefore such vertex atom can move outward due to no bond, and such T site can be expanded by occupying hydrogen. Thus I call this T site, "expandable T site". As is in Fig.5(2), the expandable T site is pink cell. Thus the total number on the surface of nano-structure can be ~10% by the eye, and it can cause HE at R=20nm and the heat generation can be caused at expandable T-site on nano roughness.

ISSN No:-2456-2165

V. ELECTRON DEEP ORBIT (EDO) THEORY

➢ *Background of EDO*

As I thought that compression of D_2 cause fusion, however I found that by rough estimation the electron density between the nucleus was too low. Thus, I looked for the theory that shows the abnormality of coulomb potential or electron density because coulomb potential is infinite at r=0. I found the theory of electron deep orbit, and the authors argued that femto D_2 causes Cold Fusion based on EDO theory in ref [5]-[17].

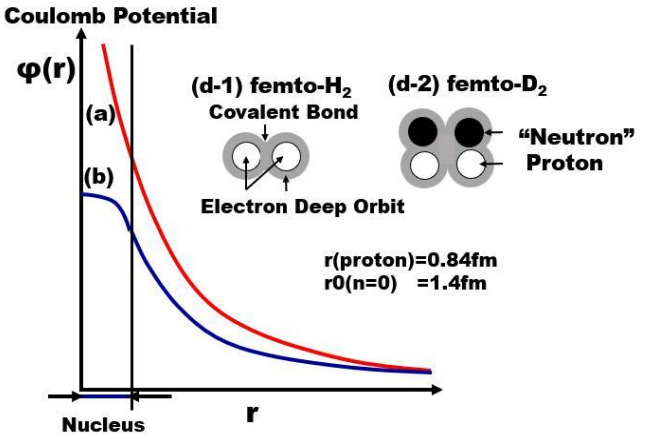

Fig 6 (a) Coulomb Potential of Point Charge Hypo and (b) Modified Hypo of Uniformly Distribution Inside Nucleus, (d-1) schematics of femto H_2 with Electron Deep Orbit. (d-2) femto D_2 with Electron Deep Orbit.

I explain the electron deep orbit theory because it is the cause of cold fusion, and because it is not in the nuclear physics as most nuclear physics researchers do not know much on it.

This section is based on the references [5]-[17], and the background of the study is described in [10,11]. I will briefly explain the history of the early days of nuclear physics. In ref [13] history is explained, and I will be summarized here.

Rutherford suggested already in 1920 that electron and proton could be tightly bound [18]. **After Chadwick's discovery of the neutron in 1932 there was a lot of discussions whether the neutron is an elementary particle or a hydrogen-like atom formed from electron and proton [19]. The assumption that the small hydrogen is a neutron was finally rejected because the wave function is infinite at r = 0.** Since nobody has observed it, the idea of the small hydrogen died. However, it revived again ~70 years later with the assumption that the proton has a finite size, and the electron experiences a different non-Coulomb potential at a very small radius [9,10]. The modified Coulomb potential is not infinite at r=0, because the positive charge is distributed inside nucleus. Because of the very narrow orbit of a few femto meters from the nucleon, it has a perfect Coulomb repulsive force shielding, shown in Fig. 5(c)(d).

In case of H_2, it should be a small H_2 (femto H_2) molecule as shown in Fig. 5(d), and femto D2 cause the cold fusion and femto H2 cause HEE, as are explained later.

➢ *Experimental Evidence of EDO of Hydrogen*

-High Compressibility of hydrogen negative ion-

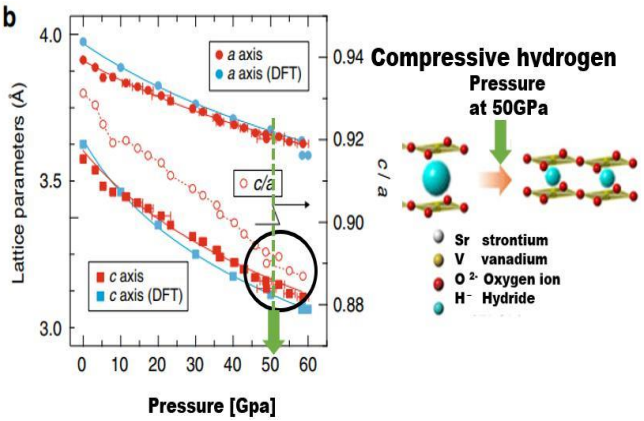

Fig 7 High-Pressure behavior of SrVO2H and SrFeO [20]

Stress dependence of lattice parameters for the experimental (red) and the DFT-computed (sky blue) values of SrVO2H – note that some error bars are smaller than the width of the symbols. The decrease in stress from 52GPa to 49GPa as the cell volume decreases suggests a phase transition to a denser phase.

This compressive hydrogen research is the direct evidence that EDO exists. Based on this research, I hypothesized the small Hydrogen molecule (femto-H_2 and femto-D_2) exists as is shown in Fig.5(d), and hypothesized the mechanism of cold fusion.

➢ *Transition from D1s to D0s (Deep Orbit) by the Compression of D–D Covalent Bond*

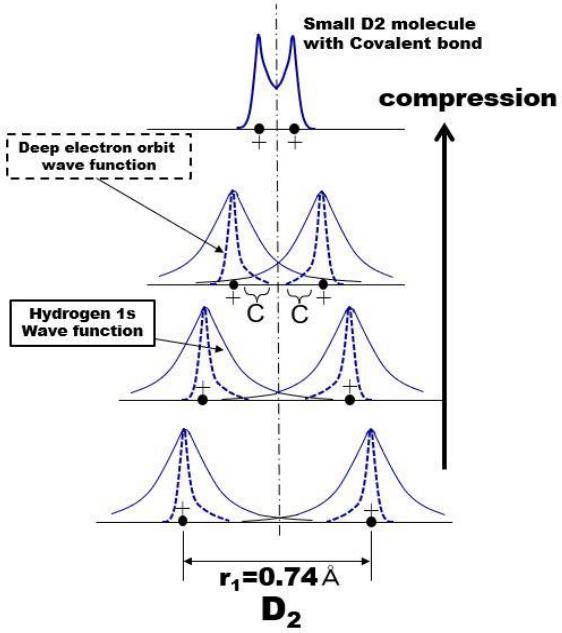

Fig 8 Mechanism of Small Molecules (Femto Molecules) Generation by the Compression of D-D Covalent Bond

The mechanism of electron transition to EDO proposed in Fig. 7.

