The second layer 72 is formed for example of Ni, Pd, Cu, Mn, Cr, Fe, Mg, Co, of an alloy thereof, or SiC. The alloy forming the second layer 72 is preferably an alloy composed of two or more Ni, Pd, Cu, Mn, Cr, Fe, Mg and Co. As the alloy forming the second layer 72, an alloy obtained by adding an additive element to Ni, Pd, Cu, Mn, Cr, Fe, Mg and Co can be used.

As a combination of the first layer 71 and the second layer 72, if the element type is expressed as "first layer 71-second layer 72 (second layer 72-first layer 71)", Pd-Ni, Ni - Cu, Ni -Cr, Ni-Fe, Ni-Mg, Ni-Co are preferable. When the second layer 72 is ceramic, it is preferable that the "first layer 71-2nd layer 72" is of Ni-SiC.

The thickness of the first layer 71 and the thickness of the second layer 72 are preferably less than 1000 nm, respectively. When the thickness of each of the first layer 71 and the second layer 72 is 1000 nm or more, it becomes difficult for hydrogen to penetrate through the multilayer film 62. Further, when the thickness of each of the first layer 71 and the second layer 72 is less than 1000 nm, it is possible to maintain a nanostructure which does not have bulk characteristics. The thickness of each of the first layer 71 and the second layer 72 is more preferably less than 500 nm. When the thickness of each of the first layer 71 and of the second layer 72 is less than 500 nm, it is possible to maintain a nanostructure which does not completely exhibit bulk characteristics.

the multilayer film 62 of the heating element 75 further comprises a third layer 77 in addition to the first layer 71 and the second layer 72. The third layer 77 is formed of a hydrogen storage metal, a hydrogen storage alloy or ceramics different from those of the first layer 71 and of the second layer 72. The thickness of the third layer 77 is preferably less than 1000 nm.

The third layer 77 is formed for example of Ni, Pd, Cu, Cr, Fe, Mg, Co, an alloy thereof, SiC, CaO, Y 2 O 3, TiC, LaB 6, SrO or BaO. The alloy forming the third layer 77 is preferably an alloy composed of two or more Ni, Pd, Cu, Cr, Fe, Mg and Co. As the alloy forming the third layer 77, an alloy obtained by adding a Additive element to Ni, Pd, Cu, Cr, Fe, Mg and Co can be used.

The thickness of the third layer 77 formed by one of CaO, Y 2 O 3, TiC, LaB 6, SrO, BaO and is preferably 10 nm or less.

"The relationship between the thickness ratio of each layer of the multilayer film and the excess heat" will be described. A heating element 14 having a Ni support 61 and a multilayer film 62 formed of a first Cu layer 71 and a second Ni layer 72, the first layer 71 and the second layer 72 is used. thick and excessive heat was investigated. Hereinafter, the thickness ratio of each layer of the multilayer film 62 is described as Ni: Cu.

In Figure 8, Experimental Example 1 is "Ni: Cu = 7: 1", Experimental Example 2 is "Ni: Cu = 14: 1", Experimental Example 3 is "Ni: Cu = 4, 33: 1 "and the experimental example" Ni: Cu = 3: 1 ", Experimental example 5" Ni: Cu = 5: 1 ", Experimental example 6" Ni: Cu = 8: 1 ", Experimental example 7" Ni : Cu = 6: 1 ", Experimental Example 8 was described as" Ni: Cu = 6.5: 1 ".

From Figure 8, it was confirmed that excess heat was generated in all heating elements 14 of Experimental Examples 1 to 8. By comparing heating elements 14 of Experimental Examples 1 to 8 when the temperature of the heating element is 700 ° C or more, it can be seen that Experimental Example 1 generates the greatest excess heat. It can be seen that the heating element of Experimental Example 3 generates excess heat over a wide range of heating temperatures of 300 ° C or more and 1000 ° C or less compared to the heating element 14 of the Experimental Examples. 1, 2, 4 to 8. It can be seen that in the heating elements 14 of the Experimental Examples 1 and 3 to 8 in which the Ni: Cu of the multilayer film 62 is 3: 1 to 8: 1, the excess heat increases as the temperature of the heating element increases. It can be seen that the heating element 14 of Experimental Example 2 having a Ni: Cu ratio of 14: 1 in the multilayer film 62 reduces excess heat when the temperature of the heating element is 800 ° C or more. The reason why the excess heat does not simply increase over the Ni and Cu ratio is believed to be due to the quantum effect of hydrogen in the multilayer film 62.

