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STUDIES OF COHERENT DEUTERON FUSION AND RELATED NUCLEAR REACTIONS IN SOLID

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ABSTRACT

In order to induce coherent deuteron fusion in metal-deuteride, three kinds of experiments have been performed. In the closed type D_2O /Pd electrolysis experiment, significant amount of helium-4 atom was detected in upper gas of electrolysis cell and inside the palladium cathode by QMS analysis. In the discharge type electrolysis experiment, anomalous elements were detected on the surface of cathode palladium by PIXE analysis after experiment. The detected elements are iron and zinc. Under electron beam irradiation to highly D-loaded palladium, anomalous spectra were taken in X-ray measurement.

1. INTRODUCTION

It is said that the coherent excitation of the harmonic oscillation and the diffusion of deuteron in a metal lattice are important factors to induce nuclear reactions in solids[1,2)]. It is assumed that this condition is not attainable in equilibrium state, but in some dynamic processes. In our group, several types of experiments are under way for stimulating such dynamic conditions and for inducing coherent multibody deuteron fusion in solids. There is one possibility that the excited energy of compound nuclei produced by coherent multibody fusion can be transferred to lattice oscillation energy by quantum-electrodynamic process. If such energy transfer associates intense short burst of X-rays, it become possible to make fission induced by multi photon process[3)]. In this paper, three types of experiments are described; i.e., the closed type D_2O electrolysis, the discharge type D_2O electrolysis and the electron beam irradiation to highly D-loaded metals.

2. EXPERIMENTAL RESULTS AND DISCUSSION

2.1 CLOSED TYPE D_2O ELECTROLYSIS

In order to create dynamic condition in highly D-loaded Pd cathode, electrolysis experiments were performed with changing electrolytic current mode.

On-line measurements of correlation between time-variation of D/Pd ratios, excess power (by mass flow calorimetry) and neutrons (measured by NE213 scintillation counter and ^{3}He detector) and off-line quantitative measurements of ^{4}He atoms accumulated in the cell and the cathodes after electrolysis (using Quadrupole Mass Spectroscopy) have been performed.

Results are summarized in Table 1. Experimental results for #1 to #7 were reported at ICCF8[4)]. Results for ^{4}He and neutron measurement are written "Yes" or "No" in the table, it means whether measured result was more than or less than detecting limitation. The limitation is 3.2×10^{10}atoms/cm^3 for ^{4}He analysis. Detected values are also written for ^{4}He result.

Meaningful increase of ^{4}He atoms was recognized for four experiments. These ^{4}He-atoms had probably been produced by some nuclear reaction during electrolysis, because it was confirmed by experiment that there was no ^{4}He contamination from air. The detected neutron was not meaningful amount through this series of experiments. The excess power was detected only in experiment #2 however that excess power was very small (about 2.6 W at most). In the other runs, clear heat generation was not detected.

For the experiment #8, newly designed electrolysis vessel, which has two glass windows to measure X-ray, was used. It is supposed that bremsstrahlung or characteristic X-rays involved to nuclear reactions would be emitted. But meaningful X-ray emission was not detected in #8 experiment.

EXP. # (Duration)	D/Pd (maximum)	^{4}He detection		Neutron	Current mode
		Inside the cell	Inside the cathode		
1 (163h)	—	No	No	No	S.U, L.H
2 (201h)	0.85	No	**Yes (3.7×10^{14} atoms)**	No	S.U, L.H
3 (264h)	0.83	No	No	No	L.H
4 (167h)	0.85	No	**Yes (1.1×10^{15} atoms)**	No	S.U, L.H
5 (243h)	0.93	**Yes (4.6×10^{15} atoms)**	**Yes (8.1×10^{15} atoms)**	Not measured	S.U, L.H S.T, C.C
6 (255h)	0.96	**Yes (3.3×10^{15} atoms)**	**Yes (8.8×10^{14} atoms)**	Not measured	S.U, L.H C.C
7 (740h)	0.85	No	No	Not measured	S.U, L.H S.T
8 (111h)	0.87	**Yes (2.2×10^{15} atoms)**	No	No	S.U, L.H

S.U: Step-up, L.H: Low-High, S.T: Saw-tooth, C.C: Constant Current

Table 1: Results for Closed Type D_2O /Pd Electrolysis

Results of closed type electrolysis experiment suggest existence of some nuclear reactions which produces ^{4}He without strong emission of neutrons and large amount of heat. At least D-D fusion reaction does not come under such reaction because of its small branching ratio for ^{4}He production. We think coherent multibody deuteron fusion such as D+D+D or D+D+D+D should have occurred in the D_2O /Pd electrolysis.