The size of D_2 at the surface T site is determined by the balance between the compression stress from the lattice metal atoms and the elastic constants of covalent bonds in D_2. The compression can cause the d-d distance shorter in d-d compression direction that brings two ds to be closer together in a collision direction. The shorter distance between ds, the electron wave function of n=1 is closer to the wave function of EDO of another d, and the overlap of wave function increases the probability of electron transition from n=1 to Electron deep orbit(n=0). Probability of this transition can be very high because the compression of D_2 continues for a long time.

VI. MECHANISM OF COLD FUSION

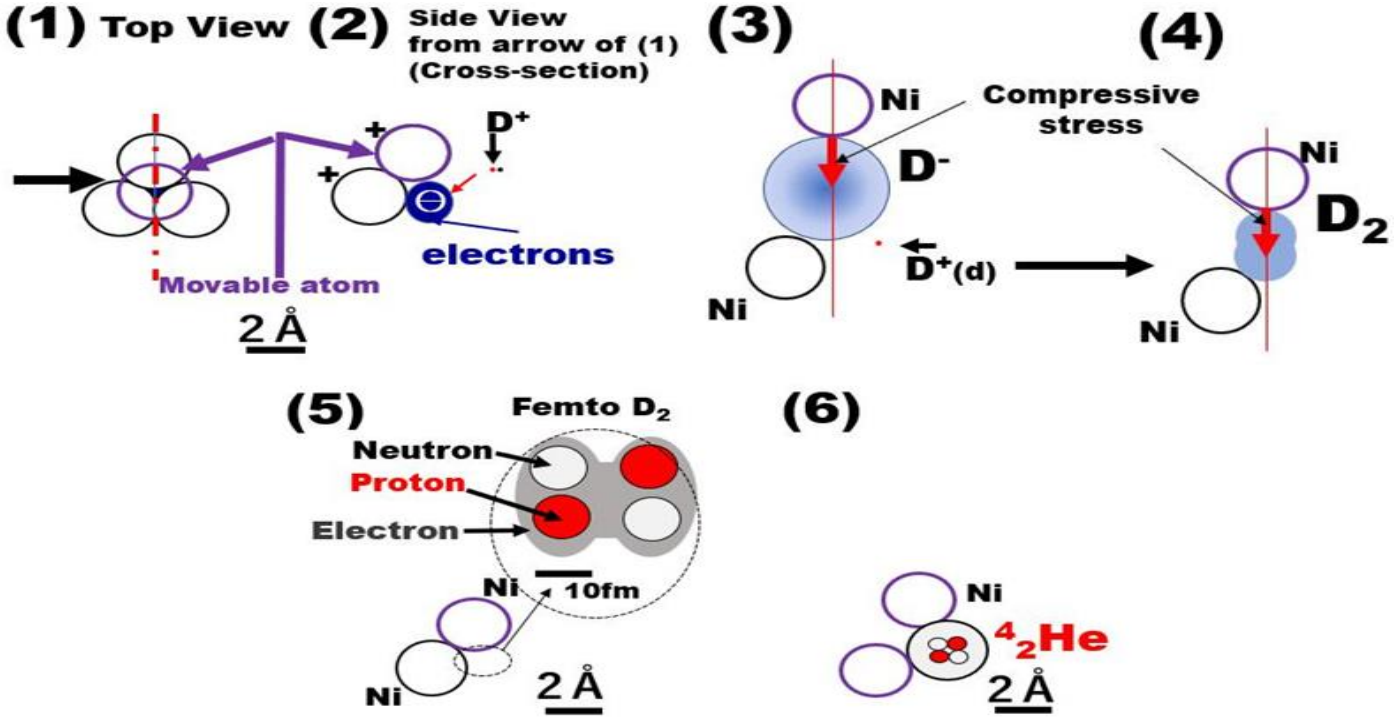

Fig 9 Mechanism of D^- occupation and cold fusion by bond compression at T site as is shown in Fig.4

- At the T site of FCC metal, there are three metal atoms and vertex atom. Fig9(1) is the top view of T site, and (2) is the cross-section of (1). The metal atoms at the space of the tetrahedral space sites (T sites) can be movable and the T site is expandable as is explained in Fig.5.
- Because of the electronegativity of metal atoms, metal atoms are positively charged and they emit electrons to the outside, so the center of the T site is negatively charged.
- Because the positive deuterium ions are around the T site, deuterium enters the T site by coulomb attractive force and becomes negative deuterium ion. The size of the deuterium anion is larger than the T site, thus it expands the T site.
- Attracted by the negative deuterium ion, the surrounding positive deuterium ion combines with the negative deuterium ions in the T site to form D_2. Since the deuterium molecule is larger than the T site, it has the compressive stress by the atoms of the expanded T site.
- When the D2 is compressed by the atoms of the expanded T site, it transitions to a small deuterium molecule (hereinafter referred to as femto D2). As shown in FIG. 5, the electron orbit of the femto deuterium molecule is close to the nucleus, shielding the Coulomb repulsion between the nuclei. The existence of this femto D2 is explained in detail in the section 5.
- A fusion reaction of D+D=$^4_2$He+24MeV produces $^4_2$He as fusion ash and excess heat generation.

VII. EXPERIMENTAL VERIFICATION THAT FEMTO-DEUTERIUM EXISTS

➢ *Transmutation Experiment by Cold Fusion with D_2*

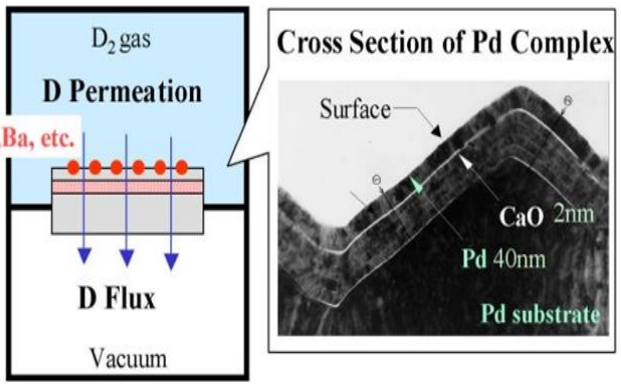

Fig 10 Transmutation Experiment Setup In [21]

ISSN No:-2456-2165

Iwamura et al studied transmutation experiment by cold fusion set-up with D_2 gas. They have so far four experiments from (1) to (4).

