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Deuteron Fusion Experiment with Ti and Pd Foils Implanted with Deuteron Beams II

Toshiyuki Iida, Morio Fukuhara, Sunarno, Hiroyuki Miyamaru and Akito Takahashi
Department of Nuclear Engineering, Faculty of Engineering, Osaka University, Yamada-oka, Suita, Osaka 565, Japan

Abstract

Deuteron implantation experiments on Ti and Pd foils have been made for the examination of the “cold” deuteron fusion reaction. In the center of a target chamber fitted to a 300 keV deuteron accelerator, a Ti or Pd foil sample was set to face toward 3 nsec pulsed deuteron beams collimated with a 3 mm diameter aperture. A Si-SSD was placed behind the foil to detect high energy charged particles emitted from the foil by the supposed deuteron fusion reactions.

In the 243 keV deuteron implantation experiments for 3-20 μm Ti and 5-22 μm Pd foils, unusual counts and peaks were measured in the energy region higher than the proton peak due to the well-known D-D reaction. And from the energy loss measurement with the screen foil in front of the Si-SSD, some of the unusual high energy peaks were found to be helium, though the original reactions are not identified. These helium peaks and unnatural counts are difficult to explain and might have something to do with the multibody fusion reactions proposed by A. Takahashi. More elaborate experiments with more detailed measurement such as correlated particle measurement should be necessary for confirmation of the multibody fusion reaction.

1. Introduction

Since Akito Takahashi, the leader of our group, proposed the very unique multibody fusion model [(1)(2)] to explain the large excess-heat produced in the D_2O/Pd electrolysis experiments[(3)(4)(5)], we have performed deuteron beam implantation experiments[(6)] with Ti and Pd foils. The goal of the deuteron beam experiments is to find out nuclear particles (energetic charged particles) which mean the evidence of the multibody fusion reaction. Vacuum environment in the beam implantation experiments is suited for the identification of nuclear reactions in a foil sample, i.e. for the exact measurement of the type and energy of the charged particles emitted from the foil. At first this paper describes the experimental method and some preliminary results obtained for Ti and Pd foil samples and then proposes a further research plan for more elaborate implantation experiments to confirm the multibody fusion reaction.

2. Experiment

It is supposed that fairly high energy charged particles are produced in Takahashi’s multibody fusion reactions. And such particles are possibly identified with energy analysis.

A 20 cm diameter × 24 cm cylinder-type vacuum chamber was installed in a 300 keV deuteron accelerator OKTAVIAN[7]. In the center of the chamber, a Ti or Pd sample foil was set to face toward the deuteron beam collimated with a 3 mm diameter aperture. The configuration of the experimental apparatus is shown in Fig. 1. A platform with a standard vacuum flange was made, and all components such as a sample foil, a silicon semiconductor detector (Si-SSD) and others were fastened to the platform with the same stand. The central portion of a foil sample was implanted with 3 nsec pulsed deuteron beams, whose repetition frequency was 2 MHz. The average beam current was 2-10 μA. To examine the nuclear charged particles from the foil, the Si-SSD was set behind the foil, in order to avoid of the disturbance of the deuteron beams. The Si-SSD was commercially available, had the effective window area of about 35 mm^2 and the depletion layer depth of about 150 μm and analyzed energy up to about 15 MeV for α-particles and about 4 MeV for protons. The distance between the foil sample and the Si-SSD was 15-30 mm. Another foil (Al or Ti) was occasionally placed in front of the Si-SSD for the examination of the types of particles emitted from the sample foil. The type of particles can be identified from their energy loss in the screen foil.

