§103. Correlation between Annihilation of Irradiation Defects and Tritium Retention for Neutron Irradiated W

Oya, Y., Chikada, T., Yuyama, K., Miyazawa, T., Fujita, H., Sakurada, S., Uemura, Y., Hu, C. (Shizuoka Univ.),
Hatano, Y. (Univ. Toyama),
Otsuka, T. (Kyushu Univ.),
Nobuta, Y., Yamauchi, Y. (Hokkaido Univ.),
Oda, T. (Seoul Univ.),
Sagara, A.

1. Introduction

Tungsten (W) is a candidate material of plasma facing components (PFCs) due to lower hydrogen isotope retention. It is known that irradiation defects will be produced in W by energetic particle irradiation including neutron. Hydrogen isotopes trapped by these defects will be not desorped until 800 K. In addition, it was reported that these defects were stabilized by aggregation at higher temperature environment during plasma operation. Therefore, it is necessary to evaluate the correlation between stability of the irradiation defects and desorption behavior of tritium. In this experiment, the stability of voids produced at various temperature, their aggregation and recovery behavior and hydrogen isotope retention were studied.

2. Experimental

The polycrystalline disk-type W (A.L.M.T.Corp.) with the size of 6 mmφ and 0.5 mm thickness was heated up to 1173 K for 30 min as a pretreatment. 6.4 MeV Fe^{3+} irradiation were performed for 6 mmφ samples with the damage level of 0.1 dpa using Dual-Beam Facility for Energy Science and Technology (DuET) in Kyoto Univeristy at 573, 873, and 1173 K. Thereafter, 1 keV D_2^+ irradiation was performed 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 deuterium (D) retention behavior was evaluated by TDS from room temperature to 1173 K. Furthermore, Positron annihilation spectroscopy (PAS) for damaged W was performed to elucidate the aggregation and recovery behavior of defects.

3. Results and Discussion

Fig. 1 shows D_2 TDS spectra for higher temperature Fe^{3+} irradiated W and post-annealed W after Fe^{2+} irradiation at room temperature. 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. Peaks 2 and 3 were assigned to those trapped by vacancies and voids, respectively.[1-3] The D retention for all samples was decreased as annealing temperature was increased. Especially, the D retention as Peak 3 was clearly reduced. The D retention as Peak 3 for the higher temperature irradiated W was clearly lower than that for the post-annealed W at lower annealing temperature (573-873 K). On the other hand, no large difference was found for the D desorption behavior in these samples at 1173 K.

Fig. 2 shows the intensity and lifetime of long-lifetime positron at higher temperature irradiated and post-annealed W. Positron life times for all samples were increased as the annealing temperature was increased, indicating that vacancy-type defects would be aggreged and those size became bigger with increasing annealing temperature. However, its intensity was decreased, indicating that the void concentration was decreased by recovery. Comparing with higher temperature irradiated W and post-annealed W, positron life time in higher temperature irradiated W was shorter.

Based on these results, it was expected that defects were recovered before the formation of stabilized cluster due to quick moving of defects at higher temperature irradiation, leading to the promotion of defect recovery[4]. On the other hand, it was thought that no large difference was found in D desorption behavior by increasing contribution of annealing influence on recovery at high temtemperature more than 1173 K

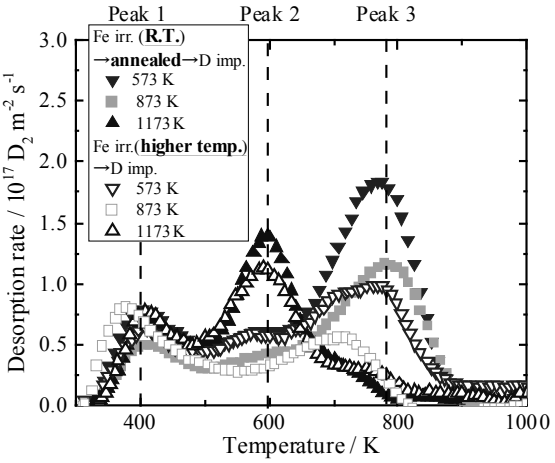

Fig. 1. Comparison of TDS spectra for higher temperature irradiated W and post-annealed W

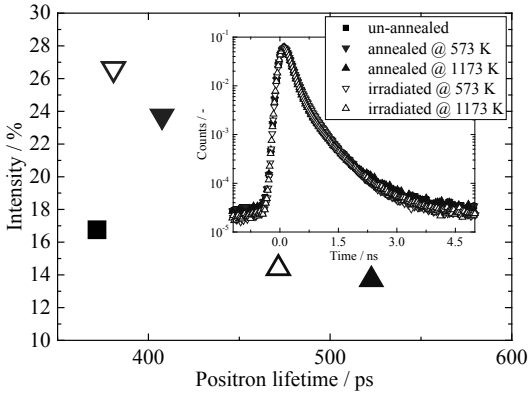

Fig. 2. The intensity and lifetime of long-lifetime positron in higher temperature irradiated and post-annealed W

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[4] O.V. Ogorodnikova et al. J. Nucl. Mater. 451 (2014) 379–386