§17. Thermal Loads Effects on Erosion Processes of Helium Irradiated High-melting PFMs

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High-Z metals such as tungsten (W) and molybdenum (Mo) are important candidate materials for plasma facing materials because of its high melting temperature, high thermal conductivity and low sputtering erosion yield. In the ITER DT phase, the burning plasma will expose plasma facing materials (PFMs) simultaneously to helium (He) and hydrogen isotopes besides high heat loads. Therefore, it is important to understand effects of thermal loads on erosion processes of irradiated materials. In this study, thermal load experiments have been performed using the He or D pre-irradiated Mo with the steady heat loading test apparatus ACT.

Mirror polished samples with a size of 10 × 10 × ^{t}0.1 mm^3 were used for thermal loading experiments with ACT after the pre-irradiation with 1~5keV He^+ or D^+ to a fluence of ~10^{23} m^{-3} at R.T. To evaluate the effects of the pre-irradiation on material properties, microstructure observation and optical measurements were performed with TEM and spectroscopic ellipsometry, respectively. The thermal load conditions were controlled with sample currents of 30keV-electron beam. After the thermal loading experiments, the changes of surface morphologies were examined by SEM.

Fig.1 shows TEM micrographs of Mo irradiated with 5 keV D^+ or He^+ at R.T. For the He^+ irradiated sample, comparatively high density of dislocation loops and helium bubbles were formed while no visible bubbles were observed even in the sample irradiated with deuterium ions to a fluence of 1 × 10^{22} ions/m^2. For optical measurements, rather large changes were similarly observed in the He irradiation sample. Fig. 2 shows refractive index, *n*, and extinction coefficient, *k*, for the virgin sample and irradiated samples with 3 keV D^+ or He^+ as a function of a photon energy. These results indicate that a helium irradiation has a larger impact on properties change of PFMs than a hydrogen isotope irradiation. A strong helium effects on surface morphology were also observed after the thermal loading. Fig.3 shows the SEM image of He^+ pre-irradiated W surface after the thermal loading of ~0.4 MW/m^2 in ACT. While D^+ pre-irradiation sample shows smooth surface after the similar thermal loading, large roughness and many holes are observed for the He^+ pre-irradiation sample. It should be noted that existence of helium causes stable defects such as helium bubbles and the influence of the helium related defects remains even at a very high temperature.

In the present experiments, no systematic data was obtained due to several experimental problems. Optimization of experimental condition and extension of heat loading condition are required in the future experiments.

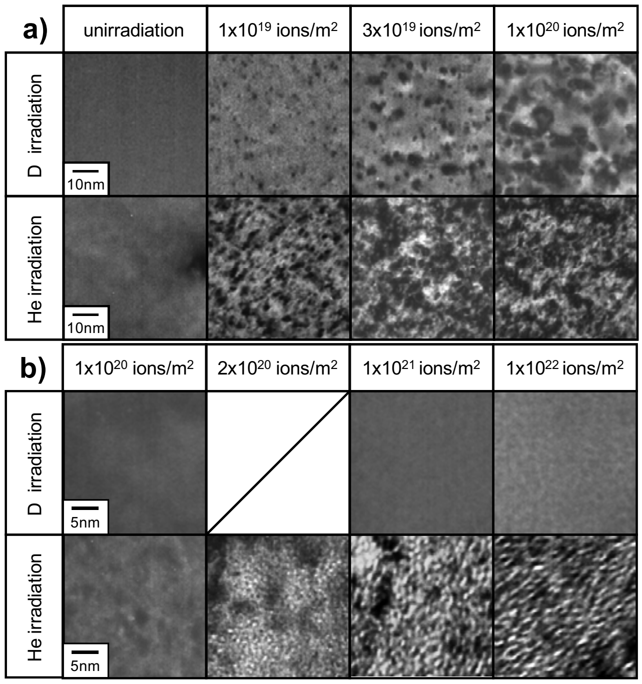

Fig. 1 Microstructure evolutions in Mo irradiated with 5 keV-D^+ or He^+ at R.T. Black dot images (a) and circular white images (b) indicate radiation-induced dislocation loops and helium bubbles, respectively.

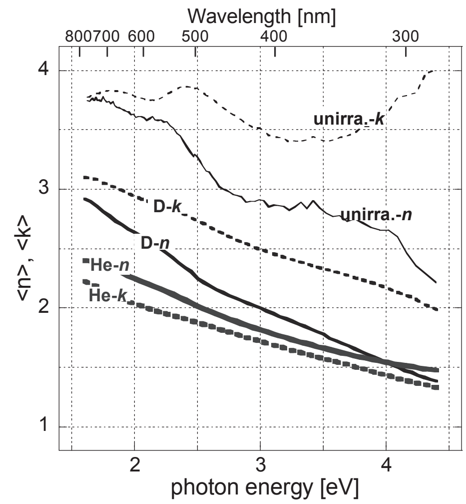

Fig. 2 Optical constants, *n* and *k*, measured with ellipsometer, in the Mo samples before and after the irradiation with 3keV-D^+ or He^+.

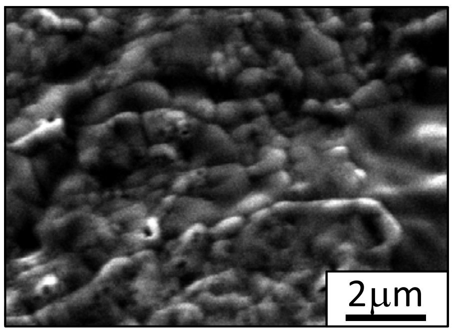

Fig.3 Surface morphology after the thermal loading of ~0.4 MW/m^2 experiments in W pre-irradiated with 5keV-He^+ to a flue1e of 10^{23} He/m^2.