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Investigation of slice thickness for FIB tomography in a plasma focused ion beam system

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DualBeam FIB-SEM instrumentation has changed how researchers characterize the microstructure of materials by offering site specific analysis for S/TEM sample preparation and serial section tomography (SST) by FIB. Recent instrumentation using plasma FIB (PFIB) technology and Xe^+ ions offer increased milling rates because of its ability to deliver up 30 – 40 times more current compared to Ga^+ FIBs. This instrumentation has expanded the DualBeam's capability to characterize in 3D a variety of large grain and hard materials by automated FIB tomography [1]. Accurate slice thickness determination remains of interest in the research community for both small and large volumes.

Obtaining a 3D reconstruction by FIB tomography involves acquisition of multiple secondary or back scattered electron images of a material as slices of the material are sequentially milled through a region of interest [2]. During the reconstruction process, corrections like slice alignment and shading removal must be considered to have a successful result. There are a variety of mathematical algorithms available to for alignment in the x-y plane of each image, but corrections for the z-direction must be determined on the actual slice thickness [3]. Methods exist to characterize the slice thickness variation by generating artificial reference structures in the region of interest [3,4].

Using a silicon MetroCal specimen designed to calibrate automated metrology tools, an etched square was rotated so that one corner of the etch feature was centered in the SEM image (Figure 1) [5]. To characterize slice thickness variation, automated FIB tomography experiments for a 100 nm and 5 nm slice thickness were performed using Auto Slice&View 4. The difference in inter-distance of the two features shown in Figure 2 between 2 successive SEM images were measured. The number of pixels measured was multiplied by the size of the x-direction of the pixel to determine the inter-slice distance (slice thickness). For small slice thickness determination the experiment employed a 30 keV, 300 pA probe. For large slice thickness (100 nm), a 30 kV, 59 nA probe was used. Both experiments were performed on a Thermo Scientific Helios G4 PFIB DualBeam. In the 5 nm FIB tomography experiment of 200 slices, results reveal an average slice thickness of 5.4 nm with a standard deviation of 1.2 nm over 50 slices. The 100 nm FIB tomography experiment revealed an average slice thickness of 103 nm with a standard deviation of 7 nm over 55 slices.

References:
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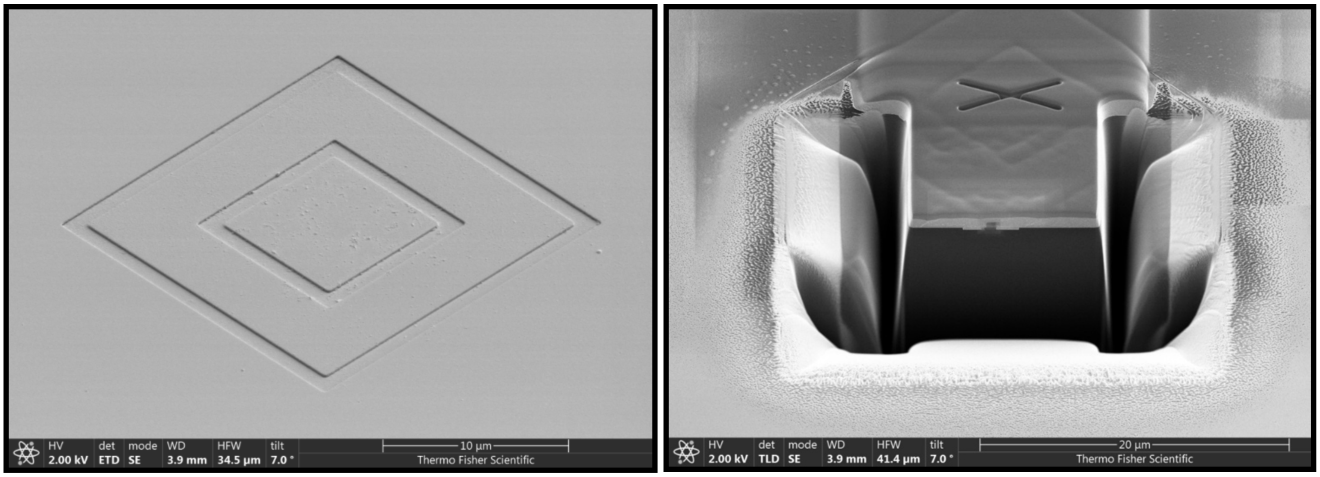

Figure 1. a) 2 keV SEM image of MetroCal etched square feature; b) 2 keV SEM image of FIB prepared cross-section site for PFIB tomography.