Sample foils had the thickness of 3-20 μm (Ti) and 5-22 μm (Pd) and were penetrated by not 300 keV deuteron beams but ~ MeV charged particles due to nuclear reactions. Inside a sample foil, deuteron beams slow down and many deuterons could come to exist in lattice atoms excited by repeated pulsed beams, which might lead to the opening of the multibody cold fusion reactions. As for some of the same sample foils, moreover, we formed about 0.1 μm thick Al layer on their surface by an evaporation process. The Al layer was oxygenated in the air. Such a thin metal oxide layer has influence on the deuterium trapping in the foil and is expected to be possibly effective in enhancing the cold fusion reactions [8][9][10][11]. A series of the deuteron implantation experiments was carried out under almost the same conditions of deuteron beams, the measuring system and other factors.

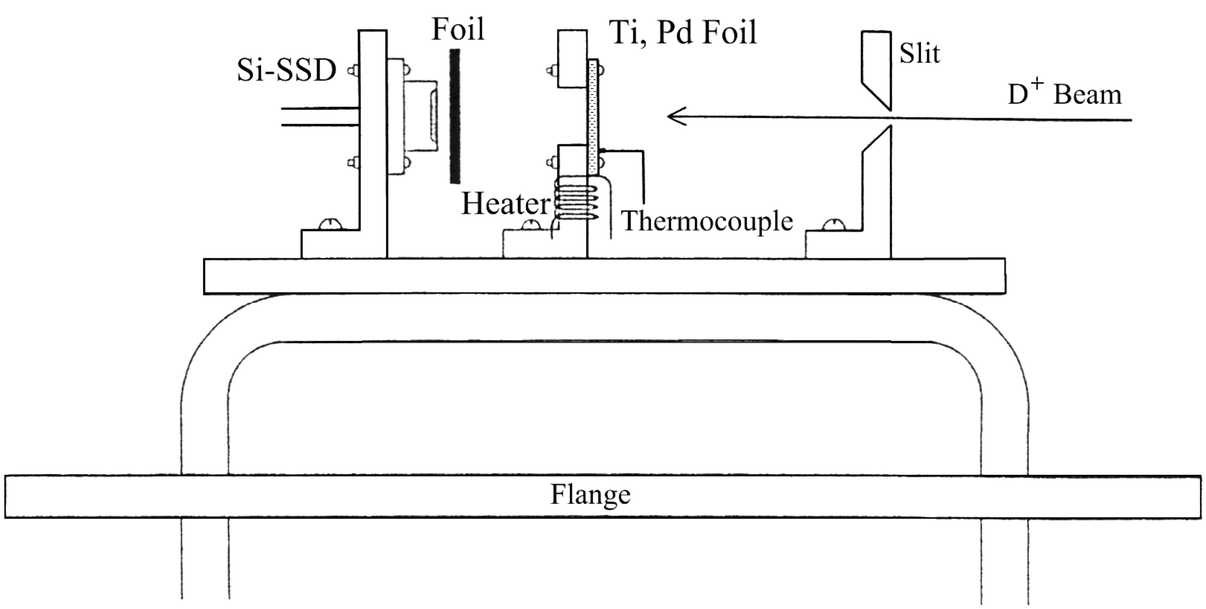

Fig. 1. Configuration of experimental apparatus

3. Result and Discussion

Figure 2 shows an example of unusual energy spectra of charged particles measured for 20 μm Ti foil with aluminum-oxide layer bombarded by 243 keV deuteron beams. Besides the normal proton peak from the well-known D-D reaction, some counts (3 ~ 5 MeV) and a group of counts (8 ~ 9 MeV) were measured in the energy region higher than the proton peak, though statistics of the counts were low. And in the similar measurement with the screen foil in front of the Si-SSD, we observed that the 8-9 MeV counts were completely removed by a 40 μm Ti foil. From this, the 8-9 MeV counts are considered to be helium. Eight MeV hydrogen can easily penetrate the 40 μm Ti foil. These helium counts might have something to do with the 3D fusion reaction; 3D → D (15.9 MeV) + ^{4}He (7.9 MeV). The 15.9 MeV D correlated with 7.9 MeV ^{4}He can not be analyzed with the Si-SSD because its depletion layer is too thin (150 μm). As for the 3-5 MeV counts, the type of the particles could not be identified because of the low statistics and the disturbance of the large proton peak.

