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Effects of Modified Surfaces Produced at Plasma-Facing Surface on Hydrogen Isotopes and Helium Release Behavior in the LHD

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In the present study, long-term samples made of stainless steel, which is the same material as the first wall panels in the LHD, were mounted at a lot of places on the plasma-facing surface in the LHD during the 17th experimental campaign (FY2013) and the surface modifications caused by plasma-surface interactions were evaluated. In addition, in order to investigate hydrogen isotopes release behavior of the modified surface, a deuterium (D) ion beam irradiation against the long-term samples was performed after the experimental campaign and the desorption behavior of D retained in the sample was investigated with thermal desorption spectroscopy (TDS). Since the samples were exposed to several months of hydrogen (H) plasma operation in the LHD, H retained in the sample should exist at much deeper regions compared to the additionally implanted D. Therefore, the H and D desorption behaviors could give a useful information to understand release behavior of hydrogen isotopes from the modified surface and deeper regions.
For most of the first wall samples, which were mounted far from graphite divertor tiles, little deposition was seen on it and helium (He) bubbles with diameter of 1-10 nm produced by He main and glow discharges were clearly observed within the depth of ~50 nm from the surface. On the other hand, for the divertor samples located in the vicinity of the divertor tiles, a thick (1-2 μm) carbon layer were observed. The desorption behavior of D significantly depended on the surface conditions. For the first wall samples, D2 desorbed at lower temperature of 350 K to 600 K, while H2 desorbed mainly in the temperature range higher than 500 K. The D2 desorption spectra for the divertor samples had a major peak at around 1050 K, which was similar to that of H2. The present study revealed that D trapped at the modified surface in erosion dominant area desorbed at much lower temperatures than that in carbon deposition area. This suggests that H release from erosion dominant area could be more significant when the wall temperature increases during a long pulse discharge in the LHD. A He ion beam irradiation against the long-term samples is in progress and the difference of desorption behavior between hydrogen isotopes and He at the modified surface will also be discussed.

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