§22. Evaluation of Effects of Multi-reflection to Polarimeter with Si Photo Elastic Modulator and the Suppression

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As the electron density in LHD is getting higher, a reliable electron density measurement is indispensable. A CH_3OD laser (57 and 48 μm) has been developed [1, 2] because a beam bending effect ($\propto \lambda^2$) in a plasma, which causes fringe jump errors, is small due to the short wavelength and is suitable for the laser source of an interferometer in LHD. On the other hand, a ι profile can be evaluated by polarimetry. The importance of measurement of the ι profile is increasing since a position of a rational surface seems to be correlated with improved confinement mode. Therefore we are designing an interferometer combined with a polarimeter with the use of a CH_3OD laser conceptually now. This system can also be adapted to the poloidal polarimeter in ITER.

From the viewpoint of measurement resolutions, maintenance and compatibility with the present interferometer system, a measurement method with the use of photo elastic modulators (PEMs) is selected. Since there was no PEM available for the FIR range so far, a new PEM was developed with high resistive silicon as a photo elastic material. Figure 1 shows the optical setup of a single PEM polarimeter. The detector output I and then the polarization angle α are as follows.

$$I = \frac{I_0}{2}\{1 + J_0(\rho_0)\cos 2\alpha + 2J_2(\rho_0)\cos 2\alpha \cos(2\omega_m t) + \cdots\}$$

J_k : *Bessel function*, ρ_0 : *Maximum of retardation*,
ω_m : *Drive frequency*, α : *Polarization angle*

$$\Rightarrow \alpha = \frac{1}{2}\cos^{-1}\left(\frac{1}{2AJ_2(\rho_0) - J_0(\rho_0)}\right), \quad A \equiv \frac{I(2\omega_m))}{I(DC)}$$

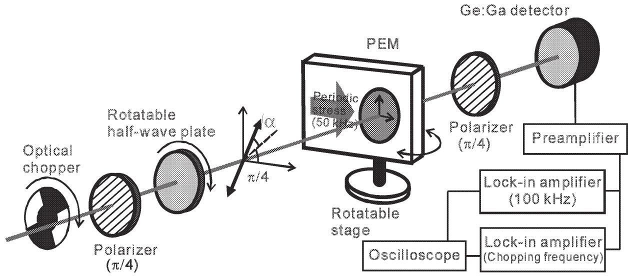

Fig. 1: Photograph of the Si PEM. It consists of the controller, the electrical and the optical head.

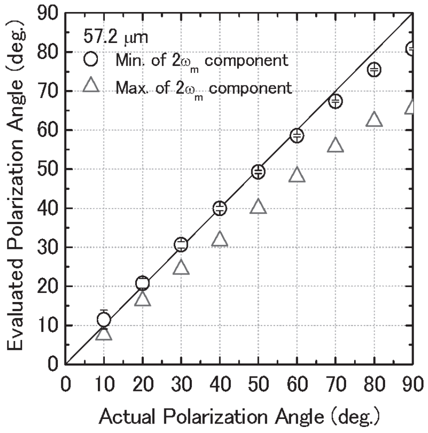

Fig.2: Measured polarization angle with Si PEM polarimeter. Amplitude of $2\omega_m$ component due to interference of multi-reflected light is varied by changing an incident angle of the beam

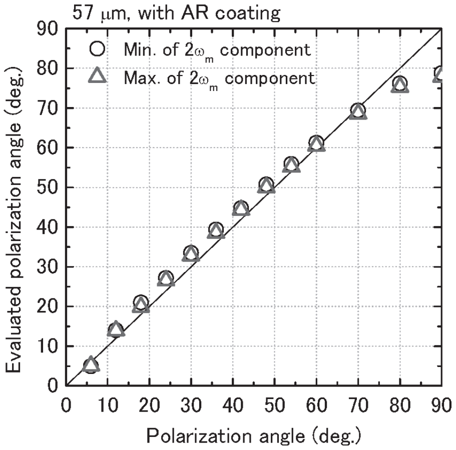

Fig.3: Polarization angle measurement after Parylene coating.

Figure 2 shows measurement results of polarization angle rotated with a half-wave plate. Since the reflective index of silicon is high (N=3.43), the multi-reflection in the photo elastic material is not negligible. These reflection components interfere and the interference is modulated at fundamental and harmonic frequencies of PEM driving. Hence such multi-reflection causes the error in an evaluation of the polarization angle. Evaluated polarization angles agree with the actual ones (except the large polarization angle) when the multi-reflection is minimized by adjusting the incident angle of beam. However, it deviates from actual ones when the amplitude of the multi-reflection is large. Although this deviation can basically be compensated by calibration experiments, the multi-reflection should be reduced to avoid frequent change of calibration expression. As an AR-coating, 8.7 μm-thickness Parylene, which is a kind of plastic, is selected. Figure 3 shows the measurement results after coating. Reflection can be suppressed successfully and even in the case that the interference component is maximum (much smaller), the deviation caused by the multi-reflection becomes negligible.

Reference

1) S. Okajima et. al., Rev. Sci. Instrum **72** (2001) 1094.
2) T. Akiyama et. al., to be published to Plasma and Fusion Research