§90. Effect of Helium and Carbon on Tritium Permeation and Retention Behavior for Plasma Facing Tungsten

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1) Introduction

Tungsten (W) is a candidate for the plasma facing materials in D-T fusion reactors like ITER due to its higher melting point and lower sputtering yield. During plasma operation, W will be exposed to energetic particles, including neutron, hydrogen isotopes, and impurities like carbon (C). It is well known that the formation of C-W mixed layer suppressed the deuterium (D) diffusion [1, 2]. In addition, irradiation defects introduced by energetic particles would be the stable trapping site of hydrogen isotope, leading to the reduction of D diffusion path. Therefore, it is important to elucidate C^+ irradiation effect on D retention behavior for damaged W for the comprehensive understanding of hydrogen isotope dynamics in actual reactor conditions. In this study, C^+ and D^+ irradiations were performed for Fe^{2+} irradiation W and D retention behavior was studied by TDS.

2) Experimental

Polycrystalline W disk type samples (10 mm$^{\varphi}$×0.5 mm^{t}) purchased from A.L.M.T. Corp. Ltd were used. To remove impurities, these samples were preheated at 1173 K for 30 minutes under ultrahigh vacuum (< 10^{-6} Pa). 6 MeV Fe^{2+} irradiation with the damage concentration of 0.01, 0.1, and 1 dpa (displacement per atom) was performed for these samples. Then, 10 keV C^+ irradiation for these damaged samples, and un-damaged W was performed with the ion fluence of 1.0×10^{20} - 1.0×10^{22} C^+ m^{-2}. Thereafter, 3 keV D_2^+ was irradiated with the ion fluence of 1.0×10^{22} D^+ m^{-2}, and the D_2 desorption behaviors were evaluated by thermal desorption spectroscopy (TDS) measurements from room temperature up to 1173 K with a heating rate of 0.5 K s^{-1}.

3) Results & Discussion

Fig. 1 shows TDS spectra for Fe^{2+} - C^+ irradiated W and Fe^{2+} irradiated W. The TDS spectra consist of three desorption peaks located at about 400, 600 and 780 K. According to the previous studies, these desorption peaks are attributed to the desorption of D trapped by dislocation loops and/or adsorbed on the surface as Peak 1 [3, 4], that trapped by vacancies as Peak 2 and that trapped by voids as Peak 3 [5], respectively. D retentions as Peaks 2 and 3 for Fe^{2+} - C^+ irradiated W (C^+ fluence of 1.0×10^{20} C^+ m^{-2}) were increased compared with that for Fe^{2+} W due to an increase of vacancy density by C^+ irradiation. However, D retention for Fe^{2+} - C^+ irradiated W at higher C^+ fluence was reduced. In the previous study, the desorption behavior of hydrocarbon by sputtering in C^+ irradiated W showed that the desorption of hydrogen as CH_4 was enhanced at higher C^+ fluence as shown in Table 1. These results suggest that the amount of D trapped by defects was reduced due to the enhancement of hydrogen recycling at the surface region by increasing C^+ fluence.

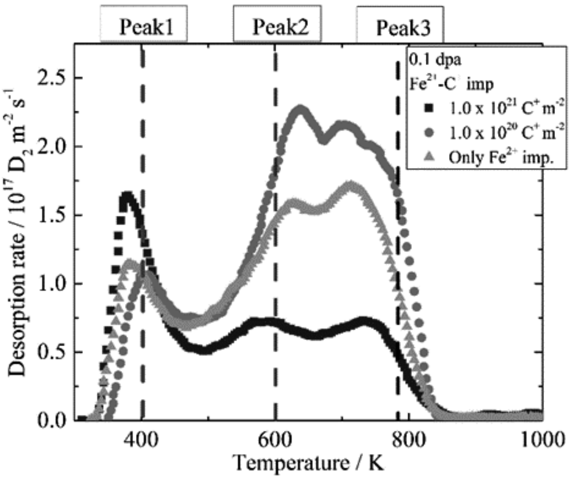

Fig. 1 D_2 TDS spectra for Fe^{2+} - C^+ irradiated W and Fe^{2+} irradiated W

Table 1. Hydrocarbon emission from 3 keV H_2^+ implanted each sample ($m^{-2}s^{-1}$)

	CH	CH_2	CH_3	CH_4	Total C	Total H
High C imp. W	2.0×10^{16}	4.7×10^{16}	1.6×10^{16}	8.1×10^{16}	1.6×10^{17}	4.8×10^{17}
Low C imp. W	5.2×10^{15}	2.6×10^{16}	3.2×10^{16}	~ 0	6.3×10^{16}	1.5×10^{17}

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