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

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Study on long-pule operation of high-temperature plasma is one of the major subjects of LHD project. The long-pule operation will be sustained in stable by controlling the balance of the fueling particles. For the better control, we should know the influx and outflux of the fueling particles through the plasma facing surface under operation. In the Cycle-18 (2014-2015), many kind of probe samples were set at many positions on the protection wall to study plasma-wall interaction in LHD globally. Post plasma-exposure examinations of these samples will be performed in the coming fiscal year. In this fiscal year, detail analysis of Cycle-17 and Cycle-16 samples have been carried out.

In the preset report, we focus on the surface damage at the erosion dominant area. Most of the data shown below were obtained with instruments installed in NIFS by the end of 2013 fiscal year. Color of the probe samples exposed to the plasmas of Cycle-17 at the wall near 8I and 9I ports were measured by using newly developed handy color analyzer MD-1 (Hitachi Metal Co.) Values of R (red), G (green), B (blue) and their average of each sample are shown in Fig.1. Even samples at the erosion dominant area (8I-3, 8I-5, 9I-3, 9I-5), RGB values decreased sensitively due to PWI. Typical microscopic changes of the erosion dominant surface are shown in Fig.2 and Fig.3. Fig.2 is a cross-sectional TEM image of W at 9I-3. Large He bubbles up to 10nm in diameter were formed in the sub-surface area about 15nm-thick. It is worth to note that holes have been formed from place to place. FE-SEM image also shows that the holes of about 10 to 50 nm in diameter are densely packed on the plasma facing surface (see Fig. 3). These results indicate that the holes are made by the exfoliation of He-blisters, which have been developed from large He-bubbles. Fig. 4 shows areal distribution of elements in the cross-sectional W sample shown in Fig. 2. In the sub-surface area, where exfoliation occurred, C and O exist. This fact indicates that the mixing of C and O make the area more brittle and cause blistering more easily. One should note that blistering make fine dusts and enhance erosion rate of the plasma facing surface. In case of stainless steel, material of LHD wall, remarkable blistering has not been observed so far in spite of similar violent bubble formation.

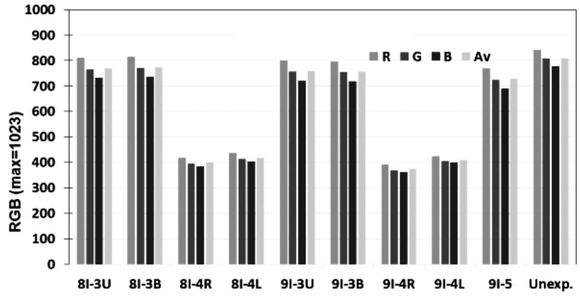

Fig.1 Color of Cycle-17 samples (RGB measurement)

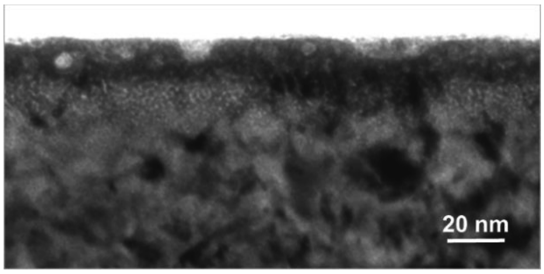

Fig.2 Cross-sectional TEM image of W at 9I-3.

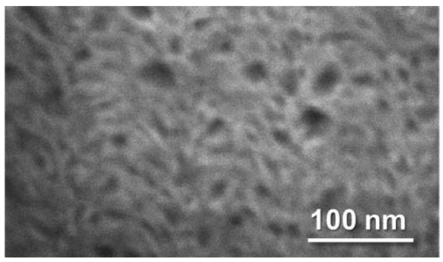

Fig. 3 FE-SEM image of W at 9I-5

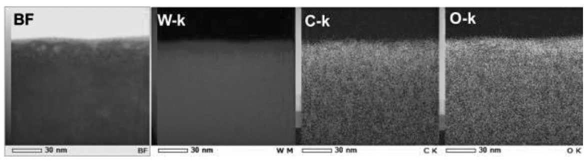

Fig.4 Distribution of elements in a cross-sectional sample of W at 9I-5