

# STUDY ON FORMATION OF TETRAHEDRAL OR OCTAHEDRAL SYMMETRIC CONDENSATION BY HOPPING OF ALKALI OR ALKALINE-EARTH METAL

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Formation of tetrahedral or octahedral condensation related to the experiments on electrolysis or deuterium permeation was studied. We obtained the scenario about the formation that alkali or alkaline-earth metal ions infiltrating into the host metal made cavities there when they hopped onto the other sites of the crystal lattice of it, then through squeezing of  $H^+/D^+$  ions in the cavity tetrahedral or octahedral condensation of protons/deuterons is caused.

## 1 Introduction

Much research on nuclear fusion and nuclear transmutation in condensed matter is currently in progress. Recently, experiments with deuterium permeation through Pd complex by Iwamura et al. have indicated that nuclear transmutations occur with alternating CaO and Pd layers, but no nuclear reaction is observed when this material is replacing it with MgO [1]. On the theoretical side, we have directed our attention to Tetrahedral Symmetric Condensate / Octahedral Symmetric Condensate (TSC/OSC) model of protons/deuterons by Takahashi, which can explain consistently the major experimental results [2-4].

We have examined the role of the alkali and alkaline-earth metal ions in the crystal lattice of the host metal when TSC/OSC is formed. As a result, we have obtained a very consistent and simple scenario as one of hypotheses about the formation of TSC/OSC that the alkali or alkaline-earth metal ions infiltrating into the host metal make cavities there, when they hop onto the other sites of the crystal lattice, then through squeezing of  $H^+/D^+$  ions in the cavity the protons or deuterons undergo TSC/OSC.

## 2 Scenario of formation of TSC/OSC

Experiments on nuclear fusion and nuclear transmutation in condensed matter are performed, for example, by the electrolysis of LiOH/LiOD or  $K_2CO$  electrolytic solution using Ni or Pd cathode, and by the deuterium permeation through alternating CaO and Pd layers respectively. The scenario about the formation of TSC/OSC is constructed from following 5 processes that would proceed in the face-centered cubic (fcc) lattice of the hydride-forming metals. This scenario would be as simple as possible with the role of the alkali or alkaline-earth metal ions.

### 2.1. Permeation of $H^+/D^+$ ions Headings, Text and Equations

Figure 1 shows the permeation of  $H^+/D^+$  ions and typical infiltration of alkali or alkaline-earth metal ions in the case of electrolysis of water and in a deuterium permeation experiment.

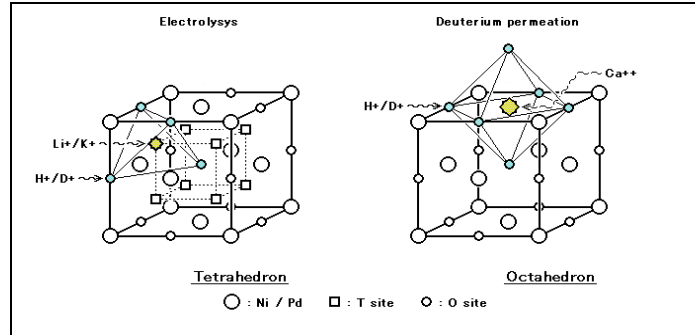


Figure 1. Permeation of  $H^+/D^+$  ions and Infiltration of alkali or alkaline-earth metal ions (typical)

$H^+/D^+$  ions permeate into the fcc crystal lattice of the host metal such as Ni and Pd by electrolytic voltage and  $D_2$  gas pressure, and they are located mostly at the O sites. Although  $H^+/D^+$  ions move corresponding to the permeation rates, they are confined at the O sites of the crystal lattice of the host metal for a short while.

### 2.2. Infiltration of alkali or alkaline-earth metal ions

Alkali metal ions such as  $Li^+$  and  $K^+$  and alkaline-earth metal ions such as  $Ca^{++}$  infiltrate into the fcc crystal lattice of it, and they come to the T sites, O sites and the lattice voids or defects.

In the case of electrolysis, alkali metal ions accumulating on the surface of the host metal infiltrate into the near surface layers due to the surface vibration and the electrolytic current, and then mostly stay at the T sites of the crystal lattice for a long while. Each of the alkali metal ions at the T sites vibrating thermally interacts with 4  $H^+/D^+$  ions at the vertexes of the tetrahedron surrounding it and vibrates them widely.

In the case of deuterium permeation, alkaline-earth metal ions staying in contact with the surface of the host metal also infiltrate into it due to the surface vibration and the deuterium flow, and then mostly stay at the lattice defects or voids for a long while. Each of the alkaline-earth metal ions at the lattice defect or void vibrating thermally also interacts with 6  $H^+/D^+$  ions at the vertexes of the octahedron surrounding it and vibrates them widely.

