Operator independent measurement of beam size using BEAMETR technique

S. Babin, I. Kravchenko,* D. Joy,** M. Machin, A. Martynov

Abeam Technologies, 5286 Dunnigan Ct., Castro Valley, CA 94546, USA, *University of Florida, Department of Physics, Gainesville, FL 32611, USA, **EM Facility, University of Tennessee, Knoxville, TN 37996 and Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

Monitoring and tuning the beam size is critical for any electron-beam system. The performance of defect inspection systems, electron beam lithography (EBL) systems and scanning electron microscopes (SEM) depends greatly on beam size. The knife edge method usually used for beam size measurement is time consuming and inaccurate; the results are operator dependent. Analytical methods based on Fourier transform analysis were developed[1] which showed that the measurement can be done in a more precise way. Still, an operator had to determine the beam size out of the spectral data, which can involve an operator dependent error. The first results on BEAMETR technique which use spatial spectral measurement for automatic beam size measurement were reported.[2]

In this paper, BEAMETR technique was further developed to allow for robust operator independent measurement of beam sizes in two coordinates. BEAMETR involves software and a specially designed pattern. In the developed method, the pattern is scanned using an e-beam. A spectra of the signal is analyzed; beam size is automatically determined using a software program.

Both pattern and SEM image may involve fabrication inaccuracies and distortions. The analysis uses an advanced model solving an ill-posed mathematical problem. Tikhonov regularization is used. The software includes an image recognition module, noise reduction technique, and contrast enhancement. The technique also includes reduction of jitter in SEM images. A spectral analysis model allows for the extraction of beam sizes significantly smaller than the minimum feature size of a pattern. The extraction algorithm can work with low contrast, as well as distorted and noisy images.

Results of design, fabrication, and analysis of the BEAMETR test pattern are presented. A specially designed and fabricated test pattern is used with the known spectral characteristic. Special attention was given to optimizing the size of a pattern, so that the high resolution of the method does not require a large number of pixels in SEM image.

Results of beam size measurements using a knife edge method are also presented. Fabrication of a pattern with vertical walls and beam measurements at various beam voltages are discussed. Comparison of knife edge method and BEAMETR technique is presented.

1. J. Kim, K. Jalhadi, S. Deo, S.-Y. Lee, D. Joy, Proc. SPIE v.6152 (2006) 61520T
2. S. Babin, M. Gaevski, D. Joy, M. Machin, A. Martynov, J. Vac. Sci. Technol, B6 (2006) 2956

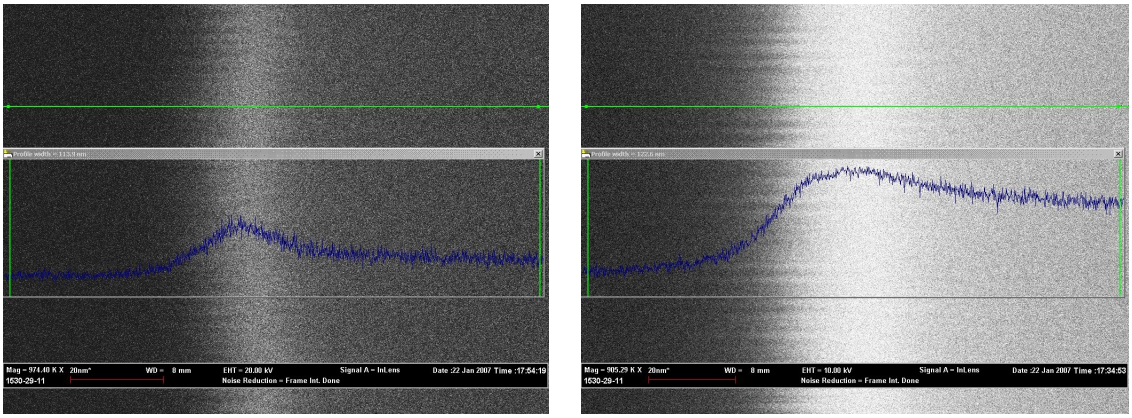

Figure 1. Knife edge measurement technique; SEM images of an edge and signal crossection at a) 2 kV and b) 10 kV electron beams. The field of view is about 120 nm. Signal peak due to backscattered electrons and SEM jitter influence results of beam size measurement, therefore the results are operator dependent.

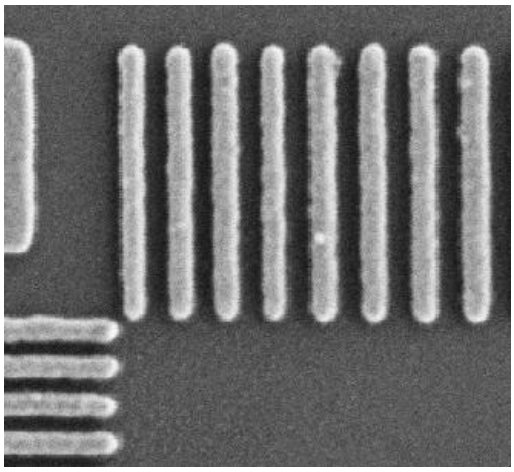

Figure 2. A part of BEAMETR pattern with minimum feature size 35 nm. The technique is independent of operator's decision. This allows for non-subjective comparison of system tuning and performance, as well as comparison of different e-beam systems.