DETECTION OF CHARACTERISTIC GAMMA RAYS FROM ELECTRODES IN PD-D SYSTEM BY HV DISCHARGE

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ABSTRACT

Evidence is presented to show the different characteristic gamma rays from electrodes in Pd-D system, by HV discharge. It might be explained as the elements of electrodes excited by high energy charged particles originated during HV discharge de-exciting radiations.

During HV pulses no neutron signal was detected.

In addition, neither neutron signals nor gamma signals were detected in the intervals between the HV pulses.

INTRODUCTION

Since M. Fleischmann, B.S. Pons [1,2] and S.E. Jones et al. [3] reported in 1989 that nuclear fusion of deuterium (D_2) occurred at room temperature in Pd or Ti cathodes during the electrolysis of heavy water (D_2O), considerable efforts have been made to investigate so -called `cold fusion' by many laboratories in the world. These experiments include several types: Electrolysis of heavy water; cold-hot cycles of deuterated palladium between liquid nitrogen temperature and room temperature; processing deuterated palladium by mechanical treatment and gas discharging of deuterated palladium [4,5] etc. However the results are in conflict with each other [6].

As is well known, there exists three reaction modes in D-D fusion:

(1) $D + D \rightarrow n(2.45MeV) + {}^3He(0.82MeV)$
(2) $D + D \rightarrow P(3.02MeV) = T(1.0MeV)$
(3) $D + D \rightarrow {}^4He + \gamma + 23.85$ MeV

From the knowledge of thermonuclear fusion, the reaction probability of mode 3 is extremely low, mode 1 and 2 have nearly the same probability. If we define

$$R = \frac{\text{(reaction rate of mode 2)}}{\text{(reaction rate of mode 1)}}$$

For normal D-D fusion $R \approx 1$.

The neutrons originated from the reactions can come out front the discharge chamber and can be detected by neutron detectors, but the charged particles originated from the reactions, P,T,^{3}He and ^{4}He cannot be directly detected because their low energies are insufficient to penetrate the chamber envelope. The charged particles would collide with the material of the reactor, such as the Pd cathode, exciting the Pd nuclei. When the excited Pd de-excites, a characteristic gamma ray would be originated, for example:

$$^{108}\mathrm{Pd}^* \rightarrow {}^{108}\mathrm{Pd} + \gamma\ (425\mathrm{KeV})$$

In order to investigate the anomalous nuclear effects, we have designed and performed a new type of experiment by using high voltage discharge. We simultaneously, during the HV period and during periods of no HV, provided detectors for both neutrons and gamma rays.

EXPERIMENT

The arrangement of the experimental set up is shown in Fig. 1. The main parts include a discharge chamber, HV pulse generator, gamma counters and neutron counters.

*γ counter

The scintillator is a Nal(Ti) with diameter of 4 cm and thickness of 4 cm. It was coupled directly with PMT(GDB-44F) via silicon oil. The spectrum of gamma counter for ^{22}Na is shown in Fig. 2. The energy resolution of the γ counter is 11% for 1270KeV. The efficiency of the γ counter is about 2.6×10^{-3} for 1270 KeV.

* Neutron counter

The diagram of neutron counter is shown in Fig. 3. In the front there is a 17cm X 17cm plastic scintillator with thickness of 5 cm, then a Φ 10cm ^{6}Li glass scintillator with thickness of 0.3cm. ^{6}Li glass was directly coupled on to PMT(GDB-l00) by silicon oil.

When ^{6}Li absorbed a slow neutron, ^{6}Li(n,α)T reaction will take place, then the glass can produce light by α and T emissions. The light is viewed by PMT and a neutron signal comes out which will be recorded by MCA.

The slow neutron spectrum of ^{252}Cf neutron source with intensity of about 3000/4 π· view is shown in Fig. 4. The FWHM (full width, half magnitude) of the peak is 25%. The efficiency of the neutron detector is about 3×10^{-3}.

First the chamber was pumped to 2.7×10^{-2} torr, and then fill with 1 atm deuterium gas. The D_2 was absorbed for some time by the electrode Pd. Switching on 10KV HV, the pulse generator produced pulses of 10KV in amplitude, 150μs in width and 10Hz in rate. At this time, sparks appeared in the chamber.

The gate A was triggered by the rising of the HV pulse and opened until the HV pulse terminated (see Fig. 1). The signal of gate A triggered MCAs A_1 and A_2. A_1 and A_2 recorded simultaneously gammas and neutrons coming out from the discharging chamber during the discharging.

