Focused Ion Beam (FIB) Applications in Nanofabrication, Nanomanipulation, Microscopy, and Microanalysis

P.E. Russell, Analytical Instrumentation Facility and Dept. Materials Science and Engineering, NC State University, Raleigh, NC, USA 27695-7531

Focused Ion Beam (FIB) systems can be used for a wide range of demanding sample preparation tasks. The site-specific milling and excellent imaging capabilities of the FIB in combination with the additional features of material deposition, mechanical micromanipulation, gas injection, and selective and chemically enhanced etching of selected materials makes the FIB system an extremely useful and versatile instrument for sample preparation techniques. The Focused Ion Beam (FIB) system is a versatile tool that can be applied to the preparation of a wide variety of materials for microscopy and microanalysis. The versatility of FIB stems from the fact that this tool can be used to both remove and add material from a substrate. In this work, a variety of semiconductor and other non-traditional applications for FIB are presented.

Both FEI and Hitachi High Technologies focused ion beam systems were used to perform site-specific modifications of a variety of samples. These modifications include both cross sectioning and materials deposition. Samples ranged from polymer nanofibers to biological cells as well as semiconductors to thin film metal and ceramic coatings. For the investigations in this work, we utilized beam energies of 5 to 40kV and beam currents ranging from 30nA down to 10pA. Examples presented include analysis of collagen clad polyester nanofibers and a carbon fiber/epoxy resin composite, as well as numerous semiconductor and optoelectronics applications.

To illustrate the challenges (and solutions) involved with FIB based analysis of complex non-traditional samples, examples of fiber analysis are presented. The first example required cross sectioning and examination of non-woven polyester nanofibers with a collagen cladding that were produced using a novel electro spinning process. The goal of the analysis was to determine the presence of, and if present, the thickness of the collagen cladding and to determine the size of the polyester core. A large area view of the sample after cross sectioning and a higher magnification view of individual fibers are presented. It was determined from the cross section that the selectively sputtered polyester core diameters range from ~100nm to 250nm, while the remaining intact collagen cladding thicknesses range from ~100nm to 200nm in diameter.

Another example involves the determination of the ability of resin filler to intimately contact embedded graphite fibers in an epoxy resin/carbon fiber composite material. This material is a candidate for aircraft applications; hence it is important to determine that the resin adheres to the fibers and that there are no voids in the resin. Images showing a large area and a higher magnification FIB induced secondary electron images of this epoxy resin/fiber composite after FIB sputtering are utilized. The results show that the resin sputters faster than the carbon fibers thus providing the delineation required to determine that the resin/fiber contact is free of voids. Although the ends of the graphite fibers are clearly damaged by the FIB ion beam, the damage does not impact on the ability to determine the quality of the resin adhesion.