Neutron Emission from Palladium Electrodes in Deuterium Gas under Highly Non-uniform Electric Fiel

Hiroshi YAMADA, Norio SUGAYA, Tsuyoshi KAMIOKA,
Michiaki MATSUKAWA, Tamiya FUJIWARA and Koshichi NOTO
Faculty of Engineering, Iwate University
Ueda 4-3-5, Morioka 020
JAPAN

ABSTRACT

The fusion reproducibility in palladium(Pd) has been searched with the detection of excess neutron for point-to-plane electrode configuration in deuterium(D_2) and in hydrogen(H_2) gas atmosphere using a Pd, nickel(Ni) and tungsten(W) point. Excess neutron counts were observed using D_2 loaded Pd points under DC high-voltage applications. To the contrary, no count except background was observed with other points under the similar test condition. The observed highest counting rate of 61 counts for 10 seconds from the Pd is equivalent to the neutron emission of $\sim 1\times10^5$ n/(s·cm^3).

1. Introduction

Since the cold fusion was claimed to occur in Pd or Ti cathodes during electrysis of D_2O[1,2], a considerable number of research groups have investigated the fusion and many positive results have been obtained in these four years. In one of these studies, De Ninno et al. have found another simple methode of the cold fusion without the process of electrysis, that is, they have observed a spontaneous neutron emission from D_2 loaded Ti powder during the process of cooling with liquid nitrogen and heating[3].

In this short report, the experimental condition has been investigated to obtain more steady excess neutron emission with a point-to-plane electrode system in D_2 gas atmosphere using a ^{3}He thermal neutron detector. The experimental arrangement presented is simple and thus would assist a theoretical approach to the mechnism of the cold fusion.

2. Experimental

A neutron measurement system is used to detect 2.45 MeV neutrons from the D(d,n)^{3}He fusion branch. The system consists of a ^{3}He thermal neutron detector(Reuter-stokes: RS-P4-0806-207), a pre-amplifier(EG & G ORTEC: 142PC), an amplifier(EG & G ORTEC 590A single channel analyzer), a Timer-and-Counter(EG & ORTEC:996), a

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polyethylene inner moderator(500 mm long, 500 mm wide and 300 mm high), 1 mm thick Cd sheet reflector and ∿ 500 mm thick outer shielding of saturated boric acid solution in water. The polyethylene inner block, having a central cavity with a cylindrical shape of 140 mm in diameter and 100 mm high, enhances the efficiency of the ^{3}He counter by moderating fast neutron emitted from a cell. The polyethylene moderator is surrounded with the Cd sheet. The cell and the detector are positioned inside the central cavity. Signals from detector are fed to the single channel analyzer through the preamplifier and the amplifier. The counts are stored on a floppy disk using a personal computer. The electromagnetic noise related to high-voltage application is avoided by adjusting the preamplifier gain, the shaping time of the amplifier and the window of the single channel analyzer. The efficiency of the detector is ∿ 1 % using ^{252}Cf source with a neutron intensity of $2.3\chi10^4$ n/s. The average background of neutron flax without test cell is 8.6 cph after the adjusting. The background level is not so low, because the measurement system is directly positioned on the ground and is only covered with an upper thin roof.

The point-to-plane electrode system with gap spacing of ∿ 15 mm was in the closed cell filled with 2 atm pressure D_2 gas. The plane electrode was a brass disk of 30 mm diameter. A commercial Pd wire of 0.3 and 0.5 mm in diameter were cut to ∿ 30 mm in length to be the point electrodes. After polishing, the Pd points were vacuum annealed at 800 °C under a pressure less than 10^{-3} Torr for 3 hours and cooled to room temperature, follwed by loading of D_2 gas under 2 atm pressure for 24 hours. Next, the Pd point was set to the cell and kept in D_2 gas atmosphere of 2 atm pressure for 20 up to 40 hours under a DC 4.5 kV application in the neutron measurement system. The negative DC voltage was applied to the point electrode. Then a DC ∿ 10 kV, the lowest voltage for flashover, was applied to activate the Pd point electrode[4]. Just after several strokes of flashover, the DC voltage was immediately decreased to a slightly lower voltage than that for flashover. Ni and W points of similar size were used as reference electrodes under almost the same voltage amplitude with the aim of measuring the change in neutron counts. H_2 and air were also used as loading and enviroment reference gas.

3. Results and Discussion

The deuteron to Pd loading ratio was 0.66 at 24 hours after the start of loading. No excess count was usually observed until the activation by the flashover. An initial burst of neutron was detected after the several strokes of flashover in 8 out of 22 runs using D_2 loaded Pd points in D_2 gas atmosphere. However, such excess counts were once observed without any flashover, suggesting that the activation by flashover is not necessary for the neutron emission. The excess counts ceased when the applied voltage was removed. This indicates that the application of DC high voltage is a key factor for the fusion in this study. Counting rate significantly higher than the background level were observed in 6 runs out of the above positive 9 runs. But, 3 out of the remarkable 6 runs were carried out using a point. One of typical time behaviors of neutron emission is shown in figure 1 (a); the rate is given by the counts summed up within 2 minutes. The time 0 in the figure shows the time when the last stroke of flashover took place. The average background of neutron flax of 0.29 counts per 2 minutes can be negligible in the figure. The average counting rate in figure 1 (a) is 96.5 counts per 2 minutes. Keeping into account the efficiency of the counter, the total number of emitted neutrons over 3 hours amounts to $\sim 1\times10^6$. The observed highest counting rate of 61 counts for 10 seconds, $\sim$ 2,500 times larger than the background counting rate, is equivalent to the emission of $\sim 1\times10^5$ n/(s$\cdot$cm^3) from the Pd electrode. In addition, excess neutron emission was also observed in H_2 gas atmosphere, as shown in figure 1 (b), and in air using D_2 loaded Pd point while these counting rate were lower than those in D_2 gas atmosphere. To the contrary, no count except background was observed with other points for all the 43 runs under the similar test condition, even though the point was H_2 loaded Pd in D_2 gas atmosphere. These results indicate that the fusion did not take place in the enviroment gas volume but in the Pd bulk or its surface. The number of positive runs to that of total runs for each condition is compiled into table 1. All the results allow us to conceive that a corona current of the order of 10 μA due to the DC high-voltage application would induce the transition of deuterons from octahedral sites in Pd to other sites[5] and that a multiplication of the transition would occur in the Pd bulk or its surface.