2.2 DISCHARGE TYPE D_2O ELECTROLYSIS

We performed electric discharge in the D_2O electrolyte. The cathode was made of palladium, and manufactured to hollow type which had good ability to emit thermal electron. In this experiment, on-line measurements of neutron (NE213 scintillation counter), X-ray (twin CdTe detectors) and light spectrum (by monochrometer and photomultiplier) were performed. For this purpose, open type glass cell was selected. After the electrolysis, elements in the cathode metal were analyzed by PIXE analysis.

The electrolysis was controlled by electrolytic voltage. In the case that the voltage escalated, current increased in linear till 40 V and became constant value of 4 A between 40 V and 65 V. At 65 V, current dropped down to 2 A and discharge was started. The discharge state shifted to normal glow discharge at 95 V and current dropped down to 0.5 A. In the experiment, the voltage was increased to 80 V sharply after D-loading (5 V, 0.5 A/cm^2, 3 hours).

Meaningful spectra were not observed by measurements of neutron and light spectrum. In X-ray measurement, there would be possibility that we observed bremsstrahlung X-rays, but electromagnetic noise from discharge region was too high to distinguish such X-rays. Increase of specific elements were observed by PIXE analysis. Results are summarized in Table 2. Impurities in the aqua region are neglected because their concentrations were within the range of 0.001 ~

0.03 ppm. The increased foreign elements larger than ones in bulk sample are iron and zinc. Their increment factors were 1.2 times and 5.6 times respectively.

sample	elements' concentration (ppm)			
	Cr	Fe	Ni	Zn
bulk Pd (before)	118.07±18.37	175.70±10.5	18.50±6.16	12.80±5.85
cathode Pd (after)	128.32±17.81	209.64±10.65	18.50±5.81	71.39±6.96

Table 2: Results of PIXE analysis for discharge Electrolysis

If fission of palladium nucleus have occurred, two new elements would be produced with various combinations[3)]. We guess observed anomalous elements are one fragment of the scission fragment pair, however, partner elements have not been found. Further experiments are needed to determine the origin of increased elements of iron and zinc.

2.3 ELECTRON BEAM IRRADIATION TO HIGHLY D-LOADED METAL

The purpose of this experiment is to make some disturbed situation by stimulating highly D-loaded metals (titanium-deuteride, TiDx or palladium-deuteride, PdDx) with electron beam irradiation and to induce nuclear reactions in solids.

Figure 1 shows the experimental setup. The electron beam was produced with an electron gun of which beam energy, beam current and beam diameter were about 3 keV, 5 µA and 1 mm, respectively. Two CdTe-detectors for X-rays, a lithium drifted silicon detector (Si(Li)) for low energy X-rays and a HPGe detector for gamma-rays were attached to a vacuum chamber. The chamber was kept in a vacuum level of about 5×10^{-6} Pa. Pd (PdDx: x~0.7, by electrolysis method) was used as a target. Surface of PdDx was coated with copper layer (~0.05 µm) by electroplating method after the D-loading (150 mA/cm^2, 8 hours), in order to attach blocking-layer to keep the deuterium inside the Pd and to make boundary atom layers in different metal interfaces.

In ICCF8, we presented that bumps in X-rays spectra from 10 keV to 20 keV were recognized in both of two spectra measured with twin CdTe detectors under electron-beam irradiation to PdDx[4)]. In order to confirm that the bumps were definitely X-rays, one of the CdTe detectors was covered with a Zr filter that had absorption by the K-shell edge at about 18 keV. Figure 2(a) shows energy spectra measured under this condition. Differences between foreground and background from 10 keV to 30 keV are recognized, though the differences are smaller than the data of ICCF8. The numbers of counts from 10 keV to 30 keV in the both of spectra are larger about 1.25 times, comparing with the background. The numbers of counts above 30 keV are not different from the background. Differences between CdTe1 and CdTe2 are also recognized (Fig.2(b)) in spectra of foreground. The numbers of counts of CdTe1 from 10 keV to 30 keV were about 1.13 times as much as that of CdTe2. We conceive that the cause of the differences was due to the K-shell absorption with the Zr filter. There are some possibilities that these spectra are responses of bremsstrahlung X-rays by slowing down of generated charged particles, scattered gamma-rays by Compton effect, or some pumped-up photons in the system.

