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The Carbon Dust Detection in an Ion Beam Transportation Region
イオンビーム輸送領域中のカーボンダスト検出

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The performance of a detection system which visualizes particles of less than 200 μm diameter in an ion beam transport region has been investigated. The detection system consists of a laser, a mirror to guide the beam to traverse the ion beam, a lens to make a sheet-shaped laser beam, and a CCD camera to construct an image of scattered light from the particles. Carbon particles (＜188 μm) loaded at the cathode of the ion source are accelerated with the ion beam by igniting a plasma, and the particle distribution in the beam has been successfully measured.

1. Introduction

Semiconductor process devices, like etching devices, produce particles of sub-mm sizes [1]. The particles adhere on the produced device surface to lower the productivity of semiconductor materials, and efforts are being made to reduce particle emission in plasma [2, 3]. In the case of an ion implantation device, particles can be produced inside of the ion source far away from the semiconductor materials to be processed, but can be transported along the beam produced plasma. When particles touch-down to a silicon wafer they cause the impurities infusion failure and therefore, the process system needs cleaning and some additional treatment to eliminate particles inside the devices.

Detection of particles in the plasma can give necessary information how particles are formed and transported. However, no information of particle behavior in an ion beam transport region is given thus far. In this study, we built a system to detect particles in an ion beam transport region using a method of laser light scattering. After constructing the detector capable of identifying particles of the micrometer order, the performance of the detection system assembled in a test device is investigated.

2. Experimental Set Up

Figure 1 shows a cross sectional view of the entire experimental set up. The vacuum chamber employed to investigate carbon particles transport has the dimensions of 165 mm inner diameter and 120 mm length. At the upper part of the chamber is located the glass window to observe inside the vacuum chamber. The CCD camera is installed at the topside of the chamber and the ion source and a laser are located in the bottom. The sample source is a cold cathode monoplasmatron ion source made of carbon materials including carbon made extraction electrodes. The distance of the observation position is 38 mm from an extraction electrode of the ion source.

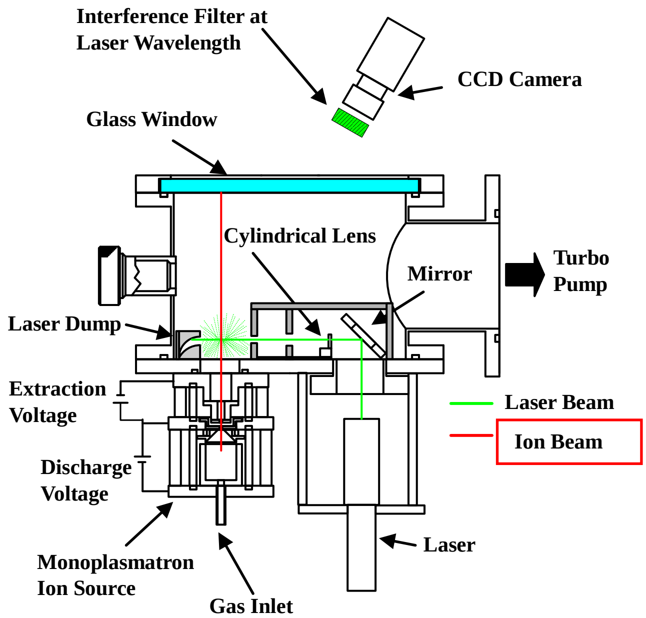

Figure 1. Schematic diagram of the experimental setup.

3. Particle detection system

The diagram showing the particle detection components is schematically illustrated in Figure 2. The particle detection system consists of a 532 nm wavelength solid state laser, an aluminum mirror, a quartz cylindrical lens, a slit to a laser dump, narrow band (3 nm or 10 nm) interference filter, and a CCD camera. An aluminum mirror guides the laser light to traverse the ion beam perpendicularly. A cylindrical lens expands the 1 mm diameter laser beam to measure particles into a region of 1 mm high and 25 mm wide. The laser dump is installed to reduce reflections of a sheet laser beam at the vacuum chamber wall. Dimensions of the laser beam incident slit guides the laser into the dump of 38 mm in width and 5 mm in height. The laser dump has a bent trench to eliminate a reflected laser light. The laser slit of 30 mm in width and 5 mm in height cuts the extra light of the laser beam and let the beam pass through toward the exposure region. The narrow band interference filter transmits light at the wavelength of the laser scattered at particles. The carbon particles irradiated by the laser light emit scattered light, then a CCD camera produces an image of the scattered light from the carbon particles only at the wavelength which is transmitted through the interference filter.

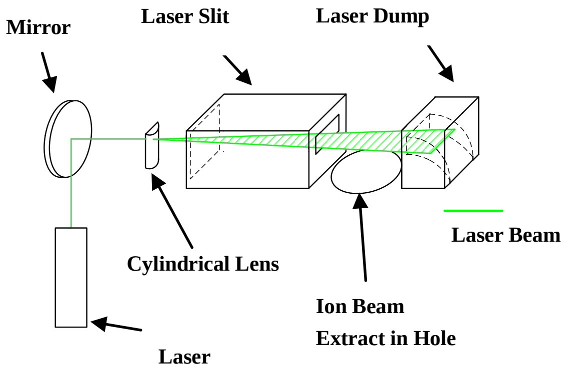

Figure 2. Schematic diagram of the particle detection system.

4. Observation of scattered light from carbon particles

The results of the scattered light of carbon particles in an ion beam transport region are shown in Figure 3. These photographs were obtained under the condition of 0.6×10^{-2} Pa Ar gas pressure, 1.6 kV extraction potential, 350 V discharge voltage, and 15 mA discharge current. A heap of carbon powder (＜188 μm) to simulate dust particle was introduced at the cathode edge. A stream of carbon particles was imaged with the CCD camera when laser beam was irradiated onto the ion beam line. Figure 3 (a) shows a photograph before applying the extraction voltage to the ion source. Figure 3 (b) shows a photograph just after applying the extraction voltage to the ion source.

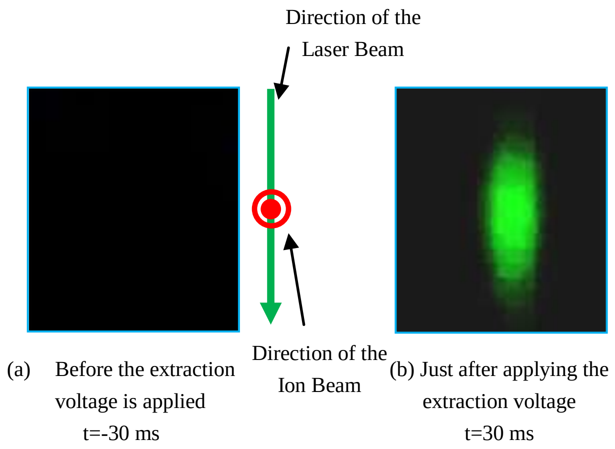

Figure 3. Photographs of carbon particles in an ion beam transportation region.
The extraction voltage is applied at t=0.

The scattered light of carbon particle was not observed during plasma electric discharge without the ion beam extraction. From the result of Figure 3 (b), carbon particles in plasma are confirmed transported toward the ion beam downstream plasma.

References

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