SEM imaging using photo-electron beam by semiconductor photocathode

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Electron beam source is becoming an important key technology in electron beam lithography and inspection using electron beam in semiconductor manufacturing process. In such equipment using electron beam, either thermionic cathode or field emission cathode is used. A higher beam current is a solution to get higher throughput of such equipment. However, there is a trade-off relationship in principle between beam current and beam monochromaticity in existing thermionic cathode and field emission cathode. It is expected that the electron beam from semiconductor photocathodes[1] can solve the trade-off relation on beam performance. Semiconductor photocathodes have progressed in high-energy accelerators, and achieved high electron spin polarization[2], large electron beam current[3], small electron energy spread[4].

In this study, the SEM image was obtained using the electron beam from the semiconductor photocathode, the spatial resolution and signal noise ratio of the SEM image were compared with those of the SEM image using the thermionic cathode.

The SEM images ware obtained by the tiny-SEM and the PC-SEM system in which the thermionic cathode gun of the tiny-SEM was replaced by the semiconductor photocathode gun[5]. AlGaAs semiconductor was used as a material of the semiconductor photocathode[6].

The emission currents of PC-SEM and Tiny-SEM were 3 and 40 μA respectively for the signal-noise ratio of 2.3. The spatial resolutions of Tiny-SEM and PC-SEM were 78 and 80 nm, respectively. The dependence of signal-noise ratio on emission current by Tiny-SEM and PC-SEM is shown in Fig. 3. The emission current of PC-SEM was obtained one fifteenth of the Tiny-SEM to the same signal noise ratio.

Therefore, the semiconductor photocathode can be expected to take the SEM image with 15 times higher throughput than the same emission current of existing thermionic cathode.

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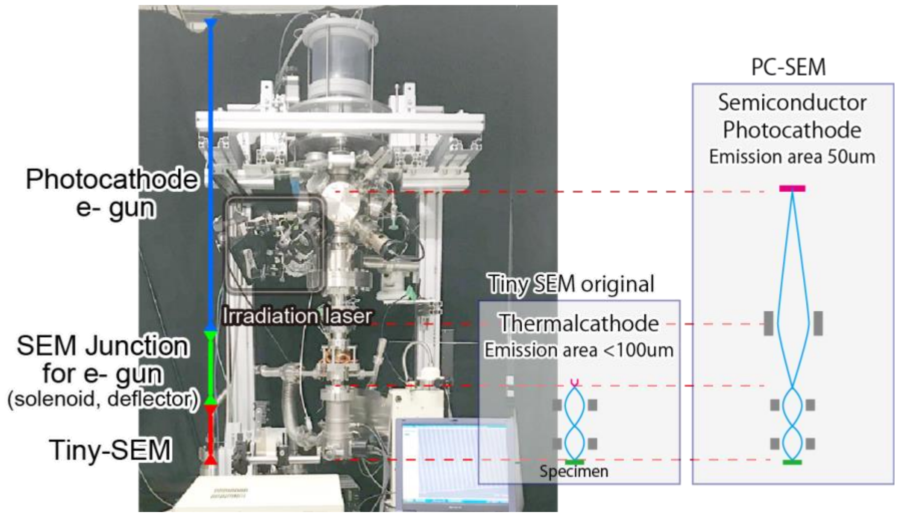

Figure 1: The PC-SEM system: The thermionic cathode gun of the tiny-SEM was replaced by the semiconductor photocathode gun.

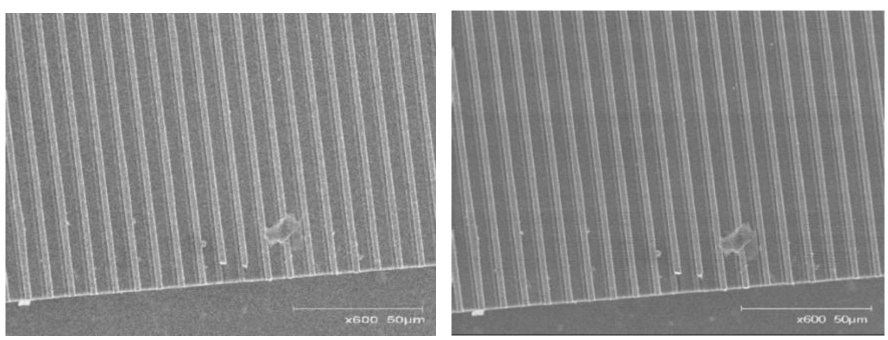

Figure 2: Imaging results of GaN semiconductor line-space sample on a Si by Tiny-SEM (left) and PC-SEM (right).

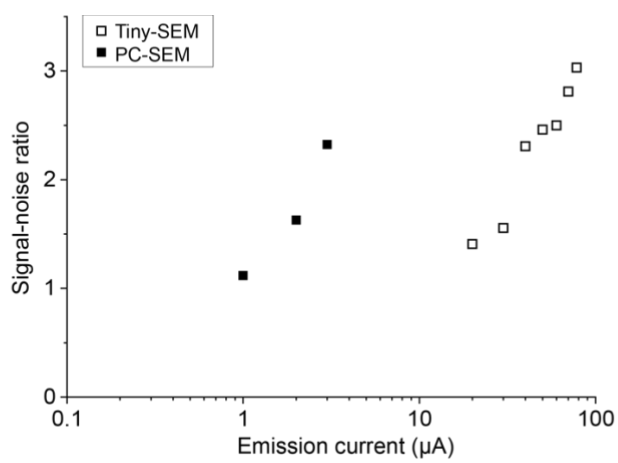

Figure 3: Signal-noise ratio dependence on emission current of the PC-SEM (close squares) and the tiny-SEM (open squares).: The signal-noise ratio was defined by nominal best type in the expression of log (Signal / Standard derivation)^2 .