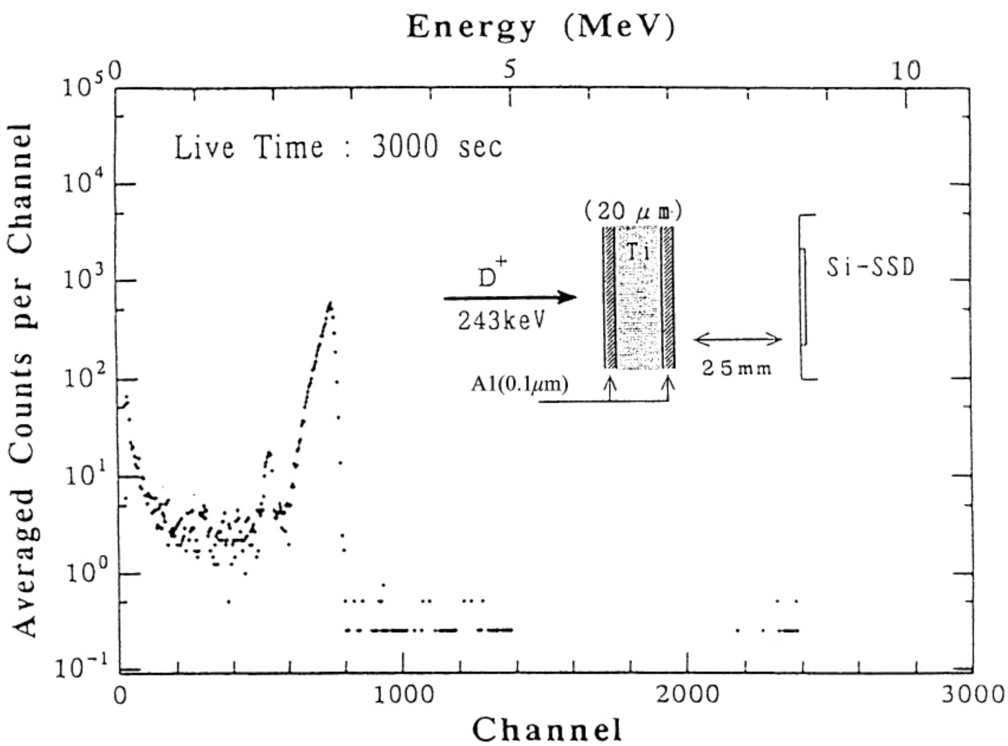

Fig. 2. Unusual energy spectrum of charged particles measured for 20 μm Ti foil with aluminum-oxide layer bombarded with 243 keV deuteron beams.

Figure 3 shows a typical energy spectrum of charged particles emitted from a 5 μm Ti foil bombarded with 243 keV deuteron beams. This spectrum has a small sharp peak around 7 MeV and seems to be apparently different from that shown in Fig. 2 in the higher energy region, though we do not see the reason. The similar energy loss measurement with screen foils was made especially for the four clear peaks (1.2, 2.7, 3.6 and 6.6 MeV peaks in Fig. 3). Figure 4 summarizes results of the relation between the particle energy and the foil thickness. The range of 243 keV deuterons is about 1.5 μm and we assumed that above reactions all took place around 1 μm from the foil surface. The energy loss curve for the 2.7 MeV peak (black circle) has a close resemblance to that for the 3.6 MeV proton peak (white circle) due to the normal D-D reaction.

Therefore the 2.7 MeV peak is considered to be a proton and seems to come from ^{12}C (*d,p*)^{13}C reaction in point of energy. The case for the 6.6 MeV peak (triangle) has a larger decline in the energy loss man that for the triton peak (cross) due to the D-D reaction, and the 6.6 MeV peak is considered to be helium though its original reaction is not identified.

