§69. Tritium Adsorption Properties on Helium Irradiated Tungsten

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Tungsten (W) has a high melting point, low neutron activation cross-sections, and low tritium (T) solubility, so that it is a candidate of plasma-facing materials. In spite of these advantages, it is known that He bubbles and fiber-form nanostructures are formed on tungsten surface by exposing to He plasma[1]. In this study, the surface area of W specimens exposed to helium plasmas was measured with B.E.T. method. In addition, tritium (T) in the nanostructured W was measured with an imaging plate (IP) and β-ray-induced X-ray spectrometry (BIXS) technique. In addition, the correlation between the increase of surface area and T retention is discussed [2].

Nano-W samples were prepared by exposing powder metallurgy tungsten sheets (Nilaco. Co.) of 10×8×0.2 mm^3 to He plasma in the linear divertor plasma simulator NAGDIS (NAGoya DIvertor Simulator) – II. The plasma parameters were measured with a Langmuir probe. The helium ion fluences for nano-W1-W4 were 1.3×10^{25} m^{-2}, 5.0×10^{25} m^{-2}, 2.0×10^{26} m^{-2}, and 5.0×10^{26} m^{-2}, respectively. The incident ion energy was controlled by biasing the electrode and was 55 eV. The surface temperature, which was measured by radiation pyrometer, was ~ 1550 K. After each exposure, the cross section of each sample was analyzed by field emission scanning electron microscopy (FE-SEM). As reference, tungsten specimens with smooth surface (Polished-W) were also prepared by polishing W sheets with colloidal silica suspension. Surface area of Nano-W was measured by B.E.T. method. After heating in vacuum at 773 K for 1 h 30 min, adsorption of Kr gas on the Nano-W was measured at 77 K as a function of pressure. The adsorption isotherm is obtained from the adsorption amount of Kr gas.

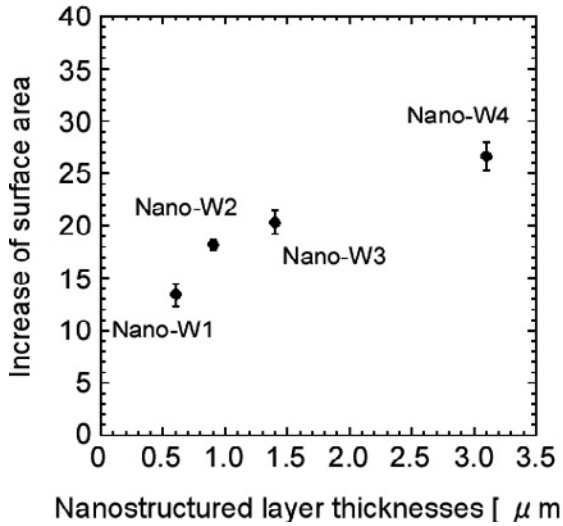

Figure 1: The increase of surface area of Nano-W plotted against the square root of He fluence.

From the B.E.T. method, the surface area of Nano-W3 was calculated 32.5 cm^2. Macroscopic surface areas of these specimens were 1.6 cm^2. Thus, the surface area of Nano-W3 was increased by a factor of 20. In the same way, the effective surface areas of Nano-W1, W2 and W4 were evaluated to be 21.5, 29.2 and 42.7 cm^2, respectively. In Figure 1, the increase in the surface area of nano-W was plotted against the layer thickness. It is found that the surface area of Nano-W increases with the nanostructure layer thickness. The surface areas of Nano-W1, W2 and W4 were increased by 13, 18 and 27 times, respectively.

Figure 2 shows the He fluence dependence of PSL intensity from IP method. The PSL intensity was proportional to the concentration of T. In addition, the PSL intensity of IP measurements for Polished-W and Nano-W1-W4 were 121, 1737, 2551, 2372 and 2380 PSL mm^{-2}, respectively. The surface T concentration from PSL intensity saturated when the helium ion fluence was higher than ~2.5×10^{25} m^{-2}.

Because the IP method uses β-ray, it should be said that only the tritium atoms near the surface, say within the depth of about several μm from the surface, can be detected. In addition, the concentration obtained from the BIXS method was also saturated. Because the BIXS method used X-ray, the tritium atoms existed in a deeper region can be detected compared with the IP method.

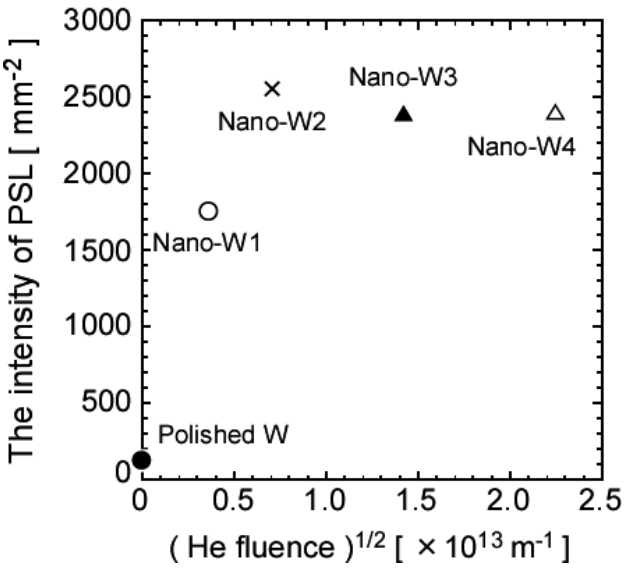

Figure 2: The helium ion fluence dependence of the PSL intensity obtained from IP method.

1) S. Takamura, N. Ohno, D. Nishijima, *et al.*, Plasma Fusion Res. **1** (2006) 051.
2) M. Yajima, Y. Hatano, S. Kajita, J. Shi, M. Hara, N. Ohno, J. Nucl. Mater (2013) (*in press*) http://dx.doi.org/10.1016/j.jnucmat.2013.01.252