§28. Hydrogen Isotope Retention Behavior on the Surface of Metal-carbon Mixture Layer under Carbon, Hydrogen Isotopes and Helium Simultaneous Irradiation Circumstance

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1. Introduction

On the surface of plasma facing components, it is important to elucidate the dynamics of hydrogen isotope behavior under simultaneous ions implantation conditions, such as carbon, hydrogen isotopes and helium ions. This study motivates us to reveal the fundamental interaction mechanism of carbon and hydrogen isotopes on the metal surface and helium implantation effects on hydrogen isotopes retention for the establishment of hydrogen recycling processes. In this physical year, a simultaneous triple ions (carbon (C^+) deuterium (D_2^+) and helium (He^+) ions) implantation system was newly developed at Shizuoka University. Several experiments using C^+, D^+ and He^+ implantation in tungsten were performed in the dual or triple ions species. TDS results were compared to the annihilation behavior of irradiation defects on thermal annealing treatment.

2. Experimental procedures

The simultaneous dual ions (C^+ and D_2^+) implantation was carried out to the preheated tungsten (W) sample. The triple ions (C^+, D_2^+ and He^+) implantation was also performed to estimate He^+ implantation effects on hydrogen isotopes retention. The chemical states of W and C on the sample surface after each ion implantation were evaluated by XPS measurements and the retention behavior of D were also studied by TDS from room temperature up to 1173 K with the heating rate of 0.5 K s^{-1}. The TEM observation was also performed to evaluate microstructures for the dual and triple ion-implanted tungsten samples. The thermal treatment and the TEM observation were performed alternately to clarify the correlation between the annihilation behavior of irradiation defects and hydrogen isotopes retention behavior.

3. Results and discussion

From the TEM images for the dual and triple ion-implanted W, it was clear that the dislocation and the dislocation loop were formed for the samples after the ion implantation. In especially for the triple ions implanted sample, the helium bubbles were also formed. For the annealed sample at 973 K, some parts of defects were annihilated and almost defects were annihilated at 1073 K. From the TDS and XPS spectra, it was found that deuterium retention decreased as the C^+/D^+ ion flux ratio increased and deuterium trapping by carbon was not observed for high C^+/D^+ ratio.[1] In $C^+/D^+ = 0.2$, it was found by the peak analysis that the D_2 TDS spectrum consisted of three D_2 desorption stages located at around 500 K, 750 K and 900 K, which are attributed to the detrapping of D from intrinsic defects, ion-induced defects and C-D bond, respectively. Figure shows the comparison between the result of the peak analysis for D_2 TDS spectrum and the annihilation behavior of defects. It was found that the temperature region of annihilation of the defects was in good agreement with that of the D desorption peak which attributed to the D desorption from ion-induced defects which were attributed to the dislocation and the dislocation loop induced by ions implantation.

[1] Y. Oya *et al., J. Nucl. Mater.*, 390-391(**2009**)622-625.

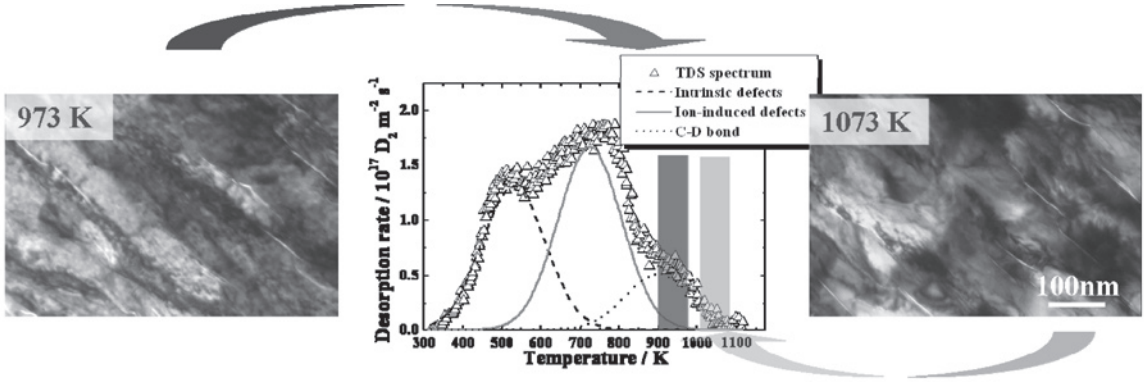

Fig. The comparison between the result of peak analysis for D_2 TDS spectrum and the annihilation behavior of defects