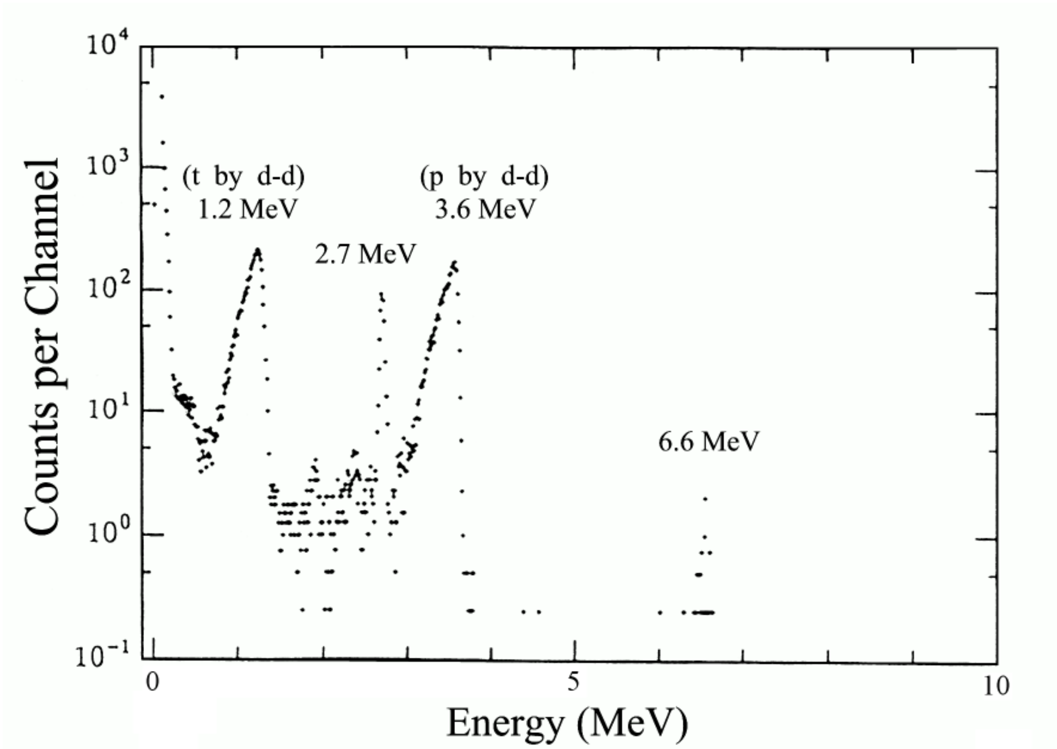

Fig. 3. Unusual energy spectrum of charged particles emitted from a 5 mm Ti foil bombarded with 243 keV deuteron beams

Table 1 summarizes unusual peaks and counts in the energy spectra measured in the present experiments. Although these peaks and counts are unnatural and difficult to explain, more significant data are needed for the discussion of the relation to the multibody fusion reactions. At least data on correlated particles emitted in opposite direction (*namely coincidence measurement for two associated particles by a reaction*[*]) should be necessary.

Table 1. Unusual peaks and counts of charged particles emitted from sample foils bombarded with 243 keV deuteron beams.

Foil Sample		**Energy Range**	
(Thickness: μm)	3 ~ 5 MeV	5~8 MeV	8 ~ 12 MeV
Ti (3 ~ 20)	Some counts	peak (He)	None
Pd (5 ~ 22)	None	None	None
Ti (10 ~ 20) + Al (0.1)	Some counts	Some counts (He)	Peak (He)
Pd (12.5 ~ 22) + Al (0.1)	Some counts	Some counts	Some counts (He)

[*] Note added by A. Takahashi in 2009.

