## §40. In-situ Diagnostics Methods for Surface Properties of PFMs

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One of the key issue for maintenance of the high performance plasma in fusion devices is diagnostics of plasma facing materials (PFMs). In order to evaluate PFMs conditions, 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 surface modification in PFMs and its applicability to a plasma confinement device is discussed.

To examine the change of the optical properties due to plasma-surface interactions, the long-term material probe samples exposed to the LHD plasma during the 18th experimental campaign were used. The reflectivity change after the exposures was measured by spectroscopic ellipsometer for the wavelength range of 280-820 nm. The microstructure modification induced by the plasma exposure was also investigated using a transmission electron microscope (TEM). The focused ion beam (FIB) technique was applied to make the sample ready for cross-sectional observation.

Fig. 1 shows the wavelength dependence of reflectivity obtained by the spectroscopic ellipsometer for the samples exposed to the LHD plasma. On these samples, the formation of the deposition layers with various thicknesses were confirmed by the cross-sectional TEM observation and the thickness for each sample is shown in this figure. Compared with the reflectivity for the unexposed sample, various changes in the wavelength dependence are observed, especially drastic for the samples with the thick deposition layers. To evaluate the thickness of the deposition layer from the optical measurements, we attempted to estimate the volume fraction and the distribution range of He bubbles in the samples exposed to LHD plasma by fitting the spectra of the refractive index, *n*, and extinction coefficient, *k*, for these samples using the following model; a substrate has the same constants as an un-irradiated sample, and a deposition layer with the thickness of *t* nm is built up with mixture of carbon impurity and SUS with the carbon content of *p* % (see Fig. 2 (a)). Fig. 2 (b) shows an example of the fitting by using *t* and *p* as free parameters. As results of the fittings, the thickness and the porosity are estimated to be *t* ~ 61 nm and *p* ~ 78 %, respectively. Fig. 3 shows the relationship of the estimated thickness by the above mentioned fitting and the measured one obtained by TEM observation. With a few exceptions, the estimated thicknesses correspond reasonably well with the measured values. As a result, the optical reflectivity measurement is considered to be a possible in-situ method for an estimation of the deposition layers on PFMs.

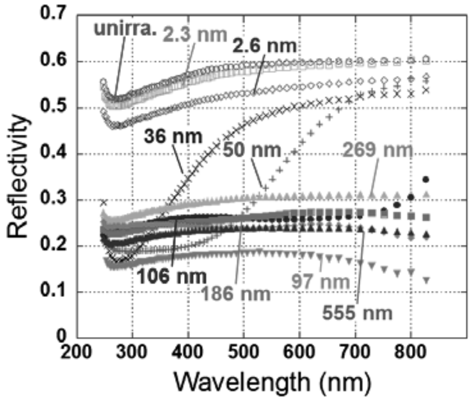


Fig. 1. Wavelength dependence of reflectivity, measured with ellipsometer, in the SUS316L samples exposed to the LHD plasma.

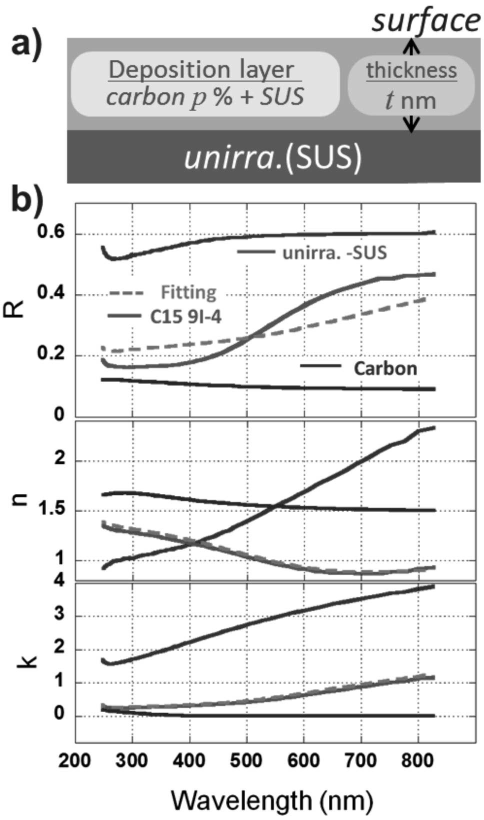


Fig. 2. The fitting of the optical constant.

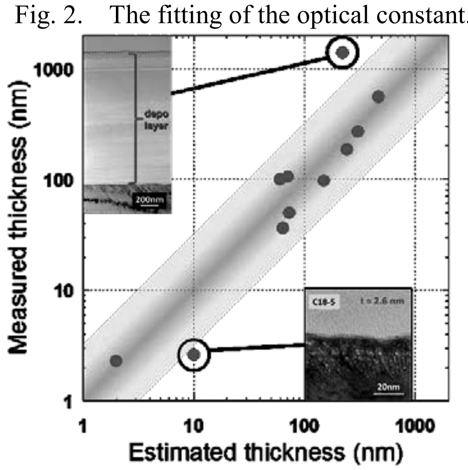


Fig. 3. The relationship of the estimated and measured thickness of the deposition layer.