Innovative Approach

Carbon Production on Palladium Point Electrode with Neutron Burst under DC Glow Discharge in Pressurized Deuterium Gas

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Abstract

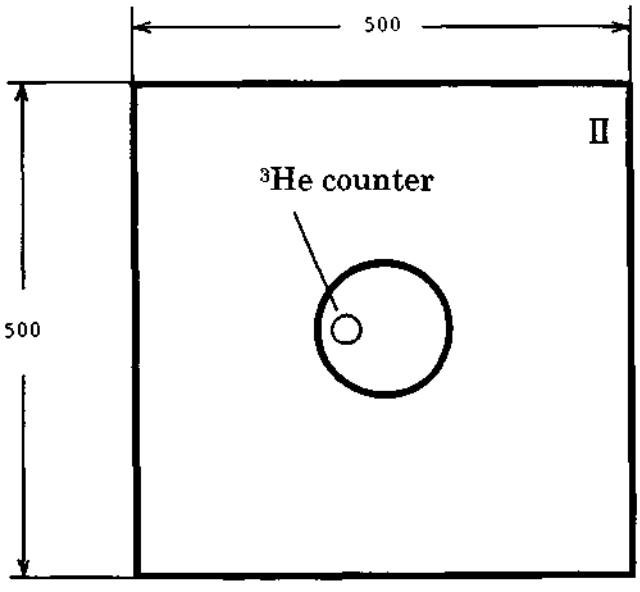
A point-to-plane electrode configuration in slightly pressurized deuterium gas for highly non-uniform electric field was employed to confirm the cold fusion phenomena under glow discharge condition. A neutron burst took place in 2 runs out of total 37 runs. Using an optical microscope, black deposit was observed to cover the tip surface of two positive electrodes. To the contrary, the tip surface of other 35 electrodes was observed to keep its beginning appearance. X-ray photo-electron spectroscopy have revealed the black deposit to be carbon, mixed with palladium at the surface of palladium point electrode. The total amount of carbon impurity in the palladium electrode and in environment deuterium gas dose not account for the large amount of carbon on the tip surface of electrode.

1. Introduction

Wada et al. have reported a spontaneous neutron emission from palladium(Pd) electrode in deuterium(D_2) gas during and after activation by flashover between electrodes[1]. The study shows that the nuclear reaction can takes place at solid in D_2 gas atmosphere[2,3] as well as in heavy water[4]. In this study, the nuclear reaction in D_2 loaded Pd point electrode in 2 atm D_2 gas under glow discharge condition has been investigated by neutron detection and X-ray photo-electron spectroscopy(XPS).

2. Methods

A neutron measurement system, including a ^3He thermal neutron detector , is used to detect the excess neutron from the nuclear reaction in Pd point electrode. A neutron moderating system of polyethylene block, as shown in Fig. 1, has a center cavity with a cylindrical shape of 140 mm in diameter and 100 mm high, enhance the efficiency of the ^3He counter by moderating fast neutron from a test cell. The test cell and the detector are positioned inside the center cavity. Signals from the detector are fed to the single channel analyzer through a preamplifier and an amplifier. The counts are stored on a floppy disk using a personal computer. The noise related to high-voltage application is avoided by adjusting the preamplifier gain and the



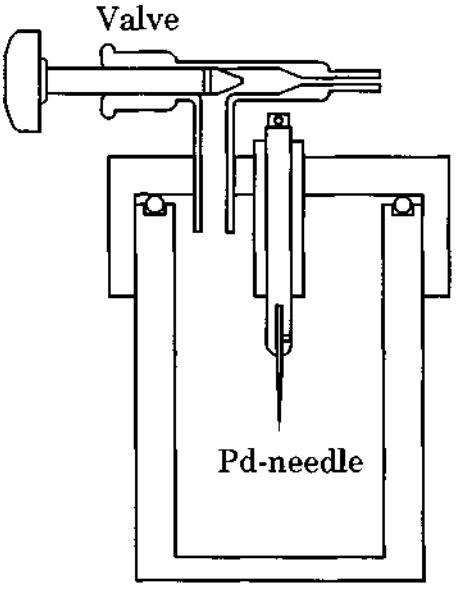


Fig. 2 Test cell

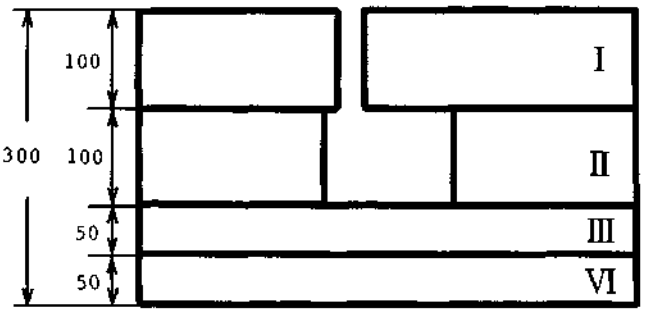


Fig. 1 Neutron moderating system

window of the single channel analyzer.

