§19. A proposal of In-situ Diagnostics Methods for PFMs under Multiple Irradiation

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The diagnostics of plasma facing materials (PFMs) is a primary issue for maintenance of the high performance plasma in fusion devices. In order to evaluate PFMs conditions which alternate continually during long duration discharges, in-situ and real-time diagnostic methods of PFMs are highly desired as an alternative to the existing postmortem methods. In this study, optical reflectivity measurement is proposed as a convenient in-situ diagnostics of the radiation induced microstructure change and its applicability is evaluated.

The in-situ reflectivity measurement was performed in LHD with a retro mirror and a super continuum white laser to verify applicability of this diagnostic method in a large plasma confinement device. Fig. 1 shows the evolution of reflectivity spectra obtained under the Ne (left) and H (right) glow discharge in LHD. The reflectivity is normalized by the initial value. For both discharge cases, significant changes are observed in the reflectivity spectra. The reduction in the reflectivity under the exposure to the Ne glow discharge seems to be caused by radiation damages formed in the sub-surface region of the mirror since a similar reduction are observed in the ion irradiated sample in the laboratory experiments [1]. On the other hand, the drastic reduction of the reflectivity and the peculiar wavelength dependences observed under the He glow discharge cannot be reproduce for ion irradiated samples. Because under the He glow discharge the chemical sputtering of carbon materials and their re-deposition have been observed, the drastic reduction is attributed to the formation of the deposition layer on the mirror. Due to the growth of the deposition layer, time dependence of the reflectivity under the He glow discharge shows a specific oscillation depending on the thickness of the deposition layer. Fig.2 shows the evolution of the reflectivity obtained under the H glow discharge. The oscillation of a reflectivity associated with an increase of a deposition thickness had been reported and apprehended as an optical interference phenomenon [2]. In this figure, the calculated reflectivity of the light with λ = 780 nm is also plotted as a function of the deposition thickness. From the comparison of the frequency in the oscillation, the deposition thickness can be roughly estimated if the homogeneous deposition of known optical constant is formed on the mirror surface. These results indicate that optical property measurement is considered to be a possible method for convenient in-situ diagnostics for PFMs in spite of the limited application. For more accurate diagnosis, a combination of several diagnostics methods and an accumulation of comparative basic data are required.

In this study, a transparent conductive film (GZO: gallium doped zinc oxide thin film) are also suggested as a new material for diagnostics. Fig. 3 shows optical transmittance (left) and electrical resistivity (right) for GZO films irradiated with 3 keV-He^{+}. By using GZO films, optical and electrical properties can be measured simultaneously, which is considered to be one of possible methods with high accuracy for in-situ diagnostics.

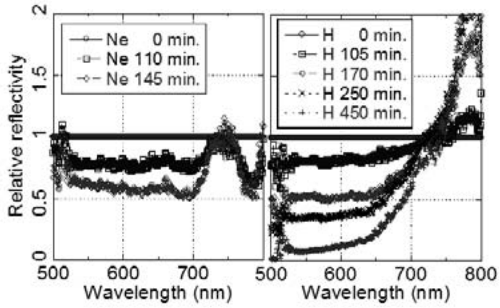

Fig. 1 Evolution of reflectivity spectra obtained under the Ne (left) and H (right) glow discharge in LHD.

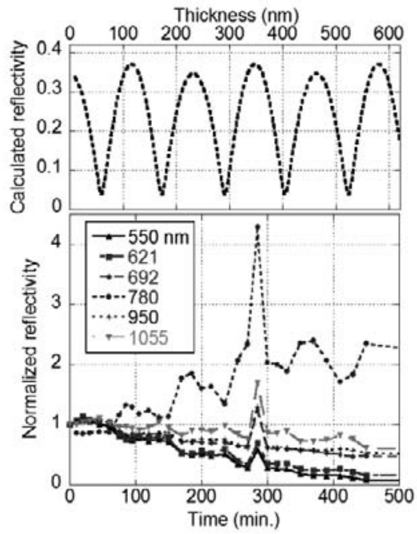

Fig. 2 Exposure time dependence of the reflectivity under H glow (bottom), and calculated dependence of the reflectivity on the deposition thickness (upper).

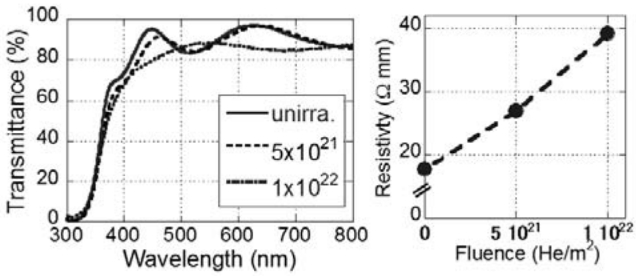

Fig. 3 Optical transmittance and electrical resistivity for GZO films irradiated with 3 keV-He^{+}.

1) Miyamoto, M. et al.: Ann. Rep. NIFS (2011-2012) 229.
2) Sagara, A.: Report of the Grant-in-Aid for Scientific Research (no. 16560726) (2005).