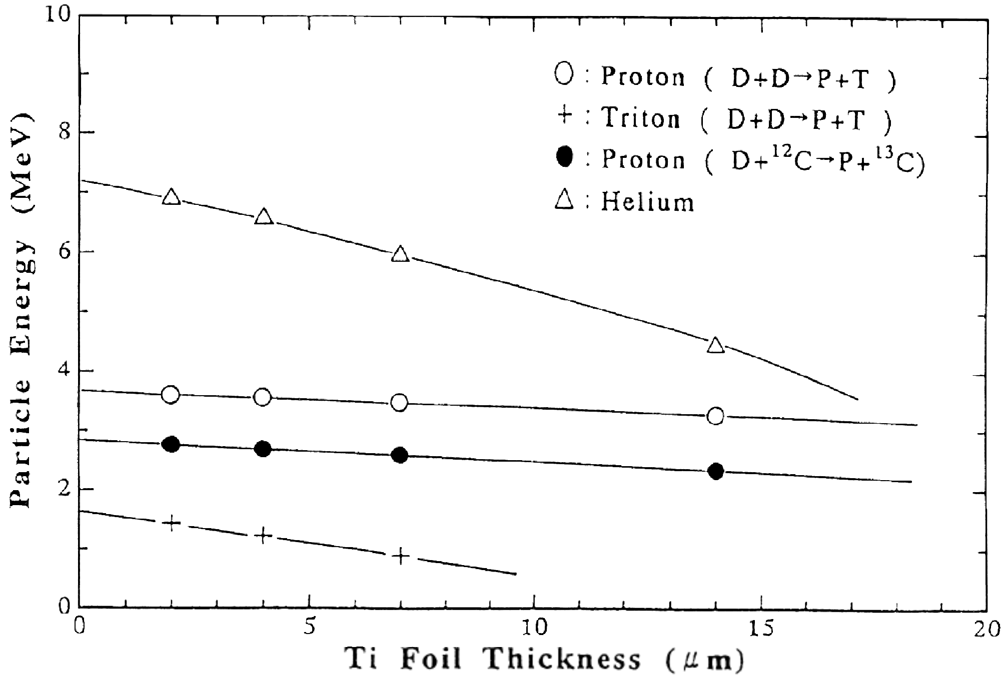

Fig. 4. Relation between particle energy and Ti foil thickness

Figure 5 shows a schematic drawing of the experimental arrangement which is now in preparation. A pair of Si-SSDs with thick depletion layer depth and ΔE counters analyze the energy and types of the correlated particles emitted in opposite direction. Also an angle θ between the deuteron beam line and the detector is changed by a manipulator. This angle-dependent measurement should also be essential to the confirmation of the cold fusion reaction. If the reaction is caused by the direct impingement of deuteron beams, the energy of emitted particles must be determined from the kinematics, in other words, must vary exactly with the angle θ. The cold fusion reaction should not have such angle-dependent energy characteristics. Another Si-SSD or a microchannel plate (MCP) with time of flight (TOF) technique analyzes the energy of deuterons scattered by the sample foil. The energy spectrum of scattered deuterons gives the information on deuterium in the surface of the foil. The measurement of the deuteron-induced nuclear reaction and the deuterium profile analysis are to be made simultaneously.

[Note by A. Talahashi, July 2009] This coincidence experiment with counter-telescope was tried in 1993-1994, but we could not detect meaningful events of coincided charged particles. We thought that the requirement of very thin foil-sample made it difficult to cool the sample to keep enough deuterium density. So we changed strategy to use thicker sample with cooling from back side to observe enhanced evidence of 3D fusion by the unique 3D → t(4.75MeV)+^{3}He(4.75MeV)+9.5MeV reaction. We reported the results in Physics Letters A 255 (1999) 89-97; Fusion Technology 34 (1998) 256; Fusion Technology 36 (1999)315; and Solid State Phenomena 107 (2005)55.

