§105. Study of D Retention Property of Tungsten Irradiated by Low Energy Ions

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In our previous study[1], dynamic behavior of deuterium (D) retention in tungsten (W) samples had been investigated by using PS-DIBA device, in which the time evolution of D retention was measured with Nuclear Reaction Analysis (NRA) during D plasma exposure. The experimental result shows that the D retention in W gradually increases to be saturated during plasma exposure. It takes about 15000 s for the D retention to be saturated when the incident ion energy is 20 eV, impinging D ion flux is $1.3 \times 10^{21}\mathrm{m}^{-2}\mathrm{s}^{-1}$ and W sample temperature is 450 K. Comparison between the experimental result and TMAP7 simulation indicated that penetrating ion flux into W surface should be three order magnitude lower than the impinging D ion flux of $1.3 \times 10^{21}\mathrm{m}^{-2}\mathrm{s}^{-1}$ in order to explain slow increase of the D retention. This phenomena has not been understood yet. One of the possible explanation would be that lower incident ion energy (20 eV) gives higher particle reflection coefficient on W surface. In this study, we have investigated dependence of D retention on the incident ion energy by using Thermal Desorption Spectroscopy (TDS) measurement, because NRA is only able to measure D retention up to 1.2 micron depth from W surface, but TDS can detect total D retention in W.

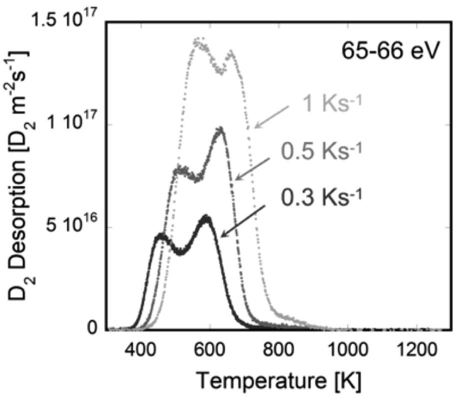

Fig. 1: TDS spectra of W sample exposed to D plasma with different elevated sample temperature.

Figure 1 shows TDS spectra of W samples exposed to D plasma with the ion incident energy of 65 eV, and ion fluence of $5.7 \times 10^{24}\mathrm{m}^{-2}$ with different elevated temperature (0.3, 0.5, 1.0 Ks^{-1}). Based on these TDS spectra, the activation energy of the trapping site was estimated. The peaks at lower and higher temperature give the activation energy of 0.17 V and 0.4 eV, respectively. The peak at higher temperature would correspond to vacancies in W, and the peak at lower temperature could be due to processing dislocation.

Figure 2 shows TDS spectra with different incident ion energy from 23 eV to 146 eV. It is found that the shape of the TDS spectra is varied depending on the incident ion energy. However, it is slightly difficult to conclude that the variation of TDS spectra occurs only due to difference of the incident ion energy, because the influence of the processing dislocation on total retention has not been understood yet and each sample should have individual difference of the processing dislocation.

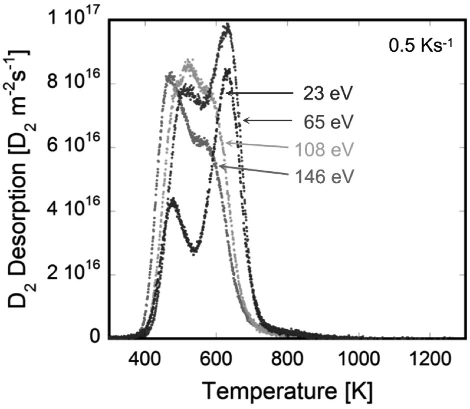

Fig. 2: TDS spectra with different incident ion energy.

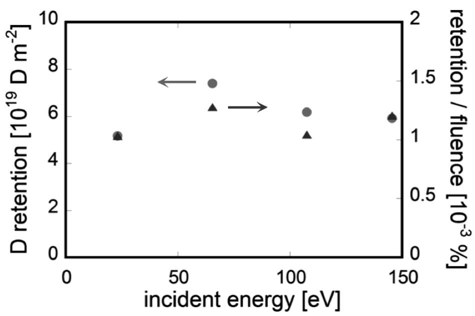

Fig. 3: Total D retention and the ratio between the D retention and D ion fluence as a function of the incident ion energy.

Figure 3 shows the total D retention and the ratio between the D retention and D fluence as a function of the incident ion energy. It is found that the D retention is almost constant, and the ratio between the D retention and fluence matches the value of the previous experiment well. Therefore, it can be concluded that the lower incident energy is not main reason to explain higher particle reflection coefficient on W surface.

1) T. Watanabe, T. Kaneko, N. Matsunami, N. Ohno, S. Kajita, T. Kuwabara, Journal of Nuclear Materials, Vol.463, 1049-1052 (2015).