Anomalous Phenomena in E<18 KeV Hydrogen Ion Beam Implantation Experiments on Pd and Ti

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Abstract

Implantation experiments of very low energy (1KeV<E<18KeV) hydrogen ions on hydrogen loaded metals have been performed with high beam density ($J_{max.}$~1.2 mA/cm^2) and weak beam density ($J_{min.}$~ 0.02 mA/cm^2). Palladium and titanium foils (plates) have been bombarded with proton and deuteron beams in order to compare the atomic and nuclear interactions between different ion beams. X ray and charged particles have been measured, and neutron and gamma doses were also monitored during implanting experiments. An anomalous peak in X-spectra, which energy is about four times of beam energy, has been observed during high beam density experiment. The peak moved from about 40 KeV to 62 KeV and FWHM reduced rapidly, while the beam energy and intensity increased. Another wide peak with over twice of the beam energy has been measured in experiment with low beam density. This peak located between 16 and 30 KeV, and its peak position grew with the growth of integrated implantation dose (implantation time). Some anomalous intensities of neutrons correlated with a charged particle peak (3-4 MeV) have been also observed in deuteron-palladium experiment. The highest neutron intensity reached about 8×10^4n/s, while the beam energy and intensity was about 15 KeV and 1.0 mA, respectively.

1. Introduction

Since 1989, much pioneering works about 'cold fusion' have been reported, and various anomalous phenomena have been observed[1-5]. The existence of 'excess power' has been represented by more and more experiments and different laboratories. However, the nature of 'excess power' is still unidentified. Especially, most of the phenomena could not be reproduced, and not enough reaction products beside 'heat' have been measured[2-5]. So that, the research about occurrence mechanism of 'excess power' is very important.

Beam implantation with low energy and high current density is used to approach the reaction mechanism and phenomena of the metal-hydrogen system described in this work.

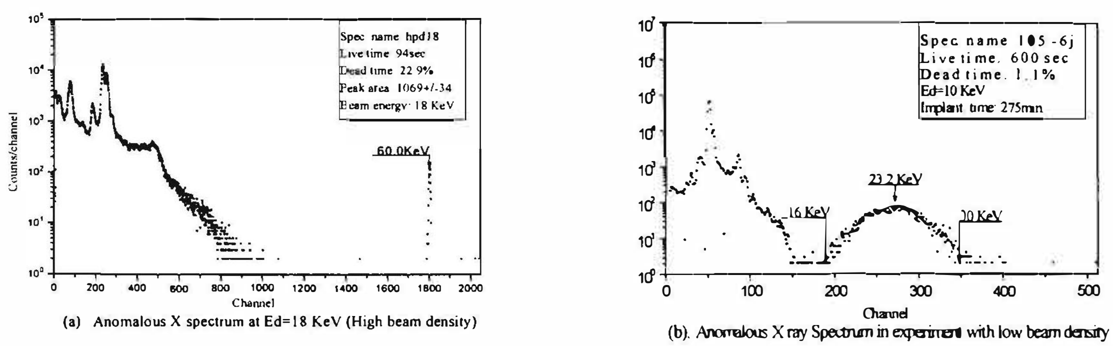
The deuterium-palladium ratio (D/Pd) can be increased rapidly to over 0.85, because of the short implantation deeps of low energy beams. The target temperature can be easily controlled under room temperature in order to avoid the escape of deuterium atoms from metal, during experiments. At the same time, ion beam type, energy, intensity and target matter and other conditions can be easily changed and chosen in experiment, so that, the conditions corresponded to anomalous phenomena can be directly determined. Otherwise, neutron, charged particles, γ and X rays etc. parameters may be measured similarly during experiments. Thus the correspondence between reaction products and excess power can be directly set up.

In this work, some anomalous X-ray spectra have been measured, and the enhancement of neutron intensity correlated with some charged particles was also observed.

2. Experimental description and results

In our experiments, both of proton and deuteron beams, which energy and beam intensity could be adjusted from 1 to 18 KeV and 0.05 to 5.0 mA, were employed to bombard palladium and titanium targets. Palladium targets with thickness of 0.005 mm and 1 mm and titanium target with thickness of 0.3 mm have been used. An effective cooling system with a thermal temperature monitor was employed to keep targets under room temperature. A Si(Li) X-ray detector and a Si(Au) detector have been applied to measured X-rays and charged particles. At the same time, a gamma-dosimeter and a neutron-dosimeter were used to monitor the change of gamma and neutron doses.

Some reproducible anomalous X spectra (Fig. 1-a) have been measured during high density (J~1.0 mA/cm^2) implantation experiments. Other spectra (Fig, 1-b) with a wide anomalous peak have been also observed during the experiment with low beam density (J~0.02 mA/cm^2).



(a) Anomalous X spectrum at Ed=18 KeV (High beam density)

(b). Anomalous X ray Spectrum in experiment with low beam density

Fig. 1 Anomalous experimental X ray Spectra

In the experiment with high beam density, the position of anomalous peak with about 10^8-10^{10}/s intensity moves from about 40 KeV to 60 KeV, while increasing the beam energy and intensity, in both of P+Pd and D+Pd experiments (Fig. 2). At the same time, the FWHM reduced rapidly (Fig. 3).Anomalous phenomena occurred only when the energies of proton and deuteron were higher than 7.5 KeV and 10 KeV, respectively. It needed to identify, whether these threshold energies were induced by absorption of the carbon foil deposited on target surface or physical nature. When a titanium target was used to instead of palladium to do the same experiment, similar phenomena have been observed, but the energy of the anomalous peak was a little lower than using palladium target at same reaction conditions. It is not sure, if the energy difference was same type interaction but between different atoms.

