§21. Change of Optical Properties of Retro-reflector Installed in LHD

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Because of limitations of port access, diagnostic mirrors often have to be installed inside a vacuum vessel. These days, degradation of optical properties due to interactions between plasmas and mirror surfaces are becoming a serious problem. Since inner mirrors in ITER cannot be replaced frequently, it is indispensable to understand how much the reflectivity deteriorates, the mechanism and the dependence of the degradation on the wavelength.

Michelson type interferometers and polarimeters often utilize retro-reflectors for a double path in plasmas. As retro-reflectors tend to be installed near plasma, damages due to interactions between plasmas and materials are expected to be significant. Hence information on change of optical properties like the reflectivity and polarization are needed.

Figure 1 shows one of retro-reflectors used for a CO_2 laser polarimeter [1] during the 4th experimental campaign. They are installed on the inner wall of LHD. The mirror surface was originally coated with a gold film to increase reflectivity in visible range for beam alignment. The gold film cannot be recognized visually on the surface. The degradation of the reflectivity strongly depends on the position on the mirror surface. Although the edge region still keeps specularity, the middle region is clouded. At the central region it appears to be gray and specularity is almost lost for visible light. White splotches whose dimension is about several millimeters are seen near the mirror edge. Since the mirrors were not insulated from the vacuum vessel, the edge region is speculated to be arc-damaged during the discharge cleaning and/or main experiments, in particular, ICRF experiments. Protection structures which reduce particle deposition on the surface are under consideration.

Figure 2 shows the distribution of the reflectivity of the retro-reflector for CO_2 and YAG laser beams along the radial direction. The reflectivity monotonically decreased, approaching the central region for both CO_2 and YAG laser beams. At the central region, the reflectivity in a wavelength range shorter than near infrared, which is often used for beam alignment and vibration compensation, is almost zero.

The surface analysis with SEM and EDS indicates the existence of a layer of the deposition of Fe and Cr, which is expected to come from the vacuum vessel or own mirror materials. The thickness of the layer in the central region is thicker than that in the external region while the edge region is eroded by sputtering [2]. Since each mirror surfaces largely tilts to the incident direction of high-energy particles, it is possible that deposited particles

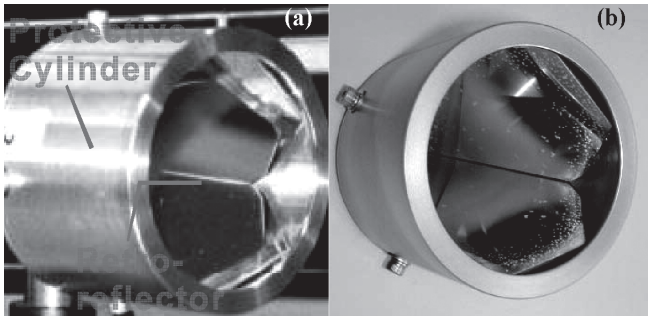

Fig.1: A photograph of one of the retro-reflectors (a) before and (b) after the experimental campaign.

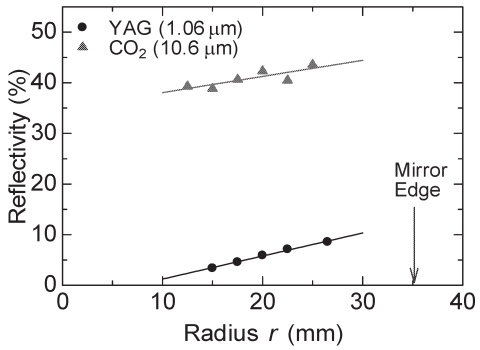

Fig.2: Distributions of the reflectivity for CO_2 and YAG laser beams as a function of the radius of the retro-reflector *r*.

Table 1: The dependences of the reflectivity and change in the polarization angle after reflection on the polarization angle

Wavelength (μm)	Polarization angle (deg.)	Reflectivity (%)	Change in the polarization angle (deg.)
10.6	0	40	0
	45	42	-1
	90	44	0
57.2	0	73	0
	45	75	-1
	90	70	-1

on surfaces are sputtered (transported) to the direction of the central region by them.

Changes in the polarization angle by reflection and the nonlinear dependence on the incident angle of the beam, which is reported in visible range [3], are also one of serious problems in polarimeters. Table 1 shows the polarization angles after reflection at 10.6 and 57.2 μm wavelength. In this case, the change in the polarization angle which was larger than the measurement angle error (about ±2 degree) was not observed even for the CO_2 laser light whose reflectivity decreased to half. The elliptization of the laser beam polarization were not also observed for both wavelengths.

Reference

1) T. Akiyama, et. al., Rev. Sci. Instrum. **74**, 2695 (2003).
2) N. Yoshida et. al., 23rd annual meeting of The Japan Society of Plasma and Nuclear Fusion Research, Tsukuba, 30aB05 (2006).
3) V.S. Voitsenya et. al., Rev. Sci. Instrum. **72**, 475 (2001).