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

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Dusts generated in a practical nuclear fusion reactor will bring serious problems, because they become sources of core cooling and tritium pollution. In order to reduce the generation of dusts in a nuclear fusion reactor, *in-situ* measurements and analyses of dust behaviors should play important roles. The methods of laser light scattering from dust particles[1,2] are good for the purpose. Especially, the Mie-scattering ellipsometry that was developed for monitoring the growth of fine particles in a processing plasma[3] 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). 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*), size distribution of dusts and scattering angle (ϕ). By the comparison of measured ellipsometric parameters with those calculated ones under a model of particle growth and transport, the process of dust formation can be analyzed. In this year, we designed and developed the optical fiber system for Mie-scattering ellipsometry, and then tentatively set it in the LHD.

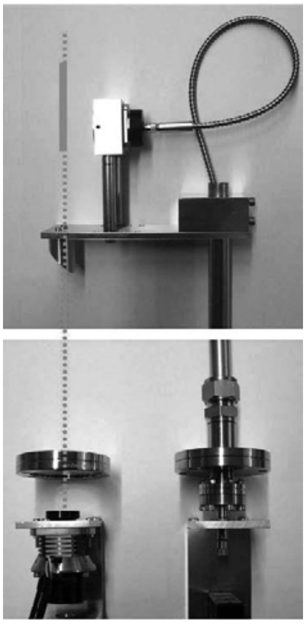

Fig. 1. Mie-scattering ellipsometry fiber system. The left and right in the lower picture are polarizer and detector modules, respectively. One in the upper picture is an analyzer module.

The developed Mie-scattering ellipsometry fiber system for monitoring in the LHD is shown in Fig. 1. The left module in the lower picture shows that composed of a laser light source (532 nm in wavelength), a polarizer prism and a rotating-compensator. The right one shows that composed of an optical filter and a photo-detector. The module in the upper picture shows that composed of a wire-grid analyzer, a collimator and an optical fiber.

The analyzer module is set around a diverter plate in the vacuum chamber of the LHD, while the polarizer and detector modules are attached to view-ports of the 4.5-L port out of the vacuum chamber. Polarization modulated laser light is scattered by dusts generated around a diverter plate. The scattered light is focused on the one end of the fiber. The light passes more than 2 m through the fiber and a vacuum feed-through to come out in front of the optical filter. The distance between the two axes of polarizer and detector modules is 12 cm.

Tentatively, the analyzer module was set in the vacuum chamber of the LHD in the atmospheric ambient as shown in Fig.2. In order to test the alignment of optical axis, laser light was projected to the measurement position of dusts, where the tip of a screw bolt was positioned. A sheet of wire mesh was attached to the analyzer module to see the deviation of laser light, i. e., misalignment, by light scattering. In this way, the alignment of optical axis of the polarizer module was examined.

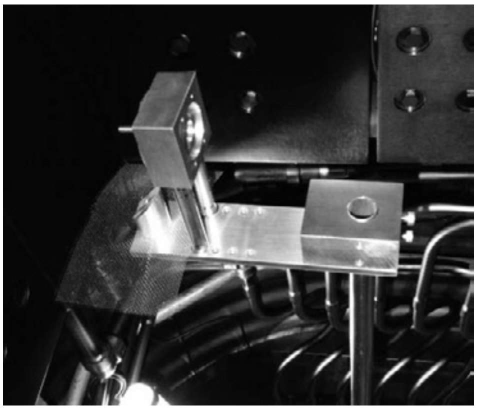

Fig. 2. Analyzer module set in vacuum chamber of LHD. Tentative alignment was carried out using a sheet of wire mesh and the tip of a screw bolt.

1) Y. Hayashi : “Coulomb-Crystallization and Behavior of Fine-Particles in Experimental Plasmas”, 29th Grain Formation Workshop, Nov.10, 2011.
2) H. Kotou and Y. Hayashi : "Observation of rotation of disc-shaped fine-particles in a plasma", 12th Workshop on Fine Particle Plasmas, P-2, Nov. 27, 2011.
3) Y. Hayashi and K. Tachibana: “Mie-Scattering Ellipsometry for Analysis of Particle Behaviors in Processing Plasma”, Jpn. J. Appl. Phys. **33** (1994) L476.