(1) $_{38}{}^{88}Sr + 2d = {}_{42}{}^{92}Mo$

(Atomic number increase = 4)

(half-life 1.9x10^{20}year)

(2) $_{55}{}^{133}Cs + 2d = {}_{99}{}^{137}Pr$

(Atomic number increase = 4)

(half-life 1.28 h)

(1), (2) are in the reference [19] and following (3), and (4) is the latest study

(3) $_{20}Ca + d = {}_{22}Ti$

(**Atomic number increase = 2**)

($_{22}{}^{46\sim50}$Ti half-life Stable)

(4) $_{74}{}^{182,183,184}W + 2d = {}_{78}{}^{186,187,188}Pt$

(Atomic number increase = 4)

(half-life 2.08h,2.53h,10.2d)

As is shown above, (1), (2), (4) shows that atomic number increase = 4 .These results clearly show that d is 2 charged particle(proton).

And (3) I interpret the same way that d is constituted by two protons in (1), (2), (4)

(5) $_{20}{}^{40}Ca + 2d = {}_{24}{}^{44}Cr$

(Atomic number increase = 4)

(half-life 54msec)

This fusion has very short half lifetime and following stabilization of transmuted nucleus will occur.

(6) $_{24}{}^{44}Cr + e^- = {}_{23}{}^{44}V$

(half-life = 111 msec)

(7) $_{23}{}^{44}V + e^- = {}_{22}{}^{44}Ti$

(half-life = 63y)

Therefore, (5)-(7) agrees that increase of atomic number is 4.

Therefore, all of experiment shows the same result that d is constituted by two protons.

These results clearly show that current nucleus model that is constituted by proton and neutron is incorrect and previous nucleus model before the introduction of neutron as a fundamental particle that the nucleus is constituted only by proton and internal electron is correct.

VIII. CORRECT NUCLEUS MODEL AND NEUTRON MODEL

- *The Nucleus is Constituted Only by Protons and Internal Electrons*

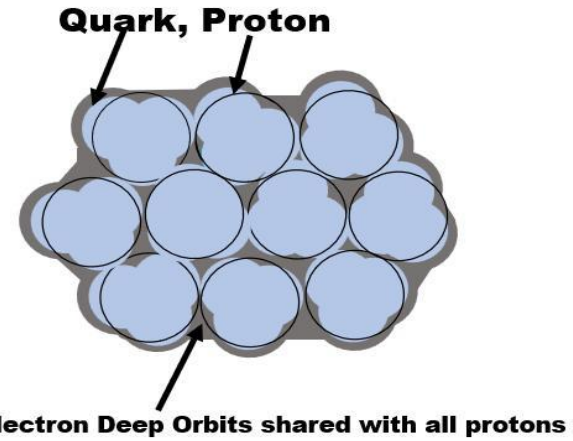

Fig 11 The Nucleus is Constituted only by Protons and Internal Electrons [22]

I explained this finding in ref [22]. The correct nucleus model is shown in Fig.11. protons can be stabilized by the internal electron in deep orbit of protons in nucleus.

- *Neutron is a Pair of Proton and Electron in Deep Orbit*

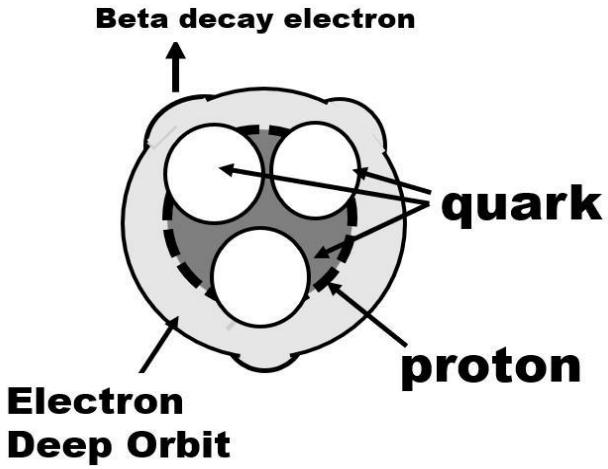

Fig 12 Neutron is a Pair of proton and Electron in Deep Orbit [22]

Because "neutron" is NOT a fundamental particle but a pair of proton and electron in deep orbit as is shown in Fig.12.

Because proton has the protrusion by quark, the electron is unstable especially at the protrusion location, electron departs from proton. This is the cause of β decay, and it is the easiest model to understand the mechanism of beta-decay of "neutron" as is also shown in 9.3.

Therefore, neutrino hypo is incorrect and no neutrino exists in this sense.

➢ *Recent Experiments to Prove the Existence of Deep Orbit*

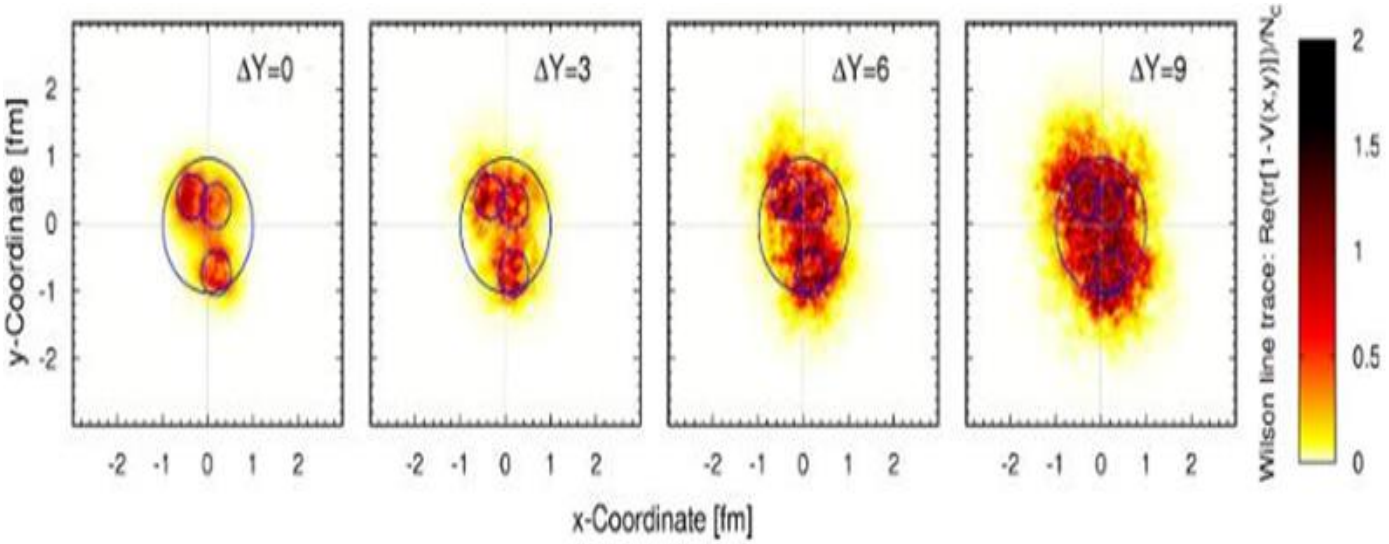

Fig 13 Proton Shape Constituted by Quarks [23]

Proton has the protrusion by three quarks shown in Fig.13.

