Nuclear Physics Approach

Deuteron Fusion Experiments in Metal Foils Implanted with Deuteron Beams

K.Ochiai, T.Iida, N.Beppu, K.Maruta, H.Miyamaru, A.Takahashi

Department of Nuclear Engineering ,Osaka University
2-1 Yamadaoka,Suita,Osaka565,Japan.

Abstract

Deuteron beam implantation experiments have been carried out for the examination of the hypothesized new class of fusion reactions to explain the Fleischmann-Pons effect. Some additional techniques were introduced in the implantation experiments by considering the effects of temperature change, pulsed-current stimulation and molecular ion beam. Energetic charged particles from the Ti and Pd foils implanted with 100~250keV deuteron beams were measured with Si-SSDs. In some of the experiments, unusual counts were observed in the energy region higher than the proton peak of the well-known D-D reaction, and they might be related to the new class of fusion reactions with large Q-values. However statistics of the counts were too poor to identify the types of their original reactions. More detailed and long-term measurements are necessary for the explanation of the unusual counts in the high energy region.

Introduction

New class of fusion reactions[1-3] with large Q-values has been proposed and discussed for the explanation of the Fleischmann-Pons(F-P) effect or the large excess heat production in D_2O/Pd electrolysis experiments[4]. Deuteron beam implantation experiments with Ti and Pd foils have been performed to find out energetic charged particles which would be emitted by the new class of fusion reactions in metal-deuterium system. 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.

In the present experiment, some additional techniques were introduced to consider the following effects; (1) temperature change, (2) pulsed-current stimulation and (3) injection of clustered particles molecular deuteron ions. The dynamic conditions like transient temperature change and pulsed-current stimulation could induce temperature change and pulsed-current stimulation could induce non-equilibrium movement of lattice atoms and could more selectively excite deuteron motion in the lattice due to their lighter mass, which might lead to the opening of the new class of fusion reactions like the multibody fusion reactions[1-2]. The use of the molecular ion beams might be effective in enhancing the local deuterium density and consequently reducing inter-atomic distances of neighboring deuterons in the foil from a microscopic point of view, in other words the proximity probability between deuterons in solid. This paper describes the experimental method and some results obtained for Ti and Pd foil samples, after our previous experiments[5-6].

Nuclear Physics Approach

Experimental

Figure 1 shows a schematic drawing of the experimental apparatus installed in a beam line of a 300kV deuteron accelerator. The central portion of a foil sample was implanted with 2~10μA deuteron beams collimated with a 5mmϕ aperture. Inside a sample foil, deuteron beams slow down and many deuterons can come to exist between lattice metal atoms which are thermally excited by the energy of the beams. Moreover, some additional techniques concerning the temperature change, pulsed-current stimulation and molecular ion effects. were introduced in expectation of the

