ANOMALOUS RADIATION INDUCED BY 1-300 KEV DEUTERON ION BEAM IMPLANTATION ON PALLADIUM AND TITANIUM

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Abstract

Low energy (1-300keV) deuterium ion beam implantation experiment on Palladium and titanium foil (plate) were preformed, in order to study the nuclear and atomic interaction in solid. X-ray, γ ray, charged particle and neutron ware measured simultaneously. A series of anomalous experimental phenomena ware observed. A clear peak at 3.2MeVwas observed, when a pre-loading TiDx was applied. This peak became evidently, following the implantation dose. Therefore, it is considered as the alpha peak from D-T secondary reaction. Its maximum ratio to D-D reaction reached 0.0015. This ratio was much higher than prediction value based on the secondary reaction of D-D fusion. Some unknown high energy counts located from 3.5MeV to 17MeV in charged particle spectra has been observed for many times. Sometimes the counts concentrated in limited area, which appeared like a peak but poor statistics. The phenomena were difficult to be reproduced. In the X-ray spectra, there were many characteristic peaks from Fe, Ni, Cu, Zn, As, Zr, Ru, Pd etc elements. The gamma radiation up to 30MeV was measured with a HpGe detector. Comparing to background, the intensity of foreground was a few orders higher. There was also a few counts distributed around 17MeV and 24MeV, which might be the gamma ray from D(d, γ)^{4}He reactions.

Introduction

Ion beam implantation experiment was used to study the beam-solid interaction in atomic and nuclear level [1-3]. Especially for the study of nuclear reaction mechanism in solid, it plays a very important role as one of the most effective methods. Deuteron reactions (e.g. D+D and D+T etc.) have been studied very intensively due to their application possibility. Since 1989, the interaction of deuteron and solid became a staring point of science, because the claim of cold fusion phenomenon [4]. At the same time, there are also urgent requirements on the data of interaction between plasma and facing-materials for the hot fusion engineering purposes, since there are almost no such data existing now [5]. According to above background, we have studied the deuterium ion beam implantation experiment on different materials. A series experiments with deuterium ion beams (D^+ and D_3^+) were preformed in China and Japan [6-10]. Some interesting anomalous phenomena were observed. The results on the emission of anomalous high energy charged particles have shown the possible existence of unknown nuclear reaction in solid. The characteristic peak from some elements might be correlated with the phenomenon of nuclear transmutation in solid. The enhancement of D+T reaction may be associated with the anomalous breeding of tritium in solid. All the above experimental phenomena may have some kinds of relation with the cold fusion.

Experimental Procedure

Many runs experiments were preformed in both Chinese and Japanese laboratory. The schematic view of the experimental system in China is shown in Fig.1. Pre-loading TiDx target with the loading ratio $x \geqq 1.6$ on the base of 0.8mm stainless steel was applied as the target for the experiment to study D-D fusion in solid. Another run experiment was done with a blank palladium foil with the thickness of five microns.

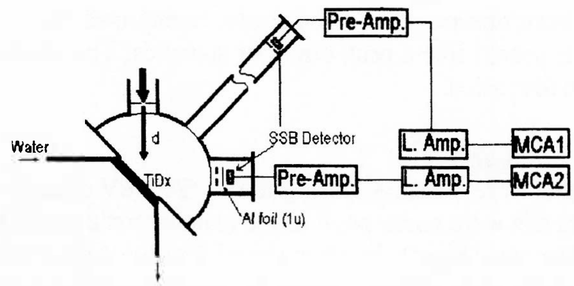

Fig.1. The schematic view of the experimental system

The TiDx target was cooled with high pressure (four atms.) cooling water. The charged particles from D-D reaction were measured with two SSB detectors. One was set up on the 135° direction with the ion beam for monitor the fusion reaction rate, it detection distance is fixed at 110cm. Another was set up on the 90° direction for measuring the charged particle spectra, and its detection distance was only about 8cm.The ion beam could be adjusted in the energy region between 60keV to 400keV, and the density of ion beam current could be adjusted between 10 μ A/cm^2 to 500 μ A/cm^2. The deuteron beam with 96keV and 70 μ A/cm^2 was applied in our experiment. The charged particle peaks were identified by change the effective thickness of SSB detector, and the spectrometer was calibrated with a Thc-Thc' alpha source.