### 2.3. Hopping of alkali or alkaline-earth metal ions

Figure 2 shows typical case of hopping of alkali or alkaline-earth metal ions, squeezing of  $H^+/D^+$  ions, recoil and condensation of protons/deuterons. The alkali metal ions hop onto the other sites of the crystal lattice of the host metal due to the thermal vibration, electrolytic voltage and most probably some electromagnetic impulses, and then make cavities at the former positions. The alkaline-earth metal ions also hop due to thermal vibration, deuterium flux, and electromagnetic impulses, also making cavities.

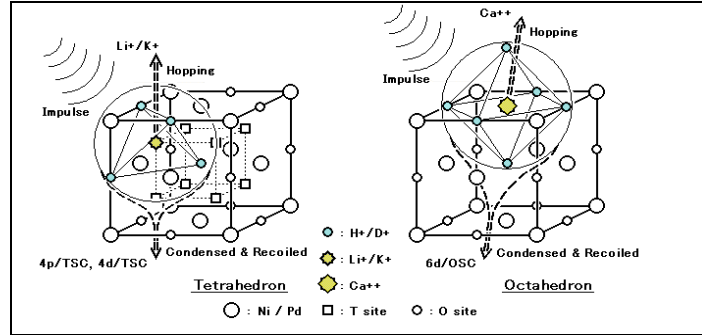


Figure 2. Hopping of alkali or alkaline-earth metal ions, Squeezing of  $H^+/D^+$  ions, Recoil and Condensation of protons/deuterons (typical)

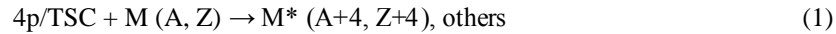
#### 2.4. Squeezing of $H^+/D^+$ ions and Recoil

The hopping of the alkali or alkaline-earth metal ion causes the cooling down of the cavity and the recoil of cluster  $H^+/D^+$  ions around it. The cluster  $H^+/D^+$  ions, namely protons/deuterons at the vertexes of the tetrahedron or octahedron that make up the surface of the cavity, are squeezed in the center of each polyhedron due to the reaction of hopping-out of the alkali or alkaline-earth metal ion. A heavy alkali or alkaline-earth metal ion causes the strong recoil of even heavy cluster  $H^+/D^+$  ions, while a light alkali or alkaline-earth metal ion causes the weak recoil of only light cluster  $H^+/D^+$  ions.

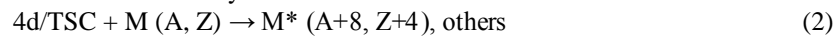
#### 2.5 Condensation of protons/deuterons and Nuclear transmutation or fusion

In the combination of strong recoil of squeezed cluster  $H^+/D^+$  ions, after the condensation of protons/deuterons, condensed 4p/TSC, 4d/TSC or 6d/OSC would collide against the atomic nucleus of the crystal lattice of the host metal or other one to cause the nuclear absorption and transmutation according to the Takahashi's TSC/OSC nuclear absorption theory [2-4].

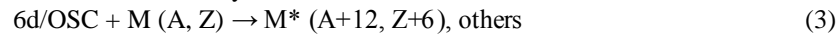
In the case of 4p/TSC by Li or K in the T site of Ni:



In the case of 4d/TSC by K or Ca in the T site of Pd:



In the case of 6d/OSC by Ca in the lattice defect or void of Pd:



On the other hand, in the combination of weak recoil of squeezed cluster  $H^+/D^+$  ions, after the condensation of protons/deuterons, condensed 4d/TSC unite together tightly to cause the cluster nuclear fusion according to the Takahashi's TSC nuclear fusion theory without collision against the atomic nucleus of the crystal lattice of the host metal or other one [2-4].

In the case of 4d/TSC by Li in the T site of Ni or Pd:



Specially, the production of  $M^* (A+8, Z+4)$  by the reaction (2) and  $M^* (A+12, Z+6)$  by the reaction (3) can explain nuclear transmutations like  $^{133}\text{Cs}$  into  $^{141}\text{Pr}$  and  $^{137}\text{Ba}$  into  $^{149}\text{Sm}$  respectively, which is indicated in the deuterium permeation experiments through alternating CaO and Pd layers by Iwamura et al. [1].

Moreover, consistent with his reports, replacing Ca with Mg in his experiments would occur with no nuclear absorption and nuclear transmutation of TSC/OSC because of being too light for  $Mg^{++}$  ion to recoil and collide 4d/TSC or 6d/OSC against the other nucleus, and no nuclear fusion because there would be too many valence (+2) and influential  $Mg^{++}$  ions to keep the symmetry of each polyhedron.

This scenario about the formation of TSC/OSC can explain some of the experimental results of the electrolysis or deuterium permeation qualitatively, but it is based on many assumptions that must be proved experimentally or theoretically. And the hopping of the alkali or alkaline-earth metal ions and the recoil of  $H^+/D^+$  ions must be considered not only on the mass difference of each other but also on the other qualities.

