§35. Accumulation of Impurity Carbon and Quantitative Evaluation of Sputtering Particles on PFMs

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i) Introduction

Tungsten (W) has been considered as a plasma facing materials (PFMs) in future fusion reactors. During plasma operation, the irradiation defects would be introduced to PFMs by energetic particles such as neutron, hydrogen isotopes, helium (He), carbon and so on. Moreover, PFMs will be exposed to higher heat load during the plasma operation, leading to the irradiation defects accumulation/annihilation. It is reported that the growth rate of the He babble in higher irradiation temperature is faster than that in lower temperature[1]. Therefore, it is likely to change the hydrogen isotopes behavior in tungsten under He^+ implantation at higher temperature. In addition, as it is difficult to ignore the impurity effect in actual fusion reactor, it is important to understand the hydrogen isotopes behavior in carbon deposited W under He^+ implantation at higher temperature . Thus, the effect of He^+ implantation at higher temperature on hydrogen isotopes retention behavior for W was performed for the systematic study of He^+, C^+ and D_2^+ simultaneous implantation experiment.

ii) Experimental

Polycrystalline W (10 mm^{φ}×0.5 mm^{t}) purchased from A.L.M.T. Corp. was used as the sample. Samples were heated at 1173 K for 30 minutes under ultrahigh vacuum to remove the impurities and damages introduced during the polishing process. After that, the 3.0 keV He^+ was irradiated into the samples with the fluence of 1.0×10^{21} He^+ m^{-2} at R.T.-1173 K. The 3.0 keV D_2^+ implantation with the fluence of 1.0×10^{22} D^+ m^{-2} and thermal desorption spectroscopy (TDS) measurements were performed to be evaluation of deuterium (D) retention behavior.

iii) Results and discussion

Fig. 1 shows D_2 TDS spectra for He^+ irradiated W at various temperatures. The D_2 desorption was observed in the temperature range of 350–750 K, which consisted of four D desorption peaks located at around 390, 430, 550 and 700 K, namely Peaks 1, 2, 3 and 4, respectively, attributing to the desorption of D adsorbed on the surface and trapped by He babble-vacancy complex, trapped by dislocation loops, vacancies and voids, respectively [2-4]. The D retention for He^+ irradiated sample as Peak 1 was increased twice as much as that for the un-damaged sample. But, the difference of He^+ irradiation temperatures did not influence on the D retention as Peak 1, indicating that the retention of D was independent with the growth of He babbles with increasing the implantation temperature. The D retentions as Peaks 2 and 3 of undamaged W were dramatically reduced comparison with that for He^+ implanted W at R.T. The retention of D as Peak 3 of He^+ impranted W at 973 K and 1173 K were reduced half and a fifth as much as that of He^+ impranted W at R.T, respectively. Therefore, it is indicated that the retention of D was reduced with increasing the implantation temperature. On the other hand, the retentions of D as Peak 2 of He^+ implanted W at 973 K and 1173 K were reduced three fifths and half as much as that of He^+ impranted W at R.T., respectively. There is a relation between the D retentions for Peak 2 and Peak 3, because dislocation loops and vacancies are Frenkel pairs. When He babble will be formed, W lattice will be expanded by increasing pressure of He in the small defect such as a vacancy in He^+ implanted W. In this case, it was considered that trapping sites of the hydrogen isotopes were formed, due to the existence of dislocation loops as strain formed by interstitial atoms flicked from W lattice. As a result, it was found that the trapping sites beneath the surface were not formed as Frenkel pairs due to the He bubbles formed by He^+ implantation at higher temperature, indicating that the deuterium enhancement in W would be induced by dislocation loops formed around the He bubbles under growth process of He bubbles and by damages such as dislocation loops and vacancies during the deuterium implantation.

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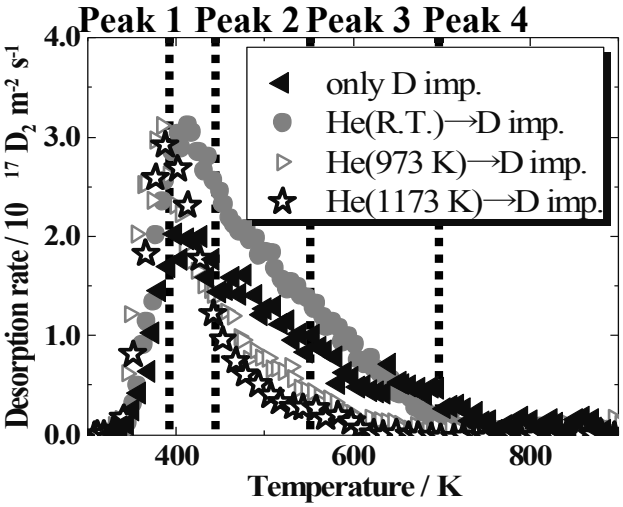

Fig.1 D_2 TDS spectra for He^+ implanted W with various heating treatment