The experiment about the gamma and X-ray emission was done in OKATAVIAN Facility, Osaka University in Japan. The experimental system in Japanese laboratory may refer to the Fig.1 of reference 8 [(8)]. HpGe gamma detector was set under target chamber in distance about 70cm. The other sides except to target chamber were shielded with 10cm lead bricks. The background spectrum was measured before and after experiment. A 100 microns beryllium plate was used as the window for X-ray detection.

Experimental Results

Results on charged particles

A clear peak at 3.2MeVwas observed, when a pre-loading TiDx was applied (Fig.2).

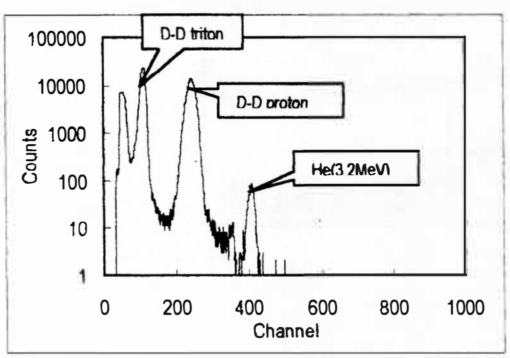

Fig.2 A charged particle spectrum from both of D-D and D-T reactions

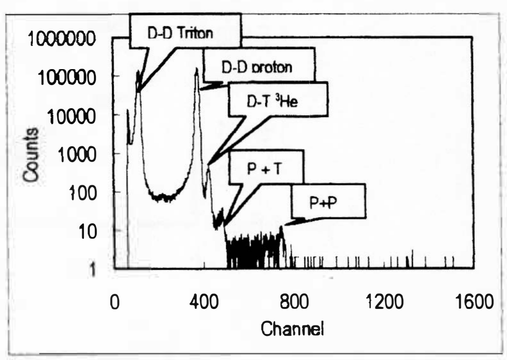

Fig.3 A charged particle spectrum with some anomalous high energy counts

This peak became evidently, following the implantation dose. Therefore, it is considered as the alpha peak from D-T secondary reaction (T(d, n)^{4}He). Its maximum ratio to D-D reaction reached 0.0015 after about one hundred hours experiment. This ratio was much higher than prediction value based on the secondary reaction of D-D fusion.

Some unknown high energy counts located from 3.5MeV to 17MeV in charged particle spectra has been observed for many times. Sometimes the counts concentrated in limited area, which appeared like a peak but poor statistics. The phenomena were difficult to be reproduced and identified.

Results on X-ray emission

Many X-rays peaks were observed during the E_d=240keV deuteron beam implantation on Pd. Some of the peaks were correspond to the characteristic peaks from Fe, Ni, Cu, Zn, As, Zr, Ru, Pd etc elements (Fig.4). In other run of E<18keV deuteron beam implantation experiment, very high intensity of low energy X-rays were observed (Fig.5). At the same time, there was a peak located in the energy region a few times higher than deuteron beam, and its location shifted regularly with the change of deuteron energy.

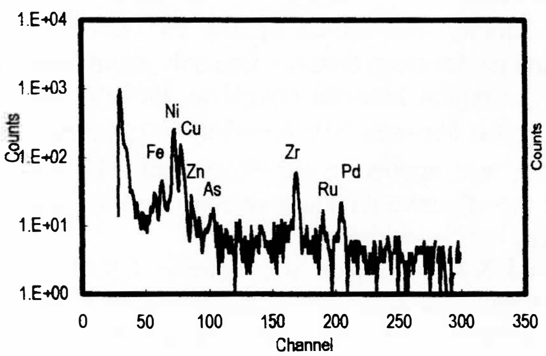

Fig. 4 X-ray spectrum in Ed=240keV D+Pd experiment (100 micron beryllium window)

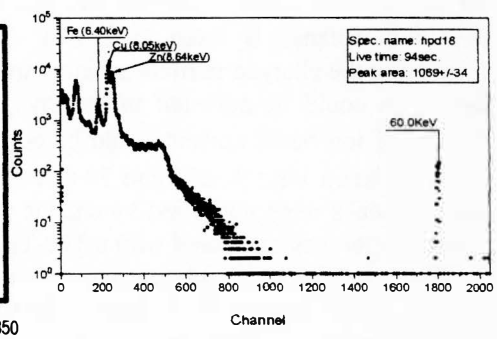

Fig.5 An anomalous X-ray spectrum in Ed=15keV D+Pd experiment (with very thin plastic window)

