Theoretical Study of the Phenomenon of Cold Fusion in Condensed Matter and

Analysis of Phases (α, β, γ)

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Abstract

The aim of this work is to explain the deuteron-deuteron reactions within palladium lattice by means of the coherence theory of nuclear and condensed matter. The coherence model of condensed matter affirms that within a deuteron-loaded palladium lattice there are three different plasmas: electrons, ions and deuterons plasma.

Then, according to the loading percentage x=D/Pd, the deuterium ions can take place on the octahedrical sites or in the tetrahedral on the (1,0,0)-plane.

Further, the present work is concentrated on Palladium because, when subjected to thermodynamic stress, this metal has been seen to give results which are interesting from both the theoretical and experimental points of view. Moreover in Pd lattice we can correlate the deuterium loading with D-Pd system phases (i.e. α , β and γ) by means of theory of Condensed Matter.

1. Introduction

This study has the aim of analyzing the possible influence that variations in the D-lattice system phases could have on the phenomenon of deuterium fusion when microdeformations or micro-cracks take places. These micro-deformations could in fact be able to even concentrate in their vicinity a significant fraction of the deuterons present in the metal. In particular, the author has suggested [2] that deuteron-plasmon coupling could increase the rate of fusion by acting as an effective interaction attractive to deuterium nuclei, reducing the distance at which Coulomb repulsion becomes dominant. On this premise, a study was made on crystalline lattices with certain structural characteristics: in particular, the analysis was focused on lattices with ten or more electrons in the "d" band. The present work is concentrated on Palladium because, when subjected to thermodynamic stress, this metal has been seen to give results which are interesting from both the theoretical and experimental points of view. Moreover in Pd lattice we can correlate the deuterium loading with D-Pd system phases (i.e. α , β and γ) by means of theory of Condensed Matter.

The analysis will attempt to determine whether, in the case of the three-dimensional isotrope, D_2 loading can lead to the formation of micro-cracks and, then, according to the D_2 -Pd phase we can observe a very high fusion rate due to contribution of micro-cracks and γ -phase transition.

2. The plasmas present within D₂-loaded palladium

We know that the deuterium is adsorbed when is placed near to palladium surface. This loading can be enhanced using electrolytic cell or vacuum chamber working at opportune pressure. By means of Preparata's theory of Condensed Matter it is assumed that, according to the ratio x=D/Pd, three phases concerning the D₂-Pd system exist [1]:

- 1) phase α for x < 0.1
- 2) phase β for 0.1<*x*<0.7
- 3) phase γ for x > 0.7

In the α – phase, the D₂ is in a disordered and not coherent state (D₂ is not charged!). Regarding the other phases, upon surface, due to lattice e.m., takes place the following ionization reaction:

$$D_{lattice} \rightarrow D^{\dagger} + e^{-} \tag{1}$$

Then, according to the loading percentage x=D/Pd, the ions deuterium can take place on the octahedrical sites or in the tetrahedral in the (1,0,0)-plane. In the coherence theory the deuterons plasma in the octahedral site is called β -plasma and γ -plasma the one in the tetrahedral.

Regarding to β -plasma it is possible to affirm that the plasma frequency is given by [1]:

$$\omega_{\beta} = \omega_{\beta 0} (x + 0.05)^{1/2} \tag{2}$$

Where:

$$\omega_{\beta 0} = \frac{e}{\sqrt{m_D}} \left(\frac{N}{V}\right)^{1/2} \frac{1}{\lambda_a^{1/2}} = \frac{0.15}{\lambda_a^{1/2}} eV/\hbar$$
(3)

For example if we use $\lambda_a = 0.4$ and x = 0.5 it is obtained $\omega_{\beta} = 0.168 \text{ eV/h}$.

In the tetrahedral sites the D^+ can occupy the thin disk that encompass two sites. They present a barrier to the D^+ ions. Note that the electrons of the d-shell oscillate around the equilibrium distance y_0 (about 1.4 Å) thus embedding the ions in a static cloud of negative charge (whose can screen the coulomb barrier). So, as reported in [1] we have:

$$\omega_{\gamma} = \sqrt{\frac{4Z_{eff}\alpha}{m_D y_0^2}} \approx 0.65 eV/\hbar$$
(4)

Due to a large plasma oscillation of d-electrons, in the disk-like tetrahedral region (where the γ -phase D⁺'s are located) a high density negative charge is condensed, emphasising a screening potential *W*(*t*) whose profile is reported in fig. 1.



Fig.1- The profile of the electrostatic potential in a

We emphasize that the γ -phase depend on *x* value and that this new phase has been experimentally observed [3].

3. The d-d potential

In reference [1], it was shown that the phenomena of fusion between nuclei of deuterium in the crystalline lattice of a metal is conditioned by the structural characteristics, by the dynamic conditions of the system, and also by the concentration of impurities present in the metal under examination.

