§26. Effects of Complex Ion Irradiation and Heat Load on Surface Characteristics of Plasma Diagnostic Mirrors

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In the optical diagnostic system, the reflectivity of the first mirror deteriorates by bombardment of energetic plasma particles and deposition of materials sputtered from the plasma facing components, which becomes a serious concern for the reliability and long term usefulness of spectroscopic system. In our previous work, it was proved that a helium irradiation has a larger impact on optical reflectivity change than a hydrogen isotope irradiation.[1)] In this study, to obtain further information of the multiple irradiation effects with helium and deuterium ions the deuterium retention properties were investigated by means of thermal desorption spectroscopy (TDS).

The sample used in this study was 99.95 % nominal purity W supplied by Nilaco Corp. After the vacuum annealing at 1473 K for 0.5 h with ACT and the electrochemical polishing, the samples were irradiated sequentially or simultaneously with 3 keV-He^+ and 1.5 keV-D^+ (3 keV-D_2^+) at room temperature. To investigate the deuterium D retention properties of the irradiated specimens, the TDS of D_2 gas was measured while heating the samples at a constant rate of 1 K/s from room temperature to 1473 K, by using a high resolution quadrupole mass spectrometer, which made it possible to distinguish masses of helium ion (4.0026 amu) and deuterium ion (4.0282 amu).

Fig. 1 and Fig. 2 show the TDS spectra of D_2 and He respectively from the sample after the irradiation with single species ion and sequential and simultaneous dual ions of D^+ and He^+. For the pre-He irradiated sample, a shift of the desorption peak to higher temperatures and an increase of deuterium retention were observed compared with the sample irradiated with the single D^+ as shown in Fig.1. This significant effect of the pre-He irradiation on the deuterium retention properties has been often reported and is considered to be due to the strong deuterium trapping efficiency of helium bubbles. The simultaneously He^+ and D^+ irradiated sample also exhibited the large desorption, while the desorption peak located at lower temperature comparable to the single D^+ irradiated sample. On the other hand, the remarkable reduction of He desorption was observed in the sequentially irradiated sample (pre-D^+ and post He^+ irradiation) as shown in Fig. 2. For this sequentially irradiated sample, only a small peak was observed at low temperature region around 550 K. Post-D^+ irradiation seems to induce a local disturbance and cause the desorption of trapped helium during the irradiation. These results indicate that the amount of retained He in W have an insignificant effect on deuterium retention. This means that even low pressure cavities from which most helium desorbed show the strong deuterium trapping efficiency.

In this study, a recovery of optical reflectivity during the post-D^+ irradiation after the pre-He^+ irradiation was also observed. It may suggest that the internal pressure of the helium bubbles are related to the reflectivity. At present, the samples irradiated at the various conditions are under investigation from the microscopic perspective with TEM.

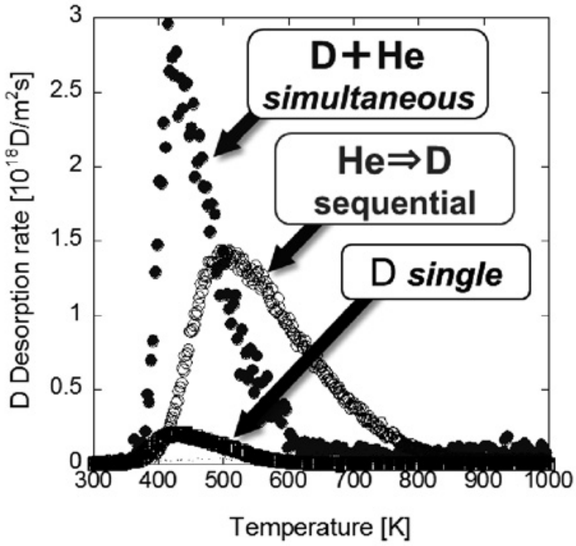

Fig. 1. TDS of D_2 from W irradiated with 3keV-D_2^+ ($1x10^{21}$ D/m^2) and/or 3keV-He^+ ($1x10^{21}$ He/m^2).

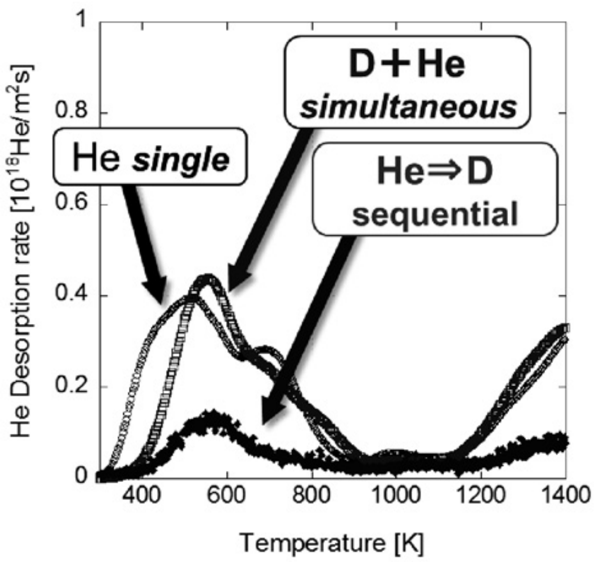

Fig. 2. TDS of He from W irradiated with 3keV-D_2^+ ($1x10^{21}$ D/m^2) and/or 3keV-He^+ ($1x10^{21}$ He/m^2).

1) T. Nakanoa et al., J. Nucl. Mater., 417 (2011) 834