TNCF Model Explanation of Carbon Production in D_2 Gas Discharge

Hideo Kozima, Masayuki Ohta
Kaori Kaki
Department of Physics
Shizuoka University
836 Oya, Shizuoka 422, Japan

Abstract

An interesting experimental result of neutron burst and an accompanying production of carbon in dc glow discharge as observed by Yamada et al. is analyzed here using a model in which we assume fairly stable trapped neutrons in the crystal. The parameter n_n (the density of the trapped thermal neutrons) was determined by the average (maximum) rate of neutron emission ~ 900/230 min (180/3 min) in a burst which lasted ~ 30 min as $n_n = 2.0 \times 10^{12}$ (4.6×10^{13}) cm^{-3}. The X-ray spectra before and after the neutron burst had shown the existence of oxygen in the former and carbon in the latter. This data was explained quantitatively by a transmutation of ^{16}O into ^{13}C due to a reaction $n + {}^{16}O = {}^{13}C + a$.

1. Introduction

After the discovery of cold fusion[1], it has become evident that nuclear reactions are occurring in some solid materials, generating excess heat, tritium, helium 4, neutrons and various transmuted nuclei. Those data on the cold fusion including the generation of excess heat, nuclear reaction products (tritium, helium 4, neutron, etc.) and transmuted nuclei had been analyzed and a consistent explanation was given by the TNCF model[2~6].

The nuclear transmutation (NT) in some solids generating new elements and isotopes is widely recognized in electrolytic and glow discharge experiments. General features of the phenomenon of NT have been analyzed on the TNCF model[7]. Recently, Yamada et al.[8] had observed neutron bursts and the production of carbon in dc discharge with Pd electrodes.

The theme of this paper will be an analysis of the above data[8] using the TNCF model[2~6] to give a possible consistent interpretation of the phenomenon of the neutron burst and the production of carbon.

2. Experimental Results[8]

To confirm the cold fusion phenomenon under glow discharge condition, a point-to-plane electrode configuration in slightly pressurized (2 atm) deuterium gas for highly non-uniform electric field was employed[8].

A neutron burst took place in 2 runs out of total 37 runs.

Using an optical microscope, a black deposit was observed to cover the tip surfaces of two positive Pd electrodes which had been used in the runs with neutron bursts. X-ray photo-electron spectroscopy (XPS) revealed the black deposit to be carbon, mixed with palladium on the surface of palladium point electrode. The total amount of carbon impurity in the Pd electrode and in environment deuterium gas did not account for the large amount of carbon on the tip surface of electrode.

From Fig.3 in Ref.(8) of neutron counts and the explanation given there, we can take the average (maximum) rate of neutron emission in the burst as ~ 900/230 min (180/3 min). The total numbers included in a burst were 10^4 and 10^5 in the run A and run B, respectively. And also, from Figs. 4 and 5 of Ref. (8), of XPS (X-ray photo-electron spectroscopy) spectra before and after the neutron burst, we can estimate that the relative number of oxygen atoms in the surface layer as the same order as that of carbon atoms ($N_O N_{C\sim}$)

1). This estimation was certified by Prof. Yamada[9] by his experience with the thicknesses of oxygen and carbon layers (2 ~ 3 nm) on the Pd surface.

3. Analysis of the Experimental Data and Conclusion

The experimental data[8] introduced briefly in the preceding section could be explained by the TNCF model[2~7] with a presumption of the quasi-stable existence of trapped thermal neutrons in solid sample.

When there are trapped neutron in a solid with a density n_n, a neutron induces a fusion reaction with an occluded deuteron generating a triton (cross section $\sigma_{nd} = 5.5 \times 10^{-4}$ barn): (1)

$$n + d = t\,(6.98\text{keV}) + \gamma(6.25\text{MeV}),$$

The number of the fusion reactions (and therefore the numbers N_t and N_g of generated tritons and photons, respectively) in a time τ could be given by a relation[3]

$$N_t = 0.35\, n_n v_n \rho_d V \sigma_{nd} \tau \xi, \qquad (2)$$

where V is the volume of the solid, ξ is a numerical factor (with a value ~ 1 in this case), and v_n is a thermal velocity of the neutron.

