レーザー散乱計測により観測したプラズマ中における微粒子の輸送および保持
Transport and retention of particulates in plasmas observed by laser light scattering technique

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1. Introduction

Particulates or dusty particles are recognized as a major problem of contamination that reduced the production yield in silicon-based solar cell and ULSI manufacturing. Contrary to the contamination problem, particulates are also of interest in numerous applications related to nanotechnology and biotechnology areas. Nanoparticles have been investigated with the intention of applying them to catalysis, photonic and sensing technologies. Since the growth and transport mechanisms of particulates in the discharge space of plasmas are very complex, the ability to control, manipulates and removes particulates are required.

In the present work, Cu particulates have been produced using high-pressure magnetron sputtering plasma. We applied laser light scattering technique to monitor the spatial distribution of Cu particulates produced in the discharge space of magnetron sputtering plasmas.

2. Experimental setup

The magnetron sputtering system is schematically shown in Fig. 1. DC magnetron sputtering plasmas employing a copper (Cu) target were produced in a cylindrical vacuum chamber with four large observation ports. The diameter of the Cu target was 50 mm. The magnetron sputtering source was covered with a grounded-shield with a diameter of 80 mm. A substrate holder was placed at a distance of 50 mm from the target surface. The diameter of the substrate holder was 100 mm. The substrate holder was connected to an rf power supply via a matching box. The discharge gas was argon and the gas pressure was measured using a capacitance manometer.

We employed cw laser at a wavelength of 457 nm to monitor the spatial distribution of Cu particulates by laser light scattering. The laser beam was arranged to have a planar shape using cylindrical lenses, and was injected into the discharge space. The scattered laser light was detected from the normal direction to the incident laser beam using an ICCD camera via interference filter at the laser wavelength.

3. Results and discussion

Figure 2(a) shows the laser light scattered by Cu particulates in the discharge space of the magnetron sputtering plasma. The dc power and the Ar pressure were 10 W and 60 Pa, respectively. As shown in Fig. 2(a), Cu particulates had a broad distribution at the boundary between the bright plasma and the dark region. The scattered laser light was connected to the anode ring of the magnetron sputtering source. In addition, a clear boundary was observed between the Cu particulates and the rf-powered substrate holder. This may be due to the forces balance on the negatively charged Cu particulates.

After the termination of dc power, the Cu particulates transported to the rf plasma at the substrate holder, as shown in Fig. 2(b). We had successfully retained the Cu particulates in the rf plasmas even when the chamber pressure was reduced to 10 Pa.

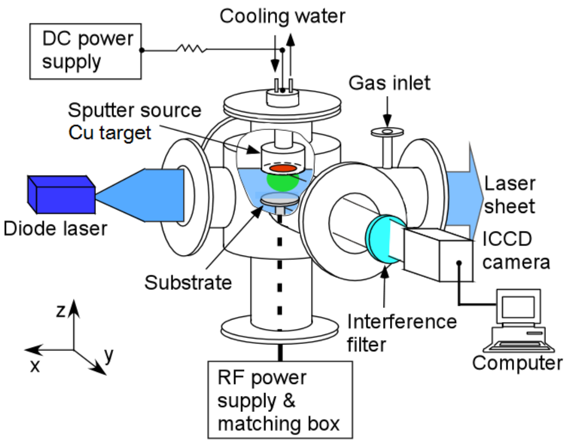

Figure 1. Experimental apparatus for applying laser light scattering technique to a magnetron sputtering plasma source.

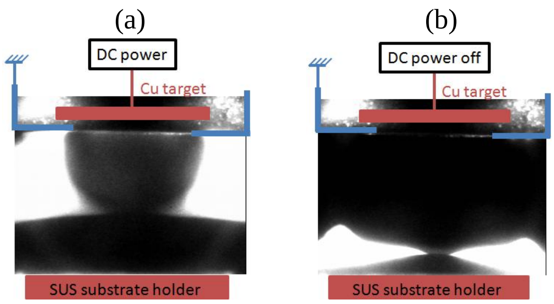

Figure 2. Spatial distribution of Cu particulates (a) during the dc discharge and (b) after the dc power was turned off. The substrate holder was powered using an rf power supply.