Automatic measurement of electron beam size by BEAMETR technique using 20 nm test patterns

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Beam size is a critical parameter 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, 2] which showed that measurements can be done in a more precise way and can be automated.

In this paper, BEAMETR technique [2] which uses spatial spectral measurement was further developed to allow for robust measurement of electron beam size. BEAMETR involves analysis software and a specific test-pattern. A specially designed and fabricated test pattern is used with the known spectral characteristic. In the developed method, an image of the pattern is taken using an electron beam. A spatial spectrum of the signal is analyzed using a software program and the beam size is automatically determined. The technique is operator independent.

The test pattern was redesigned to improve the technique. It involves variable pitch gratings in the x and y coordinates. The parameters of gratings were optimized so the high resolution of the method does not require a large number of pixels in SEM image. The software analysis was further improved to analyze low contrast images, images with low signal to noise ratio and images with strong distortion.

The test pattern was fabricated using a 100 KeV electron beam lithography system. Proximity correction was applied to improve pattern quality. In this work, the minimum linewidth was 20 nm.

Two methods were used for pattern transfer. One is conventional lift-off of a metal on a silicon wafer. A part of the test pattern is shown in Figure 1. In another method, metal electroplating on a freestanding silicon nitride membrane was used.

A few goals have been achieved compared to the previous BEAMETR version: a smaller number of image pixels is needed, smaller beams can be measured, and the accuracy of measurements was improved. Results of beam size measurements when using different SEM setups and tools are presented. An example of measurement results using BEAMETR is shown in Figure 2.

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

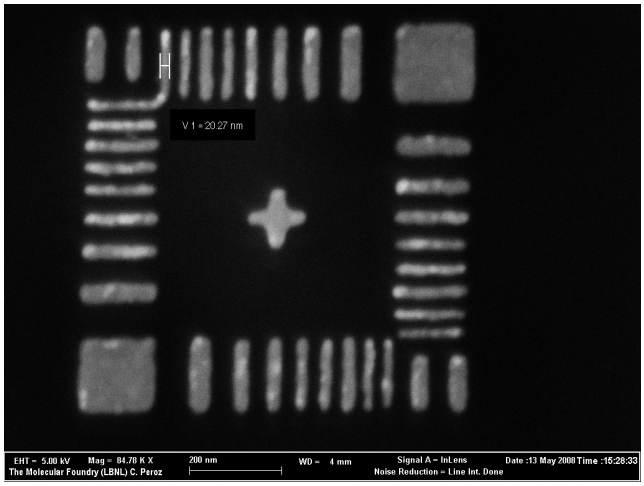

Figure 1. Scanning Electron Microscopy image of BEAMETR pattern with minimum linewidth of 20nm.

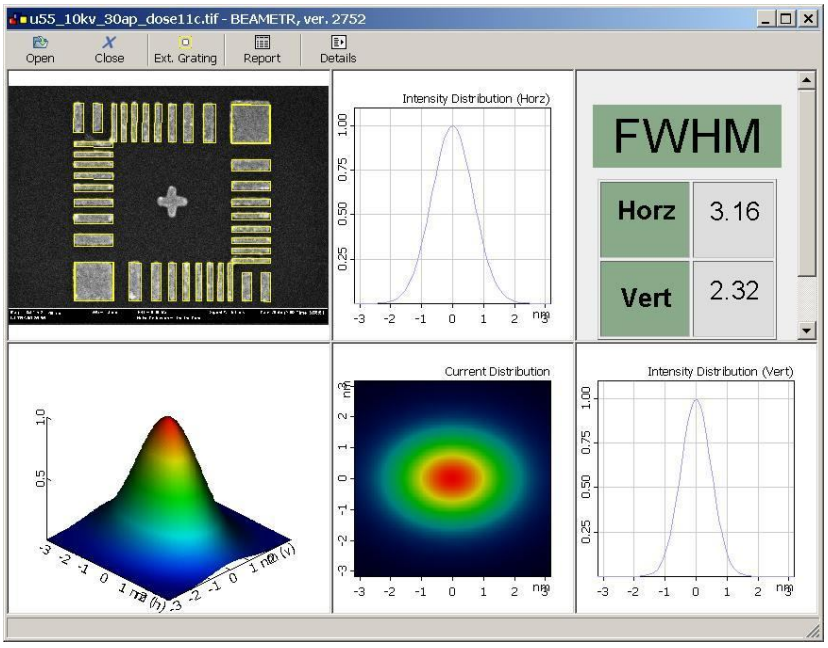

Figure 2. : Example of automatic electron beam size measurement. The measured beam size was 3.2nm in x axis and 2.3 nm in y axis for 10 kV acceleration voltage and 30 µm aperture.