§7. Change in Surface Morphology of Retroreflector Installed in LHD

Akiyama, T., Masuzaki, S., Tokitani, M.,
Yoshida, N., Tokunaga, T. (Kyushu Univ.)

Laser diagnostics and spectroscopy often need to install mirrors in a vacuum vessel. Due to sputtering by plasma particles and depositions of carbon and metallic impurities, the mirror surface changes and the reflectivity degrades. Whereas the mirrors can be frequently replaced on present devices, a long lifetime up to years is necessary on ITER and future fusion devises. This is because access to the mirror and maintenance frequency are limited. In order to prolong the lifetime, understanding of the mechanism of reflectivity degradation is necessary.

Figure 1 (a) shows a retroreflector made of stainless steel installed on the LHD vacuum vessel for a dispersion interferometer. The retroreflector consists of three mirror pieces and one of them after exposure to one experiment campaign is shown in Fig. 1 (b). Impurities deposited especially in the central region due to the accumulation effect [1]. While the reflectivity of visible laser light (633 nm) at the edge region is almost the same as that before plasma exposure, that in the central region decreases down to about 10%.

SEM images of the mirror surface are shown in Fig. 2. The surface flatness is maintained at the position ① where the reflectivity does not change. There is almost no impurity deposition there; the elemental analysis by EDS indicates only Fe and Cr, which originate from the bulk stainless steel. The sputtering by glow discharges and charge exchange particles does not cause surface roughness on LHD. Although the original reflectivity is maintained, the impurity deposition with fine surface roughness or nonuniformity in the layer appears at the position ②. The surface pattern becomes significant at the position ③ where the interference is visible. As shown in Fig. 3, the EDS analysis indicates the deposition layer consists of carbon. At the central region, branched swollenness are formed on the surface and some of them break. It is speculated that the gas trapped in the grain boundary of the stainless steel is released and then the carbon deposition layer becomes swollen. This should be a source of dusts, in addition to the reflectivity degradation.

The interference stripes indicate change in the thickness of the depositon layer. The difference in the thickness between the neighboring stripes with the same color is $\lambda/(2n)$, where λ and n are the wavelength and the refractivity. Supposing that the thickness is monotonically increases, the thickness of the deposition layer at the central region is estimated to be around 600 nm from the four black stripes.

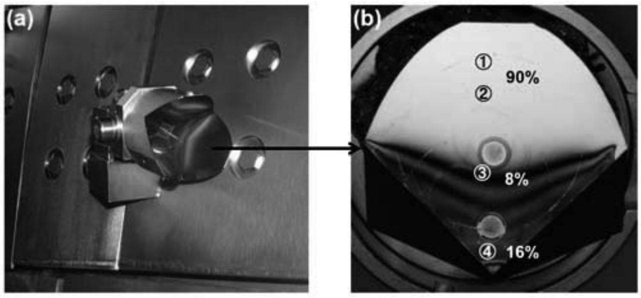

Fig. 1: (a) A retroreflector installed in LHD. (b) One of mirror pieces and the reflectivities at the visible laser light (633 nm). Circular marks near position ③ and ④ was made by GD-OES analyses (not discussed in this report).

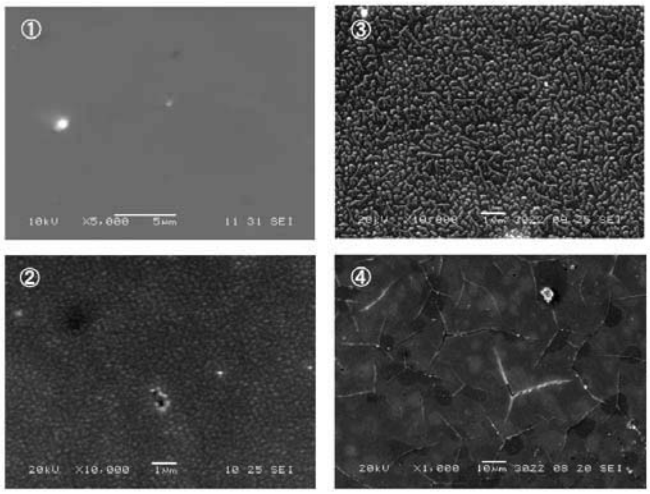

Fig. 2: SEM images at the position ① – ④ in Fig. 1(b).

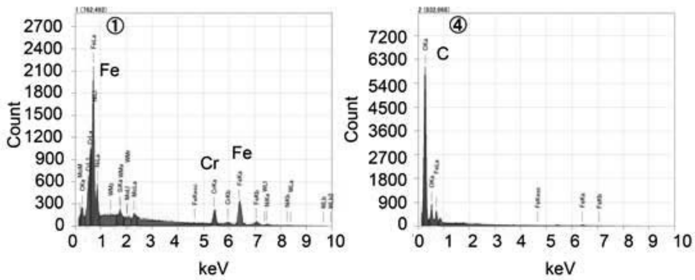

Fig. 3: EDS spectra at position ① and ④ in Fig. 1

The deposition layer with a thickness of around 600 nm is formed at the central region of the retroreflector installed in LHD. The deposite material is mainly carbon. The reflectivity at the visible region decreased to around 10% due to the interference in the deposition layer and surface modification.

1) Akiyama, T et al.: Nucl. Fusion **52**, 063014 (2012).