Next, a triton with 6.98 keV generated in the reaction (1) will react with a deuteron to generate a helium 4 (cross section σ_{td} of which is ~ 3×10^{-6} barn)

$$t + d = {}^4\text{He}\,(3.5\text{MeV}) + n\,(14.1\text{MeV}). \qquad (3)$$

Also, the gamma photon with 6.25 MeV generated in the reaction (1) will induce a dissociation of a deuteron (with a cross section $\sigma_{gd} \sim 2.5 \times 10^{-3}$ barn and the threshold energy of 2.2 MeV) supplying a neutron to be trapped in the sample:

$$\gamma(6.25\text{MeV}) + d = n + p. \qquad (4)$$

The number of neutrons 900 observed in 230 min in the sample with an initial D/Pd ratio of 0.6 and a volume 1.73×10^{-5} cm^3 used in the experiment gives the density of the trapped neutron of 2.0×10^{12} cm^{-3} using the relation (2) for the number of gamma generated in the reactions (1) and the neutrons generated in the reaction (4). For the maximum rate ~ 180/3 min of the neutron generation, we obtain a value $n^n = 4.6 \times 10^{13}$ cm^{-3} for the density of the trapped thermal neutrons.

The number of neutrons generated by the reaction (3) is smaller than that by the reaction (4) by three orders of magnitude in this case.

The neutrons with 14.1 MeV generated in the reaction (3) will induce a dissociation of a deuteron, also;

$$n\,(14.1\text{MeV}) + d = n + p + n. \quad (5)$$

N(e)de of the X-rays from ^{16}O before the neutron burst and that of from ^{13}C after the neutron burst is confirmed. This, reversely, will show reality of the fundamental assumptions of the TNCF model, i.e. existence of the quasi-stable thermal neutrons in solid in an appropriate structure and its reaction with lattice nuclei in special situations.

A possible mechanism of the neutron trapping in Pd electrode (anode inth is case) could be the band structure effect in Pd metal with PdO_x surface layer with a thickness of ~ few nm.

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References

(1) M. Fleischmann, S. Pons and M. Hawkins, "Electrochemically Induced Nuclear Fusion of Deuterium," *J. Electroanal. Chem.* **261**, p.301 (1989).

(2) H. Kozima, "Trapped Neutron Catalyzed Fusion of Deuterons and Protons in Inhomogeneous Solids," *Trans. Fusion Technol. (Proc. ICCF4)* **26**, p.508 (1994).

(3) H. Kozima and S. Watanabe, "Nuclear Processes in Trapped Neutron Catalized Model for Cold Fusion," *Cold Fusion* **10**, 2 (1995); and ICCF6-347.

(4) H. Kozima, "Neutron Band, Neutron Cooper Pair and Neutron Life Time in Solid," *Cold Fusion}*, **16**, p.4 (1996); *Proc. 3rd Russian Conference on Cold Fusion and Nuclear Transmutation (RCCFNT3)* (Oct. 1995, Sochi, Russia), p.224 (1996).

(5) H. Kozima, "Cold Fusion Phenomenon on the TNCF Model," *Cold Fusion* **20**, p.31 (1996); *Proc. Fourth Russian Conference on Cold Fusion and Nuclear Transmutation* (May 1996, Sochi, Russia) (to be published).

(6) H. Kozima, "On the existence of Trapped Thermal Neutrons in Cold Fusion Materials," p.332.

(7) H. Kozima, M. Nomura, K. Hiroe and M. Ohta, "Nuclear Transmutation in Cold Fusion Experiments," *Proc. ICCF6* (Oct. 1996, Hokkaido, Japan) p. 660; *Cold Fusion* **20**, 16 (1996).

(8) H. Yamada, H. Nonaka, A. Dohi, H. Hirahara, T. Fujihara, X. Li and A. Chiba, "Carbon Production on Palladium Point Electrode with Neutron Burst under DC Glow Discharge in Pressurized Deuterium Gas," ICCF6-610.

(9) H. Yamada, private communication.

(10) T. Nakagawa, T. Asami and T. Yoshida, "Curves and Tables of Neutron Cross Sections," JAERI-M 90-099, Japan Atomic Energy Research Institute, 1990.