### 3 Properties derived from the scenario

Some properties are derived from the above scenario. Some of the major ones are as follows.

#### 3.1 Three kinds of electrolytic current density or deuterium flux

There are three kinds of electrolytic current density  $i$  or deuterium flux  $f$ , which have the minimum and maximum respectively:

- (a) For permeation of  $H^+/D^+$  ions:  $i_{h/d}$  or  $f_d$
- (b) For infiltration of alkali or alkaline-earth metal ions:  $i_{alk}$  or  $f_{alk}$
- (c) For hopping of alkali or alkaline-earth metal ions:  $i_{hop}$  or  $f_{hop}$

Generally, it may be that:

$$0 \sim (c) i_{hop} < (a) i_{h/d} < (b) i_{alk} \quad \text{or} \quad 0 \sim (c) f_{hop} < (a) f_{h/d} < (b) f_{alk}. \quad (5)$$

However, these values might depend on the settings of experimental apparatus. Therefore, it might be necessary to control the value of the electrolytic current density or deuterium flux properly in experiments, for example in the high range for the preparation process of the permeation of  $H^+/D^+$  ions and infiltration of the alkali or alkaline-earth metal ions first for a while, and then in the low range for the response process of the hopping of the alkali or alkaline-earth metal ions, condensation of protons/deuterons and nuclear reactions lastly.

#### 3.2. Local cooling down due to hopping of alkali or alkaline-earth metal ion

When the hopping of the alkali or alkaline-earth metal ion makes a cavity in the crystal lattice of the host metal, 4  $H^+/D^+$  ions at the vertexes of the tetrahedron or 6  $H^+/D^+$  ions at those of the octahedron remain there constructing the surface of the cavity.

In the analysis of the model of surface phonons, when one of the springs composing an infinite long one-dimensional diatomic lattice is cut off, the frequency of the lowest optical mode decreases to the Wallis mode. This explained using the Rayleigh's Theorem described by the following equation: When the number  $m$  oscillator of infinite long one-dimensional lattice composed by  $f$  oscillators changes its mass and spring constant, the motion of this one-dimensional lattice is described by the proper equation as follows [5].

$$1 / (\alpha \omega^2 - \beta) + \sum_{j=1}^f \delta_{mj} / (M_j \omega^2 - C_j) = 0 \quad (6)$$

$\alpha$  : change of mass       $\beta$  : change of spring constant       $\omega$  : frequency

$M_j$  : mass of the number  $j$  oscillator

$C_j$  : spring constant of the number  $j$  oscillator       $\delta_{mj}$  : Kronecker's delta

By replacing  $z = \omega^2$  and  $z_j = \omega_j^2$ , the equation  $F(z) = F_1(z) - F_2(z) = 0$  transformed from the equation (6) gives solutions which are indicated by intersections of  $F_1(z) = F_2(z)$  on the graph, where

$$F_1(z) = \sum_{j=1}^f \delta_{mj} / (M_j z - C_j) \quad F_2(z) = -1 / (\alpha z - \beta) . \quad (7)$$

If the mass and spring constant of number  $m$  oscillator change to become  $\alpha = -M_m < 0$  and  $\beta = -C_m < 0$  which means disappearance of them respectively, the lowest frequency decreases and the highest one increases.

Applying this relationship to the diatomic lattice system consisting of light  $H^+/D^+$  ions and alkali or alkaline-earth metal ion and heavy host metal ions, it might be expected that the frequency of some mode of lighter  $H^+/D^+$  ions on the surface of the cavity decreased and the cavity was cooled down while the alkali or alkaline-earth metal ion hopped out by increasing of frequency. If the coherent phonon of the crystal lattice of the host metal is caused by electromagnetic impulse simultaneously with or after the hopping-out of the alkali or alkaline-earth metal ion, and the coherent oscillation of phonon is just in the decreased mode, it might be possible to cool down the local region effectively, although the frequencies of only a few modes decrease almost 10 meV at the most.

#### 4 Conclusion

In this study we revealed the formation of TSC/OSC explained clearly by the processes by which alkali or alkaline-earth metal ions infiltrate into the host metal and hop onto the other sites of the crystal lattice of the host metal. The hopping-out of the alkali or alkaline-earth metal ion recoil the condensed protons/deuterons strongly, causing nuclear transmutation, or weakly, causing nuclear fusion. And we showed, the important roles of the alkali or alkaline-earth metal ions is to make the cavity in the crystal lattice of the host metal by hopping, which squeezes  $H^+/D^+$  ions and cools down the cavity to cause the condensation of protons/deuterons.

#### Acknowledgements

The author wishes to thank Professor Takahashi of Osaka University for valuable information and advice.

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