4. Conclusion

Nine out of twenty-two runs with D_2 loaded Pd points in D_2 gas atmosphere have given excess neutron counts under DC high-voltage applications. Furthermore, excess neutron emission was also observed in H_2 gas atmosphere and in air using D_2 loaded Pd point, while its counting rate was lower than that in D_2 gas atmosphere. This indicates that the fusion did not take place in enviroment gas volume but occured in Pd bulk or its surface. Corona current of the order of 10 μA due to the DC high-voltage application would be responsible to the continuous neutron emission by the fusion.

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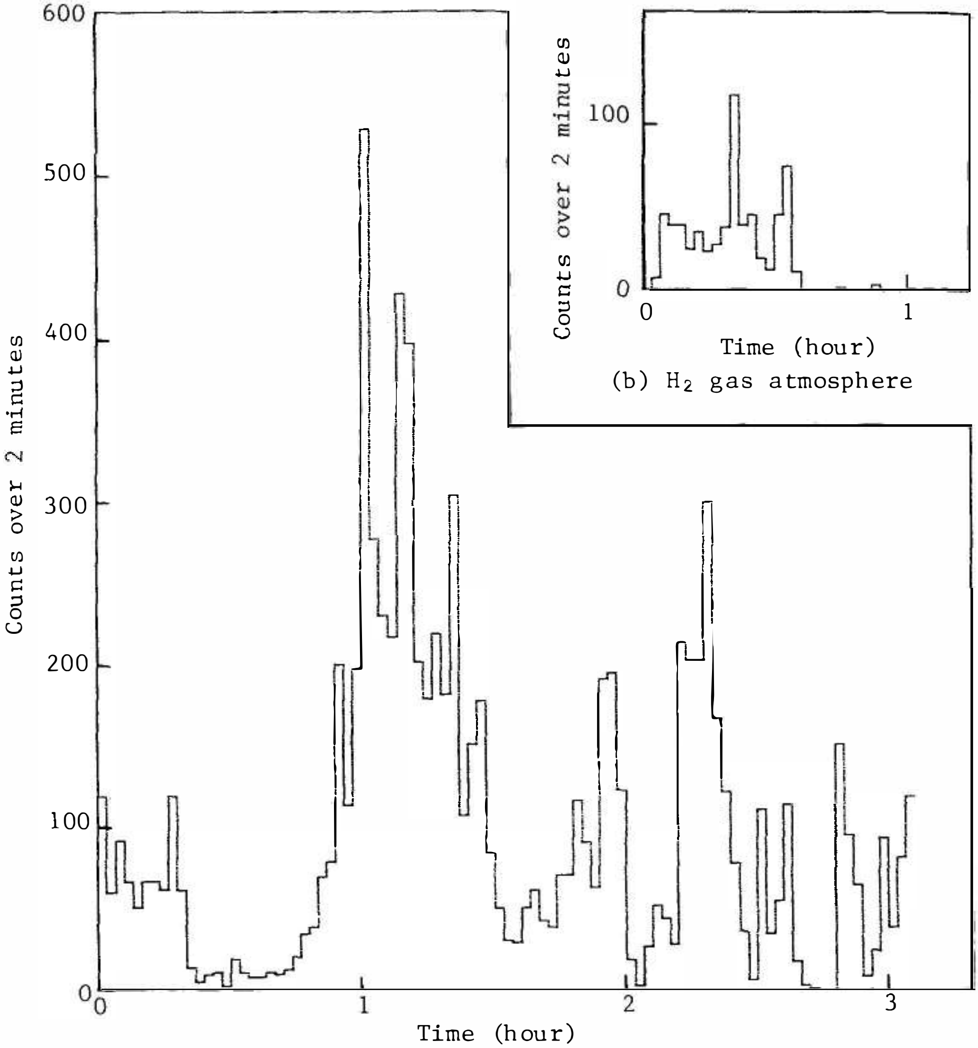

(b) H_2 gas atmosphere

(a) D_2 gas atmosphere

Fig. 1. Time dependence of neutron emission under negative DC ∿ 9 kV application after the activation by flashovers.

		Point and (loading gas)					
		Pd(D_2)	Pd(H_2)	Pd	W	Ni(D_2)	Ni
Enviroment gas	D_2	$\frac{9}{22}$	$\frac{0}{3}$	$\frac{0}{3}$	$\frac{0}{3}$	$\frac{0}{8}$	$\frac{0}{6}$
	H_2	$\frac{2}{3}$	$\frac{0}{14}$	$\frac{0}{6}$			
	Air	$\frac{1}{2}$					

Table 1. The number of positive runs to that of total runs for each condition.