➢ *Energy Spectra of Soft X-ray During Cold Fusion*

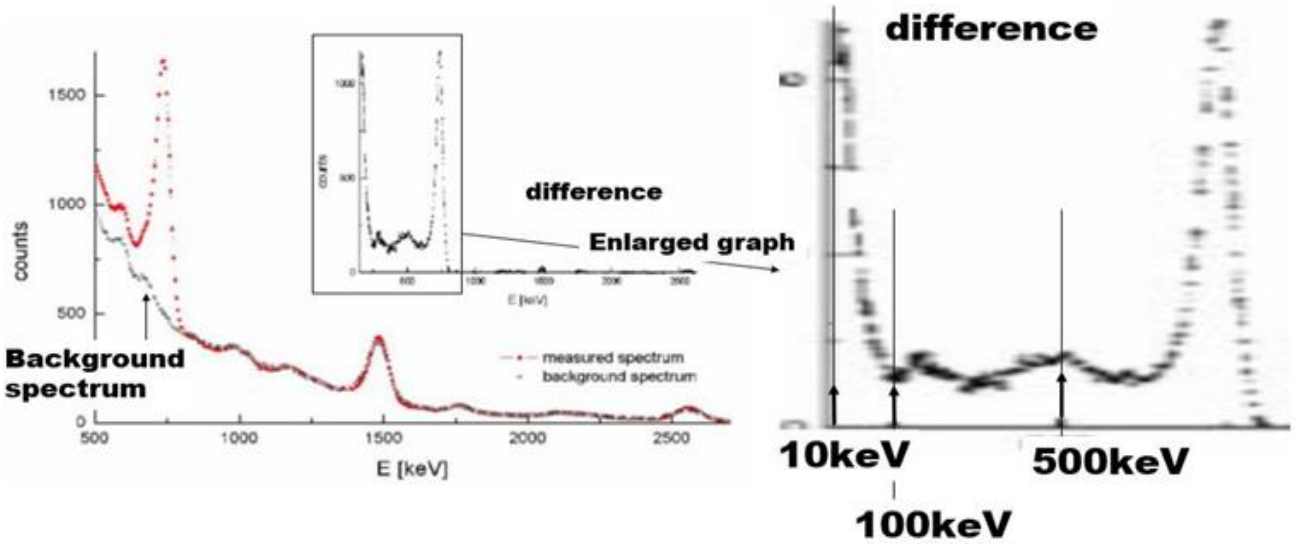

Fig 14 Energy spectra of soft X-ray during Cold Fusion [24]

Larger energy variation of deep orbit was verified by soft X-ray spectra during Cold Fusion. This experiment verified that deep electron has the larger energy variation.

I presume that current nucleus model and neutron model are incorrect based on the latest data on proton in Fig13 and cold fusion study in Fig14, which are consistent with that neutron is a pair of proton and electron in the tight state, which are more reasonable that neutron is a fundamental particle and "a pair of proton and neutron can show the mechanism of beta decay reasonably, and "neutron" can have magnetic moment due to electron in deep orbit. Because I used to study nuclear physics at university, I understand why all of nuclear physics researchers do not want to believe, however nuclear physics researcher must study the history of nucleus model and neutron introduction as a fundamental particle in ref [13], and must study the theory of Electron deep orbit and must study the Cold Fusion mechanism.

IX. CURRENT HE THEORY OF METALS

➢ *Conventional Theory of HE of Metal*

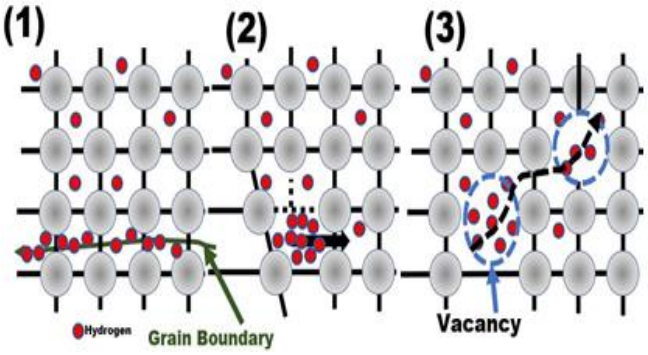

Fig 15 Previous Mechanism of HE of Metals

Many theories have been proposed for the HE theory. Fig. 15 shows schematics of three conventional HE theories.

- *Lattice embrittlement theory: Hydrogen promotes the movement and generation of dislocations, promoting local plastic deformation.*
- *Hydrogen Local Deformation Promotion Theory:*
- *Hydrogen stabilizes the formation of vacancies accompanying plastic deformation, promotes agglomeration and clustering, and facilitates the progress of ductile fracture.*
- *Hydrogen-enhanced plasticity-induced vacancy theory has been proposed, but this needs the deep discussions based on the correct analysis.*

In (1), (2) and (3), hydrogen dissolved in the interstitial space is believed to reduces the binding force between atoms, although these hypos above do not explain the mechanism to reduce binding force, and to induce vacancy. Although hydrogen atoms are believed to cause HE, hydrogen tends to be H^+(proton) in metal due to the geometric model as is in Fig15 and the mass of proton is too light to break the bond. Therefore, I Interpreted (1) and (2) by the mechanism based on the nature of hydrogen in the metal in sec 3, as is explained in 9.2.

➢ *Extended Theory of HE Based on the Volumetric Expansion by Hydrogen Atoms Inside Grain*

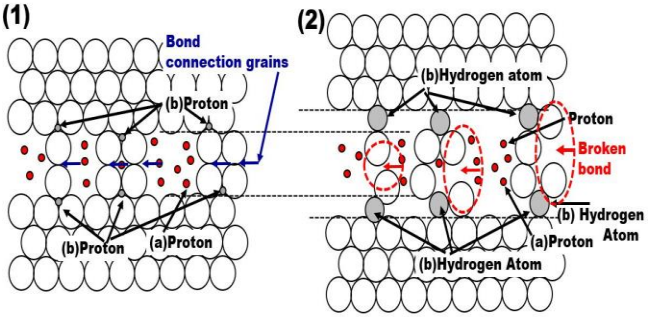

Fig 16 HE Mechanism based on Property of Hydrogen in the Metal

I would like to propose the extended HE mechanism based on the conventional property of hydrogen. Because the proton(H^+) is smaller than the metal space site it can occupy everywhere in the metal in case of metal potential is positive, and proton can segregate in grain-boundary and crystal defect due to proton's smaller size. Larger number of protons exists in the inner site of (b)(Gray) in Fig16(1) because the larger number of protons in the grain-boundary (Red) by the segregation of hydrogens(protons). After the metal potential to be on the negative side. as is shown in Fig.16(2), the proton of (1)(b) turn to (2)(b) H0(hydrogen atom) at the larger site (O site) shown in Fig.16(2)(b). If the hydrogen atom is larger than the metal space site, it expands the site to occupy the site. This can be everywhere along with grain-boundary, thus, the volumetric expansion of metal along with grain boundary can break the metal-metal bond which connects the grains shown in Fig16(2).

