§105. Synergistic Effects of Neutron (ion) and Plasma on Material in QUEST

Watanabe, H., Yoshida, N. (RIAM Kyushu Univ.),
Muroga, T.,
Kurishita, H. (Tohoku Univ.)

In a fusion reactor, plasma-facing materials are irradiated by 14MeV neutron and particles (hydrogen isotope, helium). It is known that high energy neutron causes displacement damage and nuclear reaction. Plasma particles also cause various phenomena in the plasma facing materials. In particular, helium atom is recognized that it has the strong effects on irradiated materials because helium can easily diffuse in materials and it has a strong interaction with radiation induced defects (interstitials and/or vacancies). In this study, therefore, the effects of implanted helium and hydrogen on heavy ions irradiation damage pure tungsten (W) and TFGR W-1.1TiC[1)] were studied. The 2.4 MeV Cu^{2+} ion irradiations were performed in the temperature range of room temperature to 1073K. After the ion irradiations up to 4 dpa, transmission electron microscope (TEM) and TDS experiments were conducted.

2. Results[1-2)]

In order to clarify the effect of radiation induced damage on D retention in W based materials with different microstructures, specimens of pure R-W (0.1mm thick sheet recrystallized at 2273K for 10 min,) and TFGR W-1.1TiC were employed. The pure W was electrolytically polished and TFGR W-1.1TiC was mechanically mirror polished followed by degassing at 1473 K for 5 min. The both specimens were irradiated with 2.4MeV-Cu^{2+} at room temperature up to 1 x 10^{19} ions/m^2 for pure W and 2 x 10^{19} ions/m^2 for TFGR W-1.1TiC, which correspond to 2 and 4 dpa (displacement per atom), respectively. The position of the peak damaged zone is around 400-500 nm from the surface. After the ion irradiation, the specimens were irradiated with 2.0 keV-D^{2+} at room temperature and higher temperature up to 1×10^{21} D^{2+}/m^2 and subjected to TDS at temperatures from RT to 1023K in vacuum with an heating rate of 1 K/s. Fig. 1 and 2 show the microstructure of pure W and TFGR W-1.1TiC irradiated at room temperature. Fig. 1 shows dislocation contrast images irradiated up to 2 dpa. By the irradiation, dislocation loops of interstitial type and a high density of nano-voids were observed in both materials. But, the microstructure of TFGR W-1.1TiC was almost same as the pure W. These results mean that the addition of 1.1TiC does not significant affects on the formation of dislocation loops and voids by the present irradiation conditions. Fig. 2 show the effects of displacement level (dpa) and irradiation temperature dependence of desorption rate of D_2 for pure W and TFGR W-1.1TiC, respectively. Fig. 3 shows the the dose dependence of total desorption (a) and desorption at peak H (b) of D_2 for pure W and TFGR W-1.1TiC irradiated at 300k and 873K.

These results show that the sink density (dislocation loops and nano-voids) and resultant lattice defects due to 2.4MeV Cu^{2+} irradiation have significant effects of the desorption of D_2 in both pure W and TFGR W-1.1TiC.

Reference
1) H. Kurishita, S. Matsuno, H. Arakawa, T. Sakamoto, S. Kobayashi, K. Nakai, H. Okano, H. Watanabe, N. Yoshida, Y. Tokitani, Y. Hatano. T. Takida, M. Kato, A. Ikegaya, Y. Ueda, H. Hatakeyama and T. Shikama,Phys. Scr. T159 014032
2) H. Watanabe, N. Futagami, S.Naitou, N.Yoshida, J. Nucl. Materials, 455 (2014)51-55

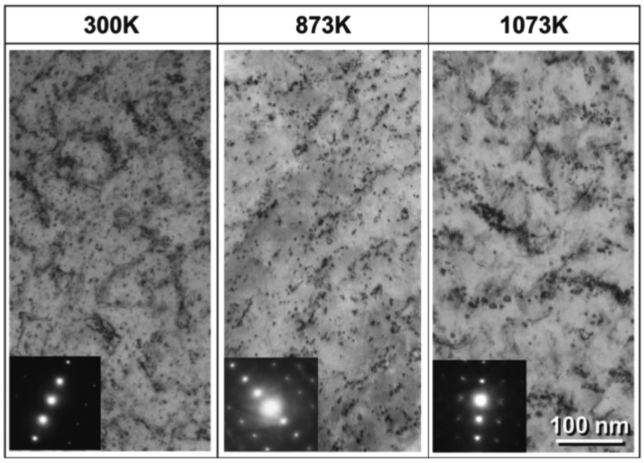

Fig.1 Dislocation loop formation of pure W airradiated in the temperature range of 300K to 1073K (2 dpa)

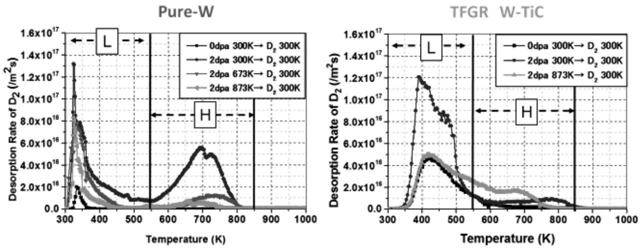

Fig. 2 Effects of higher temperature irradiation of on desorption of D_2 for pure W and TFGR W-1.1TiC

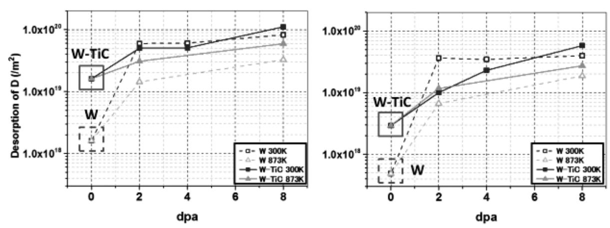

Fig. 3 The dose dependence of total desorption (a) and desorption at peak H (b) of D_2 for pure W and TFGR W-1.1TiC irradiated at 300k and 873K.