Experiments towards a high brightness 100-electron-beam source

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A high brightness 100-electron-beam source[1] has been designed to improve the throughput of SEM-type systems. The multibeam source, comprising a Schottky emitter, an aperture lens array, an accelerator lens and a blanker array, has the following unique properties:

1) Up to 90% filling of the aperture lens due to its small spherical aberration coefficient;
2) Reduced off-axial aberrations by shifting current limiting apertures for off-axial lenses;
3) Fully compensation of field curvature by adjusting the geometry and potentials of the accelerator lens; and
4) Small transverse chromatic aberrations.

The multibeam source is designed to deliver more than 1 μA current with minimized aberrations.

The performance of the multibeam source depends on the Schottky emitter, the microfabricated lenses and the blanker array. Only axial properties of the Schottky emitter, such as the brightness and energy spread, have been investigated, and it is not yet clear if off-axial beams will have the same properties. The quality of microfabricated optical components, in terms of roundness, alignment, etc. is essential to the multibeam source. These issues will be addressed. A blanker array with minimized crosstalk has been designed and tested separately.[2, 3]

In this work, we present the experiments towards the high brightness multibeam source. A multibeam source with a maximum acceleration voltage of 12 kV is chosen for the experiment. It requires the Schottky emitter working at low extraction voltage while having high brightness. A low power Schottky emitter (LPSE) with a tip radius of 0.55 μm is mounted in a vacuum system with a background pressure of 5×10^{-11} mbar. Opposite to the emitter at 300 μm is the micro-fabricated extractor with a diameter of 80 μm. The emitter is positioned by a 3-axis Piezo stage, where X- and Y-axes are used to align with the extractor, and the tip-extractor distance is adjusted by the Z-axis. A YAG screen images the emission pattern and collects the current coming through the extractor hole. In Fig. 1, the emission patterns, as a function of Piezo voltages on X-, Y- and Z-axes are recorded by a CCD camera, where 10 Volts change in the Piezo voltage equals to 6.67 μm shift in position. Once the emitter is aligned, the Z-axis Piezo brings the tip closer to the extractor. The Schottky plot for different Z-axis voltages is illustrated in Fig. 2. The multibeam components are under fabrication, as shown in Fig. 3. These components will be aligned in a mask aligner and mounted for further experiments. We expect to present experimental results on spot sizes and beam currents of the 100-beam source.

1, Yanxia Zhang, and P. Kruit, J. Vac. Sci. Technol. B 25, 2239 (2007).
2, Yanxia Zhang, C. T. H. Heerkens, M. J. van Bruggen, and P. Kruit, J. Vac. Sci. Technol. B25, 504 (2007)
3, C. T. H. Heerkens, M. J. van Bruggen, Y. Zhang, B. van Someren, and P. Kruit, Presented in MNE 2007, Book of Abstracts, 4C-2

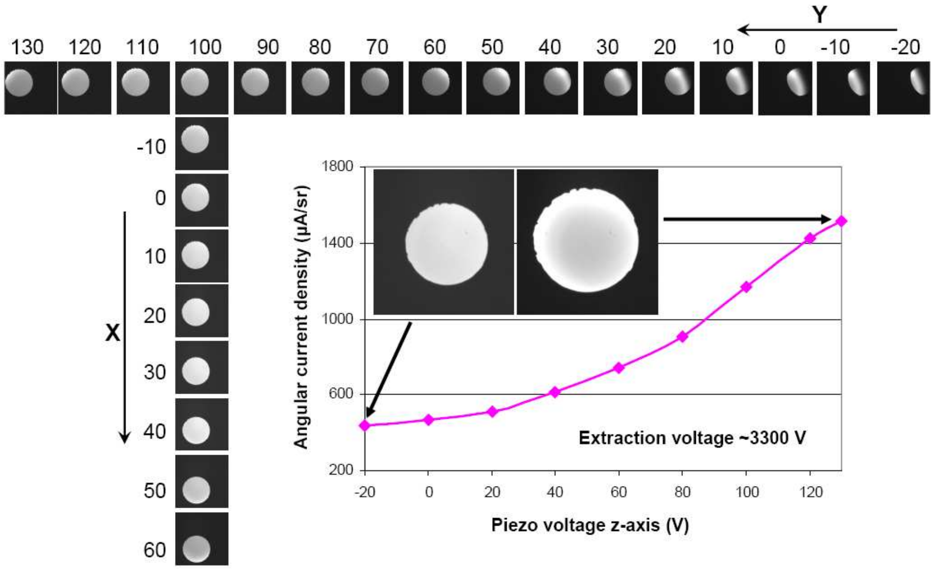


Fig.1: The emission patterns as a function of Piezo voltages on X-, Y- and Z-axes.

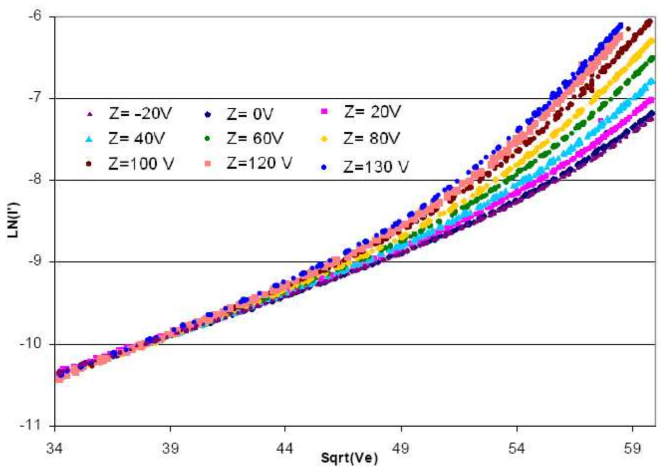
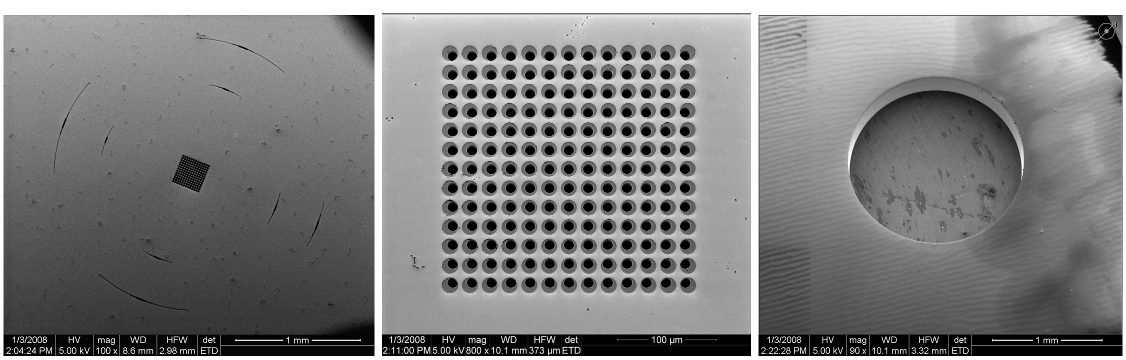


Fig.2: The Schottky plot for different Piezo voltages on the z-axis.



a) b) c)

Fig. 3: a) the aperture lens array with alignment marks for the two accelerator electrodes; b) enlarged aperture lens array shows shifted current limiting apertures for the off-axial lenses; and c) one of the accelerator electrodes.