§80. Microstructure and Thermal Desorption of Deuterium in Irradiated Pure Tungsten

Sakamoto, M. (Univ. Tsukuba),
Watanabe, H., Yoshida, N. (RIAM, Kyushu Univ.),
Tokitani, M.

Introduction

Tungsten (W) and its alloys are primary candidates for plasma-facing materials in fusion reactors owing to properties such as low sputtering yield, low hydrogen permeability, and high melting temperature. In the present study, the interaction between deuterium (D) atoms and radiation-induced defects in pure W was experimentally investigated by comparing the spectra of implanted D obtained using thermal desorption spectroscopy (TDS) and the microstructures of samples irradiated different irradiation temperature and dose.

Results[1,2)]

A pure W sheet obtained from Nilaco Co. Ltd. in Japan (0.1 mm-thick, 99.95% purity) was used in this study. The major impurities of the sheet are Mo (<300ppm), Fe (<50ppm), C, Si, O. Ca and Co (<30ppm). Samples for TEM observation and TDS analysis were punched from the sheet. Heavy ion (Cu^{2+}) irradiation was performed at room temperature up to a dose of 4 displacements per atom (dpa). The peak distribution up to approximately 600 nm were calculated using the SRIM code with displacement energy of 55 eV as shown in Fig. 1.

Before and after ion irradiation, exposure of the samples to 2 keV-D_2^+ ions was performed at room temperature up to a dose of 1×10^{21} D_2^+/m^2 in an ultra-high vacuum evacuation apparatus equipped with a small duo-plasma-type ion gun. After exposure, the samples were transferred to the TDS apparatus, where the thermally desorbed D gas was measured with a quadruple mass spectrometer. Desorption rate for D was calculated from the data obtained for the D_2. Figure 2 shows dislocation contrast images. Figure 3 shows the corresponding void contrast images and the results of TDS due the ion irradiation at room temperature, respectively. By the ion irradiation at room temperature, dislocation loops of interstitial type and a high density of nano-voids were observed. It is also known that desorption of D_2 at lower temperature region are strongly controlled by surface contamination and/or oxidation of specimen surfaces. Therefore, tapping sites of the peak L is probably due to the mixture of surface contamination, oxidation of surface and also single vacancies formed by irradiation. On the other hand, from TEM observations, the trapping sites of the peak L corresponds to nano-voids formed by cascade collisions. Figure 4 shows irradiation temperature dependence of void density and size for pure W. Growth of voids was prominent at higher temperature irradiation.

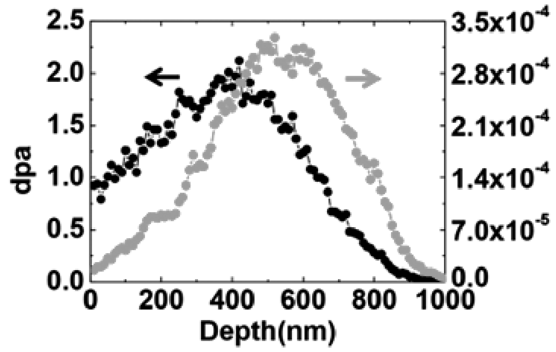

Fig. 1 Estimated depth profiles of displacement damage and implanted ion range distribution in W calculated using the SRIM code.

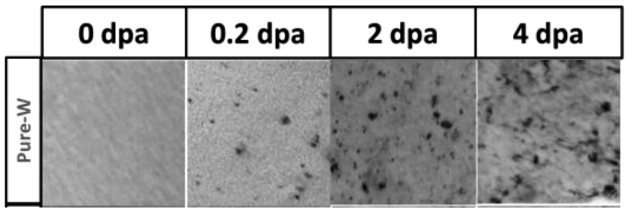

Fig. 2 Microstructure of pure W irradiated at room temperature (dislocation contrast image).

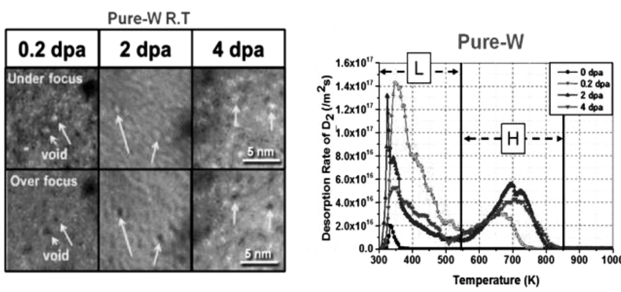

Fig. 3 Void contrast images and effects of irradiation on desorption of D_2 for pure W irradiated at room temperature.

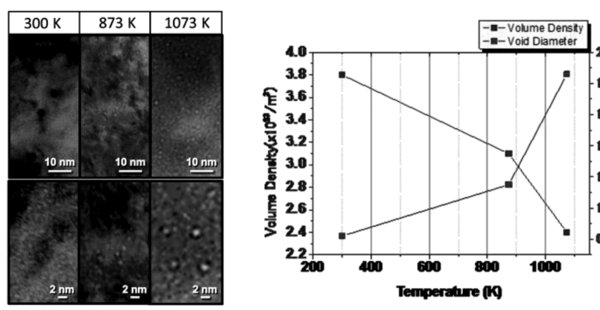

Fig. 4 Irradiation temperature dependence of void density and size.

1) H.Watanabe, N. Futagami, S.Naitou, N.Yoshida, J. Nucl. Materials, 455 (2014) 51-55.
2) H. Watanabe et al. presented at ICFRM 17.