In fact, studying the curves of the potential of interaction between deuterons (including the deuteron-plasmon contribution) in the case of three typical metals (Pd, Pt and Ti), a three-dimensional model showed that the height of the Coulomb barrier decreases on varying the total energy and the concentration of impurities present in the metal itself. The potential that takes into account the role of temperature and impurities is given by the expression [1]:

$$V(r) = k_0 \frac{q^2}{r} \cdot M_d \left(V(r)_M - \frac{J k T R}{r} \right)$$
(5)

In (5), $V(r)_{M}$, the Morse potential, is given by:

$$V(r)_{M} = (J / \zeta) \left\{ \exp\left(-2\varphi\left(r - r_{0}\right)\right) - 2\exp\left(-\varphi\left(r - r_{0}\right)\right) \right\}$$
(6)

Here parameters $\varphi \ ed \ r_0$ depend on the dynamic conditions of the system, ζ is a parameter depending on the structural characteristics of the lattice, i.e. the number of "d" band electrons and the type of lattice symmetry, varying between 0.015 and 0.025. Of course the Morse potential is used in the interval that includes the inner turning point r_a and continues on towards r=0 near it is linked with the coulomb potential (fig. 2).



Fig.2- d-d potential features

In this work, according to coherence theory of condensed matter, we study the role of potential (5) in the two different phases : β and γ .

So in this theoretical framework needs for clarification:

1) what is *KT*

2) what is the role of electrons, ions plasma

Regarding the first point, according to the different deuteron-lattice configurations, *KT* can be:

- i) ω_{β} if we consider the deuterons in β -phase
- ii) ω_{γ} if we consider the deuterons in γ -phase

Whereas regarding the second point, the question is more complicate.

In fact the lattice environment is a mixing of coherent plasmas (ion Pd, electron and deuterons plasma) at different temperature, due to different masses, thus describing a very hard emerging potential. The method that in this work we propose is the following: considering the total contribution of lattice environment at d-d- interaction (i.e. V_{tot}) as random potential Q(t). So in this model we can write:

$$V_{tot}(t) = V(r) + Q(t) \tag{7}$$

Of course we assume that:

$$\left\langle V_{tot}\left(t\right)\right\rangle_{t}\neq0$$
 (8)

that is, we suppose that Q(t) (a second order potential contribution) is a periodic potential (the frequency is ω_Q) that oscillates between the maximum value Q_{max} and 0. The role of potential Q(t) is increasing or decreasing the barrier distance from origin. In the figure [3] we report the plot of potential V_{tot} for two different value of Q(t).



Fig.3- Potential features for two different value of Q(t)

It means that according to ω_Q and to the energy of particles incoming to the barrier, we can have the following main cases:

1) the particle crosses the barrier in the point α

2) the particle crosses the barrier in the α '

For these reasons we can speak about scenario 2 as the worst case having high tunneling probability, and scenario 1 as the best case.

To determine the model parameters we have to hypothesize on Q(t) and ω_Q . In this work we approximate Q(t) as the screening potential W(t) due to d-electrons.

To summarize, we can have the following cases in a palladium lattice according to loading ratio:

i) β -phase

When x is bigger than 0.1 but less 0.7, the phase β happens. The interaction takes place between deuteron ions that oscillate by following energy values:

$$0.1 \ eV < \hbar\omega_{\beta} < 0.2 \ eV$$

In this case W(t) is zero, so the potential is given by the expression (9):

$$V(r) = const \frac{q^2}{r} \cdot M_d \left(V_M(r) - \frac{J\hbar\omega_\beta R}{r} \right)$$
(9)

ii) γ-phase

Finally when the loading ratio is higher than 0.7, the deuteron-palladium system is in the phase γ . According to the approximation made in this work we have:

In this way the deuterons undergo the screening due to d-electrons shell, so the d-d potential can be written as:

$$V(r) = const \frac{q^2}{r} \cdot M_d \left(V_M(r) - \frac{J\hbar\omega_{\gamma}R}{r} \right) + Q(t)$$
(10)

About Q(t) we can only assume that:

$$\left\langle Q(t)\right\rangle_{t} \approx \frac{W_{\max}}{\sqrt{2}}$$
 (11)

As said previously, we suppose that is the screening potential due to d-electron and its role that reduce the repulsive barrier.

CONCLUSION

The present work has shown that micro-cracks and deuterium loading in the lattice at room temperature have a significant influence on the probability of fusion.

In fact, calculating the probability of interaction within a micro-crack, an increase of at least 2-3 orders of magnitude are compared to the probability of fusion on the surface. Further, with the theoretical analysis developed it is possible to obtain relatively high values for the probability of fusion for D_2 loaded impure metals at room temperature if the loading ratio is higher than 0.7.

On the other hand, results very close to the experimental data have already been obtained when x>0.7 but without micro-crack contribution (for example, for J $\approx 0.75\%$,

 $E \approx 250 \ eV, P \approx 10^{-24}$).

Reference

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