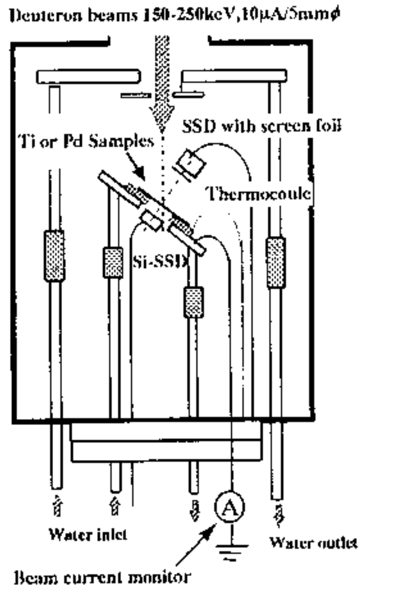


Fig.1 Configuration of experimental apparatus

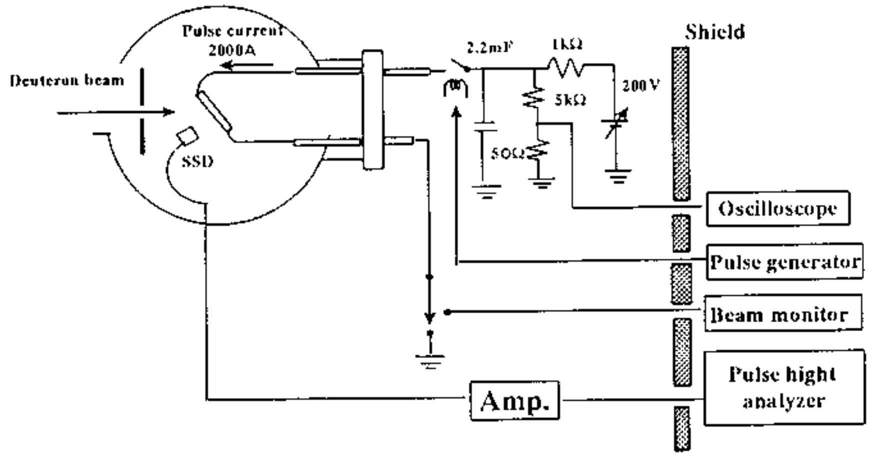
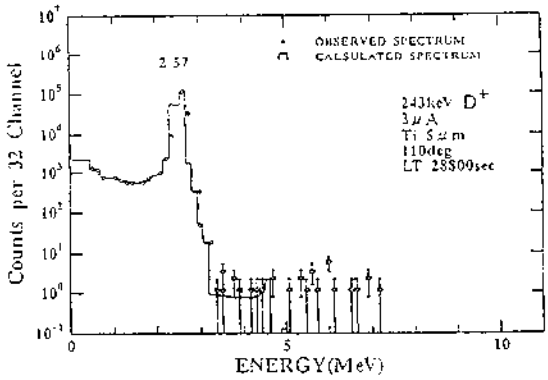


Fig2. Schematic drawing of experimental apparatus for examination of pulsed current stimulation effect

enhancement of the deuteron fusion reaction rate in the sample. The temperature of the sample foil, monitored with a thermocouple, was controlled by using a ceramic heater.

Nuclear Physics Approach

Figure 2 shows a schematic drawing of an apparatus for the pulsed-current stimulation experiment. Pulsed-currents were generated by dischange from a capacitor and were periodically supplied to the sample during deuteron beam implantation. The characteristics of the current pulses were about 2500A in peak, 300μs in pulse with and 0.2Hz in repetition rate. Occasionally molecular ions(D_3^+) were also used as implantation beams. They were easily provided by adjusting the current for the ion analyzing magnet of the accelerator. A pair of Si-SSDs with screen foils analyzed the energy, and type of the correlated particles emitted in opposite directions. The Si-SSDs were placed at the position 15~30mm away from the sample foil and had the effective window area of about 35mm^2 . One of the Si-SSDs had the depletion layer thickness of about 2mm and could analyze high energy proton up to about 18MeV.



Results and Discussions

Figure 3 shows typical energy spectra of charged particles emitted from a 5μm Ti foil bombarded with 243keV deuteron beams. Besides the normal proton peak from the well-known D-D reaction, unusual counts were measured in the higher energy region, though statistics of the counts were very poor. In order to discuss the counts in the higher energy region, the amount of the counts due to the pile up of the D-D proton and other signals should naturally be estimated and thus we have developed a computer simulation program for the estimation of the pile-up effect in detected signals[7]. The spectra shown in solid line in the figures were calculated by using this program, and they indicate that the counts in the energy region over 5~6MeV are not due to the pile-up effect. However, statistics of the counts are too poor to identify the types of their original reactions.

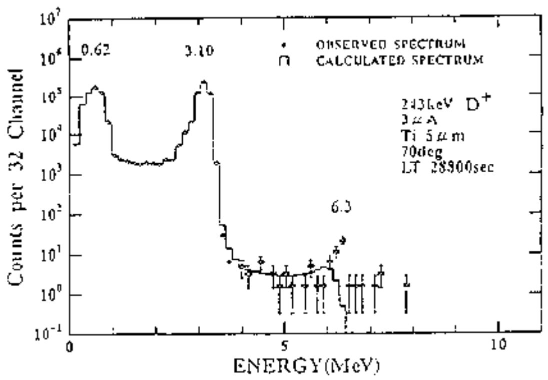


Fig3. Typical energy spectra of charged particles emitted from, a 5μm Ti foil bombarded with 243keV deuteron beams; detected at 110deg (upper) and at 70deg (lower).

Nuclear Physics Approach

Figures 4 and 5 show results for 50μm Ti foils implanted with D_3^+ and D^+ beams. There was no significant difference in the energy spectra between the D_3^+ and D^+ beam experiments. Moreover, the counts measured in the higher energy region agreed well with the high energy component estimated from the calculation of the pile up simulation. These spectra also do not show any counts in the energy region over 5MeV, which are different from the spectra shown in Fig.3. The reason is not clear.

As for the temperature effect, the temperature of the sample was controlled from 100 to 573K and was kept constant during the deuteron beam implantation. The counting rate of D-D protons went down at higher temperature due to the enhancement of deuteron diffusion in metal. The energy spectra of the charged particles, as shown in Fig.6, seem to be similar as a whole to those shown in Fig.3, though sufficient statistics of the counts are not obtained in the higher energy region. We have not done such transient experiments as that the temperature of the sample is changed quickly during the deuteron beam implantation.

