§9. Study on Plasma-wall Interaction and on Hydrogen Recycling Behavior Using Long-term Samples in LHD

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Long term sample is a useful tool to study plasma surface interactions in fusion devices. In the LHD, long-term samples mounted on plasma-facing wall have been analyzed in each experimental campaign since the first experimental campaign. The results of sample analysis should be compared with that of early campaigns to know how the experimental conditions influence the wall surface. Also, hydrogen retention behavior of the "modified" surface is needed to be investigated in order to understand hydrogen recycling behavior during main discharge operation. In this study, first, long-term samples in the 17th experimental campaign were analyzed to grasp the wall conditions.

In this study, stainless steel and silicon substrate were selected as the material of long-term sample. Sample positions are shown in fig.1. Samples were located at lower side of torus in each toroidal sector. These samples were extracted from the vacuum vessel after the campaign. Depth profile of atomic composition was analyzed with Auger electron spectroscopy. Desorption behavior and hydrogen retention was evaluated with thermal desorption spectroscopy.

Thermal desorption spectra of hydrogen (H_2) in the samples at sectors 1, 5 and 10 is shown in fig.2. Desorption of H_2 in sector 5 started from 150 ^oC and had a major peak at around 480 ^oC. On this sample, no deposition was observed and this spectrum was similar to those of other sectors without no deposition. This wide temperature range of H_2 desorption indicates that retained hydrogen in the stainless steel wall had wide variety of trapping energies. Desorption spectra of H_2 in sector 1 had a large desorption rate in relatively low temperature range from 200 to 600 ^oC. On this sample, a thick (several hundred nm) boron film containing a little amount carbon was observed. This boron deposition would be the reason for the H_2 desorption at relatively low temperatures. In the sector 10, retained hydrogen was desorbed at high temperatures (600-900 ^oC) owing to a carbon deposition on this sample. These results indicate that the hydrogen desorption behavior is significantly influenced by deposited elements. Hydrogen retention at each toroidal sector is shown in fig.3. In sector 1, hydrogen retention was several times larger than that in other sectors. As mentioned above, a thick boron film was observed in sector 1. This would be a reason for the large retention. Apart from sector 1, hydrogen retention was almost in the same level. In the early experimental campaigns, hydrogen retention was large near the glow anodes due to a large ion flux during glow discharge conditioning[1]. However, in the 17th experimental campaign, total duration of H_2 glow discharge was much less than that in the early campaigns. For this reason, hydrogen retention became the same level except sector 1.

The change of micro structures is being studied by TEM observation. Also, in order to investigate the hydrogen retention behavior in the top surface of the LHD walls, deuterium ion irradiation for the samples will be performed. Based on these results, hydrogen recycling behavior of the modified surface will be discussed.

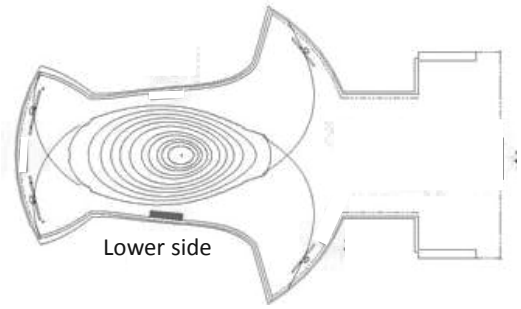

Fig.1 Schematic diagram of poloidal cross section of LHD. Samples were mounted on lower side of the torus.

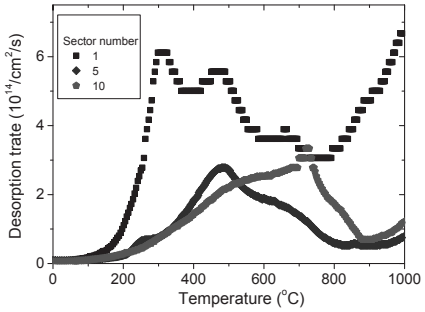

Fig.2 Thermal desorption spectra of H2 in samples located at sector 1, 5 and 10.

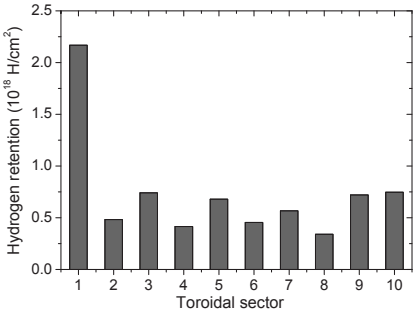

Fig.3 Hydrogen retention at each toroidal sector.

1) Nobuta, Y. et al.: Fus. Eng. Des., 81(2006) Pages 187.