There is a gate B in the interval between HV pulses. The gate B is triggered by the falling of the HV pulse and opened until another HV pulse rising. The width of gate B is about 0.1 sec. The signal B triggered MCAs B_1 and B_2. B_1 and B_2 recorded simultaneously the gammas and neutrons which came from the chamber.

RESULT

Results are summarized as follows:

1. The spectra of both gammas and neutrons outside the period of HV pulse detected by system B are consistent with background spectra recorded with no HV within statistical error.

2. During HV discharging, the neutron signals are comparable with background.

However, there are extra gamma rays. Figure 5(a) is the gamma ray spectrum detected by MCA A_1 in 8h. Figure 5(b) is the background spectrum in 4h. From Fig. 5(a), we subtracted the background for 8h to obtain Fig.5(C). In Fig.5(C) it is very clear that there exist two peaks. According to the calibration curve of system A_1, one peak is at 425±40KeV, another is at 870±50KeV. Because the electrodes are made of Pd, Fe and also W, the spectrum of gamma rays might be relevant to the following nuclear deexcitation processes:

$$^{108}Pd^* \rightarrow {}^{108}Pd + \gamma\ (E_\gamma = 425KeV)$$
$$^{56}Fe^* \rightarrow {}^{56}Fe + \gamma\ (E_\gamma = 854KeV)$$
$$^{184}W^* \rightarrow {}^{184}W + \gamma\ (E_\gamma = 110KeV)$$

However, the energy of γ originated from $^{184}W^*$ is too low to be seen against noise.

Pd was used as cathode, and Cu as anode discharging in deuterium for another data run. We made two background runs: first, Pd was used as cathode and Cu as anode but air was used instead of deuterium for discharge, second, Cu was used both as cathode and anode discharge in deuterium. In addition, we made another calibration run. Fig.6 is the net gamma ray spectrum after background subtraction. There are another two peaks of gamma ray. The energies of the two rays are at 430 Kev and 990 Kev respectively. It might be explained as $^{108}Pd^*$ and $^{83}Cu^*$ excited by high energy charged particles de-exciting radiations.

Since the HV is only 10KV, the electron/deuteron with energy of 10KeV can excite only atoms, but not nuclei. So, the high energy gamma ray could be produced only from nuclear Coulomb excitation by charged particles with high energies [7]. The gamma yields are about 10^{-6} per 3.0 HeV proton absorbed in palladium [8]. Our result can probably be explained by the exciting Pd, Fe and Cu in the products from the reaction mode 2. From the present experiment, we would conclude that in HV pulse discharging experiment we only detected the characteristic gamma ray without neutrons. It seems that the reaction rate of mode 2 is much higher than mode 1 in the low energy D-D fusion under palladium environment.

Taking the acceptance into account, from our experimental results, we can deduce: $R > 10^9$.

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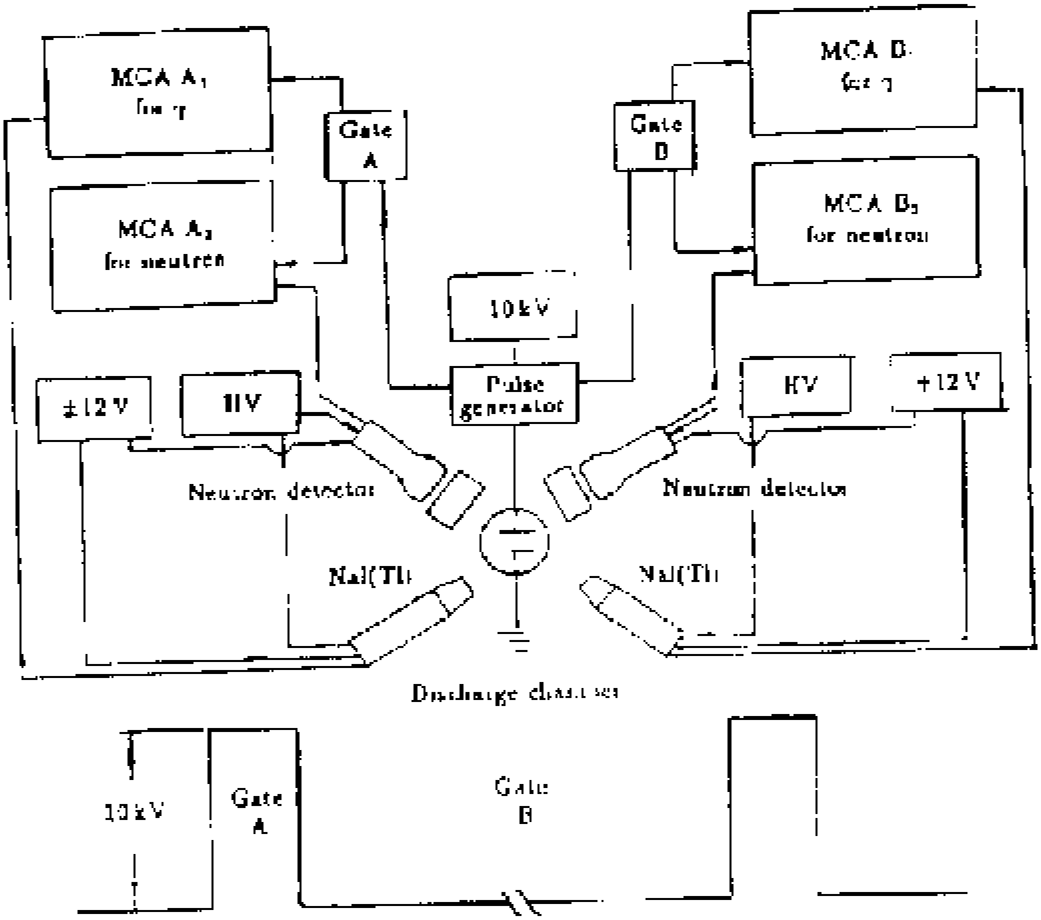

