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

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1. Introduction

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 873K. After the ion irradiations up to 10 dpa, the samples were prepared by Focused Ion Beam (FIB) for TEM Transmission electron microscope (TEM) and TDS experiments were also 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/H 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 1019 ions/m2 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 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 results of TDS for pure W and TFGR W-1.1TiC. It is obvious from the figures that before Cu ion irradiation the D retention is much higher in TFGR W-1.1TiC than in pure W. However, when irradiated with 2.4MeV Cu^{2+}, pure W exhibits a sharp increase in D retention, whereas TFGR W-1.1TiC exhibits D retention less sensitive to the irradiation. This is likely due to the differences in sink density and resultant lattice defects due to 2.4MeV Cu^{2+} irradiation between pure W and TFGR W-1.1TiC. As the damage level increases, a distinct peak around 700K appears at 0.2 dpa for pure W and 4 dpa for TFGR W-1.1TiC. To identify the nature of these small clusters formed by neutron irradiation at lower temperature irradiation, additional electron irradiation using an HVEM is very useful. The electron irradiation of already existing interstitial (or vacancy)-type loops has shown that they can grow (or shrink) by absorbing interstitials because the mobility of vacancies in model alloys is very low at room temperature (see Fig. 3).

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, presented at PFMC14 .
2) H. Watanabe, N. Futagami, S.Naitou, N.Yoshida, Y. Hatano.' to be published in ICFRM16.

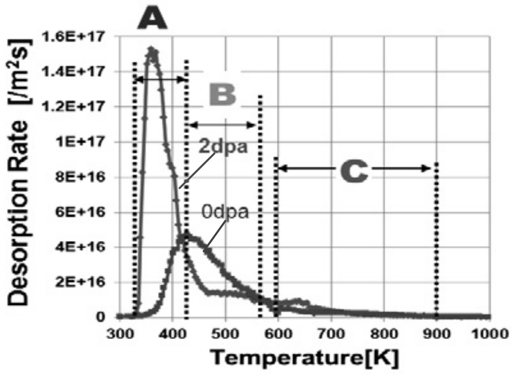

Fig.1.Effects of Cu ion irradiation on desorption of D_2 for Pure W.

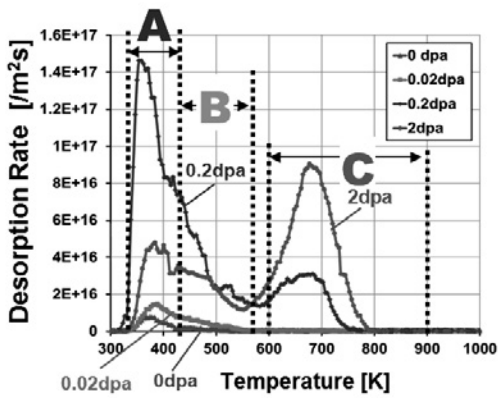

Fig.2.Effects of Cu ion irradiation on desorption of D_2 for TFGR W-1.1TiC.

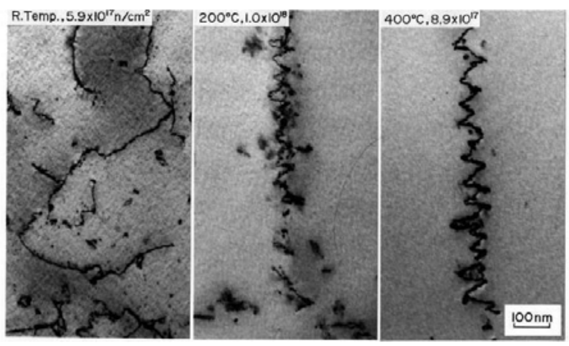

Fig.3. TEM images of 14MeV neutron irradiated in RTNS-II. Nature of dislocation loops can be identified by an additional electron irradiation using HVEM in Kyushu Univ. (Mo, RT irradiation up to about 0.01 dpa)