§69. Correlation between Crystal Structure Change and Tritium Retention on Mixed-layer of First Wall

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i) Introduction

The combination usage of tungsten and carbon has been considered for the diverter region of plasma facing components in D-T fusion reactors. The diverter region is exposed to energetic particles, and then carbon is sputtered during plasma operation. Tungsten is exposed to hydrogen isotopes and carbon simultaneously, and then the hydrogen isotope trapping occur simultaneously with the W-C mixed layer formation. It is important to elucidate the hydrogen isotope retention behavior on mixed layer in the actual fusion environment. Therefore, the deuterium ion was implanted into the polycrystalline tungsten and varied ion fluence in this study.

ii) Experimental

Polycrystalline tungsten (10 mm^{φ}×0.5 mm^{t}) purchased from Allied material Co. was used. The deuterium ion (D_2^+) implantation was performed at R.T. after heating treatment up to 1173 K. The flux of D_2^+ was fixed to 1.0×10^{18} D^+ m^{-2} s^{-1} and the D_2^+ energy was 3.0 keV. D^+ fluence was changed in the range of $(0.3\text{-}1.8)\times10^{22}$ D^+ m^{-2}. In the case of C^+-D_2^+ sequential implantation to elucidate the hydrogen trapping effects in the mixed layer. 10 keV C^+ was implanted with the ion fluence of 2.0×10^{21} C^+ m^{-2} s^{-1}. Thereafter, 3 keV D^+ was implanted with the ion flux of 1.0×10^{18} D^+ m^{-2} s^{-1} up to the ion fluence of $(0.03\text{-}1.8)\times10^{22}$ D^+ m^{-2}.

After the ion implantation, thermal desorption spectroscopy (TDS) measurements were performed to evaluate D retention at a heating rate of 0.5 K s^{-1}, from R.T. up to 1173 K. The TEM observation was also done using the sample with the size of 3 mm^{φ}×0.3 mm^{t}.

iii) Results and discussion

D_2 TDS spectra for various fluences were consisted of three deuterium desorption stages, located at around 400 (Peak 1), 550 (Peak 2) and 650 K (Peak 3), respectively. From the previous studies, Peak 1 was attributed to the desorption of D adsorbed on the surface. Peaks 2 and 3 were attributed to the desorption of D trapped by various irradiation defects[1]. Figure shows the results of deuterium retention for Peaks 1, 2 and 3 using Gaussian distribution function. The deuterium desorption for Peaks 1 and 2 were appeared under the fluence of 3.0×10^{21} D^+ m^{-2}, but that for Peak 3 was not observed. After the saturation of D retention for Peak 1, that for Peak 3 was increased significantly over the fluence of 1.0×10^{22} D^+ m^{-2}, indicating that the deuterium trapping near surface region was quickly saturated in the initial implantation stage and thereafter D was trapped by the irradiation defects produced by ion implantation and some of deuterium would be diffused toward the bulk.

Comparing the D retention behavior for sequential C^+-D_2^+ implanted sample to that for only D_2^+ implanted one, D desorption for Peaks 1 and 2 were increased up to the fluence of 3.0×10^{21} D^+ m^{-2}. However, D retention for Peak 3 was drastically decreased even in the fluence of 1.8×10^{22} D^+ m^{-2}, suggesting that the mixed layer would act as a diffusion barrier of D toward the bulk. These facts indicate the W-C mixed layer would control the deuterium trapping in the actual fusion condition, which is consistent with the previous report[2].

In the further research, the effect of the mixture layers on the hydrogen isotope retention will be clarified under simultaneous C^+-D_2^+ implantation from the viewpoint of the behavior of irradiation damage, crystal structure and hydrogen isotopes retention in detail.

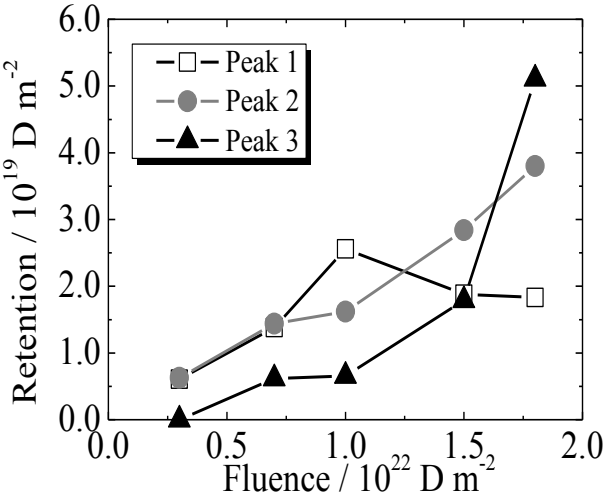

Fig. The amount of D trapped as each peak in each ion fluence.

1) H. Eleveld et al., *J. Nucl. Mater,* 191 (1992) 433.
2) T. Shimada et al., *J. Nucl. Mater,* 313 (2003) 204.