## §13. Reflection Properties of Hydrogen Ions at Helium Irradiated Tungsten Surfaces

Yamaoka, H. (RIKEN SPring-8 Center),
Doi, K., Tawada, Y., Kato, S. (Doshisha Univ.),
Sasao, M., Wada, M. (Doshisha Univ.),
Lee, H.T., Tanaka, N., Ueda, Y. (Osaka Univ.),
Kisaki, M.,
Nishiura, M. (Univ. Tokyo),
Matsumoto, Y. (Tokushima Bunri Univ.)

Particle reflection properties at the wall of plasma confinement devices are important input parameters for several computational studies of edge plasma modeling and impurity transport analysis. Especially, data on tungsten (W) and hydrogen have been required because ITER will use full-tungsten divertor. Under the fusion plasma environment, however, the surface is modified due to exposure to the intense heat load caused by plasma. Helium bombardment on W at high surface temperature forms nanostructured surface layers composed of micron-bubble or fuzz-like morphology. We prepared two types of He-modified W surfaces as shown in Fig. 1(a); He-bubble W where He nano bubbles localized within 20 nm of the surface is called He-bubble W and fuzz W where W nanostructure was formed on the surface. [1] $H^+$ ions at 1 keV energy were injected onto the samples. Angle-resolved intensity and energy distributions of both scattered $H^+$ and $H^-$ ions were detected by a momentum magnetic analyzer with a single scan.

Figure 1(b) shows two-dimensional (2D) counter intensity maps of $H^-$ and $H^+$ reflected from W surfaces of the reference W, He-bubble W, and fuzz W for the $H^+$ beam injection at 1 keV energy. The angular distributions of ions reflected from the He-bubble W and fuzz W were broader than the reference W. Figures 2 shows the reflection angular dependence at the incident angle $\alpha = 10°$ with ACAT simulation results for hydrogen atoms reflected from normal density W (19.3 g/cm$^3$) and low density W (3.86 g/cm$^3$). The low-density W equivalents to the virtual surface density of fuzz W. The intensity of reflected ions decreases in the following order: the polycrystalline W, the He-bubble W, and the fuzz W. The reflection intensity from the fuzz W remarkably reduced to be as small as about 30% of that from the reference W. The simulated width of the angular intensity distribution is wider than that of the experimental ones. Reflected particles detected as ions potentially possess higher energy since they are backscattered near the surface layer. This explains the difference on results obtained by the experiment and the numerical simulation.

1) K. Doi *et al.*, *Physca Scripta* **T167**, 014044 (2016).

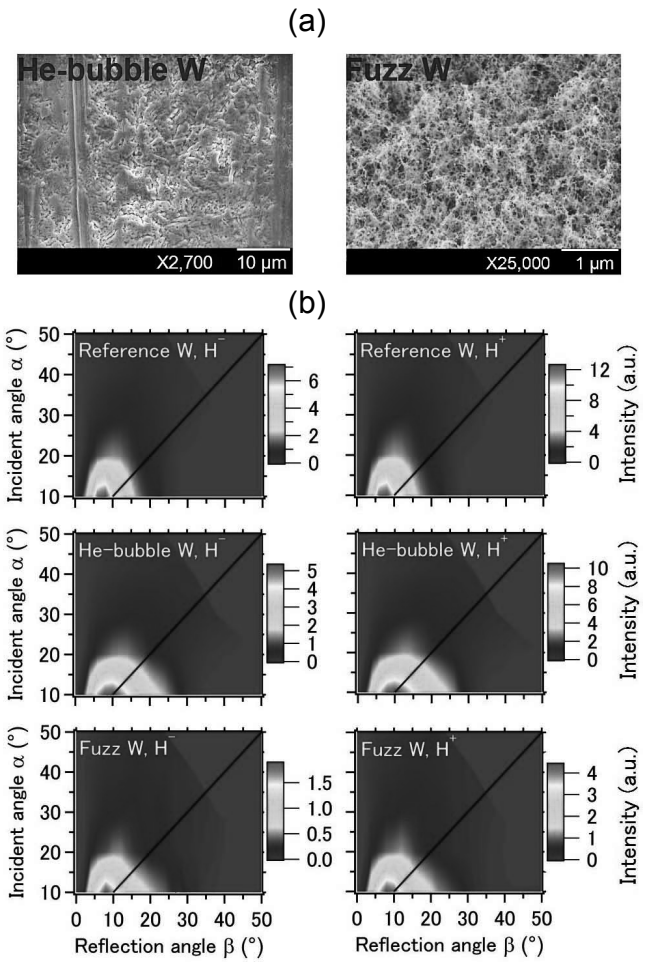


Fig. 1: (a) FE-SEM images of He-bubble W (left) and fuzz W (right). (b) Experimental results of the 2D counter intensity map of the $H^-$ and $H^+$ ions reflected from the reference W, He-bubble W, and fuzz W for the $H^+$ ion injection at 1 keV energy. Solid lines correspond to the specular reflection.

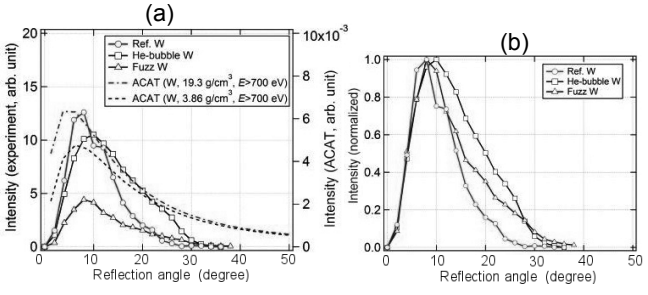


Fig. 2: Reflection angular dependence of (a) the intensity with ACAT simulation results for hydrogen atoms, (b) the normalized intensity. The incident hydrogen particle energy is 1 keV at the incident angle $\alpha = 10°$.