In Figure 9, depending on the thickness of each layer, Experimental Example 1 is “Ni 0.875 Cu 0.125 5 layers”, Experimental Example 9 is “Ni 0.875 Cu 0.125 3 layers” and Experimental Example 10 is "Ni 0.875 Cu 0.125 7". Experimental example 11 is "Ni 0.875 Cu 0.125 6 layers", Experimental example 12 is "Ni 0.875 Cu 0.125 8 layers", Experimental example 13 is "Ni 0.875 Cu 0.125 9 layers "and Experimental Example 14 is" Ni 0.875 Cu 0.125 12 layers "., Experimental Example 15" Ni 0.875 Cu "" 0.125 4 layers "and Experimental Example 16 were described as" Ni 0.875 Cu 0.125 2 layers ".

From Fig. 9, it was confirmed that excess heat was generated in all heating elements 14 of Experimental Examples 1 and 9 to 16. By comparing heating elements 14 of Experimental Examples 1 and 9 to 16 when the heating temperature is 840 ° C or more, the excess heat is greatest in Experimental Example 11 in which the number of layers of the multilayer film 62 is 6, and the number of layers of the multilayer film 62 is tall. We see that Experimental Example 12, which is 8, is the smallest. In this way, the reason why the excess heat does not simply increase over the number of layers of the multilayer film 62 is that the wavelength of the behavior of hydrogen in the multilayer film 62 as a wave is on the order of a nanometer, and the multilayer film 62 is probably because they interfere.

In Figure 10, depending on the thickness of each layer, Experimental Example 17 is "Ni 0.793 CaO 0.113 Cu 0.094", Experimental Example 18 is "Ni 0.793 SiC 0.113 Cu 0.094" and Experimental Example 19 is "Ni 0.793 Y 2 O 30.113 Cu 0.094"., Experimental Example 20 is "Ni 0.793 TiC 0.113 Cu 0.094", Experimental Example 21 is "Ni 0.793 Co 0.113 Cu 0.094" and Experimental Example 22 is " Ni ".0.793 LaB 60.113 Cu 0.094", Experimental Example 23 was described as "Ni 0.793 ZrC 0.113 Cu 0.094", Experimental Example 24 was described as "Ni 0.793 TiB 20.113 Cu 0.094" and Experimental Example 25 has been described as "Ni 0.793 CaOZrO 0.113 Cu 0.094".

From Figure 10, it was confirmed that excess heat was generated in all heating elements 75 of Experimental Examples 17 to 25. In particular, Experimental Example 17 in which the material forming the third layer 77 is CaO, Experimental Example 20 in which TiC is used and Experimental Example 22 in which LaB 6 is LaB 6 are compared with other Experimental Examples 18, 19, 21, 23 to 25. It can be seen that the excess heat increases almost linearly over a wide range where the heater temperature is 400 ° C or more and 1000 ° C or less. The material forming the third layer 77 of the Experimental Examples 17, 20, 22 has a smaller working function than the materials of the other Experimental Examples 18, 19, 21, 23 to 25. From here it can be seen that the type of material forming the third layer 77 is preferably a material having a small working function. From these results, it is possible that the electron density in the multilayer film 62 contributes to the exothermic reaction.

An example of the configuration of the multilayer film 62 as a function of the temperature of the heating element 14 will be described. In view of the "relationship between the ratio of the thickness of each layer of the multilayer film and the excess heat" mentioned above for the heating element 14, when the temperature of the heating element 14 is low (e.g. example, in the range of 50 ° C or more and 500 ° C or less), the multiple layers The thickness ratio of each layer of the film 62 is preferably in the range of 2: 1 or more and 5: 1 or less. When the temperature of the heating element 14 is an average temperature (for example, in the range of 500 ° C or more and 800 ° C or less), the thickness ratio of each layer of the multilayer film 62 is preferably within the range of 5: 1 or more and 6: 1 or less. .. When the temperature of the heating element 14 is high (for example, in the range of 800 ° C or more and 1500 ° C or less), the thickness ratio of each layer of the multilayer film 62 is preferably in the range of 6: 1 or more and 12: 1 or less. .

From Figure 46, it was confirmed that excess heat was generated when the temperature of the heating element was between 300 ° C and 900 ° C. It was confirmed that the excess heat was approximately 2 W maximum at 600 ° C or less, increased at 700 ° C or more, and reached approximately 10 W at approximately 800 ° C.

From Figure 47, it was confirmed that excess heat was generated when the temperature of the heating element was between 200 ° C and 900 ° C. It was confirmed that the excess heat was approximately 4 W at most in the range of 200 ° C to 600 ° C, increased at 700 ° C or more, and exceeded 20 W at about 800 ° C.