Transmission electron microscopy sample preparation employing a "triple" beam instrument

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The continuous shrinking of microelectronic structures has made transmission electron microscopy an indispensable tool for structural characterization and chemical analysis of the smallest and most critical structures in semiconductor manufacturing.
As a consequence also of the rapid evolution of TEM technology, preparation methods for delivering samples that provide a minimum thickness at minimum surface damage and roughness have tremendously gained in importance.

State-of-the-art combined scanning electron microscope (SEM) / focused ion beam (FIB) instruments are generally capable of providing high quality site specific cross-section samples of layered materials with high throughput and precision[1]. However, while SEM defect localisation and observation already reduces the amount of beam induced damage to the sample, the FIB milling procedure typically still causes a significant surface amorphisation that potentially degrades the achievable TEM image quality.

One proven method for reducing the amorphous layer in a FIB prepared sample is the use of an Argon ion gun to remove the damaged surface by gentle sputtering at low voltages (1 kV to 500V) typically employing a dedicated preparation chamber[2].

The system presented now combines the SEM/FIB preparation technique with an Argon gun within a single instrument and the three beams being coincident on the sample surface. It will be shown that this "triple" beam instrument allows exploiting the advantages of both techniques, namely speed and accuracy of a SEM/FIB instrument and the gentle milling capability of an Argon ion beam. Additionally, the essential feature of high resolution live imaging of the FIB preparation process is extended to also include live imaging during Argon ion beam milling. Example images will demonstrate the achievable TEM sample quality.

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[1] H. Hoffmeister, A. Schertel, A. Thesen, P. Gnauck, “New Developments in CrossBeam® Technology”, Proc. of M&M 2006, 1244CD

[2] S. Sadayama, H. Takahashi, K, Iwasaki, T. Fujii, “FIB Damage Reduction Technique in TEM Membrane Using Triple Beam System”, Proc. of M&M 2006, 1298CD

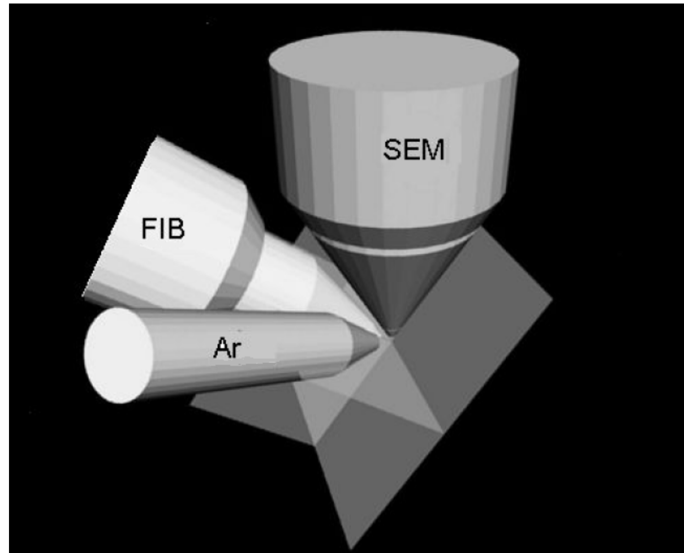
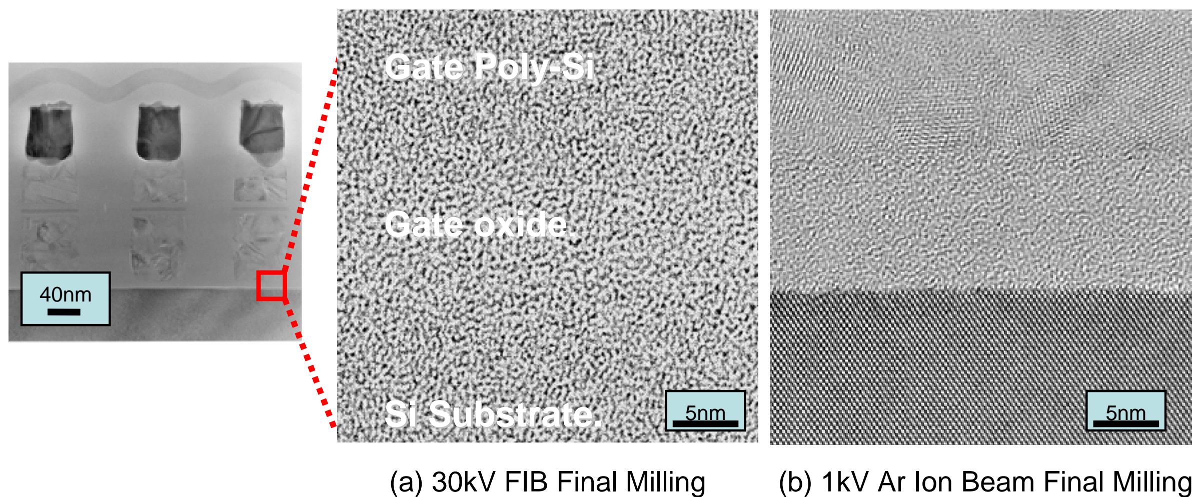


Fig. 1 Basic Configuration of a Triple Beam Instrument: All three beams, EB, FIB and Ar ion beam, are coincident in a single point on the specimen surface. Real time live SEM imaging during FIB as well as Argon ion beam milling allows close control of the preparation process



(a) 30kV FIB Final Milling (b) 1kV Ar Ion Beam Final Milling

Fig. 2 TEM Observation of sample prepared using "triple" beam technology: Gate oxides of a 65nm node NAND Flash Memory were investigated using TEM imaging. The application of 1 kV Argon ion beam final milling/polishing in the TEM lamella preparation allows easy visualization of the lattice structure of the sample. A specific portion of a specimen is observed by this method.