➢ *Impact of Metal Potential on Volumetric Expansion by Hydrogen Atoms Inside the Grain*

Root cause of this HE I Fig.16 is complicated on the metal potential. Initially proton exists at the grain-boundary and after the voltage turn to negative, hydrogen occupy the space site inside grain adjacent to the grain-boundary to expand the volume by hydrogen atom. Thus, potential affect complicated way.

➢ *Grain Boundary Embrittlement Theory*

In recent years, the inverse Hall-Petch phenomenon, in which the hardness decreases when the grain size is reduced to 10-20 nm, has become a hot topic. It has been clarified that in metals with crystal grains smaller than 10-20 nm, the inverse Hall-Petch phenomenon can be explained by the deformation mechanism via the grain boundary structure as is Fig.5.

➢ *Hydrogen Erosion*

In a high-temperature, high-pressure hydrogen gas environment, hydrogen penetrates into the steel and reacts with carbide (cementite) in the steel to decarburize the steel and generate methane gas. It is believed that methane gas accumulates at grain boundaries and causes many fine cracks due to its high pressure. The mechanism of this hydrogen erosion has been clarified.

➢ *Hydrogen Environmental Embrittlement (HEE)*

Hydrogen environment embrittlement (HEE) is a new type of embrittlement that has recently been recognized as embrittlement in high-temperature hydrogen that is not caused by hydrogen Erosion.

Embrittlement is observed under stress in high-temperature hydrogen. Moreover, this embrittlement is found in materials that are put to practical use in high-temperature hydrogen utilization plants under the temperature and hydrogen pressure of industrial operating conditions, so this is an important industrial problem.

X. PROPOSED MECHANISM OF HE BASED ON COLD FUSION

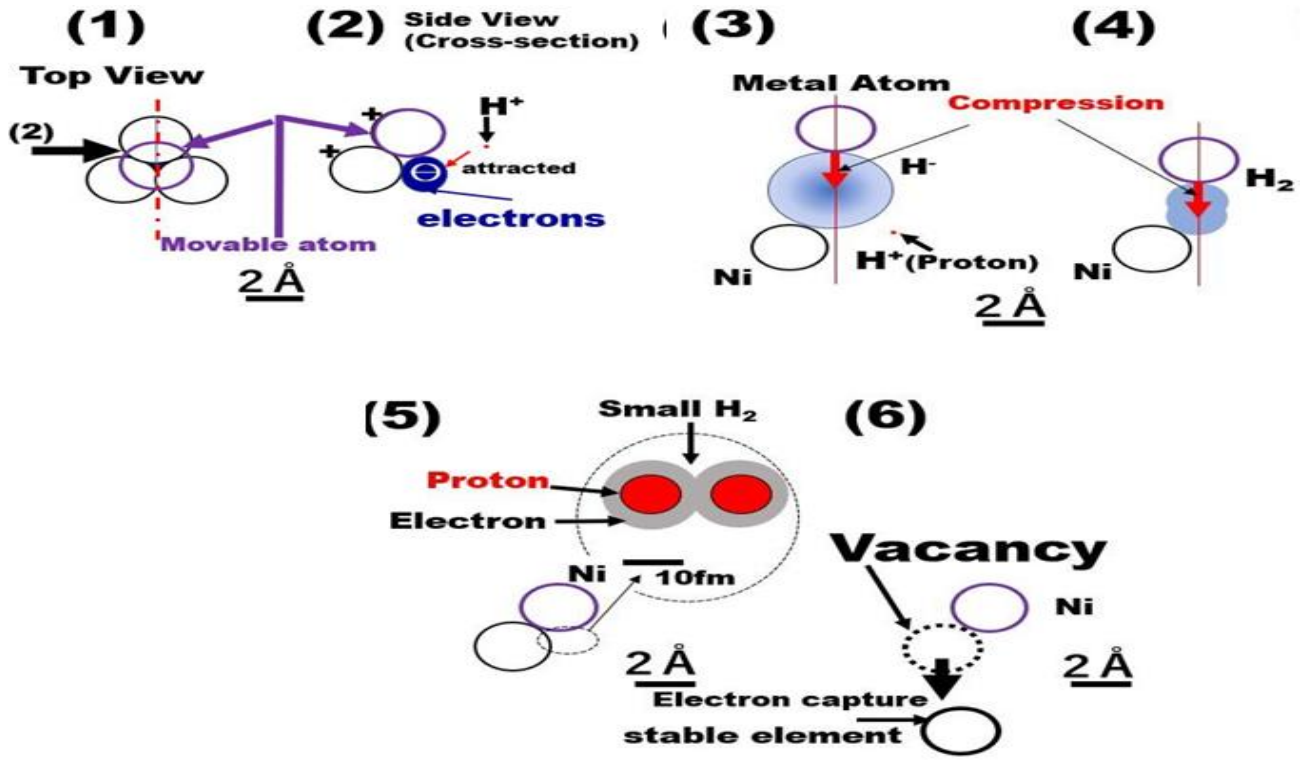

Fig.17 Mechanism of HE
(1)-(3) volumetric expansion at T site
(4)-(6) transmutation with femto-H2 to generate vacancy.

