§28. Analysis for Plasma Wall Interactions in LHD and Characterizations of Co-deposited Carbon Film Using Material Probes

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Controls of plasma-wall interactions (PWI) in fusion devices are key issues for the improvement of the plasma parameter toward to commercial fusion reactor so that the interactions in the present device must be investigated and improved. In addition, carbon deposition incorporating hydrogen isotope has been recognized as one of significant concerns in the point of view of safety and particle control in the fusion reactor. In the present study, plasma-wall interactions in the LHD were evaluated by means of material probe analysis. The distributions of impurity deposition and fuel gas retention during the discharges were investigated. Also, the co-deposition of carbon and hydrogen in the LHD was also evaluated.

In the 12th and 13th experimental, the sets of material probes were installed on the walls at each sector for the evaluation of the PWI distribution. Also, the multifaceted holder was prepared for the evaluation of the co-deposition, and the material probes were set on the holder and was also exposed in the LHD plasmas during 13th experimental campaign. After the experimental campaign, the composition and the microstructure of the probes and the deposits were evaluated by means of Auger electron spectroscopy and scanning electron microscope. The gas retention such as hydrogen and helium of the probes were evaluated by thermal desorption spectroscopy, TDS.

For the 12th experimental campaign, boron (B) and titanium (Ti) films were prepared to demonstrate the wall in the LHD and then used as material probes. The thickness of B and Ti films were 1.5 μm and 0.5 μm, respectively. Figure 1 shows toroidal distribution of eroded thickness of B film. After 12th experimental campaign, the surface melting was observed for the B probe at #5 sector. It might be owing to high heat load associated with radial NBI at #5 port. Similarly to 10th and 11th campaigns[1], the large erosion was observed for 12th campaign in the vicinity of anodes for GDC and NBI. The large C and Fe depositions were observed near the anode and the NBI, respectively. Also, the hydrogen retention of the probes around the anode was large, similarly to previous experimental campaigns. Figure 2 shows changes in hydrogen retention for #3 material probe and H_2 glow discharge time. For the stainless (SS) probes (~11th experimental campaign), comparison of the hydrogen retention with the H_2 glow discharge time clearly indicate the hydrogen retention mainly occurred during the glow discharge. The hydrogen retention of B probes was larger than that of SS probes. The large hydrogen retention for B probes, which was also observed in the simulation experiment[2], suggest that the hydrogen retention in the boronized wall for the LHD seem to be large, compared with the un-boronized wall. The helium retention for the probes was an order of magnitude lower than the hydrogen retention. The helium retention in the vicinity of the anode was high, resulting from low-energy helium uptake during the glow discharges. Similarly to the hydrogen retention, the helium retention for B and Ti probes tended to be large compared with those of SS.

The hydrogen retention of the probes for 13th experimental campaign was large, compared with those for 10th or 11th campaign, although the toroidal distribution was similar to those for the previous campaigns. The large hydrogen retention might be associated with absent of helium glow discharge cleaning at the end of this campaign. Hydrogen desorbed at low temperature region during TDS analysis was large for the probes with large boron deposition, while those desorbed at high temperature region was large for the probes with large carbon deposition. Helium retention of the probes for 13th campaign were also large, compared with those for the previous campaigns. The probes in the vicinity of the anode had sharp helium desorption peak at around 800 K. This might be owing to the impurity deposition.

The evaluation of the co-deposits produced in the vicinity of the helical divertor plate indicates that the film formation with many defects and the large carbon deposition at the position with large angle of view for the helical divertor plate.

1) Matsunaga, Y. et al: 14th International Conference on Fusion Reactor Materials (2009).
2) Tsuzuki, K. et al: J. Nucl. Mater. **241-243** (1997) 1055.

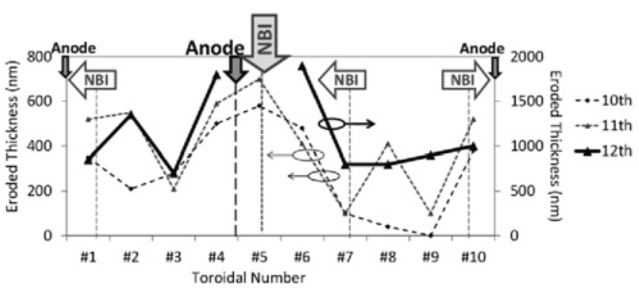

Fig.1 Toroidal distributions of eroded thickness of B film for 10th, 11th and 12th experimental campaigns.

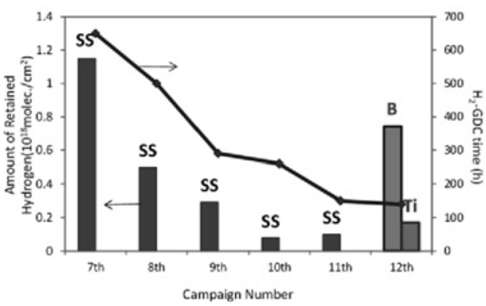

Fig.2 Changes in hydrogen retention for #3 material probe and H_2 glow discharge time.