The test cell, shown in Fig. 2, have a cylindrical shape with volume capacity of 110 cm^3. The point-to-plane electrode system with gap spacing about 10 mm was employed in the closed cell to obtain highly non-uniform electric field. A Pd wire of 0.5 mm in diameter was cut to about 30 mm in length to be a point electrode. After polishing the surface with sandpaper, the Pd point electrode was vacuum annealed at 400℃ for 3 hours under a pressure about 10^{-4} Torr then cooled down to room temperature, followed by loading of D_2 gas under 2 atm pressure for 24 hours. Next, the Pd point electrode was set to the test cell, followed by filling the test cell with 2 atm D_2 gas. After positioning the cell and the detector inside the center cavity of moderating system, positive DC 4 or 8 kV was applied to the Pd point electrode. The neutron measurement started just after the voltage application and continued for 24-65 hours. The deuteron to Pd loading ratio was measured to be about 0.6.

The efficiency of the detector was measured to be approximately 1% using ^{252}Cf source. The average background of neutron flax without the test cell is about 25 counts per hour after the adjusting. The counting characteristics of background neutron has been stable over total about 3,500 hours of background measurement period for these 7 years.

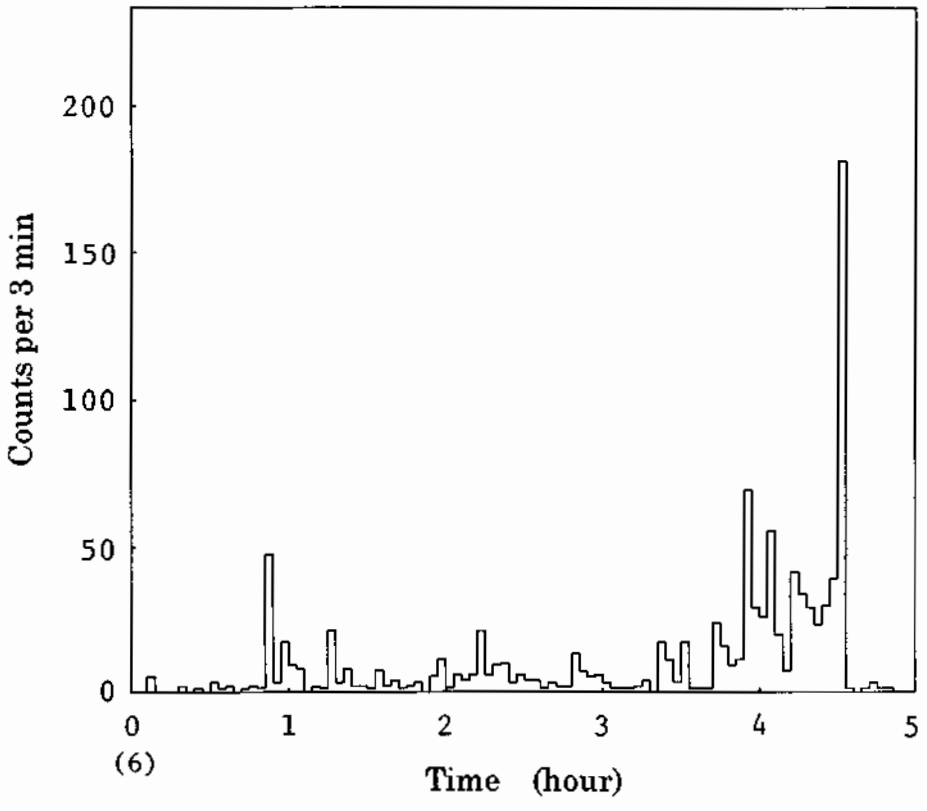


Fig. 3 Time dependence of the neutron counts from deuterium-palladium system

3. Results

The neutron burst was observed in 2 out of 37 runs. The electrodes used in the positive 2 runs are assigned to the names "Electrode-A" and "Electrode-B". The time behavior of the neutron emission rate for Electrode-A is shown in figure 3, where the emission started at 6 hours 48 min after the beginning of the 8 kV application and continued 3 hours 50 min. No excess count was observed for 30 hours after the emission ceased. The highest count rate of 180 counts per 3 min, observed just before the emission ceased, is 140 times larger than that of the background neutron. The number of total neutron counted was about 900. In the case of Electrode-B, The burst was started just after the voltage application and continued for about 15 min. The next burst started about 5 hours after the first burst and continued for 5 min. The number of neutron counted during the 2 bursts amounts to 3×10^4. The highest count rate of 2,700 per 5 sec was 9×10^4 times larger than that of the background neutron. The total number of excess neutron is estimated to be 35 times larger than that for the Electrode-A, even though the emission period was shorter than that for the Electrode-A. No excess neutron was observed for 65 hours after the second burst ceased.

The electrodes after the voltage application were viewed by an optical microscope. The tip surface of two positive electrodes was found to be covered with black deposit. Of particular interest is that several craters of about 10 μ m in diameter were formed on the tip surface of Electrode-A. The covered area was measured to be more than 0.32 mm^2 for Electrode-A. To the contrary, the tip surface