➢ *Volumetric Expansion by Hydrogen Negative Ion*

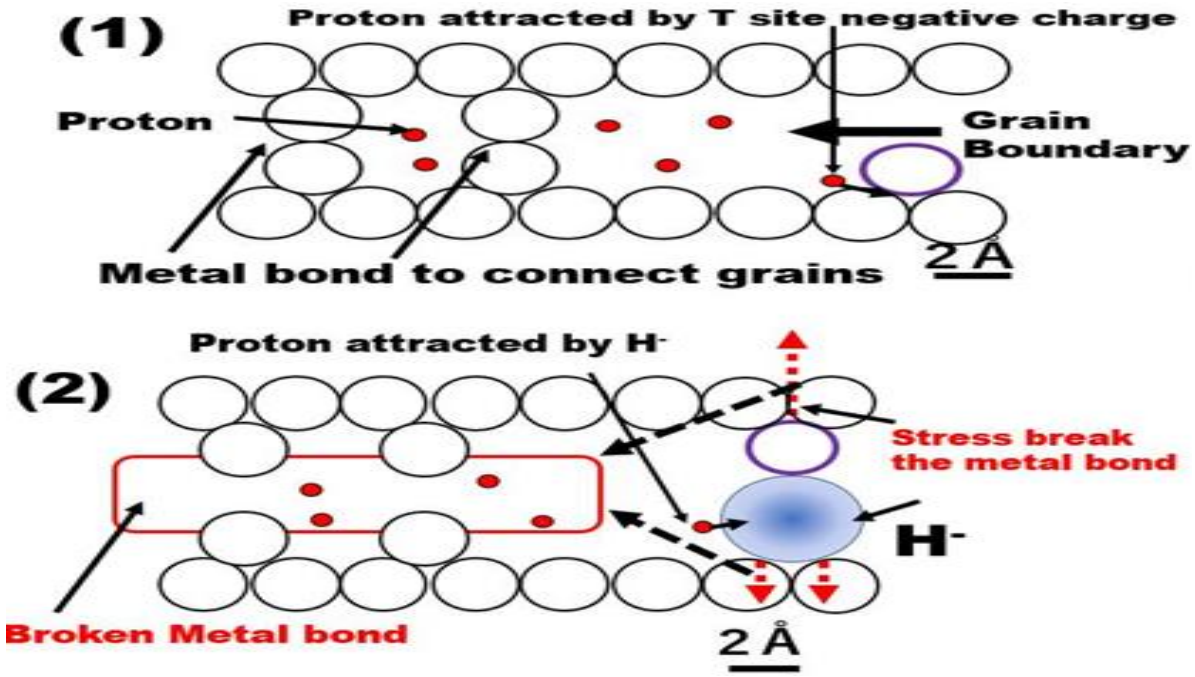

Fig 18 Mechanism of Volumetric Expansion at T Site and Vacancy Generation

Fig 18(1)-(2) shows the mechanism of HE at low temperature by volumetric expansion by hydrogen negative ions at grain-boundary shown in Fig.17(1)-(2)-(3). The larger size of hydrogen negative ions at the expanded T site causes very high stress to break the bond to connect the grains shown in Fig.18(2). Because the concentration of hydrogen at grain boundary is so high due to the segregation of hydrogen, and also due to the geometric model of hydrogen in metal, as H^+(proton) which size is by far smaller than grain boundary, the larger number of expanded T site by hydrogen negative ion under the condition of positive metal potential.

➢ *Impact of Metal Potential on Volumetric Expansion by Hydrogen Negative Ion*

This larger number of H+ can be also caused by the metal positive potential wile less electrons in the metal to prevent proton. And the higher electron density shields the Coulomb attraction between protons and negative hydrogen ions.

Thus, it is necessary to consider the effects of metal potential for research and prevention of HE.

➢ *Vacancy Generation by Transmutation with Femto-H2 by Cold Fusion –(HEE)*

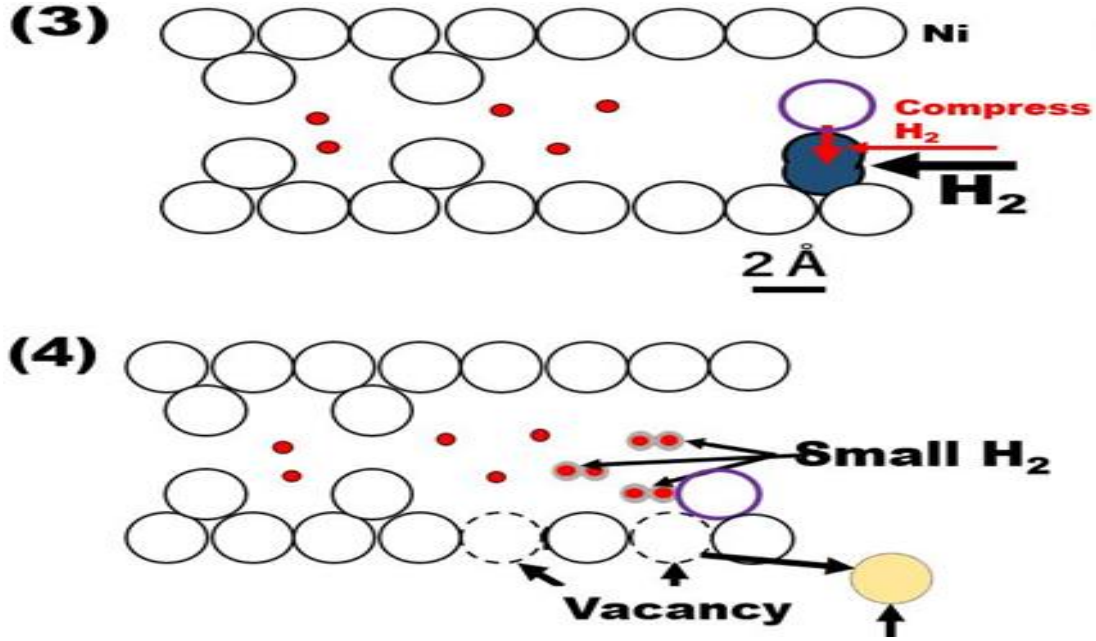

Fig 19 Mechanism of HEE based on Transmutation of Cold Fusion with Femto-H_2 to Generate the Vacancy and Interstitial Element

Cold fusion generates excess heat by D+D=4He+24MEV, but no fusion occurs by H+H, so the femto-hydrogen will transmute the metal element around the grain-boundary because femto H_2 has deeper electron orbit with a few femto meters from the protons acting as a neutral particle. Transmuted element by femto H_2 has no bond to the original metal bond and it will be interstitial element. Vacancy is generated over wide area on the lower side due to less interaction with metal nucleus.

XI. PROPOSITION OF TRANSMUTATION EXPERIMENT WITH H_2 GAS TO USE FEMTO-H_2

➢ *Conceptualized Transmutation Reactor*

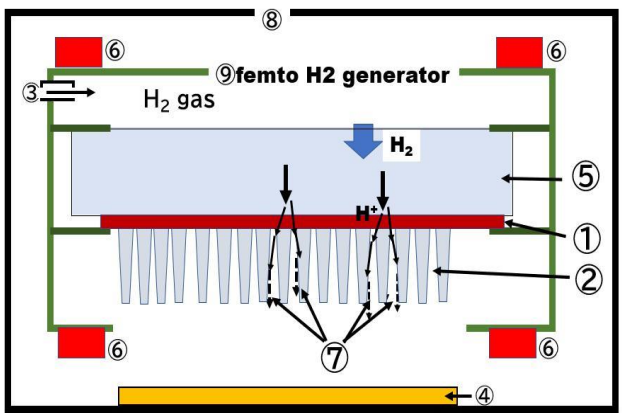

Fig 20 Conceptualized Transmutation Experiment set-up

I designed the transmutation reactor to generate femto-H_2 in polycrystalline metal thin film. The reaction site is on the grain sidewall and thus the total number of reaction site can be larger.

