High brightness 100-electron -beam source for high-resolution applications

Yanxia Zhang and P.Kruit

Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

The progress in microelectronics, microfabrication and material science demand an ever-increasing spatial resolution and throughput in charged particle beam lithography and inspection. Multibeam systems with high brightness electron sources are under research,[1-4] which improve the throughput and reduce coulomb interaction by splitting the broad beam into beamlets. In such a system, the aberrations of the multibeam source must be carefully minimized to prevent deteriorating the effective brightness of the beamlets.

A multibeam source with arrayed Schottky emitters at a pitch of 1.5 mm, and 100 beamlets per emitter, has been presented.[4] The requirement that the 100 beamlet –single Schottky emitter units had to be stacked in a closely packed array, limited the design parameters. This results in a design with severe engineering challenges due to fine alignment, extremely high tip stability requirement and high electrical field. We are also worried about the coulomb interactions in that design.

In this paper, a multibeam source for single-column systems is analyzed. The multi-beam source comprises a low extraction voltage Schottky source, an aperture lens array, an accelerator lens and a blanker array, as shown in fig. 1. The aperture lens array, at the potential of the extractor, splits the broad beam into multiple beamlets and projects multiple source images at the blanker array. The current limiting aperture for each aperture lens is shifted according to the incident angle to minimize off-axial aberrations.[4, 5] The distance between the tip and aperture lens array is kept small to reduce coulomb interactions (~1.2 mm), while leaving enough space for a deflector, which is used to compensate for tip drift. The accelerator lens increases the potential to around 11 kV, and provides the electrical field for the aperture lenses. The equipotential lines for the multibeam source are plotted in fig.2.a, and the electrical field in front of aperture lenses are plotted in fig.2.b as a function of the off-axial height. This field variation results in variation of aperture lens strength, which is used to correct for field curvature. In fig.3, the aberration disks in a through-focus series for the central 3x3 array illustrate that the field curvature and astigmatism of the accelerator lens are negative.

Currently an experimental setup is being prepared for testing the multibeam source. The multibeam source is capable of generating 100 beamlets with a beamlet current of 8.5nA.

1. M. J. van Bruggen, B. van Someren, and P. Kruit JVST B 23, 2833 (2005)
2. Masato Muraki and Susumu Gotoh, JVST B 18, 3061 (2000)
3. Stefan Eder-Kapl ,et al, Microelec. Engin. 83, 968-971, (2006)
4. Yanxia Zhang and P.Kruit, presented in CPO7, submitted to NIMR A
5. Kenji Kurihara J. Vac. Sci. Technol. B 4, 1251 (1986)

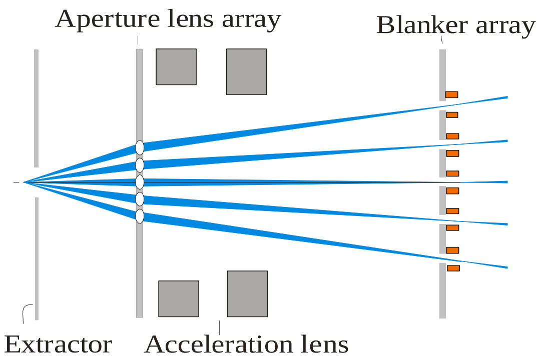
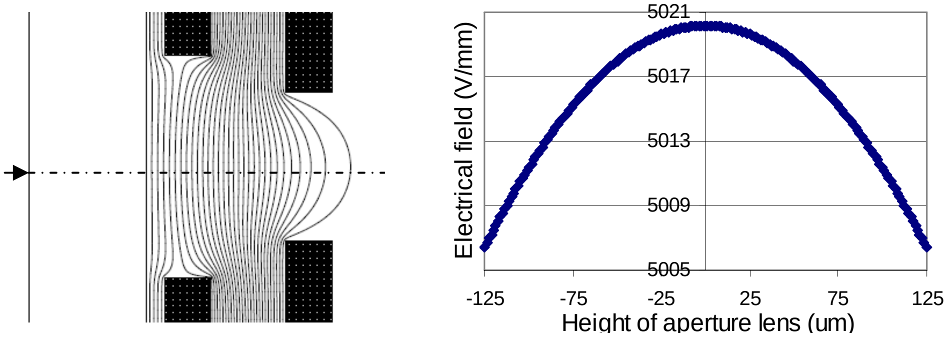


Fig.1: The schematic of the multi-beam source



a) b)

Fig. 2: a) the equipotential lines of the multibeam source; b) the electrical field in front of the aperture lens as a function of the off-axial height of the aperture lens.

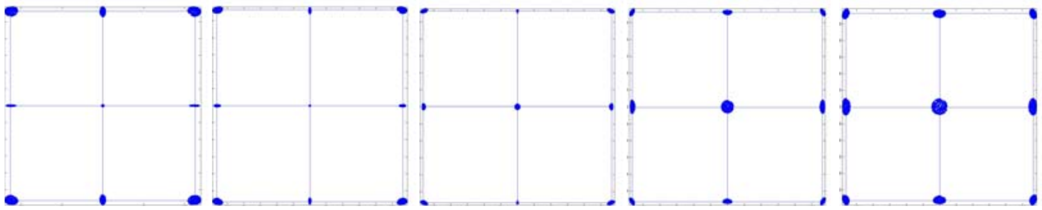


Fig. 3: The aberration disks in a through focus series for the central 3x3 array (with the first image closer to the aperture lens array)