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

Miyamoto, M., Sakoi, Y. (Dept. Mater. Sci. Shimane Univ.),
Tokitani, M., Masuzaki, S.

High-Z metals such as tungsten (W) and molybdenum (Mo) are considered the leading candidate first-wall materials for next generation fusion reactors 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. We had performed thermal load experiments for the samples pre-irradiated He or D with the steady heat loading test apparatus ACT. As a result, it was indicate that a helium irradiation has a larger impact on surface morphology change and defects formation in the samples than a hydrogen isotope irradiation. These strong helium effects were observed even after the high thermal loading with ACT. Although some works suggested He induced defect have various influences on hydrogen isotopes retention depending on experimental conditions, consistent mechanism of the He effect is not entirely clear. Therefore in the present study, well-controlled sequential irradiations have been performed using He and D ion beams and the D retention was examined with thermal desorption spectroscopy (TDS).

Polycrystalline pure-W samples with a size of 10 × 10 × ^{t}0.1 mm^3 were used for TDS experiments after vacuum annealing at ~1500K for 0.5h with ACT. To investigate the effect of He irradiation on D retention in W, pre- or post- He implantation were performed using D implanted samples. The irradiations were performed using 3 keV-He^+ and 1.5 keV-D^+ with a flux of ~10^{18} ion/m^2s, and a fluence of ~$10^{21\sim23}$ ion/m^2 at room temperature. Retention properties of D and He are examined using a high resolution TDS system capable of distinguishing between mass four He and D_2 signals.

Pre-He^+ irradiation showed conflicting effects on D retention depending on the fluence. Fig.1 shows the fluence dependence of pre-He^+ irradiation on the thermal desorption spectra of D_2. At the rather low pre-He^+ fluence of ~10^{21} He/m^2, significant amount of retained D was observed. This indicates that He irradiation induced defects such as He bubbles probably act as strong trapping site for D. On the other hand, at the higher pre-He^+ fluence of ~10^{23} He/m^2, D retention remarkably decreased, which was far below that for the single D irradiation. The similar suppression of D retention was also observed for a sample pre-exposed to He plasma. Taking account of the results of microstructure observations with TEM, desorption mechanism that injected D atoms diffuse back to the surface through the connecting bubbles were suggested. The remarkable reduction of D desorption was also observed in post-He irradiated W samples. Fig. 2 shows thermal desorption spectra of D_2 in W subsequently irradiated with 3 keV-D^+ before or after the He^+ irradiation at R.T. For the sample with post-He irradiation, only small peak was observed at high temperature region of around 700 K. Post-He irradiation seems to induce rearrangement of trapped D in W, creating new trapping sites such as He bubbles.

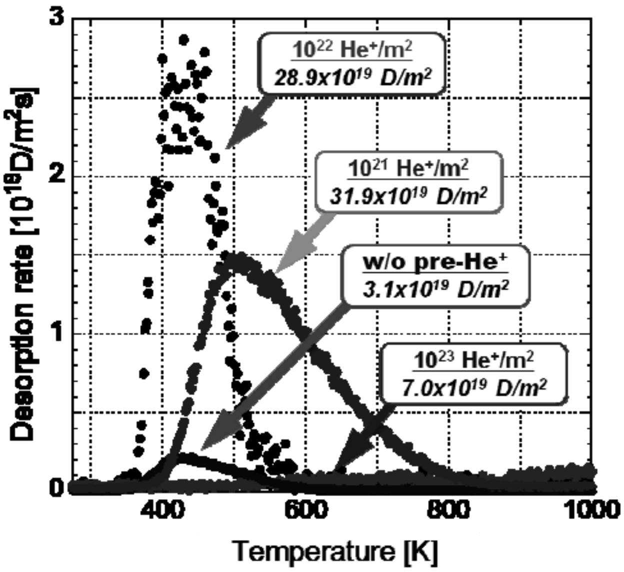

Fig. 1 Thermal desorption spectra of D_2 in W subsequently irradiated with 1.5 keV-D^+ of $1x10^{21}$ D/m^2 after the pre-He^+ irradiation with 3 keV-He^+ up to 0 ~ 10^{23} He/m^2 at R.T.

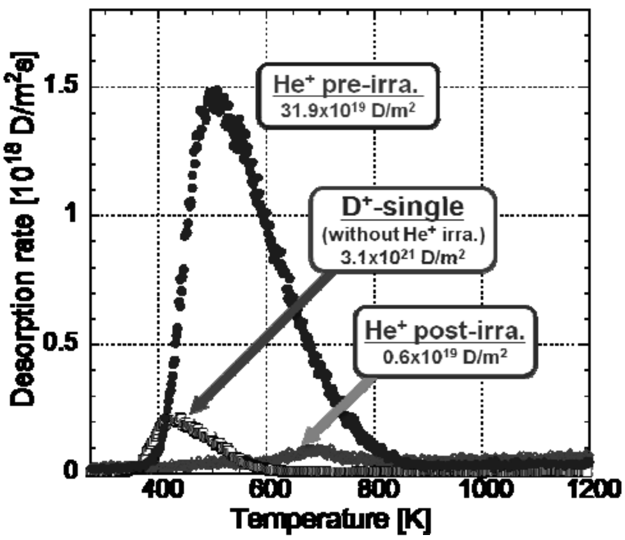

Fig. 2 Thermal desorption spectra of D_2 in W subsequently irradiated with 3 keV-D^+ of $1x10^{21}$ D/m^2 before or after the He^+ irradiation with 3 keV-He^+ of 10^{21} He/m^2 at R.T.