Sub-10nm test-sample for characterization and tuning of focused electron beam used in technology, inspection and diagnostics.

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Control and tuning of focused electron beam is key point when the beam is used for diagnostics (SEM), technology (EBL) or defect and CD inspection. The control is especially important for multi-beam projection system like RIMANA tool [1]. In the report a critical review of existing methods for beam focusing control is presented. Inherent drawbacks of the reviewed methods (like 22nm test pattern in [2]) are low contrast of signal and technological difficulties in fabrication of test samples with accuracy of some nanometers.

Test-samples with high signal contrast and with high fidelity in size are suggested to use [3]. The idea of the test-sample is shown in Fig.1; instead of traditional lateral patterning [2] a planar technology used earlier for fabrication of X-ray Bragg-mirrors is applied. The technology guarantees at least 10% of accuracy in heavy material deposition.

Very simple and original approach was developed to measure beam diameter for test sample containing W layer of 10nm width. A width of signal curve was measured at 3/4 of maximal signal height counting off constant level from bulk Si (similar to method of “half width at half height”). Resulting dependence is shown in Fig.2b. It is seen that the test-sample and measurement method allow characterizing beam diameter with high accuracy.

Also a new test-sample containing four layers (5nm, 10nm, 20nm, 30nm) is fabricated. New measurements and simulations with 5nm W layer at accelerating voltage up to 50keV are presented to confirm high contrast of the signal and high accuracy for focused beam characterization. Simulation performed for W layer of 5nm at 10keV shows that contrast decreases with beam diameter whereas signal width increases. Comparison to experimental results allows estimating beam diameter as 10nm.

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1. Christof Klein, Elmar Platzgummer, Hans Loeschner, and Gerhard Gross, “Progress in projection maskless lithography”, http://spie.org/x19638.xml
2. S. Babin, S. Cabrini, S. Dhuey, B. Harteneck, M. Machina, A. Martynov, C. Peroza, Fabrication of 20nm patterns for automatic measurement of beam size using BEAMETR technique, 34th International conference on micro and nano-engineering, Septermber 15-19 2008, Abstract book, page A4-3.
3. S. Zaitsev, A. Svintsov, Eu. Yakimov, S. Borisov and G. Mozdzen, Registration marks for the characterization and tuning of individual beamlets of a PML2 Tool in the sub-10nm range, accepted for SPIE Advanced Lithography, 22-27 Febr. 2009, San-Jose, CA

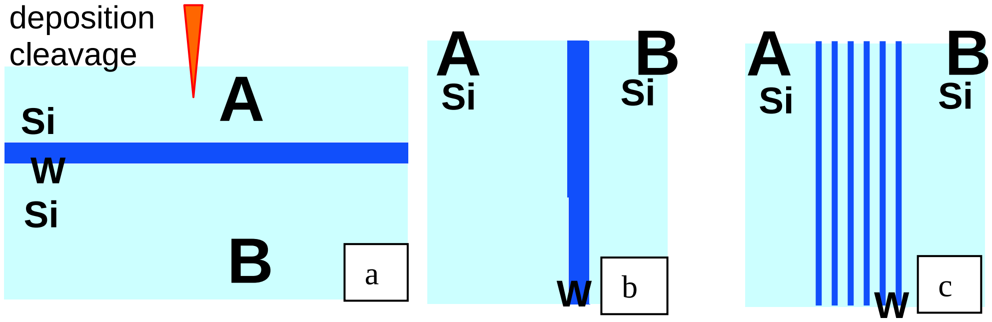

Fig.1 Planar deposition of heavy layer of nanometer size (a) can be used as a test-sample after cleavage (b). Several heavy layers also could be used (c).

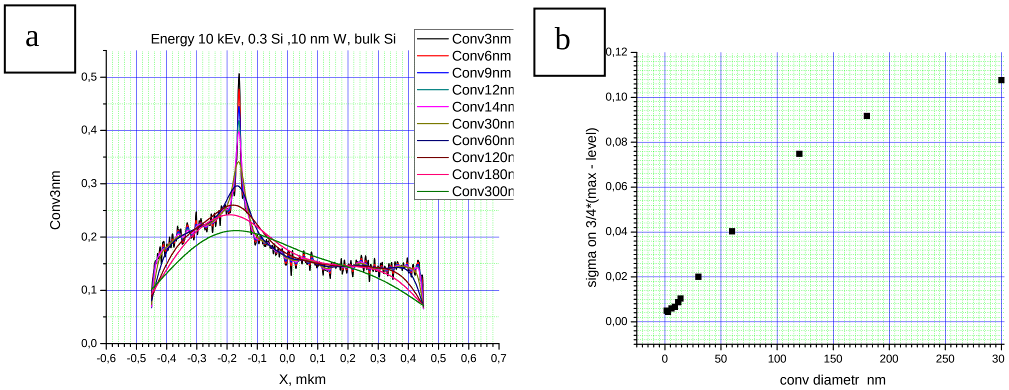

Fig.2 (a) BSE signals (simulation) of the test-sample consisting of (from left to right) 300nm of Si, 10nm of W, bulk Si simulated for a set of beam diameter (from 3nm to 300nm). The curves become wider with increase of beam diameter. (b) Width of the curve (sigma) measured at 3/4 of height as function of beam diameter is remarkably dependent on beam diameter allows to measure beam diameter, high accuracy and resolution can be achieved.

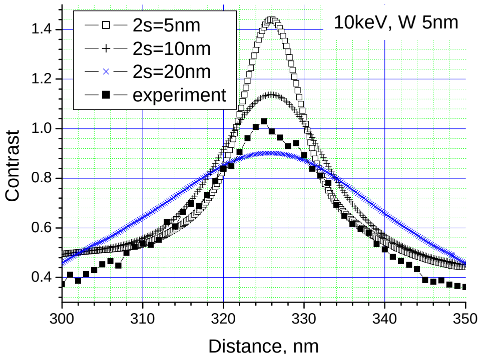

Fig.3 High contrast experimental BSE signal for 10keV electrons from W layer of 5nm (solid squares), comparison to simulation data (beam diameter 2s=5, 10, 20nm) show that experimental beam diameter is about 10nm.

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