§93. Tritium Retention for Neutron Irradiated Tungsten at Higher Temperature

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1. Introduction

Tungsten (W) which has lower hydrogen isotopes retention is a candidate material of plasma facing components (PFCs). Irradiation defects are produced in W by energetic particle irradiation including neutron. Hydrogen isotopes are stablely trapped by these defects. In previous works, deuterium retention behavior for Fe^{2+} irradiated W with various damage concentration was evaluated. This result shows that additional trapping sites were produced as increasing the damage concentration. It is necessary to evaluate the thermal effects on hydrogen isotopes retention, as these defects will be recovered and/or stabilized by annealing under higher temperature during plasma operation. Therefore, the effects of stability of voids produced at higher damage concentration and those recovery behavior on hydrogen isotopes retention were studied.

2. Experimental

The polycrystalline disk-type W (A.L.M.T.Corp.) with the size of 10 mm diameter and 0.5 mm thickness was heated up to 1173 K for 30 min as a pretreatment. W samples were irradiated with 6 MeV Fe^{2+} at 3 MV tandem accelerator (TIARA at JAEA) up to the damage concentration of 0.3 dpa. Then, the samples were annealed at the temperature between 573 and 1173 K for 30 min and 1 keV D_2^+ irradiation was performed a with the ion flux of 1.0×10^{18} D^+ m^{-2} s^{-1} up to the ion fluence of 1.0×10^{22} D^+ m^{-2} at room temperature. The D retention behavior was evaluated by TDS from room temperature to 1173 K. Transmission electron microscope (TEM) observation and positron annihilation spectroscopy (PAS) for damaged W was performed to elucidate the recovery behavior of defects.

3. Results and Discussion

The D_2 TDS spectra for damaged W with various temperatures were shown in Fig. 1. These desorption spectra were divided into 3 peaks located at 400, 600 and 800 K, respectively. Peak 1 is known to be the desorption of D adsorbed on the surface and trapped by dislocation loops. Peak 2 and 3 were assigned to those trapped by vacancies and voids, respectively.[1-2]

The deuterium retention at each peak was sumamrized in Fig. 2. It is found that the D retention at Peak 3 was clearly reduced as temperature increased due to the recovery of voids by annealing. On the other hand, no large difference for Peak 1 was found even if the annealing temperature was increased.

TEM observation showed that the size of dislocation loops was clearly increased and its density was decreased after annealing above 573 K. Almost all dislocation loops were recovered at annealing temperature up to 1173 K. Based on the fact that no reduction of D retention at Peak 1 and TEM observation, it was considered that the amount of D retention trapped by dislocation loops would be smaller.

Positrons life times for Fe^{2+} irradiated W would be longer as increasing the annealing temperatures by PAS measurements, indicating that vacancy-type defects in Fe^{2+} irradiated W would be aggreged and grown bigger by increasing annealing temperature.

In these results, it is considered that recovery of defects would induce the reduction of deuterium retention in W, which is mainly caused by recovery of voids. In future work, the hydrogen isotopes retention behavior for Fe^{2+} irradiated W at higher temperature will be elucidated in detail to understand that for neutron irradiated W at higher temperature.

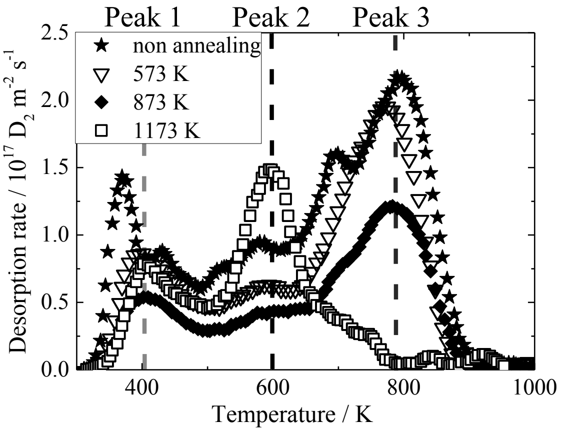

Fig. 1. D_2 TDS spectra for various damaged tungsten

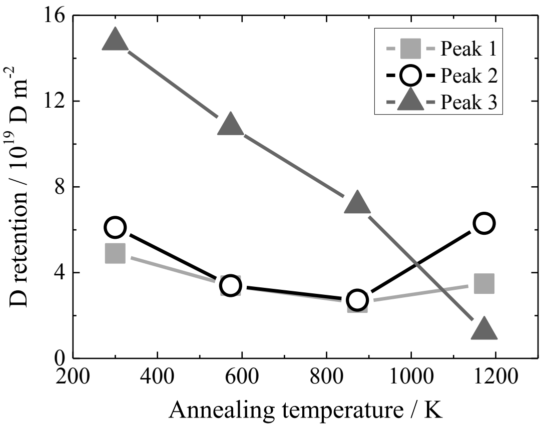

Fig. 2. Annealing temperature dependence of D retention at each Peak

1) M. Kobayashi, et al.: Fusion Eng. Des. 88 (2013) 1749
2) G.N. Luo et al., Fusion Eng. Des. 81 (2006) 957