Measurement of scattered electron current distribution in scanning electron microscope

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Electron beam (EB) has been used to fabricate surface structure in lithography. However, if an insulator is irradiated by the beam, electrons are accumulated in the specimen, and negative charging occurs. Not only beam electrons, but also fogging electrons (FGEs), which are produced by multiple backscattering events occurred between the specimen and the optical components in the vacuum, give a contribution on the charging. Since the FGEs spread over a wide range, even if the contribution on the energy deposited is negligible, but if the electron stays at the position provided for a long time, the accumulated charge continues to deliver the influence. In order to avoid the charging problem, we have been trying to quantify the contribution by measuring the FGE distribution.

Figure 1 shows a schematic diagram to measure FGE current in scanning electron microscope (SEM) specimen chamber at the acceleration bias. We obtained the FGE current density, when bias voltages are applied to the specimen. Annular Cu electrodes made on a printed circuit board are used to measure the FGE current. When EB is irradiated the central electrode, FGEs spread over a wide range will be measured at each electrode. We measured them in the following conditions, EB energies are 0.8 keV and 30 keV, EB current is 1nA, working distance (WD) is 20 mm and applied bias voltage is from 0 V to 300 V. Since the Everhart-Thornley SE detector in the SEM is always on, while it is in normal operation mode, the electron collection field influences on especially low energy electron trajectories. To avoid the field, we attached a shutter in front of the detector.

Figures 2 and 3 show the FGE current density distributions as a function of the radius when the EB energies are 0.8 keV and 30 keV, respectively. The current density decreases with the increase of the radius. Because positive bias is applied to the specimen, except for 0V, electrons in vacuum above the specimen are attracted by the field. Since the higher density is obtained at the smaller radius, it is understood that FGEs are distributed close to the EB irradiation point. However, if FGEs with higher-energy are present, current density can be measured at the larger radius. In consideration of these effects, the experimental values were approximated by the Gaussian at large radii. The reason why the current density when the EB energy is 0.8 keV is larger than that at 30 keV is because the lower the energy, the larger the secondary electron-yield from the specimen and the larger the amount of FGE present in the vacuum. On the other hand, at 0.8 keV, the current density attenuates faster with radius. The reason is that low energy FGE quickly lowers its energy and makes it impossible to produce secondary electrons. On the other hand, in the case of 30 keV, FGE has high energy, has the ability to generate more multiple scattering phenomena, and FGE has the ability to make secondary electrons even at long distances.

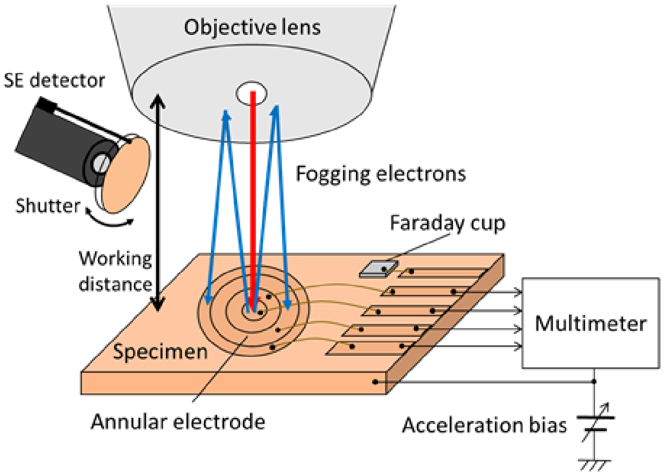

Figure 1. The Schematic diagram of the measurement system of the FGE current.

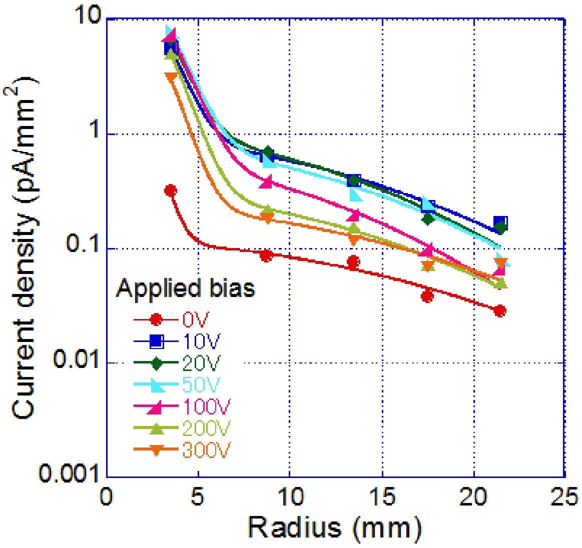

Figure 2. Radial distribution of the FGE current density with accelerating voltage of 0.8kV.

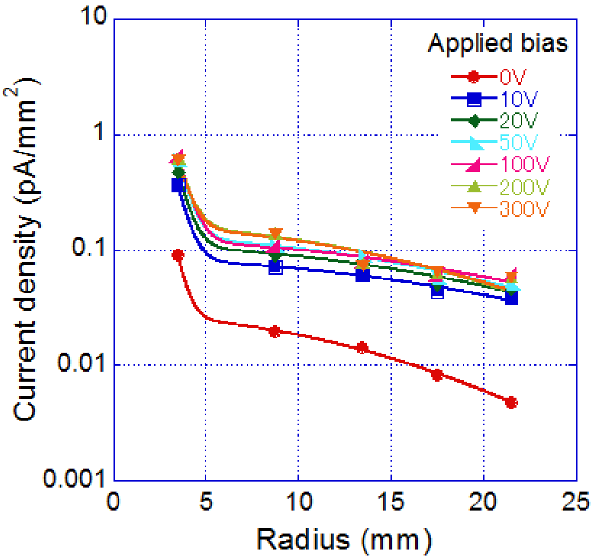

Figure 3. Radial distribution of the FGE current density with accelerating voltage of 30kV.

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