§2. Research on Dust Generation and its Observation Method by Light Scattering

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According to the development of experimental devices of high-temperature plasma for nuclear fusion, dusts generated in plasma or from reactor walls by long-time operation are causing a problem for continuous running. Moreover, they should play as sources of core cooling and tritium pollution in future. Therefore, study on the generation and behavior of dust in a high-density plasma device becomes important. However many phenomena, such as the generation of dusts including carbon or tungsten and their growth and transport, have not been well analyzed and clarified. *In-situ* measurements of dusts should play roles for the solution of such issues. Mie-scattering ellipsometry that was developed for monitoring the growth of fine particles in a processing plasma[1)] can be a useful method for the analysis of dust growth and behavior in a nuclear fusion reactor. We are developing a new Mie-scattering ellipsometry system[2)] for the analyses of generation, growth, behavior and transport of dusts in the Large Helical Devise (LHD).

In this year, we attached the Mie-scattering ellipsometry system to the view-windows of AD01-02 and AD01-03 of the 4.5 L port in the LHD to observe dusts generated around a diverter plat. Along with the experiment, we examined the basic performance of the developed ellipsometer system. In order to carry out the latter experiment, we attached the system to an RF fine particle plasma equipment under the same arrangement as in the LHD as shown in Fig.1.

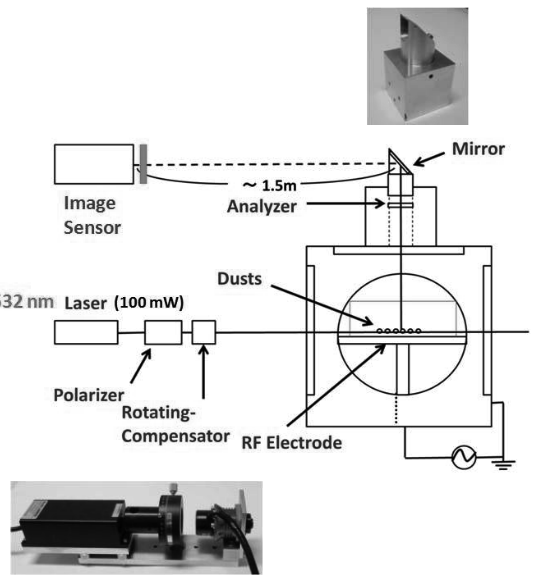

Fig. 1. Schematic diagram of the ellipsometer system attached to RF fine-particle plasma equipment. Photos of analyzer module (upper) and polarizer module (lower) are inserted.

The ellipsometer consists of polarizer and analyzer modules. The polarizer module is composed of a 532 nm wavelength laser, a polarizer (azimuth angle: 90° from scattering plane), and a rotating-compensator. The analyzer module is composed of a wire-grid polarizer (analyzer, azimuth angle: -45°) and a mirror. A video camera containing an image sensor for the detection of change of light intensity during the modulation of polarization state was set at a distance of 1.5 m from the mirror.

Spherical divinylbenzene polymer particles of 2.25 microns in diameter were injected and suspended in an argon plasma under the pressure of 50 Pa. Light scattered by thousands of particles passing through the analyzer was observed and recorded with the video camera. Video images were captured 30 times per second during the compensator rotation at a speed of 0.5 turn per second.

Figure 2 shows light intensity variation with the azimuth angle rotation of compensator[3)]. For rotating-compensator ellipsometer, light intensity I changes with compensator azimuth angle C as,

$$I = A_0 + A_2\cos 2C + B_2\sin 2C + A_4\cos 4C + B_4\sin 4C.$$

Fourier transformation was carried out for the variation and the coefficients were calculated to be 6.9009 for A_0, -0.5825 for A_2, 0.7225 for B_2, 0.3876 for A_4, and -1.3953 for B_4. Ellipsometric parameters were obtained from these values: Ψ=73.7°, Δ=214.5°. Calculation for spherical particles of 2.25 microns in diameter and refractive index of 1.56 resulted in: Ψ=76.3°, Δ=229.7°.

It is concluded that the values of ellipsometric parameters obtained by the experiment reasonably agree with those by calculation.

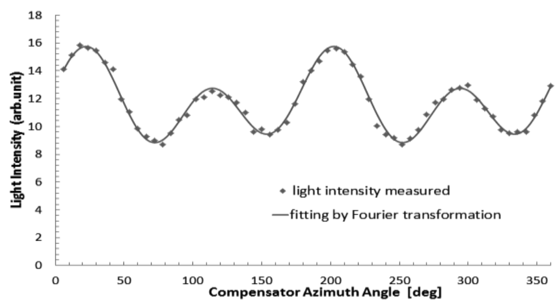

Fig. 2. Variation of intensity of scattered light with compensator azimuth angle. Monodisperse and spherical divinylbenezen particles of 2.25 microns in diameter were measured.

1) Y. Hayashi and K. Tachibana: "Mie-Scattering Ellipsometry for Analysis of Particle Behaviors in Processing Plasma", Jpn. J. Appl. Phys. **33** (1994) L476.
2) H. Kotou, Y. Hayashi and S. Masuzaki: "Development of ellipsometer system for measurement of dusts in nuclear fusion reactor", 14th Workshop on Fine Particle Plasmas, P-3, Dec. 13, 2013.
3) M. Kawano, H. Kotou, Y. Hayashi and S. Masuzaki: "Mie-scattering ellipsometry system for dust measurement in Large Helical Device", 15th Workshop on Fine Particle Plasmas, P-4, Oct. 17, 2014.