Infrared Laser Manipulation of Single Fine Particle Levitated at Plasma/Sheath Boundary

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Physical and chemical interactions between plasmas and nano-featured surfaces are one important issue in the plasma processing. Typical examples are interactions between plasmas and surfaces of particles suspended in the plasmas [1, 2]. Here we report trapping and manipulating a single fine particle levitated at plasma/sheath boundary using an infrared laser to realize in-situ analysis of such interactions. Experiments were carried out with a radio frequency low pressure plasma reactor, where we set two quartz windows as top and bottom flanges to irradiate an infrared laser light of 1064 nm wavelength from the bottom side. A powered ring-electrode of 10 and 25 mm in inner and outer diameter was set at the bottom of the reactor and a grounded stainless steel mesh grid of 25 mm in diameter was placed at the center of the reactor. Ar plasmas were generated at 100 Pa by applying 13.56MHz voltage. The particles injected into the plasmas were monodisperse methyl methacrylate-polymer spheres of 10 μm in diameter. Negatively charged particles were suspended at plasma/sheath boundary at the center of the powered electrode. One of the particles was trapped vertically there because strong electrostatic force, ion drag force, neutral drag force, and gravity exerted on the particle were balanced. However, the particle can move horizontally. At the focal point of the irradiated laser light due to the transfer of momentum from the scattering of incident photons. The pressure of light can hold the particle like tweezers. We succeeded in trapping and manipulating a single fine particle in plasmas by controlling precisely the focal point and power of the laser light. In the presentation, we will discuss interactions between the trapped particle and the surrounding plasma.

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References