As the hydrogen is confined at the grain boundary by its segregation, the reaction rate is larger than conventional surface reaction of Cold fusion, and femto-H_2 is generated on the grain boundary sidewall surface. Because femto-H_2 is neutral, it falls due to gravity. less interaction with metal nucleus, it can reach the target metal.

In Fig.10, they use multi-layer metal film with target metal and Pd and they use D_2 to cause Cold Fusion. Because D_2 gas cause fusion to generate heat, so it is difficult to control the temperature, because at higher temperature there is no A left at high which is consumed by Cold Fusion thus, they need the multi-layer stack. In order to increase the reaction rate, a multilayer structure was used, and the target metal film was in contact with Pd.

My conceptualized reactor does not need such special structure, just put film metal so has wide range of applications.

This transmutation reactor adds two protons to target metal. Therefore, I think that this reactor will enable interesting studies in nuclear physics, and can be used for HEE study.

This reactor can determine the elements to be analyzed by mass spectrometry to prove the mechanism of HEE and to study HEE by metallurgical research institutes and related companies.

➢ *Application to Nuclear Study and Radioactive waste of Transuranium Nuclides by Conceptualized Transmutation Reactor*

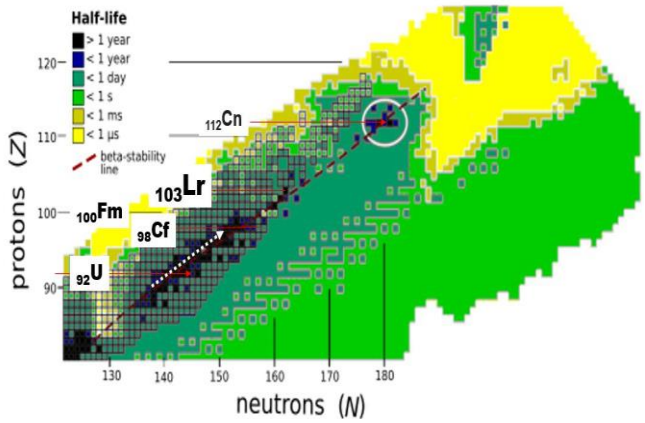

Fig 21 Stability Island and Location on Proton-Neutron Map

Because this conceptualized transmutation reactor just add two protons with softer fusion less energy and less rotational moment thus the transmuted nucleus is stable. Therefore, it can be used for the nuclear physics study. And uranium can be transmuted up to $_{98}$Cf and beyond $_{103}$Lr the half-life is less than one day. Thus, if the transmutation speed is higher than one day per two protons, it can reach stable island around $_{112}$Cn.

Thus, I think this conceptualized reactor is Worth developing and researching. However, the variation of the atomic number of transmuted elements is very large.

➢ *Higher Heating Temperature*

High temperature heat treatment for femto-hydrogen molecule formation may cause femto-hydrogen molecule to separate**.**

XII. VOLTAGE CONTROL OF METAL

➢ *HE Caused by Hydrogen Atoms*

This case it is complicated because negative metal voltage reduces the number of protons at the grain-boundary or crystalline defect, but this causes proton to occupy the metal space to expand the space. Thus, polarity change can cause this type of HE. Thus, metal positive voltage can mitigate this HE.

The space size affects this HE and the comparison between the size of hydrogen and the site of the space site is needed.

➢ *Cold Fusion based HEs*

Cold fusion based HE is volumetric expansion by negative hydrogen ion and transmutation with femto H_2. Both can be prevented by negative metal voltage to prevent proton to occupy expandable T site on the grain boundary or crystalline defect sidewall surface by the coulomb attractive force between negative charge at the expandable T site and proton. Note that only metal with FCC cause Cold Fusion.

XIII. HYPOTHESIS VERIFICATION OF HEE

➢ *Impurity Element Analysis by ICP-MS.*

Because small H_2 is neutral and it can transmute the metal element, and if the transmuted element is unstable, it usually captures electron to stable element. Thus, before mass analysis, it is convenient to know the possible element for mass analysis. mass spectra will show the transmutation by small H_2.

I recommend the transmutation experiment with H_2 gas before mass analysis because it will prove the mechanism of cold fusion as well. However, you can find the stable element by element data in wiki as I did in 7.1. Note that femto H_2 add two protons to the metal nucleus, the number of protons sometimes is larger than the stable nucleus with shorter life-time. In this case nucleus tend to capture electron from orbit to decrease the atomic number by -1 to stabilize the nucleus.

If HEE mechanism is probed by your study, please publish study in journal of Metallurgy, and inform me. I will collect information and I will summarize the paper to inform nuclear physics community that HEE and Cold Fusion mechanism have been proved by multiple institutions to show that nucleus model and neutron model are incorrect.

➢ *An Embrittlement Test with Different Voltage Application to Metal During Annealing*

I propose researchers to do the embrittlement test on metals by controlling the potential positively and negatively. Based on the cold fusion mechanism positive potential

As I explained in sec 12, metal voltage dependence is complicated, thus categorization of size of space site and type of crystal lattice. And I would like you to study EB dependency on metal voltage based on this paper's mechanism of HE and categorized the result by info mentioned above.

I think researchers would discover accelerated parameters for accelerated reliability test by this study.

XIV. REQUEST FOR THE TRANSMUTATION EXPERIMENT BY COLD FUSION WITH H_2.

I would like to propose the study on HEE to prove the mechanism of HEE and Cold Fusion (femto D_2 theory) by femto H_2 transmutation experiments as many as possible, because this big change of nucleus model needs the same results from multiple research institutions, which published paper in major scientific journals, and nuclear physics journal would not accept this kind of paper. Because the

study of the mechanism of hydrogen embrittlement will have a great impact on industry, I believe it will be accepted by major metallurgical journals.

So far, I have provided information to nuclear researchers and research institutes around the world, but there has been no response. I do not think that nuclear physics society by themselves will correct their important theory, thus we need to study based on the correct physics and show them the correct nucleus model.

XV. SUMMARY

Low-temperature hydrogen embrittlement is caused by volume expansion of negative hydrogen ions at grain boundaries. High-temperature hydrogen environmental embrittlement (HEE) is caused by transmutation of metal atoms based on Cold Fusion.

