§1. Effects of Modified Surfaces Produced at Plasma-Facing Surface on Hydrogen Isotopes Release Behavior in the LHD

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The plasma-facing surface in fusion devices receives energetic hydrogen isotopes and He bombardments during a plasma operation, which causes a modification of the plasma-facing surface by erosion, re-deposition and irradiation damages. The formation of modified surface could significantly change the hydrogen isotopes release behavior. This could give rise to an unexpected gas release from the wall and the plasma density might be uncontrollable. These phenomena are inevitable in magnetic fusion devices and apply both to tokamak and helical type reactors. Thus, to understand the hydrogen isotopes behavior in the modified surface is necessary for a stable fusion plasma operation.

Long-term samples, which are mounted on plasma-facing surface in fusion devices, are useful to grasp the surface condition. Studies on PSIs using long-term samples or plasma-facing tiles were usually focused on a localized area [1-3]. Thus, hydrogen release behavior at the modified surface of entire wall area has not been clarified. In the present study, a number of long-term samples made of stainless steel, which is the same material as the first wall panels in the LHD, were mounted on the plasma-facing surface at each toroidal sector in the LHD during the 17th experimental campaign. The poloidal positions of the samples are shown in figure 1. The 'First wall' samples were located far from the graphite divertor tiles and close to the main plasma. On the other hand, the 'Divertor' samples were in the vicinity of the divertor tiles. These samples were mounted at each toroidal sector. After several months of plasma operation, the samples were extracted from the vacuum vessel, and deposition species and H retention were investigated with Auger electron spectroscopy (AES) and thermal desorption spectroscopy (TDS), respectively. Irradiation damages were observed with transmission electron microscope (TEM). In order to clarify the hydrogen isotopes release behavior at the top surface of the modified layer, a D ion irradiation against the long-term samples of the 17th experimental campaign was performed. In this irradiation, D_3^+ ion beam with energy of 5 keV was irradiated with a fluence of $3x10^{17}$ D/cm^2. The sample temperature during the irradiation was room temperature, which is similar to the LHD first wall temperature. Just after the irradiation, the D desorption behavior was investigated with TDS.

For most of the First wall samples, little deposition was seen on it (erosion area), while a thick (1-2 μm) carbon deposition layer was observed on the Divertor and Port samples (deposition area). Thermal desorption spectra of H_2 and D_2 for the First wall and Divertor samples are shown in figure 2. Since the samples were exposed to several months of H plasma operation in the LHD, H retained in the samples would exist at much deeper regions compared to D. In the first wall sample (Fig.2 (a)), H_2 desorbed mainly in the temperature range between 500 and 900 K, while D_2 desorbed lower temperature region, from 350 to 600 K. The desorption spectra of D_2 for the Divertor sample (Fig.2 (b)) had a major peak at around 1050 K, which was similar to that of H_2.

The present study revealed that H retained in the modified surface in the erosion dominant area desorbed at much lower temperatures than that in carbon deposition area. This suggests that H release from the erosion dominant area could be more significant in terms of fuel recycling when the wall temperature increases during the start-up of a long time discharge in the LHD.

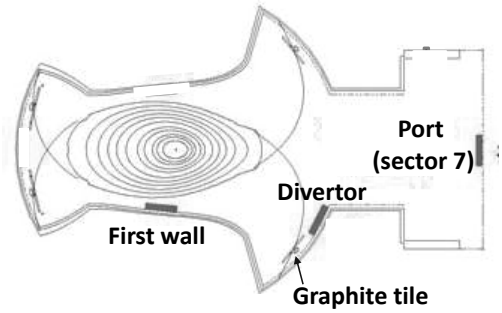

Figure 1 Poloidal cross section of the LHD and sample positions. 'First wall' sample was far from the graphite tiles and 'Divertor' sample close to the tiles. 'Port' sample was mounted only at toroidal sector 7.

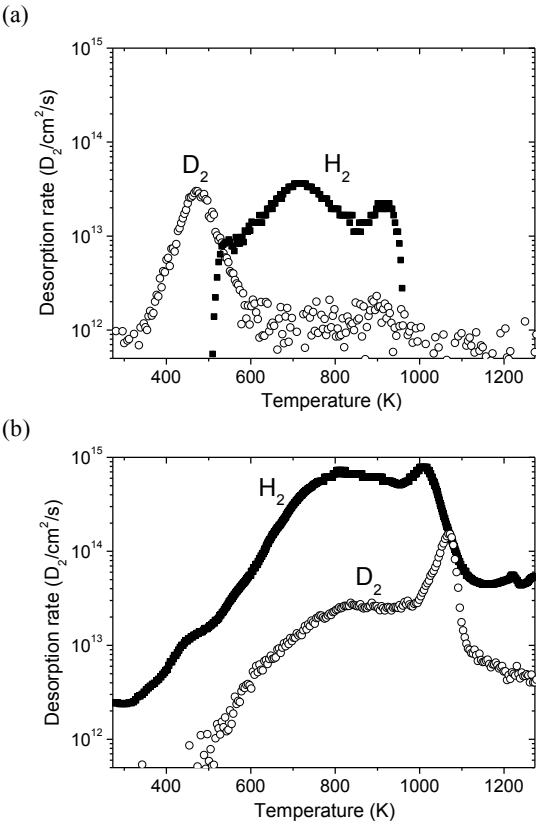

Figure 2 Thermal desorption spectra of H_2 and D_2 for the 'First wall' (a) and 'Divertor' (b) samples, which are located at toroidal sector 2 and 3, respectively.

[1] Nobuta, Y., et al.: J. Nucl. Mater., **438** (2013) S1040.
[2] Tokitani, M. et al.: J. Nucl. Mater., **463** (2015) 91.
[3] Kreter, A., et al.: J. Nucl. Mater., **438** (2013) S746.