§37. Double-Sheath Structures and Trapping of Dust Grains in a Plasma

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The presence of particulate contaminants in etching, sputtering and deposition processors remains a major problem in engineering plasma. The particulates occur in the range of sizes, 0.01-10μm being the most common although grains of 10μm or larger are also possible. They tend to congregate into particle traps due to their electrical nature, sometimes referred to as electrostatic traps. It is shown that these traps have long-lived structures (lasting many tens of minutes) at the edge of the plasma sheath boundary by the laser scattering measurements. These phenomena can have the appearance of *domes* , *rings* or *filaments* associated with particulates suspended above the experimental devices.

The density of electrons n_e forms the Boltzmann distribution. The secondary electron density n_s produced by the secondary emission. In order to investigate the dust grain density including trapped particles, we introduce the distribution function;

$$f_d = n_0\left(\frac{m_d}{2\pi k_B T_d}\right)^{\frac{3}{2}} \times exp\left[-\left(\frac{m_d}{2k_B T_d}\right)(v_r^2+v_\theta^2)-\frac{Q\Phi}{k_B T_d}\right],$$

where the curve $v_\theta(v_r)$ has to be found, depending on the trajectories of particles, and $Q = eZ$. Poisson's equation in the sheath (Φ <0) is given as

$$-\epsilon_0\frac{d^2\Phi}{dx^2} = e(n_e - n_i - n_s + Zn_d) \equiv \rho, \qquad (1)$$

where ρ is the space charge density. Quasineutrality condition holds at the sheath edge. The boundary conditions are also considered. In this case, integration of Poisson's equation gives rise to the electric field in the sheath. Fig.1 shows the sheath structure of the cases of secondary electrons and no secondary electrons. The electric fields are shown in Fig.2. It turns out that trapped dusts form the multiple-sheath, and the potential and electric field become mild due to the secondary electrons. These facts connect with the study of the plasma-wall interaction.

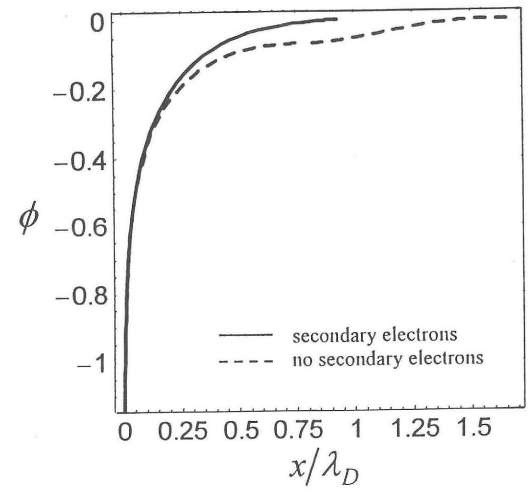

Fig.1 Sheaths with secondary electrons and no secondary electrons.

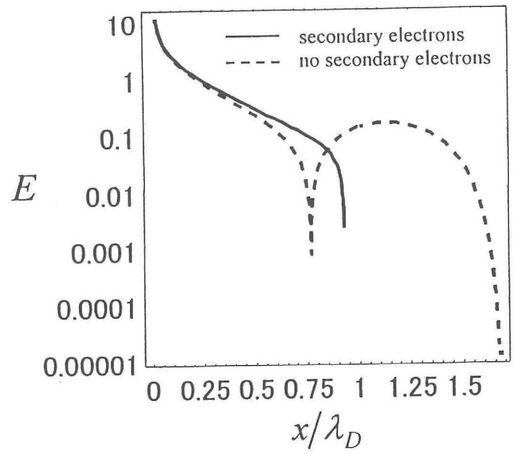

Fig.2 Electric fields with secondary electrons and no secondary electrons.

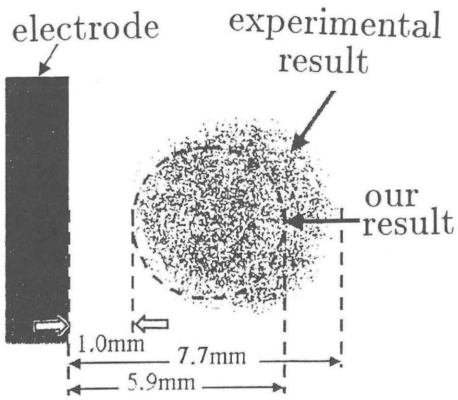

Fig.3 Comparison of our result with the experimental one on the trapping of dust grains.

References
Y.N.Nejoh, Phys. Plasmas, **8** (2001) to be published; Nonlin. Proc. Geophys., **5**, 53, (1998); Phys. Plasmas, **6**, 1048, (1999).