Fast Prototyping of Functional Devices Using a DualBeam

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DualBeams (FIB-SEM) have been used for materials characterization and failure analysis for many years. Their capability to perform direct write patterning and prototyping has also been explored for some time [1]. Key components to successful prototyping with a Dualbeam are a high performance focused ion beam with time-of-flight correction and differential pumping, a high resolution pattern engine, adequate pre-cursor chemistries for selective etching and deposition as well as software that allows for automation of patterning processes.

State of the art FIBs provide resolution of sub-5 nm resolution at 30 keV, while maintaining high current density and stable focusing optics for large beam currents (up to 65 nA) [2]. Time-of-flight correction and differential pumping provide for more accurate direct writing at short dwell times (figure 1) and improved resolution while using gas injection for deposition and selective etch. Integration of a high-resolution 16-bit patterning engine allows the user to access up to 65,000 X 65,000 points for a given field width and a pattern memory of up to 8 million points.

Chemical precursors used in conjunction with the DualBeam can provide an expanded capability to create 2D and 3D nano- and micro-scale structures. Precursor molecules are adsorbed onto the surface and then decomposed by the SEM or FIB to form a deposition [3]. To aid in state-of-the-art experimentation and growing direct write applications, FEI has designed a new gas delivery module that allows control of pumping speed and independent gas mixing. Together with the FEI DualBeam platform, users can precisely control each parameter of deposition or etch process in an automated format [4].

Nanoprototyping software that automates multi-site, complex direct-write processes can be an invaluable tool for pattern and process optimization. Nanobuilder provides an environment that automates beam conditions including energy and current, patterning parameters, the use of beam chemistry with the use of onboard patterns GSDII files or stream files using an optional layer-by-layer alignment step.

References:
[1]H.W. Li, D.J. Kang, M.G. Blamire, W.T.S. Huck. *Nanotechnology*, **14** (2003), 220-3
[2]R.J. Young. *Vacuum*, **44** (1993), 353-356
[3] F.A. Stevie, D.P. Griffis, P.E. Russel. Introduction to Focused Ion Beams, eds. L.A. Giannuzzi and F.A. Steve. Springer (2005), 52-72
[4]J.J.L. Mulders, D. Wall, L.Y. Rousell. Microsc. Microanal. 18(Suppl 2). 2012

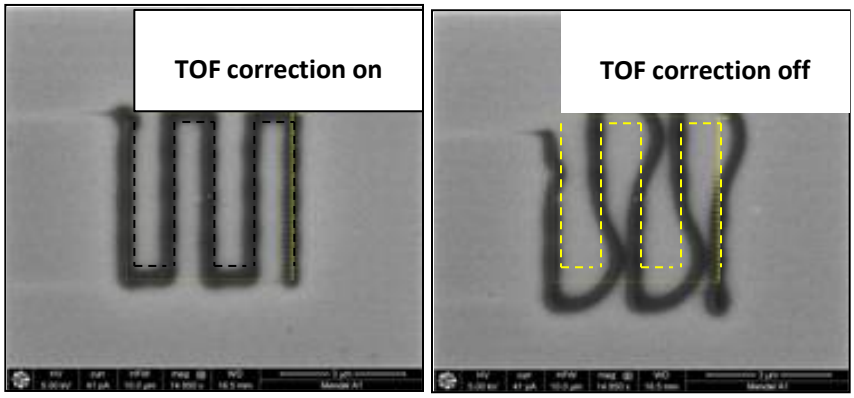

Figure 1. Effect of Time-of-flight correction on scan profile of FIB raster.