§23. 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. Therefore, it is important to clarify the retention behavior of hydrogen isotope with the formation of carbon-metal mixed layer to simulate actual fusion environment [1, 2]. In this study, carbon (C^+), deuterium (D_2^+) and helium (He^+) ions were implanted into tungsten, and the deuterium retention and the dynamics of irradiation defects were investigated by means of Thermal Desorption Spectroscopy (TDS).

2. Experimental procedures

The ion energies of C^+, D_2^+, and He^+ were, respectively, set to be 10 keV C^+, 3 keV D_2^+ and 3 keV He^+ to keep the same implantation depth. The D flux was fixed to 1.0×10^{18} D^+ m^{-2} s^{-1} up to a fluence of 1.0×10^{22} D^+ m^{-2}. D_2^+-He^+ implantation experiment was also performed to understand He effect on deuterium retention and flux ratio of He^+/D^+ was changed to 0.2, 1.0, 1.8. In the C^+-D_2^+-He^+ triple implantation, the fluxes of C^+, D_2^+ and He^+ was fixed to be 0.2×10^{18} C^+ m^{-2} s^{-1}, 1.0×10^{18} D^+ m^{-2} s^{-1} and 0.2×10^{18} He^+ m^{-2} s^{-1}. TDS measurements were performed to elucidate the interaction mechanism of D with C and He, at a heating rate of 0.5 K s^{-1}, from R.T. up to 1300 K.

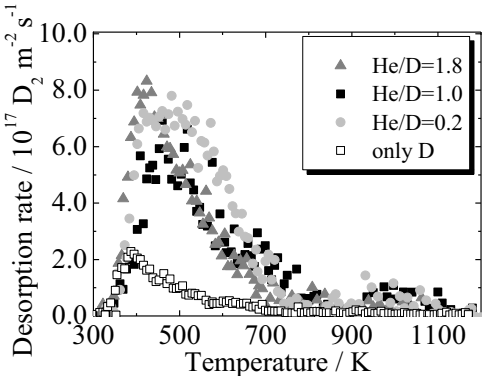

Fig. 1 The D_2 TDS spectra for simultaneous He^+-D_2^+ implanted tungsten with various flax ratio of He/D

3. Results and discussion

Figure 1 shows D_2 TDS spectra for the D_2^+-He^+ implanted tungsten as a function of He^+/D^+ flux ratio and for only D_2 implanted one. It was found that the large amount of D_2 was desorbed in the temperature of 400-700 K compared to that for only D_2^+ implanted sample. The D retention was almost constant among these samples even if the He^+/D^+ flux ratio was changed, and was about 5 times as large as that for sample with only D_2^+ implantation. The profile of D_2 TDS spectra for all the D_2^+-He^+ implanted tungsten was also the same, indicating no impact for the He^+/D^+ flux ratio was found on the D retention/desorption behaviors, suggesting that the He bubble prevented the D diffusion toward the depth like diffusion barrier [3]. The D_2 TDS spectra for various simultaneous ion implantation conditions were compared in Figure 2. It was found that the D_2 desorption for the only D_2^+ implanted tungsten was observed at low temperature of less than 600 K. The shape of the D_2 TDS spectrum for the C^+-D_2^+ implanted tungsten as reported in last year was quite different from the other ones. The large amount of deuterium was desorbed at higher temperature of 800-1000 K, which corresponded to desorption of D as C-D bond by the formation of carbon and tungsten mixed layer. For the triple ion (C^+, D_2^+ and He^+) implantation, the desorption temperature was almost the same as that for the only D_2^+ implanted tungsten and D_2^+-He^+ implanted tungsten. The deuterium trapping site around 700 K for C^+-D_2^+ implantation and around 550 K for D_2^+-He^+ implantation were decreased compared to that for triple ions implantation, suggesting that the D retention would be suppressed in the case of triple ion implantation, since helium would occupy the irradiation defects induced by C^+ implantation.

[1] Y. Oya, et al., J. Nucl. Mater., 390-391 (2009) 622-625.
[2] M. Kobayashi, et al., Phys. Scr. T138 (2009) 014050.
[3] S. Nagata and K. Takahiro, J. Nucl. Mater. 290-291 (2001) 135.

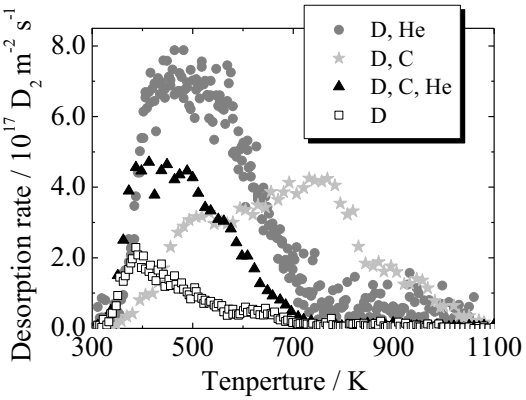

Fig. 2 D_2 TDS spectra for D_2^+ and the simultaneous C^+-D_2^+, D_2^+-He^+ and C^+-D_2^+-He^+ implanted samples.