3. CONCLUSION

The phenomena that observed in above three experiments suggest nuclear reactions in solids such as coherent deuteron fusion and multi photon induced fission of palladium. These phenomena are witnessed with the generation of helium-4 atom for closed type D_2O electrolysis, the anomalous increase of specific elements in cathode metal for discharge type D_2O electrolysis and the reproducible bumps in X-rays spectra from 10 keV to 20 keV for electron beam irradiation to highly D-loaded metal. However, further experiments are needed to assert the suggested nuclear reactions in solids.

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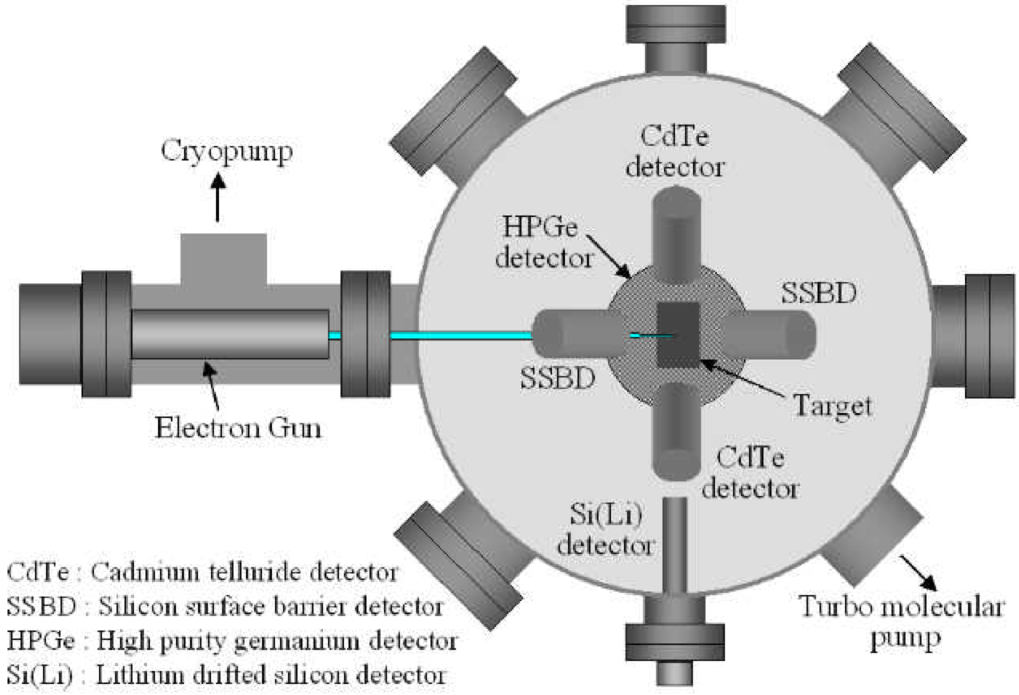
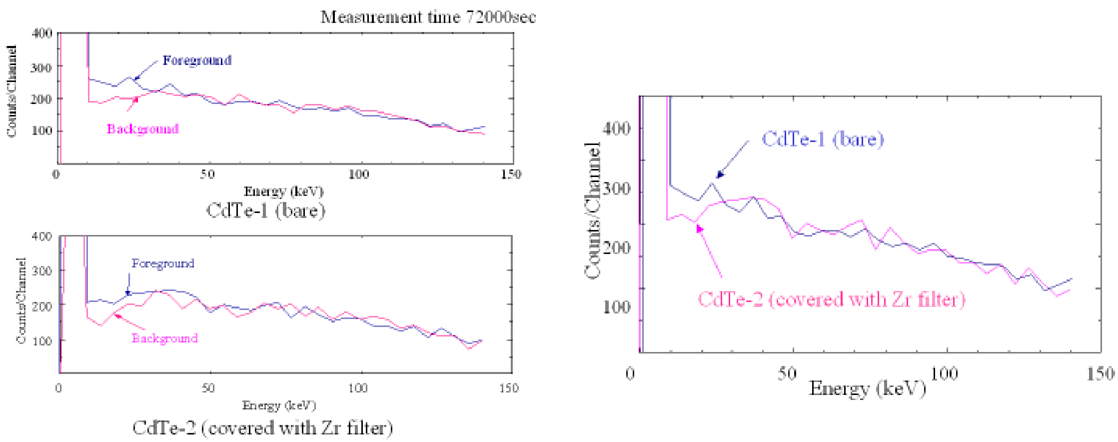


Figure 1: Scematic view of the experimental setup



(a) foreground and background

(b) foreground for CdTe1 and CdTe2

Figure 2: Energy spectra under electron-beam irradiation