Figure 7 shows results for the pulsed-current stimulation experiments. Measured energy spectrum of the charged particles resembles the spectra shown in Fig.3. Though some counts were measured in the higher energy region than 5MeV, their statistic were too poor to definitely say the effectiveness of the pulsed-current stimulation. Here, it should be noted that many efforts were made for rejecting possible noise signals in this experiment.

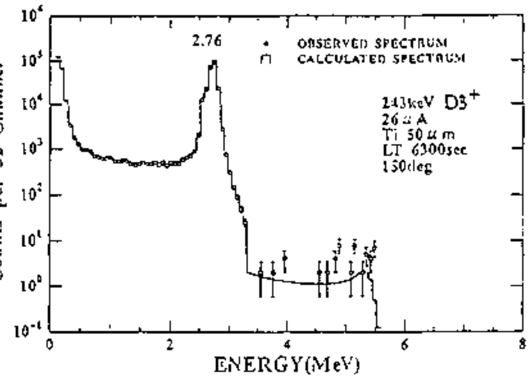


Fig4. Energy spectrum of charged particles measured for a 50μm Ti foil implanted with 243keV D_3^+ beams

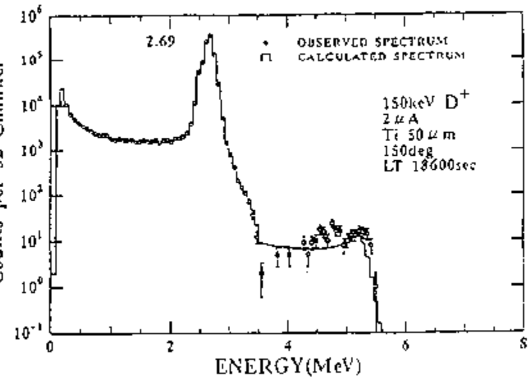


Fig5. Energy spectrum of charged particles measured for a 50μm Ti foil implanted with 150keV D^+ beams

Nuclear Physics Approach

Summary

Deuteron beam implantation experiments have been done for the examination of the new class of fusion reactions for the explanation of the F-P effect. The energetic charged particles from the Ti and Pd foils were measured with Si-SSDs. In principle, the types of the particles can successfully be identified from the energy loss in the screen foil set up in front of the Si-SSDs. Considering the low counting rate in the higher energy region, we have developed the computer simulation program for the estimation of the pile up component in the energy spectrum. This program should be useful for the detailed discussion on measured energy spectra and for the subtraction of the pile-up component from the spectrum. In addition to the deuteron beam implantation, some modified experiments in consideration of temperature change, pulsed current stimulation and molecular ion effects were done. Unusual high energy counts were measured in the spectra of some of the experiments. These counts might be related to do with the new class of fusion reactions hypothesized by several authors, but statistics of the counts were too poor to identify the type of their original reactions. More detailed and long term measurements are needed to clarify the origin of usual high energy counts.

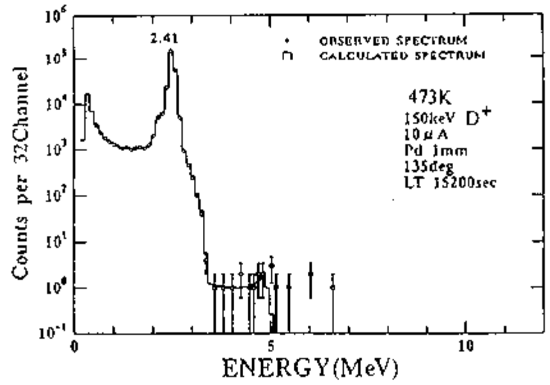


Fig6. Energy spectrum of charged particles measured for a 1mm Pd plate implanted with 150keV deuteron beams. The plate was heated with a ceramic heater.

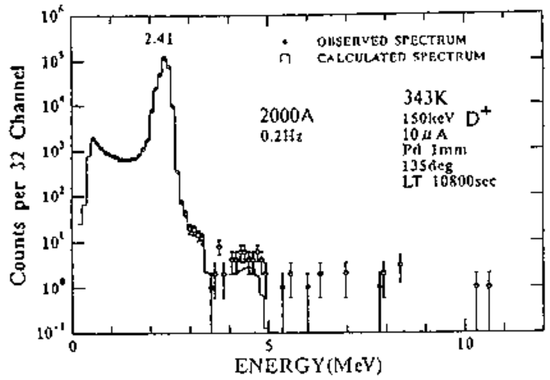


Fig7. Energy spectrum of charged particles measured for 50μm Ti foil implanted with 243keV deuteron beams. Pulsed current were periodically supplied to the plate.

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