§22. Thermal Loads Effects on Erosion Processes of Helium Irradiated Tungsten

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Tungsten (W) was chosen as a plasma facing material in the ITER divertor region because of its high melting temperature, high thermal conductivity and low sputtering erosion yield. In the ITER DT phase, the burning plasma will expose the W simultaneously to helium (He) and high heat loads. Therefore, it is important to understand effects of thermal loads on erosion processes of helium irradiated tungsten. In this study, thermal load experiments has been performed using the He pre-irradiated W with the steady heat loading test apparatus ACT.

Mirror polished W with a size of ϕ10mm × ^{t}1mm were used for thermal loading experiments with ACT after the pre-irradiation with 1keV-He^+ or 5keV-He^+ to a fluence of ~1.8×10^{23} m^{-3} at R.T. The thermal load conditions were controlled with sample currents of 30keV-electron beam. Isochronal thermal loading with steps by 0.1MW/m^2 for 10min were performed to a maximum heat load of 0.7 MW/m^2. During the thermal loading, sample temperature, He desorption rate and emission of sample surface were measured in-situ. In addition, the changes of surface morphologies were examined by SEM.

Fig.1 shows the results of thermal load experiments obtained from the W irradiated with 1keV-He^+ (left) and 5keV-He^+ (right). (a) Ion current due to thermal desorped He (*m/e*=4) measured by a mass spectroscope, (b) sample temperature by a radiation thermometer and (c) heat flux were respectively plotted as a function of time. As shown in these figures, He desorption behavior have significant dependence on the irradiation energy. In the sample irradiated with 1keV-He^+, large desorption occurred above 800K, which is consistent with the normal TDS experiment after He irradiation. This desorption seems to correspond with diffusion of He-V complexes and He bubbles. On the other hand, little significant desorption was observed to high temperature around 900 K in the 5keV-He^+ irradiated sample. This means little He retention for 5keV irradiation sample as contrasted to 1keV irradiation. It seems that He retained as He-V and He bubbles desorped directly by surface sputtering and exfoliation during irradiation for the 5keV irradiation sample. Fig.2 shows the surface structural changes before and after irradiation. While 1keV irradiation sample showed smooth surface, large roughness was observed for the 5keV irradiation sample. For both samples, grain growth and change of surface roughness were also observed after thermal loading although direct comparison cannot be made because of difference of heat loading conditions.

In the present experiments, no significant signal was detected by spectroscopic measurement. Optimization of experimental condition and extension of heat loading condition were required in the future experiments.

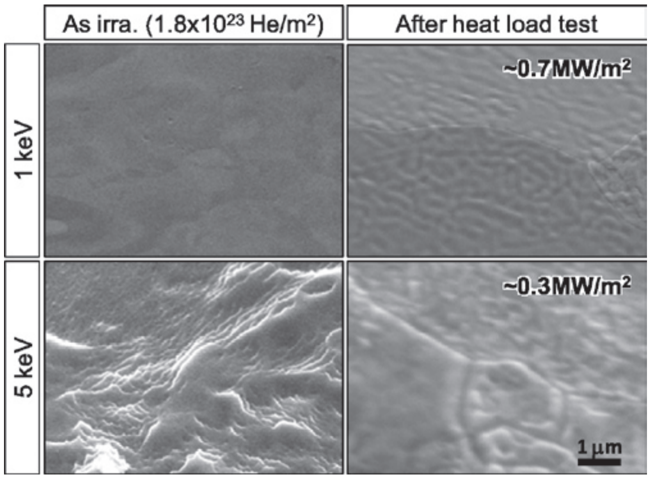

Fig. 2 Changes of surface morphologies after the thermal load experiments.

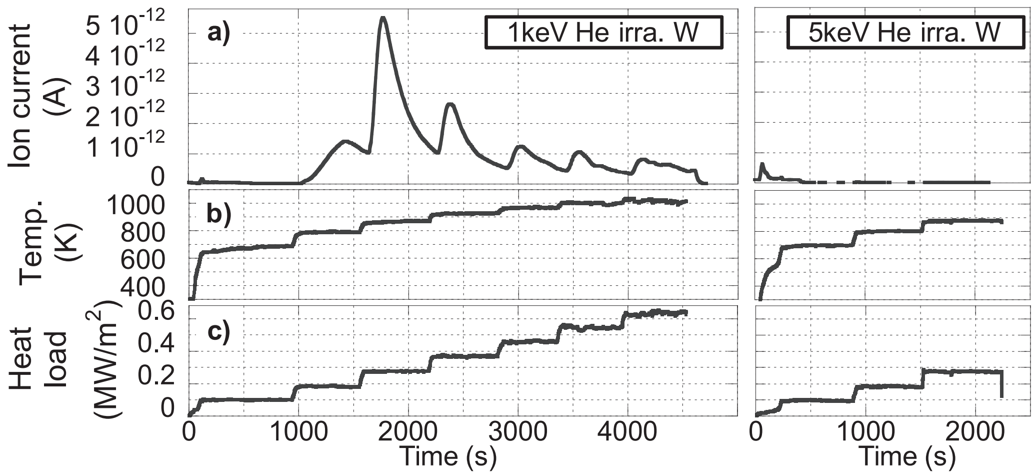

Fig. 1 Time evolution of (a) ion current due to thermal desorped He (m/e=4), (b) sample temperature by a radiation thermometer and (c) heat flux during heat load experiments.