Focused Ion Beam (FIB), E-beam lithography, and *in-situ* Microscopy in Investigating Mechanical Properties of Nano-Scale Materials.

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Abstract

Recent advances in the 2-beam focused ion beam (FIB) and electron beam technologies have enabled researchers to not only perform high-precision nanolithography and micro-machining, but also to apply these novel fabrication techniques to investigating a broad range of materials' properties at the micron and nano scales. In our work, both the FIB and E-beam lithography are utilized in manufacturing of nano- and micron-sized cylinders from different materials, as well as of TEM cross-sections to directly investigate the link between mechanical properties of materials at these small length scales and evolved morphology and microstructure. We present results of *in-situ* uniaxial deformation (compression and tension) of vertical nano-pillars, ranging in diameter between 100nm and 1micron fabricated by these techniques, as well as of carbon nanotube (CNT) foams with tens of microns diameters. Several types of materials are investigated: single crystals, nanocrystalline metals, and metallic glasses, as well as CNTs. Experiments are performed in a one-of-a-kind instrument, SEMentor, combined of Scanning Electron Microscope (SEM) and Nanoindenter. All samples show significant size-dependent mechanical properties, remarkably distinct from their bulk counterparts. These phenomena are discussed in the context of unique evolved microstructures.

Keywords: Focused Ion Beam (FIB); E-beam lithography, Nano-mechanics; Micromachining; TEM; Plasticity.

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