§21 Retention and Desorption of Hydrogen and Helium in Plasma Facing Surfaces of LHD under Long Pulse Operation

Yoshida, N. (Kyushu Univ.),
Masuzaki, S., Tokitani, M., Motojima, G., Yajima, M., Nagata, D.,
Hatano, Y. (Univ. Toyama), Oya, Y. (Shizuoka Univ.)

In order to understand the grovel behavior of PWI occurred in LHD, probe samples (SUS316L and W) more than 200 pieces were exposed to the plasmas through the Cycle 18 campaign of LHD. These samples were put separately at the 12 positions on the first wall (protection plates) representing typical PWI in LHD, namely, inner board wall near the 9I port, outer board wall near the 9O port and near the saddle point of the wall between the 9I port and 8O port. Effects of the plasma bombardment on the surface properties of the samples were examined comprehensively by allotting as following. (a) Selection of the sampling positions at the wall and preparation of the probe samples (Masuzaki, Tokitani, Yoshida), (b) Microstructure of modified surface layer (TEM and SEM: Yoshida, Tokitani, Nagata), (c) Chemical analysis of the modified surface layer (GD-OES: Hatano, XPS: Oya), (d) Effects on the surface color (Motojima), (e) Retention and desorption of He (TDS: Yajima)

Following are the main results obtained so far.

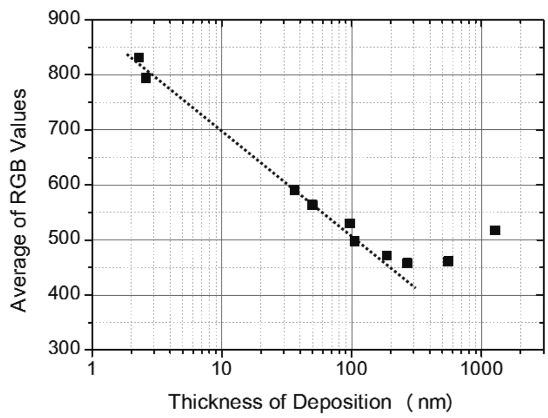
(1) It was revealed that the surface color (average of RGB values) and the thickness of the impurity deposition, which had been estimated directly from both TEM observation and GD-OES measurement, had a simple relation up to about 200nm as shown in the figure. On the other hand, RGB values of any points of LHD wall can be measured easily and quickly by using the newly developed handy-type color analyzer for metallic surface. Applying the thickness-RGB relation, three-dimensional distribution of the surface modification of LHD was estimated successfully [1]. This will give a way to understand grovel behavior of PWI in LHD, which is essential for steady-state operation under the controlled particle balance.

(2) In case of LHD, He is used mainly as working gas for the long-pulse operation. Therefor mechanisms of trapping and thermal desorption of He were extensively investigated by means of TDS, GD-OES, TEM and SEM. In the area of erosion dominant, which distributes mainly in the inner board area close to the main plasma, majority of He are retained in the He bubbles in nano-size formed in the sub-surface region up to about 70nm-deep. However, large thermal desorption of He below 370K, which is commonly occurred in the heavily He-irradiated SUS316L near room temperature (detrapping from the weak trapping sites, probably strong stress field around He bubbles) was lacked. This result indicates that the temperature of the wall of this area increased up to about 370K gradually under the long-pulse operation. It means that at the beginning of the long-pules operation He are trapped in the weak trapping sites while they desorb with increasing wall temperature. It is remarkable that not only sputtering but also blistering of the mixing layer of about a few 10nm in diameter causes erosion.

(3) On the other hand, in the deposition dominant area, which distributes mainly at the outer board and the area close to divertor plates, He are retained in the impurity deposition and in the substrate (SUS316L). The latter occurred under the initial He-GDC. According to the GD-OES analysis retention of He in the carbon rich impurity deposition was less than 1 at%. Thermal desorption data indicated that the surface of this area was near the room temperature and did not change much even under the long-pulse operation. It is considered that the trapping sites for He is always full and He will be retained slowly only by the co-deposition with newly deposited impurity atoms (carbon).

Detail analysis of TDS and microstructure are still carrying on.

[1] G. Motojima *et al.*, Plasma. Fus. Res. **10** (2015) 1202074.



Relation between the average of RGB values and the thickness of impurity layer estimated by the cross-sectional TEM observation.