§64. Investigation of Carbon Films on Material Probes in the Vicinity of Local Island Divertor in LHD

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In LHD, the local island divertor (LID) experiments have been conducted since 2003. Figure 1 shows a LID configuration. The pumping duct surrounds the divertor head. Plasma-surface interaction occurs only at the divertor head, and thus the wet area is less than one tenth of that of helical divertor. The divertor head receives relatively high heat and particle fluxes comparing to the helical divertor, and the eroded carbon co-deposit with hydrogen on the plasma facing components. Four sets of material probes made of Si were installed in the vicinity of the LID head in the experimental campaign in 2005. A number of the discharges with the LID configuration were 707. The material probes locations are also shown in Fig. 1. One set of probes was placed inside the pumping duct (1U, 1L), and faced to the head. The other set of probes has shallow line of sight to the head (2U, 2L). After the experimental campaign, the probes were extracted and their surface morphology, depth profiles of atomic composition and hydrogen retention were investigated using scanning electron microscope (SEM), Auger electron spectroscopy (AES) and thermal desorption spectroscopy (TDS), respectively.

The surface of 2U was very smooth, but sub-micron size protuberant structures were observed on the surface of 1U. This difference of surface morphology might have been caused by the deposition angle of carbon to the probe surfaces. If the incident angle of carbon atoms to the probe surface is shallow, the carbon may deposit selectively on the protuberant parts. The smooth surfaces of 2U and 2L might have been caused by the deposition of hydrocarbons, and/or low energy carbon atoms and deposition of carbon reflected by the wall. Very uniform carbon depositions were observed on the surfaces of all the probes with the depth profile of atomic composition measurement using AES, and the concentration of oxygen was only 1%. The thickness of carbon films was measured by using a surface roughness meter, and it was in the range from 200 to 700 nm.

In TDS analysis, most of retained hydrogen desorbed in form of hydrogen molecular. The retained hydrogen also desorbed in form of methane but its fraction was only several percents. The temperature of the pumping duct during the LID discharges was up to 570K. The desorption rates for 4 probes start to increase in the temperature range from 500 - 600K, which is consistent with the pumping duct temperature. The desorption spectra of 1U and 1L have a peak around 1000K and 1050 K, respectively. This tendency is similar to that of graphite. However, the spectra of 2U and 2L were very different from that of 1U and 1L. A desorption peak was observed at lower temperature regime, around 950 K. This suggests that the carbon film structures on 2U and 2L are very different from that of graphite, i.e. the binding state of hydrogen differs from that in graphite. The amounts of retained hydrogen for carbon films of 4 probes were also obtained. It is necessary to assume the mass density to estimate the hydrogen concentration in the films in the form of atomic ratio, H/C. We here assume that the mass density of present carbon film is in the range from 1.0 to 1.8 g/cm^3. The hydrogen concentrations in the carbon films on 1U, 2U, 1L and 2L are estimated to be H/C=0.42-0.60, 0.70-1.1, 0.31-0.45 and 0.65-0.94, respectively. The hydrogen concentration in graphite after hydrogen ion irradiation at temperature from room temperature to 600K is approximately H/C=0.4. The H/C ratios on 1U and 2U are close to this value. This result suggests that the carbon film with graphite like structure is produced in the vicinity of LID head. However, on 2U and 2L, the hydrogen concentrations are approximately double of the graphite case. This result suggests that the carbon film on 2U and 2L is not graphite, perhaps amorphous with relatively high hydrogen concentration. The present results contribute to evaluate the tritium concentration of carbon film or dust produced in ITER.

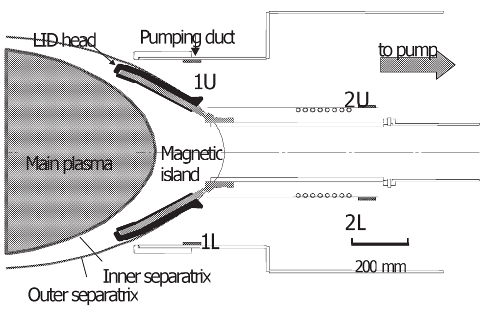

Fig.1 A schematic view of the LID configuration.

Reference

1) T. Hino et al, Plasma and Fusion Research, 2, (2007) 011-1 – 011-3