§13. Prototype and Test of the Retro-reflector with the L-shape Protective Cylinder

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A retroreflector (corner cube mirror) consists of three flat mirrors which are orthogonal each other like a corner of a cube. It is a useful mirror for laser diagnostics such as an interferometer and a polarimeter because the reflected light is always parallel to the incident one regardless of an incident angle. In ITER it will be embedded in the first wall of the high field side and around divertor region for the poloidal polarimeter [1].

However, the reflectivity of retroreflectors installed inside LHD decreased, especially in the central region [2]. This is because the deposited metallic impurities at the peripheral region tend to be transported to the central region by sputtering and to accumulate there due to the hollow shape of the reflector [3]. The surface roughness of the deposition layer, which is one of the reasons of decrease in the reflectivity, is more significant at the central region than that at peripheral region. Cross-sectional TEM observation reveals that the surface roughness is attributed to hydrogen blisters, which are formed on a dense oxidized layer in the deposition layer.

To prevent the decrease of the reflectivity of the retroreflector, following two measures are should be taken.

1. Hydrogen flux should be reduced to suppress formation of blisters.
2. Accumulation of metallic impurities should be reduced.

A hood, which can reduce the solid angle of the reflector, is effective for (1). However, it should be noted that the hood also plays a source of the metallic impurities; both a material of the hood itself and impurities deposited on the hood, which come from the wall and the divertor, can be sputtered and fall on the mirror below. The fin structure inside the hood can reduce falling of impurities and this was demonstrated in LHD [4]. As for (2), the retroreflector should be placed where high energy particles do not come directly since the accumulation of the impurities is due to the sputtering by high energy charge exchange particles. Figure 1(a) shows the retroreflector with the L-shape protective cylinder with fins. All parts are made of stain less steel. The bend mirror is used to keep the reflector from facing plasma directly. Though a certain amount of depositions on the bend mirror is expected, the decrease in the reflectivity will be less significant than that in the case of the retroreflerctor because the flat mirror does not have the accumulation mechanism of the impurities.

The reflector was installed in the LHD and was exposed to all main and glow discharges during 11th experimental campaign. It was installed on the inner wall where was about 30 cm away from plasmas. Mirror surfaces of the bend mirror and the retroreflector after the plasma exposure are shown in Fig. 1. The SEM and EDS observations found that there is a roughened

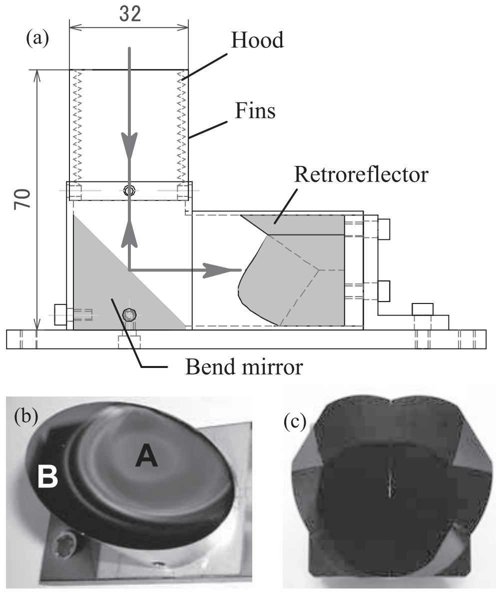

Fig.1: (a) the schematic view of the retroreflector with the L-shape protective cylinder, (b) the bend mirror and the retroreflector after exposure to LHD plasmas.

deposition layer of Fe, O (FeO) and C on the central region A of the bend mirror while the peripheral region B is the almost balanced area of sputtering and deposition. Fe is assumed to come from the inner wall material of LHD and the protective cylinder itself. C is from divertor plates. The reflectivity at a wavelength of 1 μm decreased from 70% to 3% at the central region A. On the other hand, the reflectivity at the peripheral region B does not change. The surface of the retroreflector is covered by a thin and smooth layer of Fe, O and C with a thickness of 20 nm, which looks dark brown. These are impurities which are transferred from the surface of the bend mirror by the sputtering. The accumulation of the impurities is not observed. Even though the smooth surface, the reflectivity at 1 μm (10 μm) decreased from 70% (80%) to 10% (70%). This significant degradation at near-infrared region is expected to be caused by absorption by FeO and C and interference between the deposition layer and the mirror surface. As ITER will use Be for a first wall, Be oxidization is expected to formed instead of Fe.

For the improvement of the impurity deposition, it is planned to lengthen the cylinder and to change the fin structure from thread to stack of thin plates and spacers [5]. They will be made of Mo or W. In order to increase the sputtering-dominant area on the bend mirror, incident angle is planned to be reduced since the sputtering yield increase when the incident angle is small. Au coating, which is inactive with oxygen, on the bend mirror may be effective to reduce the oxidized layer.

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