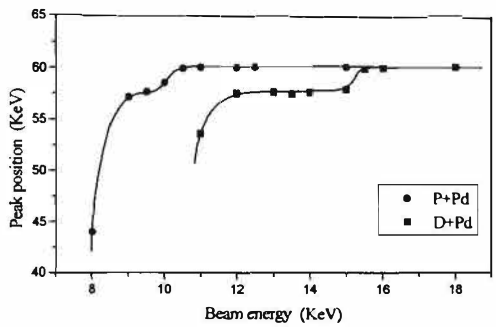


Fig.2 Curves of anmalous peak positions vs. beam energy (High beam density)

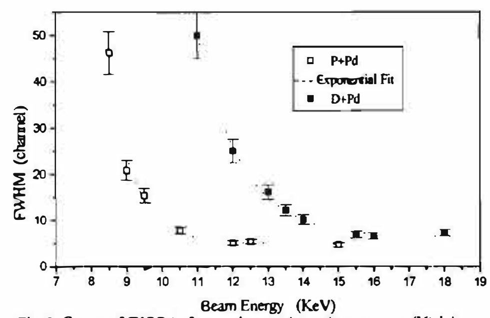


Fig. 3 Curves of FWHM of anomolous peaks vs. beam energy (High beam density)

In the experiment with low beam density, the position and intensity of the anomalous peak increased with the implantation dose or time. The total peak is located between 12 KeV to 30 KeV region. The maximal position of peak moved from 17 KeV to 23.2 KeV during about 300 minutes implanting. At the beginning, a part of the peak located on the tail of the normal spectrum, and then separated slowly. After about 275 min. implanting, the anomalous peak was total separated with the normal spectrum (Fig. 1-b).

A quasi-atom multi-body theoretical model[6] has been proposed to interpret these phenomena. However, both the anomalous phenomena and the theoretical model are needed to investigate further.

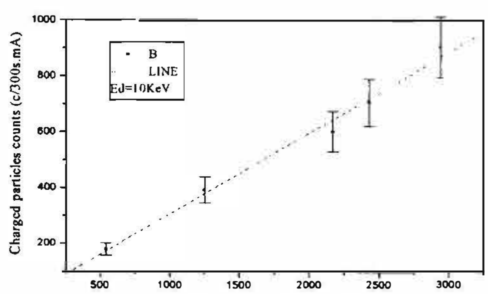


Fig. 4 Intensity of charged particles vs neutron intensity

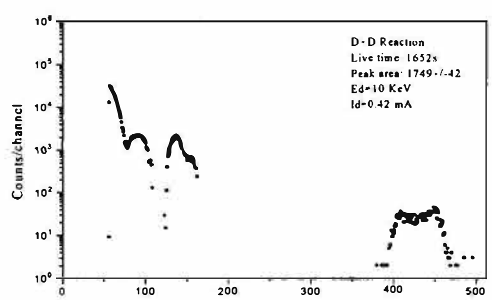


Fig 5 Spectrum of charged particles

In D+Pd experiments, some anomalous intensities of neutrons correlated with a wide charged particle peak has been observed. The neutron intensity grew linearly with the growth of beam intensity, but rapidly with the growth of beam energy. The highest neutron intensity was about 8×10^4n/s, while about 1 mA, 15 KeV deuteron beam was applied. That was much higher than the prediction for D-D neutron with a self built-up target at such beam conditions. The ratio of neutron and charged particle intensities changed not evidently (Fig. 4), while beam intensity and energy were changed.

Otherwise, the energy of charged particles was located among 3-4 MeV region, thus, the charged particles should be protons from D(d,p)T reaction (Fig. 5), and then the neutrons should be neutrons from D(d,n)^{3}He reaction.

3. Discussion and Conclusion

The identifying experiments have shown, that the anomalous phenomena were beam-target effects. However, what was the anomalous peak in experimental spectra could not be determined. If the peak was only some pile up of electronic signals, why did it change regularly with the change of beam energy and intensity? and why were there no double pile up peak in the spectra? If the peak was really from X ray, it was unable to be interpreted with basic physical theory, why the energy of the anomalous peak in the X spectra moved continuously among 4-5 times of implanting beam energy with the change of beam parameters. If further investigation could identify above experimental results as X ray or other emission of energy, that could be correlated with 'excess power' observed in other pioneering works. Maybe, a new physical interaction can be discovered.

To interpret the phenomena, a quasi-atom multi-body model is proposed[6]. In such a quasi-atom, two deuterons rotate around a negative center, which can be a complex effect of one or more electrons. Electrons could rotate around the axis connecting two deuterons in some orbits. In the process to form a quasi-atom, some energy may be released in emission of X rays. Because two deuterons have been bound in about 10~150 fermi scale in such a 'Quasi-atom,' so that, the cross section of general D-D reaction could be much larger than they were in separated state. Thus, there were some enhancements of neutron intensity. Otherwise, the state of such quasi-atom might depend on reaction conditions, so, the peak moved with change of beam and there were seems to be two energy states in the curves of Fig. 2. That should be investigated, whether these two energy states were corresponded with electron orbits or other inner structures of the quasi-atom.

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