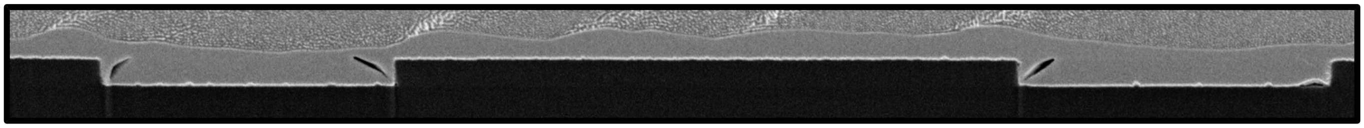

Figure 2. 2 keV SEM cross-sectional image of MetroCal etched square feature. HFW is 6.38 µm, while the image resolution is 1 nm/pixel.

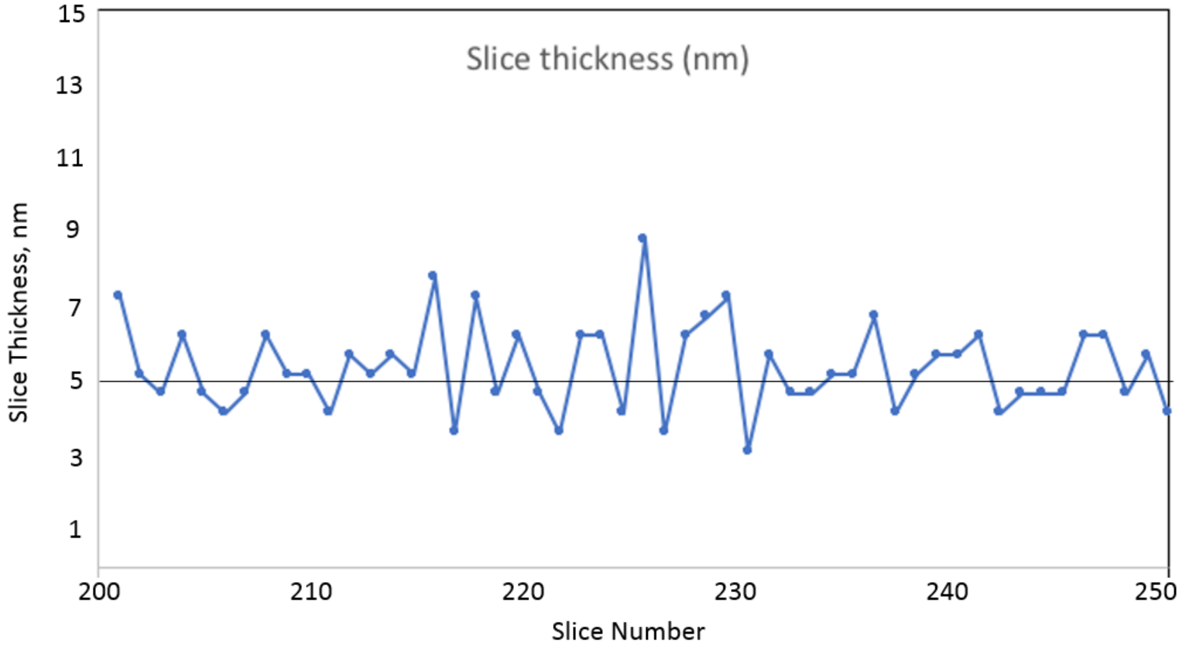

Chart 1. Summary of slice thickness measurement for 50 slices from a 200-slice acquisition