Fig. 1. Schematic diagram of the experimental arrangement and electronic system.

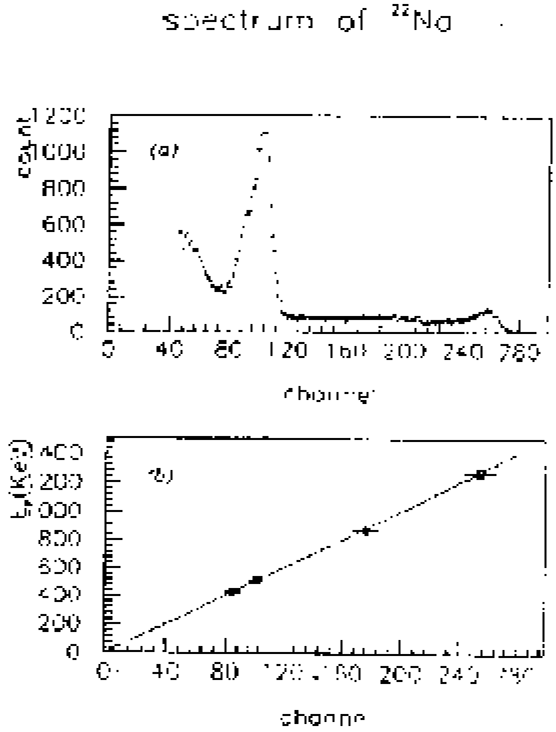

Fig.2 Calibration of NaI(Tl) γ-ray [illegible]
(a) Spectrum of source [illegible]
(b) Calibration curve

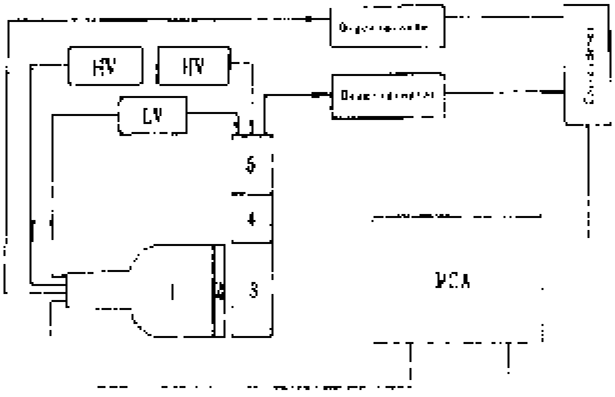

Fig.3 Neutron detector system
1—GDB-[illegible] 2—ϕ 100×3 [illegible]
3—5cm thickness of plastic scintillator
4—Light guide 5—56 AVP PM

