§15. Color Measurements of the First Wall toward the Systematic Evaluation of the Thickness Ddistribution of Deposition Layer in LHD

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An innovative color measurement technique is employed in the Large Helical Device (LHD). This study provides a method for obtaining in broad spatial extent and in great detail the color information of the first wall relating to the thickness of the deposition layer. The RGB (Red, Green, and Blue) value, mainly of the stainless steel plates on the helically twisted coil, is measured by the handy color analyzer.

In the LHD, long-term exposed sample analysis reveals that the deposition layer is primarily composed of carbon formed on the first wall, and may be a contributing factor to wall retention. The total amount of the deposition layer formed in the vacuum vessel influences the wall retention rate. Thus, reliable evaluation of the total amount of the deposition layer is crucial. The color depends on the composition, the structure, and the thickness of the deposition layer. In LHD, the composition of the deposition layer is primarily carbon. Although the surface roughness on the deposition layer presumably affects the reflection coefficient at each RGB, the color is almost certainly related to the thickness of the deposition layer assuming the same surface structure. In this study, a method for obtaining in broad spatial extent and in great detail the color information of the first wall has been provided using an innovative concept for the color measurement[1].

The first wall plates in the vacuum vessel of LHD are stainless steel (SUS316L), while isotropic graphite plates are installed in the divertor section. The former is the main material in LHD (700 m^2), while the graphite area (30 m^2) constitutes only about 5% of the total plasma facing area. We measure the RGB mainly of the stainless steel plates on the helically twisted coil in one of 10 toroidal sections of the vacuum vessel as shown in Fig. 1. The number of measured stainless steel plates totaled 530. On the outer torus side, the colors of almost all stainless steel plates are close to black. On the inner torus side, all plates are close to white, which indicates the reflection coefficient of around 1, except for those neighboring the divertor plates. These results suggest that the outer torus side is deposition-dominant, while the inner torus side is primarily erosion-dominant. Characterization of the deposition layer by this study is qualitatively consistent with the previous results from the direct specimen analysis.

The relation between the thickness of deposition layer and the colors is clarified from the analysis of samples amounted on the same toroidal section with color measurements as part of the long-term exposed sample analysis, using a focused ion beam system and a transmission electron microscope etc. Then, the analysis shows that the thickness of deposition layer reduces exponentially with respect to the color. Figure 2 shows the thickness distribution of the deposition layer. On the inner torus side, there is almost no deposition layer. However, on near the divertor region, thickness is reaching to several hundred nm. On the outer torus side, the thickness is about 100 nm.

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1) G. Motojima *et al.*, Plasma Fusion Res. **10**, 1202074 (2015).

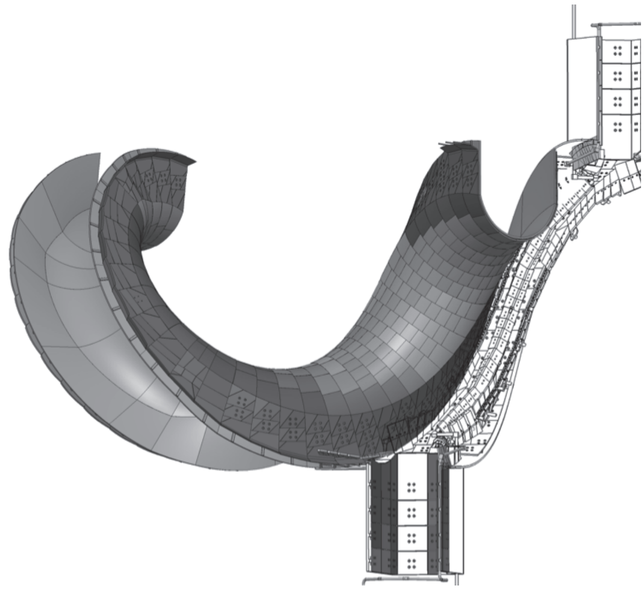

Fig. 1 CAD showing the color distribution of the measured stainless steel plates.

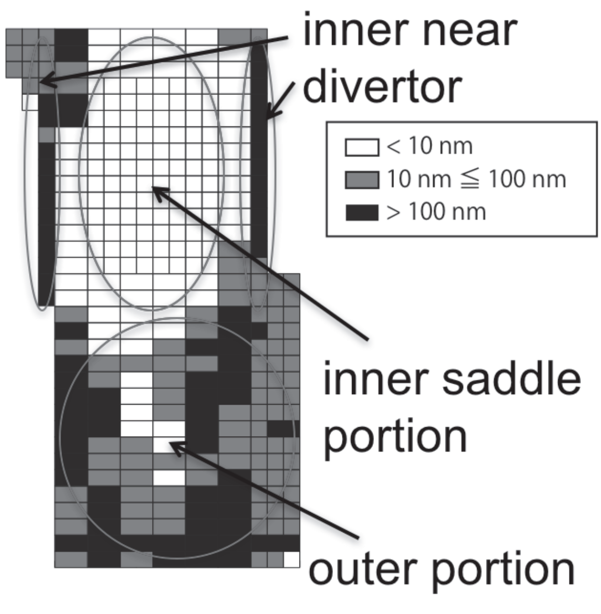

Fig. 2 Thickness distribution of the deposition layer.