§33. Analyses of Generation and Behavior of Fine Particles by Laser Light Scattering

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In order to analyze and reduce the generation and transport of dusts in a nuclear fusion reactor, *in-situ* measurements of dust behaviors will play important roles. Recording the distribution and trajectory of dusts in a reactor by laser light scattering using a CCD video camera is one of the *in situ* measurement methods[1,2]. The Mie-scattering ellipsometry that was developed for monitoring the growth of fine particles in a processing plasma[3] can be a useful method also for the analysis of dust growth in a fusion reactor. Therefore, we are developing a Mie-scattering ellipsometry system for the analysis of generation and transport of dusts in the Large Helical Devise (LHD). In Mie-scattering ellipsometry, the change of polarization state of light by scattering is expressed by two angle parameters: the arctangent of absolute value of ratio of two complex amplitude functions, Ψ, and the phase angle of the ratio, Δ[3]. They have correlations with the complex refractive index (m), size (d), and size distribution of dusts as well as scattering angle (ϕ). By the comparison of measured ellipsometric parameters with those calculated ones under a model of particle growth, the process of dust growth is pictured. In this year, we constructed the system of Mie scattering ellipsometry and examined the attachment of the system to the LHD.

Figure 1 shows the system of Mie-scattering ellipsometry. It consists of two modules. One is the polarizer module composed of a laser light source (532 nm in wavelength), a polarizer prism and a rotating-compensator. The other is the analyzer module composed of the analyzer, which is the same polarizer prism as the polarizer, and a photo-detector. The polarizer module projects polarized light at dusts. The polarization state after scattering is analyzed with the analyzer module by the following equations. When the analyzer azimuth is set to 0°, the intensity of light incident on the photo-detector varies with the compensator azimuth C as,

$$I(C) = A_0 + A_2\cos 2C + B_2\sin 2C + A_4\cos 4C + B_4\sin 4C \quad (1)$$

, where

$$A_0 = 2 + S_1, \quad (2a)$$
$$A_2 = 0, \quad (2b)$$
$$B_2 = -2S_3, \quad (2c)$$
$$A_4 = S_1, \quad (2d)$$
$$B_4 = S_2, \quad (2e)$$

when the imperfections of compensator are neglected. S_1, S_2, and S_3 are the Stokes parameters that have the following relationship with the two angle parameters of Mie-scattering ellipsometry,

$$S_1 = -\cos 2\Psi, \quad (3a)$$
$$S_2 = \sin 2\Psi \cos\Delta, \quad (3b)$$
$$S_3 = -\sin 2\Psi \sin\Delta, \quad (3c)$$

when the polarizer azimuth is set to 45° and fine particles are monodisperse.

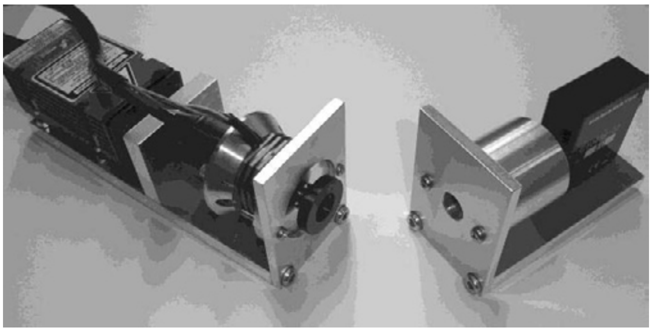

Fig. 1. Mie-scattering ellipsometry system. The left is a module of a laser-light, a polarizer, and a rotating-compensator. The right is a module of the analyzer and a photo-detector.

The system of Mie-scattering ellipsometry will be installed into the LHD. The polarizer module of Mie-scattering ellipsometry measurement is attached to a viewing port of diverter. Polarized and modulated laser light enter into the vacuum chamber through a viewing window to the region of dust suspension. For the analyzer module, the analyzer is separated from the photo-detector. The analyzer is set up in the vacuum chamber around the region of dust suspension. The photo-detector is attached to another viewing port of diverter in the atmosphere. The modulated light, whose intensity is indicated by eq. (1), is transported through an optical fiber to the photo-detector. The light is brought out to the atmosphere through an optical coupler connected to a vacuum flange.

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2) Y. HAYASHI, Y. MIZOBATA and K. TAKAHASHI: " Experiments of Fine-Particle Plasma Using Planar Magnetron System ", 8th Japan-China-Korea Workshop on Microgravity Sciences, 2010.9.24
3) Y. Hayashi and K. Tachibana: "Mie-Scattering Ellipsometry for Analysis of Particle Behaviors in Processing Plasma", Jpn. J. Appl. Phys. **33** (1994) L476.