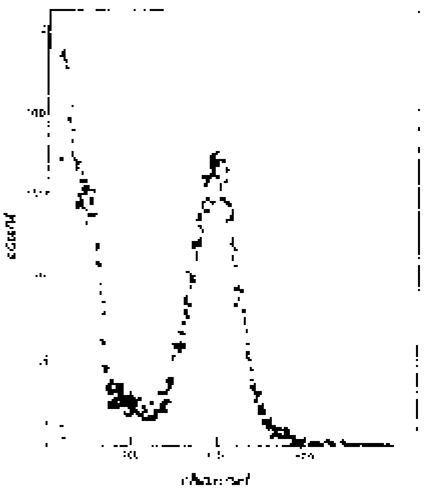

Fig.4 Slow neutron and γ-ray spectrum from lithium glass detector

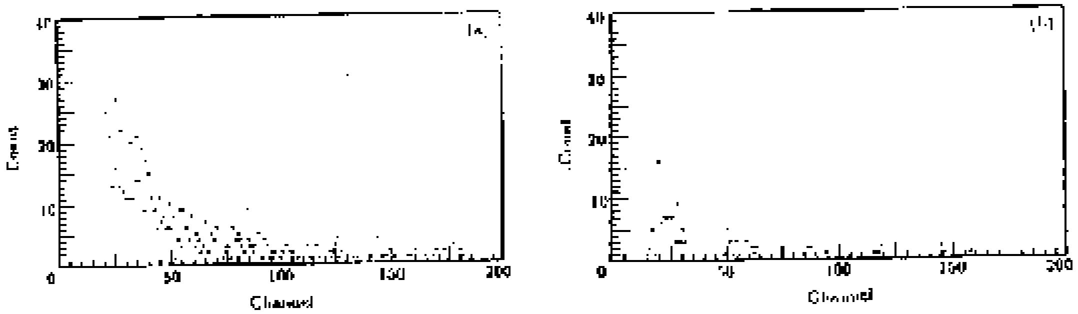

Fig. 6. The gamma rays spectrum.
a) Spectrum during HV pulse for 8 h.
b) Background for 4 h

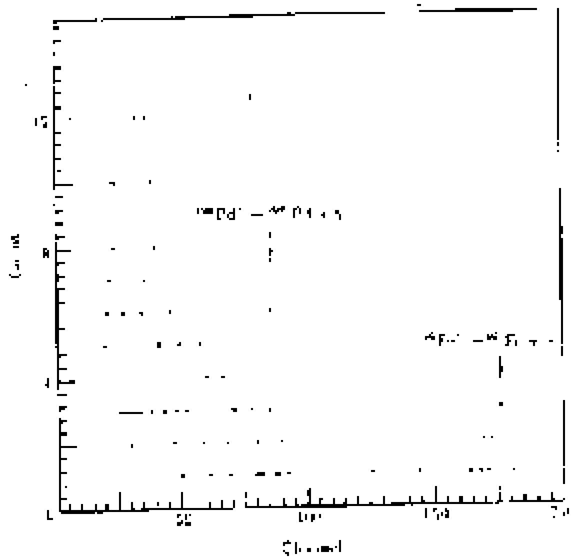

Fig. 6 (c). The net spectrum of gamma ray.

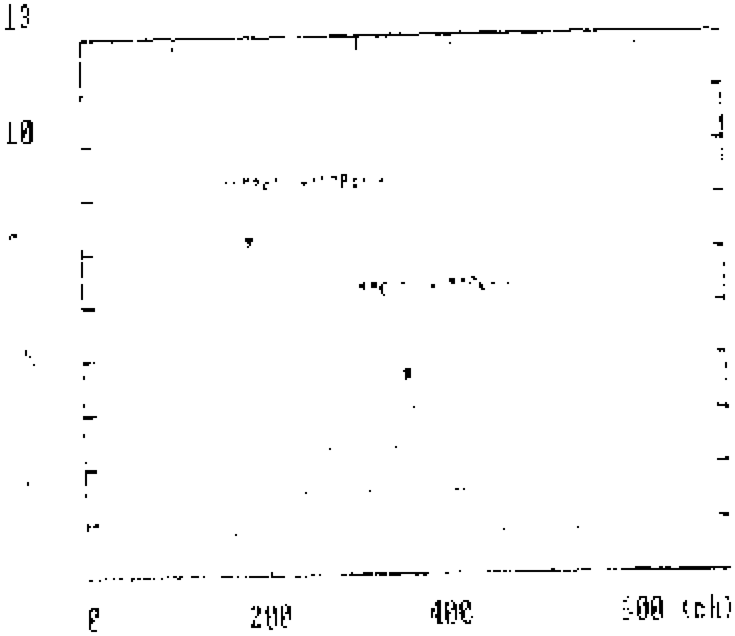

Fig. [illegible] Characteristic [illegible] gamma ray from [illegible]