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

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Control of plasma-wall interactions is a key issue for the improvement of the plasma parameter toward to commercial helical-type fusion reactor so that the interactions in the present device must be investigated and improved. We have investigated the toroidal and poloidal distributions of impurity deposition and gas retention using material probes and have discussed the deposition/retention mechanism so far. In the present study, plasma-wall interactions during 15th campaign in the LHD were evaluated by means of the material probe analysis. Namely, the distributions of impurity deposition and gas retention during discharges were investigated. The obtained results were discussed with the probe locations, the plasma parameter and the discharge history.

The material probes made of stainless steel or silicon for the evaluations of plasma-wall interactions were installed on the first wall in the LHD, then exposed to the plasmas during the 15th experimental campaign. After the campaign, the probes was taken out and then analyzed. The impurity deposition were evaluated by means of Auger electron spectroscopy, and the gas retention such as helium and hydrogen was evaluated by means of thermal desorption spectroscopy.

Carbon depositions at #1, #9 and #10 sectors, boron deposition at #1 sector were large. In addition, iron deposition near anode for glow discharge cleanings (#1, #4 and #10 sectors) was clearly observed. This results from re-deposition of iron originated from the first wall during the discharge cleanings. Figure 1 shows examples of hydrogen desorption spectra of the material probes. For sectors 1 and 3, at which large boron and carbon deposition were observed, the peaks appeared at ~700 and ~1100K. The low and high temperature peaks were owing to desorption of hydrogen trapped by boron and carbon, respectively. Figure 2 shows the toroidal distribution of the amount of retained hydrogen. The hydrogen retention was high at around the anode. This results indicate that the retention mainly occurred during the glow discharge cleaning, and suggest that the hydrogen recycling at the wall near the anode would occur frequently, compared with other positions. Figure 3 shows examples of helium desorption spectra of the material probes. For sector 1, large helium desorption at around 800K was observed. For other sectors, helium peak appeared at around 900K. The difference of implanted energy of helium might be responsible for the deference of the desorption temperature. Figure 4 shows the toroidal distribution of the amount of retained helium. It is noted that the amounts of retained helium were only an order of magnitude smaller than those of retained hydrogen. Control of helium re-mixing into the core plasma during the main discharges would be necessary, because the remixing of helium originated from large helium retention might lead to severe fuel dilution. The amount of retained helium for #1 probe, which had a thick carbon/boron deposition layer, was very small. Large helium retention in the vicinity of ICRF antenna was observed.

These results suggest that the plasma wall interactions including the impurity deposition and the gas retention largely depend on the wall position, namely the distances from the heating devices, the glow discharge anode, the titanium ball and so on.

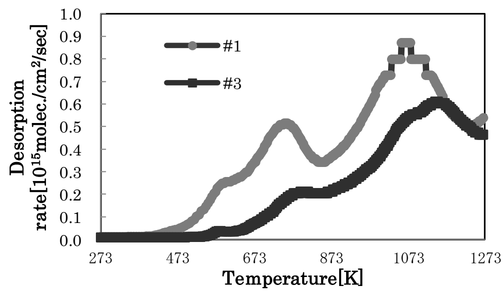

Fig.1 Thermal desorption spectra of hydrogen for probes at sectors 1 and 3.

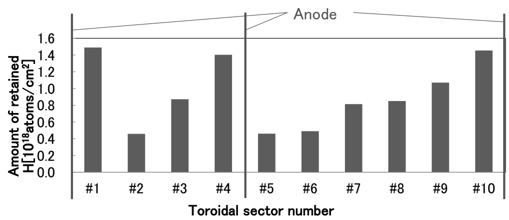

Fig.2 Toroidal distribution of amount of retained hydrogen.

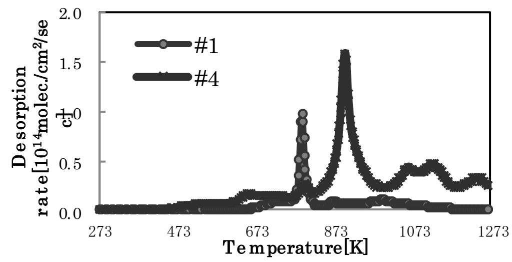

Fig.3 Thermal desorption spectra of helium for probes at sectors 1 and 4.

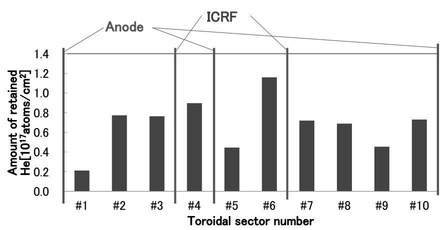

Fig.4 Toroidal distribution of amount of retained helium.