Glancing Angle Method for Bulk Material Removal in Cross-sectioning and TEM Sample Preparation by Ion Beam

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Introduction

Advances in Focused Ion Beam (FIB) instrumentation and control software have transformed FIB preparation of samples for electron microscopy (1) into a routine procedure, however FIB cross-sectioning and TEM sample preparation still remains a time-consuming process. Dependence of etching yield on the angle of ion beam incidence is known (2) and differences of etching in up-slope vs. down-slope directions were explored (3). Nonetheless FIB etching at glancing angle (4) has not yet become commonplace in practical applications. We tested FIB etching of silicon material with multiple-raster and single-raster scanning at glancing angle of ion beam incidence, and evaluated the possibility of using glancing angle etching processes for practical application of producing FIB cross-sections.

Multiple Raster Tests

Multiple raster tests were completed on a FIB 620 Dual-Beam machine with a 30kV Ga ion beam, 2.7nA beam current, and 20µm x 10µm box dimensions. To compensate for geometrical distortion at the glancing angle, the dimensions were adjusted to maintain a constant area of exposure to the ion beam.

Single Raster Tests

Single raster tests were completed on a Micron 2510 FIB tool with a 50kV Ga ion beam, 1nA beam current, a dose of 1x10¹⁰ ions/µm² and 20µm x 20µm box dimensions. To compensate for geometrical distortion at the glancing angle, the dimensions of the box and dose of ion beam exposure were adjusted to maintain a constant area and exposure of sample surface to the ion beam.

Results

We evaluated dependency of sputtering materials by FIB on the angle of ion beam incidence with multiple-raster and single-raster etching, and observed an increase in volume of material removed at glancing angle of incidence in both cases. Utilizing glancing-angle etching with multiple raster scanning to enhance removal of material in cross-sectioning application proved difficult at this time (Img. 3&4), but we were able to demonstrate the concept of cross-sectioning with enhanced material removal at glancing angle with single-raster scanning in up-slope direction (Img. 6).

Future Directions

Promising results of single raster etching at glancing angle suggest possibility of using glancing-angle etching processes in practical applications of FIB cross-sectioning and TEM sample preparation applications. However, this process clearly requires more attention from the operator of the FIB to perform each step of the cross-section. Practical implementation of the glancing-angle cross-sectioning process would require developing scripts to automate setting up the multiple parameters for each cut, thereby reducing the time and cost associated with completing cross sections. Work on creating practical cross-sectioning application with multiple-raster etching is ongoing.

References


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