Microscopic deformation of tungsten surfaces by high energy and high flux helium/hydrogen particle bombardment with short pulses

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High energy and high flux helium and hydrogen particles were irradiated with polycrystalline tungsten specimen by using neutral beam injection (NBI) facility in AIST [1]. Incidence energy and flux of NBI shot are 25 keV and 8.9×10^{22} ions/m^{2}s, respectively. Duration time of each shot was 30 ms with 6 min interval. Surface temperature may be reached over 1800 K. In the cases of helium irradiation, total fluence was selected 2 cases of 1.5×10^{22} ions/m^{2}s and 4.1×10^{22} He/m^{2}s. The former case, large sized blisters with the diameter of 500 nm were densely observed. While, the latter case, blisters was disappeared and fine nano-branch structures appeared instead of blisters. Cross-sectional transmission electron microscope (TEM) observation was performed by using focused ion beam (FIB) technique. Fig. 1 shows that TEM image after irradiated with 4.1×10^{22} He/m^{2}s. It was clear that very dense fine helium bubbles with the size of 1-50 nm were densely observed, the density of tungsten matrix was drastically decreased by void swelling with growth of helium bubbles. In the hydrogen irradiation case, these damages were not observed.

To investigate the effect of bombardment of helium and hydrogen particles, optical reflectivity was measured by means of spectrophotometer for the wavelength between 190 and 2500 nm. The hydrogen irradiation case, it was scarcely changed before and after irradiation. However, reduction of reflectivity has occurred in helium irradiation case, and it near 200 nm or less and also infrared region was remarkable. It is considered that reduction of optical reflectivity is due to the multiple scattering of light by the helium bubbles in the sub-surface region.

The helium or hydrogen irradiation experiment with critical condition is important for not only elucidation of the damage evolution but also safety assessment of tungsten walls for fusion devices. This study is fundamental research focused on the microscopic damage evolution in tungsten due to the energetic particle bombardment.

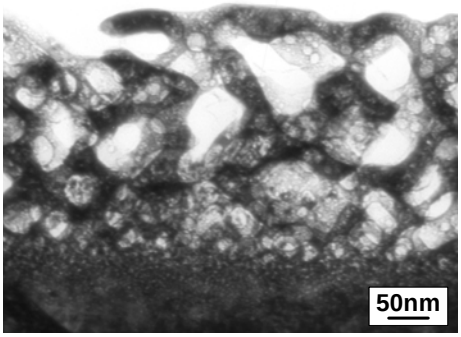

Fig. 1 Cross-sectional TEM image of tungsten after irradiated by helium (4.1×10^{22} He/m^{2}s).

[1] H. Sakakita et al., Proc. of IAEA Fusion energy conf. 2006, FT/P5-2