Tritium Generation in Mo/D Cathode in Glow Discharge with D_2 Gas

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Abstract

The trapped neutron catalyzed model for cold fusion (TNCF model) was used to analyze experimental data showing tritium generation in a glow discharge system with Mo cathode and D_2 gas. The density of the trapped thermal neutron n_n in the Mo cathode was determined from the production rate of tritium of 10^{15} s^{-1} observed in the gas where deuteron density was 10^{20} cm^{-3} and a path length of tritium in the cathode was assumed as 10^{-2} cm:

$$n_n = 10^7 \text{ cm}^{-3} .$$

1. Introduction

The group of V.A. Romodanov in the Research Institute Lutch in Moscow, Russia has been working on cold fusion experiments in a solid cathode – plasma system[1-6]. In a recent experiment[1], they succeeded in measuring the tritium generation with high qualitative reproducibility in a gas discharge system using a cylindrical Mo cathode. The essential points of the experiments and the typical results are given here, with an analysis of them using the TNCF model.

2. Experimental Results

Cylindrical Mo cathodes (monocrystal and polycrystal) was filled with D_2 gas with a pressure of 1 atm and the gas was able to diffuse out through the wall of the cylinder with a thickness $\ell_0 = 1 \sim 5$ mm. The cylinder cathodes had diameters d = 10 ~ 25 mmϕ and a length $\ell = 100$ mm.

The gas pressure outside of the cathode was ~ 0.2 atm, where a DC discharge between the cathode and an Mo anode took place with a voltage of 1 ~ 2 kV and a current 5A. The Mo cylinders were made of monocrystalline or polycrystalline molybdenum.

After the start of the powerful glow discharge it was necessary to wait several hundreds to a thousand hours to obtain a condition where a high generation of tritium occurred – of $N_t = 10^7 \sim 10^8$ s^{-1} up to $N_{t,max} = 10^{15}$ atoms/s. In a case of a monocrystalline cathode with $\ell_0 = 0.5$ cm, d = 2.5 cm and $\ell = 10$ cm, a stationary tritium generation of 10^7 s^{-1} was obtained.

In the experiments neutrons have been measured together with tritium with a result $N_n/N_t (= n_t) \sim 10^{-7}$.

3. Analysis of the Experimental Data on TNCF Model

The TNCF model[7-10] assumes a stable existence of thermal neutrons in a crystal with a density n_n. The neutrons could be considered as standing wave in a crystal: a superposition of travelling waves with wave vectors of the opposite direction in the crystal. Each travelling wave is reflected at a boundary with penetration of a short distance into it.

A large disorder in the periodicity of the crystal potential for neutrons will work as a perturbation on the neutron Bloch wave to destroy its stability, resulting in absorption of neutrons by a nucleus, causing the disorder. In the cathode with a temperature ~ 3000°C, neutrons can be absorbed by a deuteron with a large deviation from its equilibrium position.

Then, relevant nuclear reactions are listed as follows;

$$n + d = t\,(2.7\ \mathrm{MeV}) + \tau(6.25\ \mathrm{MeV}), \qquad (1)$$

$$t\ (2.7\ \mathrm{MeV}) + d = {}^4\mathrm{He}\ (3.5\ \mathrm{MeV}) + n\ (14.1\ \mathrm{MeV}) + 2.7\ \mathrm{MeV}, \qquad (2)$$

$$t\ (2.7\ \mathrm{MeV}) + d = t'\,(\varepsilon') + d'(\varepsilon''), (\varepsilon' + \varepsilon'' = 2.7\ MeV, \qquad (3)$$

$$d\,(\varepsilon) + d = {}^4\mathrm{He}\ (0.82\ \mathrm{MeV}) + n\ (2.45\ \mathrm{MeV}) + \varepsilon, \qquad (4)$$

$$= t\,(1.01\ \mathrm{MeV}) + p\ (3.02\ \mathrm{MeV} + \varepsilon. \qquad (5)$$

The cross sections for the first two reactions are $\sigma_{n\text{-}d} \sim 9 \times 10^{-4}$ and $\sigma_{t\text{-}d} \sim 1.4 \times 10^{-1}$ barns, respectively. (1 barn = 10^{-24} cm^2.)

So, we can calculate n_n assumed as a constant throughout the experiment by a following relation between the observed tritium number N_t and n_n:

$$N_t = 0.35\, n_n v_n n_d \ell_0 S \sigma_{n\text{-}d} T,$$

where T is the duration of the tritium generation, ℓ_0 and S are the thickness and the surface area of the cylindrical cathode, respectively, and $v_n = 8.5 \times 105$ cm/s (T = 3000°K). Using parameters given above, we obtain a relation between n_n and n_d as follows; $n_n n_d \sim 3 \times 10^{27}$ cm^{-6}.