We must the probe Cold Fusion mechanism by femto-D_2 and HEE mechanism by femto-H_2 by Cold Fusion at the same time by transmutation experiment with femto-H_2 to study the mechanism of HEE, and will also probe whether the current nucleus model and neutron model are incorrect.

➢ *Acknowledgment*

I would like to thank Vavra Jerry and Jean-Luc Paillet for useful discussions on Electron Deep Orbit.

REFERENCES

[1]. Noriyuki Kodama, Novel Cold Fusion Reactor with Deuterium Supply from Backside and Metal Surface Potential Control, Volume6, Issue 6, June-2021 International Journal of Innovative Science and Research Technology Also available from https://ijisrt.com/novel-cold-fusion-reactor-with-deuterium-supply-from-backside-and-metal-surface-potential-control

[2]. Masuhiro Yamaguchi, Applied Physical Properties of Metal Hydrides, Hydrogen Energy Systems Society of Japan, Association magazine, 1986, Vol.11, No2, PP30-41, Abailable from http://www.hess.jp/ Search/ data/11-02-030.pdf

[3]. Hideo Kozima, Physics of the cold fusion phenomenon, Proc. 13th International Conference on Cold Fusion, Sochi, Russia, 2007. Also available from https://www.researchgate.net/publication/ 237142695

[4]. Osamu Yamamuro, Studies on Novel Materials by Complementary Use of Calorimetric and Neutron Scattering Method, Netsu Sokutei 44 (3), 117-123 (2017)Available from https://www.jstage.jst.go.jp/ article/jscta/44/3/44_117/_pdf

[5]. J. Va'vra, ON a possibility of existence of new atomic levels, which were neglected theoretically and not measured experimentally.

[6]. A. Meulenberg, K. P. Sinha, Deep-electron Orbits in Cold Fusion, J. Condensed Matter Nucl. Sci. 13 (2014) 368–377,

[7]. J. Va'vra, A simple argument that small hydrogen may exists, Phys. Lett. B, 794 (2019) 130-134. Also available from https://arxiv.org/ftp/arxiv/papers/ 1906/1906.08243.pdf

[8]. J.L. Paillet, On highly relativistic deep electrons, J. Condens. Matter Nucl. Sci. 29 (2019) 472–492. Also available from https://www.vixra.org/pdf/1902. 0398v1.pdf.

[9]. J.-L. Paillet, A. Meulenberg, Basis for EDOs of the hydrogen atom, Proc. 19th International Conference on Condensed Matter Nuclear Science, Padua, Italy, 13-17 April 2015. Also available from https://www.proceedings.com/30912.html

[10]. J. Maly and J. Va'vra, Electron transitions on deep Dirac levels I, Fusion Technol., 24 (1993) 307-318. Also available from https://doi.org/10.13182/FST93-A30206

[11]. J. A. Maly, J. Vavra, Electron transitions on deep Dirac levels II, Fusion Technol. 27 (1995) 59-70. Also available from https://doi.org/10.13182/FST95-A30350

[12]. J. Va'vra, On a possibility of existence of new atomic levels, which were neglected theoretically and not measured experimentally, presented at Siegen University, Germany, November 25, 1998.

[13]. J. Va'vra, A new way to explain the 511 keV signal from the center of the Galaxy and some dark matter experiments, ArXiv: 1304.0833v12 [astro.ph-IM] Sept. 28, 2018. Available from https://doi.org/ 10.48550/arXiv.1304.0833

[14]. J.-L. Paillet, A. Meulenberg, Highly relativistic deep electrons and the Dirac equation, J. Cond. Matter Nucl. Sci. 33 (2020) 278–295. Also available from https://www.academia.edu/41956585/Highly_relativisti c_deep_electrons_and_the _Dirac _ equation.

[15]. Z.L. Zhang, W.S. Zhang, Z.Q. Zhang, Further study on the solution of schrödinger equation of hydrogen-like atom, Proc. 9th International Conference on Cold Fusion, May 21-25, 2002, Beijing, China, pp. 435-438. Available from https://lenr-canr.org/wordpress /?page_id=691

[16]. A. Meulenberg, Deep-orbit-electron radiation absorption and emission, Available From https://mospace.umsystem.edu /xmlui/ bitstream/ handle/10355/36501/DeepOrbitElectronRadiationAb stract.pdf?sequence=1&isAllowed=y

[17]. A. Meulenberg, J.L. Paillet, Implications of the EDOs for cold fusion and physics–deep-orbit-electron models in LENR: Present and Future, J. Condens. Matter Nucl. Sci. 24 (2017) 214–229

[18]. R. Reeves, "A force of Nature", page 114, Atlas books, New York - London, 2008

[19]. A. Pais, "Inward bound", page 397, Clarendon press - Oxford, 1986.

[20]. T. Yamamoto, D. Zeng, T. Kawakami, V. Arcisauskaite, K. Yata, M.A. Patino, N. Izumo, J.E. McGrady, H. Kageyama, M.A. Hayward, The role of π blocking hydride ligands in a pressure-induced insulator-to-metal phase transition in SrVO2H, Nature Comm. 8 (2017). Also available from https://www.nature.com/articles/s41467-017-01301-0

https://www.jst.go.jp/pr/announce/20171031/index.html

[21]. Yasuhiro Iwamura, Takehiko Itoh, Mitsuru Sakano, Noriko Yamazaki, Shizuma Kuribayashi, Yasuko Terada, Tetsuya Ishikawa, Jirohta Kasagi, Observation of nuclear transmutation reactions induced by D2 gas permeation through Pd complexes, Condensed Matter Nuclear Science, pp. 339-350 (2006), Available from DOI: 10.1142/9789812774354_0027

[22]. Noriyuki Kodama, Correct Nucleus Model Proved by Transmutation Experiment by Cold Fusion, Volume 7, Issue 5, May –2022, International Journal of Innovative Science and Research Technology, Available from https://ijisrt.com/assets/upload/files/IJISRT22MAY292_(1).pdf

[23]. S. Schlichting, B. Schenke, The Shape of the Proton at High Energies, Phys. Lett. B, v739, 313–09, 2014. https://doi.org/10.1016/j.physletb.2014.10.068 https://www.sciencedirect.com/science/article/pii/S0370269314008016

[24]. E.Campari, S.Focaridi, V.Gabbani, V.Montalbano, F.Piantelli, S.Veronesi, Overview of H-Ni systems Available from https://www.newenergytimes.com/v2/library/2004/2004CampariEGoverviewOfH-NiSystems.pdf