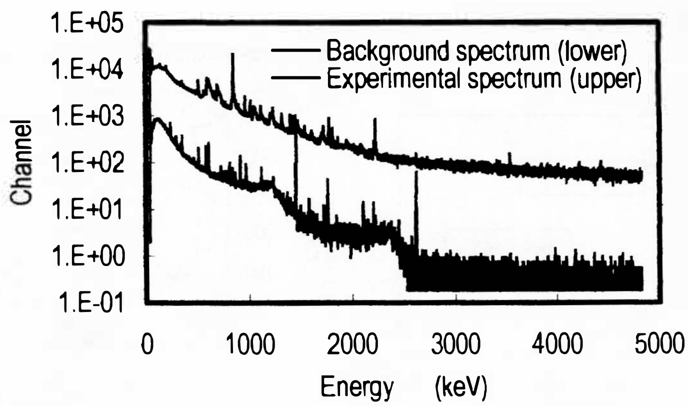

Fig.6. Comparing of the gamma spectra

Results on gamma ray emission

The gamma radiation up to 30MeV was measured with a HpGe detector. Comparing to background, the intensity of foreground was a few orders higher (Fig.6). There were many transient gamma rays were observed. Most of them might from the neutron reaction. There were also a few counts distributed around 17MeV and 24MeV in the spectrum, which might be the gamma ray from D(d, γ)^{4}He reactions.

Discussion and Conclusion

About the charged particles

The alpha peak of D-T reaction corresponds to an anomalous tritium content in target. Usually the tritium in target should be from the accumulation of D-D fusion products. However in the case of our experiment the tritium content was one to two orders more than the accumulation of D-D fusion product. One possible cause is due to the tritium pollution during preparation of the target. However, the count rate of 3.2MeV alpha peak was increased with the implantation dose, thus the tritium was breed up during the experiment. Because the tritium breed up rate was higher than the accumulated rate of tritium from D-D reaction, there must be other source of tritium in the experiment. Another source might be from the accumulation of tritium from other unknown reaction, for example the tritium from multi-body reaction of three deuterons, (D+D+D=T+^{3}He+9.5MeV) [(9)]. If so, we should measure 4.75MeV charged particle peak in the spectrum, but we did not measured any clear peak except some counts in that energy region, which could not be a proof for this assumption because of poor statistic.

The counts that distributed from 3.5MeV to 17MeV seemed to be something, but no peak could be confirmed in this energy region. Although there was no peak existing, the count rate was much higher than any possible disturbance signal (e.g. cosmic ray). The nature of the high energy signals is need to be identified further.

About the X-ray emission

The characteristic X-rays from many elements were anomalous, because the target was high pure (99.999%) palladium foil and the content of pollution elements should be less than 10ppm. However, the intensity of most peaks was more intensive than the palladium peak, thus their contents should be comparable with the content of Pd. That meant there were quite high ratio of pollution element in target. Where were these elements from? A possible cause was the nuclear transmutation reaction in solid. However, it is just a deduction, more reliable proofs are needed.

The anomalous peak in Fig.5 was very mysterious. It might be not X-ray peak, because it shifted with growth of deuteron beam energy. What is its nature is not yet identified[(10)].

About the gamma ray emission

The problem with gamma radiation was rather complex. Although there were no neutron-charged particle reaction could be induced by D-D neutron, the neutron inelastic scattering and neutron-gamma reaction could be induced. Therefore, there were many possible reactions could be induced by D-D neutron in surround environment. In this case, there were too much disturbances, no anomalous gamma in the spectrum could be easily identified in experiment. The counts located around 17MeV and 24MeV might imply some relations with D(d, γ)^{4}He reaction, but the counts had no much scientific meaning due to the poor statistics.

Conclusion

Some anomalous experimental phenomena were observed in deuterium ion beam implantation experiments. Most of them could have some relations with the CF phenomena observed by other researchers. However, most of the results are still preliminary, it might be useful for reference purpose, but for getting a scientific conclusion, the results need to be improved and further proved.

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