If we assume a value $n_d = 10^{20} (10^{24})$ cm^{-3} for the average density of deuterons in the cathode, which was not determined in the experiment, then we obtain the density of the trapped thermal neutrons: $n_n \sim 3 \times 10^7 (10^3)$ cm^{-3}

This value is compared with the values obtained in the previous analyses[9]: 10^3 cm^{-3} (Takahashi et al.; n and t, 10^7 cm^{-3} (Bush and Eagleton; Q and NT from Rb to Sr), $10^9 \sim 10^{10}$ cm^{-3} (Fleischmann et al.; Q, t, and n), $10^9 \sim 10^{10}$ cm^{-3} (Miles et al.; Q and ^{4}He) and 10^{12} (Arata et al.; Q and ^{4}He).

The tritium generated in the reaction (1) may run a path length ℓ_t of an order of ≃ 1 ~ 10 μm ($10^{-4} \sim 10^{-3}$ cm) inducing the reaction (2) with a deuteron. The neutron generated in this reaction with an energy 14.1 MeV can be observed outside. The number of reaction (2) for a triton is equal to the number of neutron and is given by a relation with $\sigma_{td} \sim 10^{-5}$ barns: $N_n = 1 \times 10^{-4}\, n_d \sigma_{td}$
For $n_d = 10^{20} (10^{24})$ cm^{-3}, we obtain $N_n/N_t \sim 10^{-13} (10^{-9})$.

We have assumed the density of the deuteron in the Mo cathode as $10^{20} (10^{24})$ cm^{-3}

arbitrarily in the above calculation. To fit the experimental data of $N_n/N_t \sim 10^{-7}$, we have to take a rather elongated path length ℓ_t of the triton as 10^{-2} cm due to the channeling effect than the usually accepted value of ~ 1 μm (= 10^{-4} cm). The maximum value of $n_d \sim 10^{24}$ gives, then, following values:

$$n_n = 10^3 \text{ cm}^{-3}, \quad N_n/N_t = 10^{-7}.$$

4. Conclusion

The amount of tritium atoms observed in the experiment gave us the density of trapped neutrons $n_n \sim 10^3$ cm^{-3} in the case of $n_d \sim 10^{24}$ and $\ell_t \sim 10^{-2}$ cm. This is not always an absurd result considering the complex situation of the experimental system.

The neutron affinity η of Mo and D are + 0.73 and - 0.02, respectively[9]. This difference in η will suffice the trapping condition for thermal neutrons in the cathode. From the ambient neutrons with an observed flow density 0.2 cm^{-2} s^{-1}, it will be concluded that ~ 10^6 neutrons entered into the cathode in 10^3 η (~ 10^6 s) which could be trapped by the band structure effect[11].

Piling up the trapped thermal neutrons in the sample, the condition of Cooper pair formation changes, i.e. the stability of the trapped thermal neutron changes. The less stable neutron interacts with deuterons in the high temperature cathode (3000°C) to fuse with one of them with a cross section ~ 10^{-3} barns to generate tritons observed in the experiment.

Numerical relation between the observed tritium and neutron has been consistently explained by the model supporting the postulates of the trapped thermal neutron[12].

Consistency of the explanation by the TNCF model of whole experimental data in the cold fusion elucidates the physics of its phenomenon to develop researches in this field and opens the way to cultivate a new energy source.

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Cold Fusion Phenomenon Explained By Using The TNCF Model

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Abstract

A model based on the stable existence of thermal neutrons in crystals was used to analyze experimental data obtained in electrolytic cold fusion experiments in these seven years. The density of the trapped thermal neutrons n_n in samples was determined by using the experimental results of excess heat, helium 4 (^4He), tritium, neutrons and/or nuclear transmutation (NT). The values of the density n_n determined by the experimental data were $10^5 \sim 10^{15}$ cm^{-3}. Other quantities we could determine from experimental data were the ratio of events generating tritium and neutrons t/n and the ratio of events generating the excess heat and tritium (and ^4He) N_Q/N_t which had been a controversial quantities to reconcile with the existing common sense of physics. The values determined on our model were $t/n \sim 10^5$ and $N_Q/N_t \sim 10$, substantially consistent with experimental data to one order of magnitude.

1. Introduction

In the cold fusion phenomenon which was discovered in 1989 and developed in the seven years since, a lot of experimental data has piled up. Various phases of the results obtained have been waiting a consistent explanation.

The results showing the cold fusion phenomenon have been obtained using various materials which have generated various products, including excess heat, ^4He, tritium, neutron, γ and the nuclear transmutation of elements. These results were difficult to understand in the conventional physics framework. Therefore, it has been desirable to have a common basis which might explain all of the data. A model I've explored is the TNCF model, which supplies a basis for the needed analysis.

2. The TNCF model

We have developed a model[1–4] based on the existence of the stable ther-