§20. Analyses of Generation and Behavior of Fine Particles by Laser Light Scattering in LHD

Hayashi, Y. (Kyoto Inst. Technol.),
Masuzaki, S.

The generation of dusts in nuclear fusion reactors is becoming a serious problem, because they play as sources of core cooling and tritium pollution. *In-situ* measurements and analyses of dust behaviors are important issues to reduce the generation of dusts in a nuclear fusion reactor. 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 have been developing a Mie-scattering ellipsometry system for the analysis of generation and transport of dusts in the Large Helical Devise (LHD).

We had installed the laser-light source and detector modules of an ellipsometry system using an optical fiber last year, however, the volume of outgas from the optical fiber exceeded an allowable value under 100 ℃. Hence, the use of the optical fiber in the system of ellipsometry was abandoned. In this year, a new system of ellipsometry without an optical fiber was developed for the monitoring of dust generation in LHD [2].

The ellipsometer system consists of two modules. One module composed of a laser-light (532 nm) source, a polarizer, and a rotating-compensator was attached to the view-window of AD01-02 of the 4.5 L port. The other module of analyzer, which is composed of a wire-grid polarizer, a focusing lens, and a light-diffusing plate, was set in the vacuum chamber of LHD. The image of distribution of scattered light is projected on the light-diffusing plate through the focusing lens and wire-grid and is observed out of the chamber by using a CCD camera attached to the view-window of AD01-03. Figure 1 shows the schematic diagram of the ellipsometer system attached to LHD.

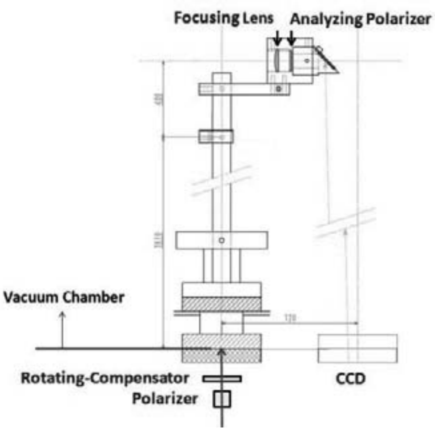

Fig. 1. Schematic diagram of the ellipsometer system attached to LHD. Light source module and CCD camera are attached to view-windows of AD01-02 and AD01-03 of 4.5 L port, respectively. Analyzer module is set in vacuum chamber.

Figure 2 shows a photo taken from the AD01-02 view-window out of the chamber. The left arrow indicates the position of dust measurement, where a scattering object was put instead of dusts. The projected image of the scattered light is observed at the position indicated by the right arrow.

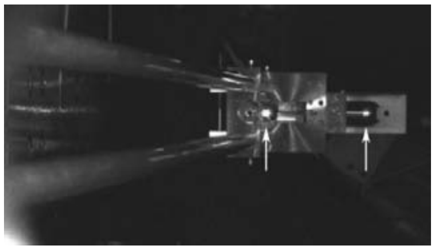

Fig. 2. Photo taken from AD01-02 view-window out of vacuum chamber. Left and right arrows indicate the positions of dust measurement and projected image of scattered light from substitution object, respectively.

The basic performance of the developed ellipsometer system under the same arrangement as in LHD was examined being attached to an RF plasma equipment. Spherical divinylbenzene fine particles of 2.25 μm in diameter were suspended on an RF electrode. The intensity of light on CCD as a function of rotating-compensator azimuth C, i. e., I(C), was obtained as shown in Fig.3. Fourier coefficients of I(C) were calculated, then ellipsometric parameters were obtained to be Ψ=51.4°, Δ =313.9°, which are valid values for the measurement.

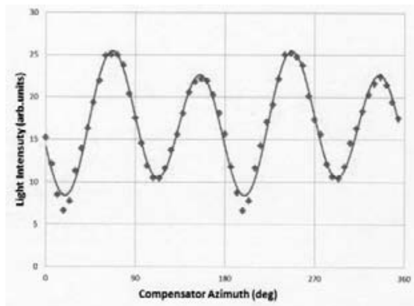

Fig. 3. Variation of scattered light intensity on CCD with rotating-compensator azimuth for spherical divinylbenzene fine particles of 2.25 μm in diameter. Measured values are indicated with dots and a curve obtained by Fourier transformation is also indicated.

The measurement of dusts generated in LHD using the ellipsometer system was tried, however, it could not be carried out because of lower dust formation than expected.

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.