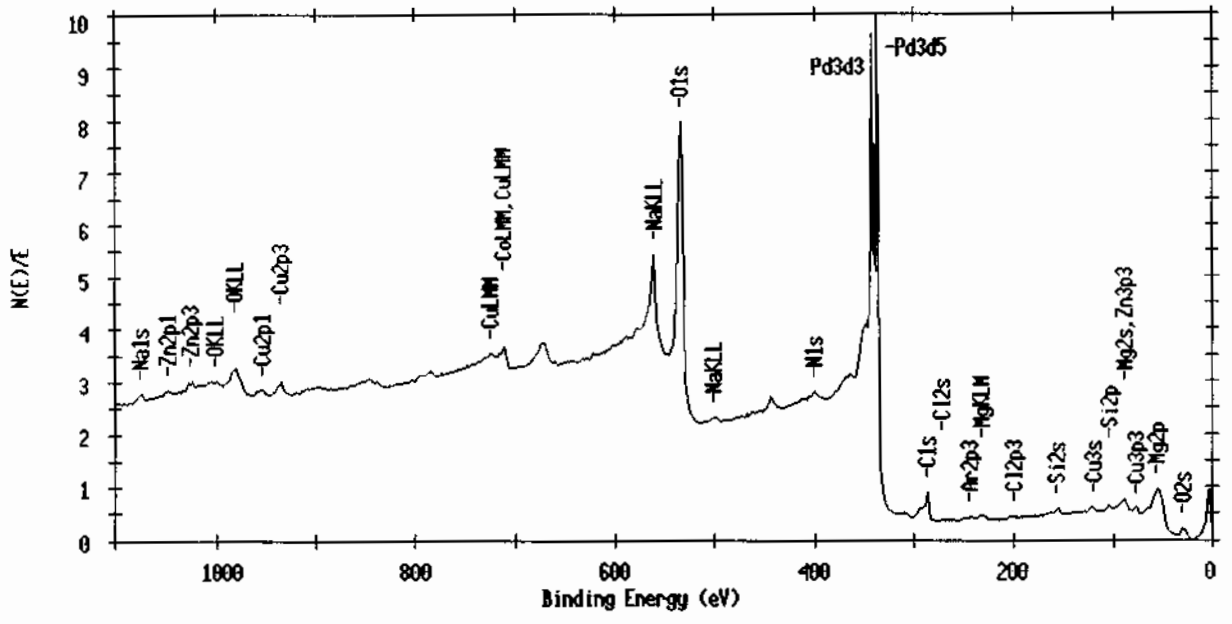


Fig. 4 XPS spectrum of the Pd point electrode before neutron emission

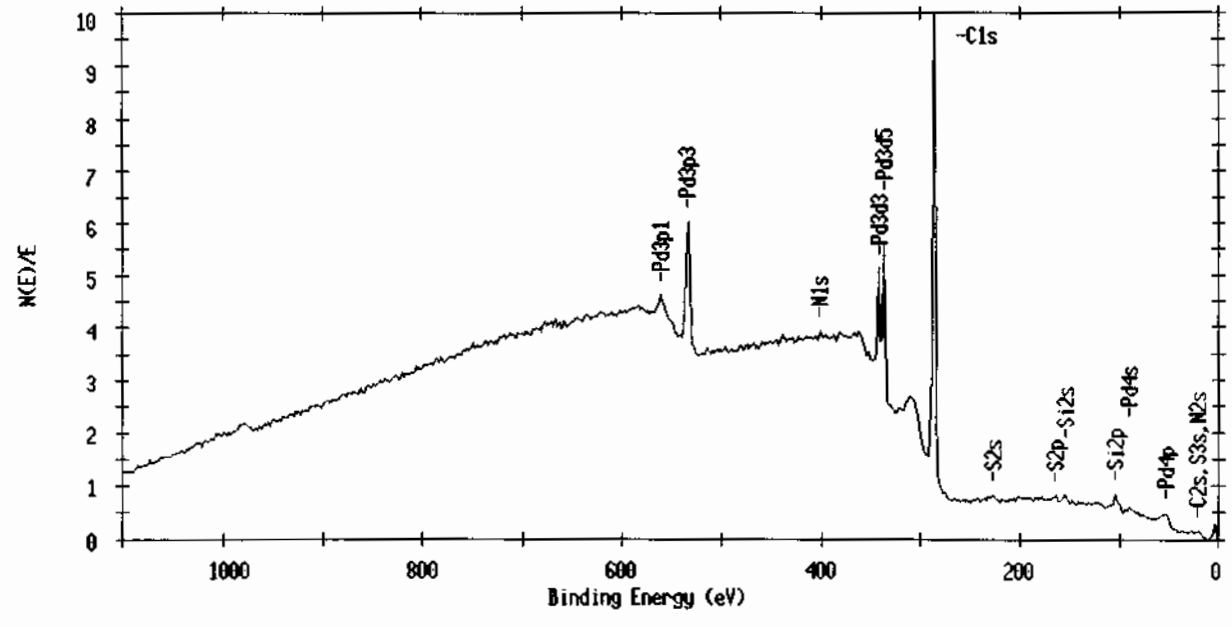


Fig. 5 XPS spectrum of the Pd point electrode after neutron emission

of negative 35 electrodes was observed to keep its beginning appearance.

An XPS spectrum for D_2 loaded Pd point electrode before the voltage application is shown in Fig. 4, where the tip of electrode was etched in about 0.5 nm depth with argon ion to remove molecules of air contamination. The figure shows a strong absorption of oxygen on the surface. To the contrary, a large carbon peak is seen in the XPS spectrum of the tip of Electrode-A after the neutron emission, as shown in Fig. 5. It seems that the carbon atoms were mixed with Pd atoms in the bulk region from the electrode surface to the depth in several atomic size at least .

4. Discussion

The Pd point electrode may include 1 PPM carbon at most. The point positive condition excludes the possibility that the carbon in the bulk of Pd point electrode was collected and condensed into the surface region by an electro-migration. Even though there exists another unknown mechanism for carbon impurity to migrate to the surface, the carbon collected should be 17 nm in thickness, based on that the deposit density of 1.5 and carbon impurity of 1 PPM. Whereas the thickness of the deposit should be more than 340 nm for the deposit to be seen black.

