§81. Synergistic Effects of Neutron (ion) and Plasma on Material in QUEST[1)]

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1. Introduction

In a fusion reactor, plasma-facing materials are irradiated by 14MeV neutron and also particles (hydrogen isotope, helium). It is known that high energy neutron causes displacement damage and nuclear reaction and plasma particles cause various phenomena in materials. Research on the use of plasma-facing components for fusion application has focused in recent years on tungsten materials due to their low sputtering yield and low tritium retention. One of the key issues in tungsten is tritium retention and recycling under the irradiation conditions. In this study, desorption of D_2 and DH in heavy ions irradiated tungsten were studied.

2. Experimentals

Tungsten sheet (0.1mm-thick)of nominal purity of 99.95% was used. Samples for TEM observation were manufactured as following. Disks of 3mm were punched out from the sheet, and heated for 15 minutes at about 2273K in a good vacuum. These samples are almost defects free. Samples for analysis of depth distribution of D_2 and DH were prepared. Platelets of 12×12 mm were heated for 3 hours at 1273K to release residual stress. Ion irradiations with 2.4 MeV Cu^{2+} were carried out at room temperature up to 1 dpa in the Tandem accelerator at Kyushu University. The damage rate was about 2.5 x10^{-4} dpa/s. After Cu $^{2+}$ irradiation, the samples were also irradiated by D at room temperature. For TEM (Transmission electron microscope) .the area near the peak damage region (at around 700 nm) was prepared by Focused Ion Beam (FIB) and also electro-polishing by the back-thinning method. The retention and desorption behavior were analyzed by the thermal desorption spectroscopy (TDS)..

3. Resuls

As shown in Fig.1, by room temperature irradiation, nucleation of I-loops and formation of voids occur continuously via cascade collision. These I-loops grow by absorbing free interstitials and they become large. The aligned loops change to dislocation network by coalescing each other. By the annealing in vacuum condition, the density of these dislocation loops start to decrease above 973K and voids grow above 1073K..Voids are only formed in neighborhood of specimen surface. Fig.2 and 3 show desorption rate of D_2 and DH, respectively, obtained by the TDS analysis. By the irradiation at room temperature, 3 desorption peaks are appeared. They are namely, peak1 : desorption of D_2 adsorbed on the surface. Peak2 : desorption of D_2 trapped in various kinds of defects such as dislocation loops, vacancies and grain boundary. Peak3 : desorption of D_2 trapped in vacancy cluster (voids). As shown in the figures, desorption at high temperature (peak3) is increased with increasing ion dose. GDOES analysis showed that large amount of D_2 exist in neighborhood of surface, because they are trapped in voids formed near specimen surfaces. Present results show that the formation of voids is very important for hydrogen isotope and ions irradiation damage has strong effects on the desorption of not only D_2 but also DH.

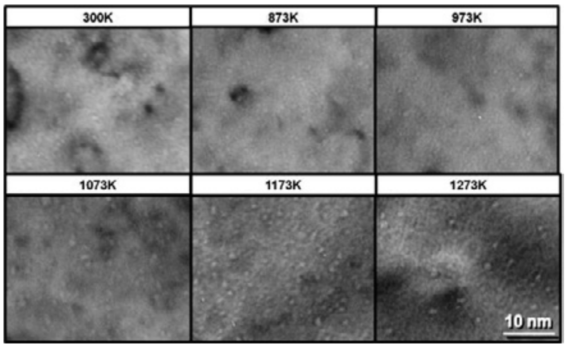

Fig. 1 Formation of voids and their thermal stability**.** Dislocation loops start to decrease above 973K and voids grow above 1073K.

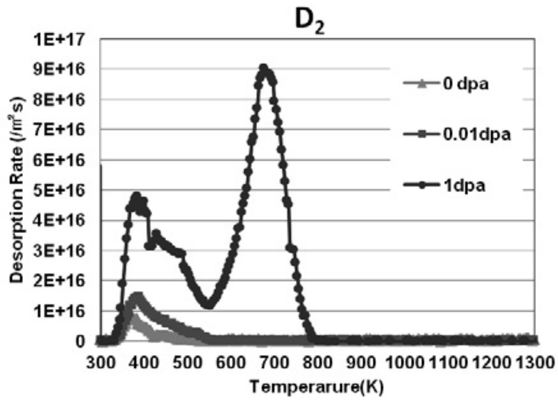

Fig. 2 D_2 desorption rate in recrystallized W(pre-irradiation 2.4MeV-Cu^{2+}, irradiated at room temp up to 1dpa)

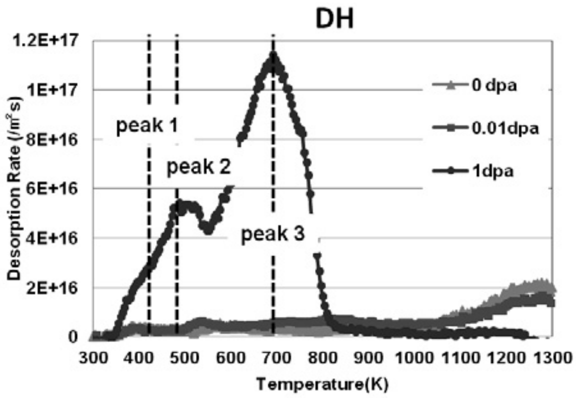

Fig. 3 DH desorption rate in recrystallized W(pre-irradiation 2.4MeV-Cu^{2+}, irradiated at room temp. up to1dpa)

1) This study is presented at Japan-US Workshop on Heat Removal and Plasma Materials Interactions for Fusion, and IEA Workshop on Solid Surface Plasma Facing Components (2011.8.29～31) "Interaction of High Energy Heavy ions Irradiation Damage with Hydrogen Isotope and Helium in Tungsten" Futagani et al.