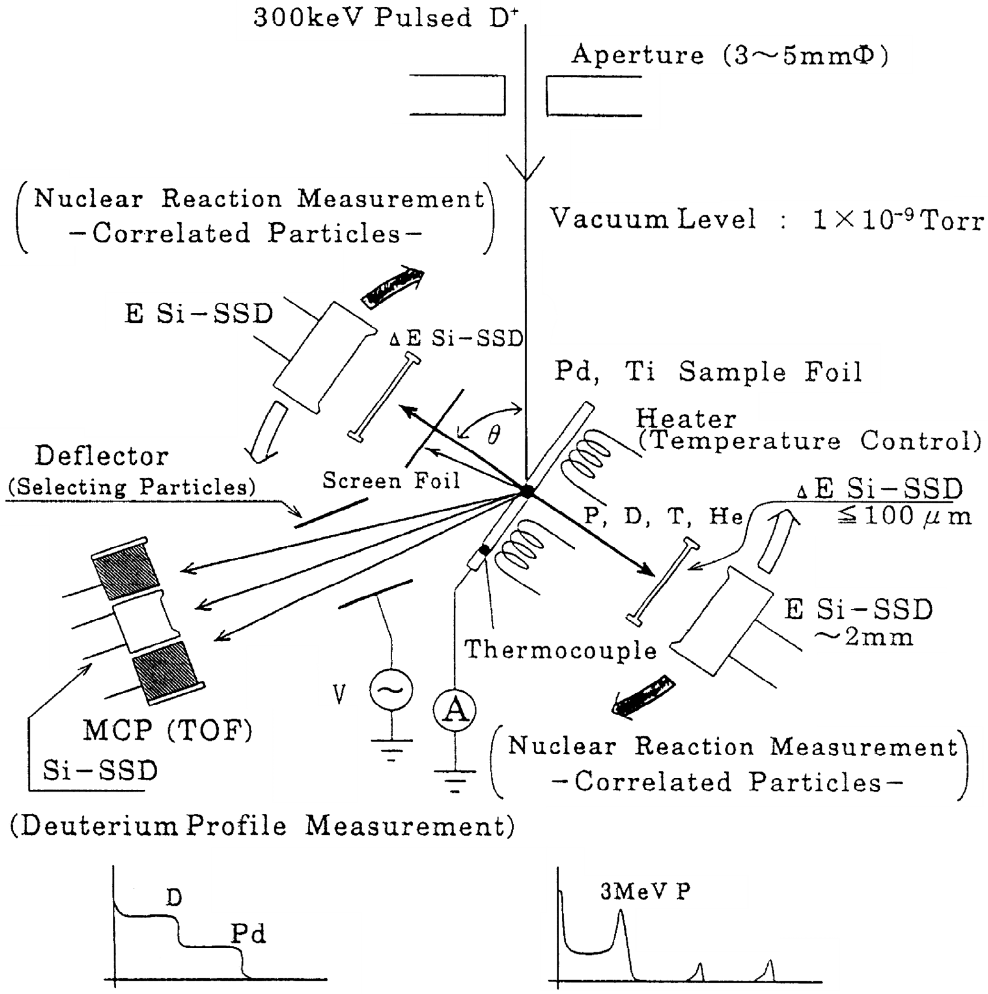

Fig. 5. Schematic drawing of new experimental arrangement

4. Conclusion

In order to examine the cold fusion reaction, 3-20 μm Ti and 5-22 μm Pd foils were implanted with 243 keV, 3 nsec pulsed deuteron beams. The energetic charged particles from the foils were measured with the Si-SSD which was placed behind the foil.

In the implantation experiments, unusual peaks and counts were measured in the energy region higher than the proton peak due to the well-known D-D reaction. And from the energy loss measurement with the screen foil in front of the Si-SSD, some of the unusual high energy peaks were found to be helium, though their original reactions are not identified. These helium peaks and unnatural counts are difficult to explain and might have something to do with the multibody fusion reactions proposed by A. Takahashi, for example, $3D \rightarrow {}^4He$ (7.9 MeV)+D(15.9 MeV). However, the confirmation of the multibody fusion reaction requires more significant data at least about the correlated particles and the angle-dependent energy characteristics. More elaborate experiments with more detailed measurements should be necessary for further cold fusion research.

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