The environmental D_2 gas in the test cell includes 0.4 PPM CO , 0.6 PPM CO_2 and 0.1 PPM CH_4 at most. The total amount of carbon impurity in the gas can form carbon deposit of 250 nm in thickness. Thus, the carbon impurity both in the Pd electrode and in the environment D_2 gas does not account for the large amount of carbon on the surface of Pd point electrode.

The plausible explanation for the neutron burst and the carbon production is that the high current density at the point electrode and its fluctuation by glow discharge would stimulate the accumulation of deuterons to induce a fusion in the bulk near surface of Pd point electrode. The relatively low loading ratio of 0.6 allow us to conceive that high loading ratio is not always necessary but high current density is rather an important factor for the nuclear reaction. An atom such as helium would be produced from deuterons at first reaction step; carbon would be produced from the atoms next. However, the total excess neutrons estimated was considerably few compared with the estimated number of carbon atoms on the surface of Pd point electrode. This indicates that the first reaction would produce a large number of atoms such as helium but few neutrons.

5. Conclusion

The large amount of carbon deposit was observed at the tip of D_2 loaded Pd point electrode after neutron burst under glow discharge condition in 2 atm D_2 gas, even though the phenomena are rare. The phenomena could be explained in terms of a nuclear fusion at the Pd point electrode.

Acknowledgment

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Reference

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