§37. Study of the Co-deposition of Hydrogen and Helium in the LHD

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During the long-term plasma experiments, He and H recycling affects the plasma performance, and elucidation of their He and H retention behavior is quite important for high performance plasma operation. The purpose of this study is to clear the mechanism of He and H atoms trapping in the mixed-material desorption layer and parent metal. In this year's study, we investigated He desorption behavior by using a high temperature thermal desorption spectroscopy (TDS) system and transmission electron microscopy (TEM).

In the 18th experimental campaign (in FY2014), SUS316L specimens (the specimens are hereafter denoted as "C18") were placed on the plasma facing surfaces made by stainless steel in the unique positions in LHD. After a few month of experimental period, the samples were extracted from the vacuum vessel, the thickness of the mixed-material desorption layer and He retention were investigated with TEM and TDS, respectively. In the TDS analysis, the sample was heated continuously up to 1273 K at a heating rate of 0.5 K/s.

From cross-sectional TEM analysis, He bubbles of 1-2 nm diameter were observed in the surface area of C18-5, which was mounted on the plasma-facing wall that was nearest to the plasma. In addition, the thickness of the desorption layer was 2.6 nm. On the other hand, the some thick mixed-material desorption layer was formed on C18-4 and 7. Those specimens were mounted on erosion dominated area. The thickness of the desorption layer of C18-4 and 7 were 140 and 555 nm, respectively. This result were caused by the glow discharge, the C18-4 was more strongly influenced by it than C18-7. In addition, the bulk material of C18-4 had even more large He bubbles than another specimens.

Fig.1 shows the TDS spectra of He from C18 specimens. The desorption peaks of the TDS spectra can be roughly divided into two temperature regions: low-temperature (300–1000 K) and high-temperature (1000–1273 K) region. In the TDS results, He desorption in the high-temperature region corresponds to helium trapped by the strong trapping sites of bubbles which corresponds to trapping site. On the other hand, He desorption in the high-temperature region were not observation in TDS result of C18-7. Because the majority of the He trapped in the mixed-material deposition layer of C18-7, He will possibly be desorbed in the low-temperature region.

The total amount of retained He in C18-5, 4 and 7 were estimated to be 2.6×10^{20} m^{-2}, 3.5×10^{20} m^{-2}, and 1.5×10^{20} m^{-2}, respectively. Fig.2 shows the relation between the thickness of the mixed-material desorption layer and the total He desorption from C18. Because the C18-4 was more strongly influenced by discharge than another sample, the total He desorption of C18-4 was most large. Outside of C18-4, this results suggested that the desorption rate of He reduced with increasing the thickness of desorption layer.

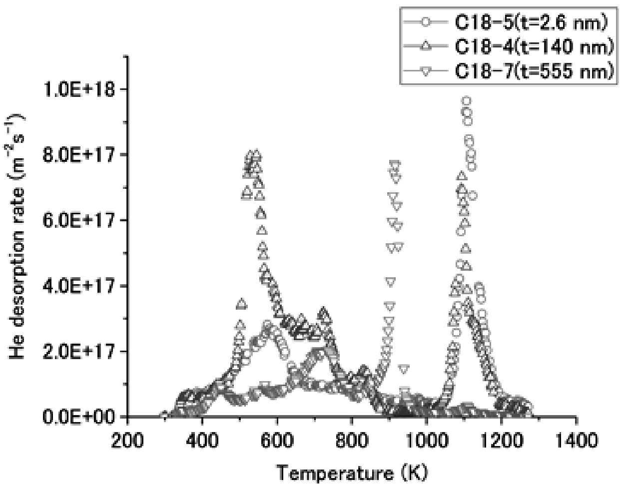

Fig. 1. Thermal desorption spectra of He obtained from the SUS316L specimens exposed to long-term plasma in LHD.

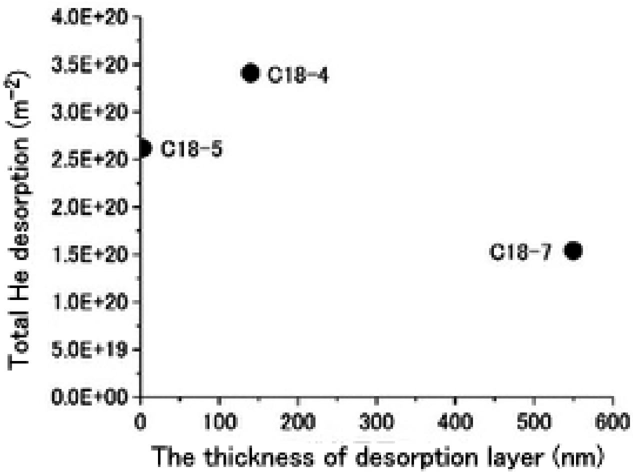

Fig. 2. The relation between the thickness of the mixed-material desorption layer from the cross-sectional TEM images and the total He desorption from SUS316L specimens.