Mechanical Properties of Semiconductor Nanowires

M. A. (Aman) Haque
Department of Mechanical and Nuclear Engineering
Penn State University, Tel: (814-865-4248), Email: mah37@psu.edu

Semiconductor nanowires show strong size effects in individual (electrical, mechanical and thermal) domains as well as strong inter-domain coupling. These one dimensional materials will play important role as both interconnect and functional units in fabricating electronic, optoelectronic, electrochemical, and electro mechanical devices with nanoscale dimensions. However, little is known about the individual and multi-domain mechanics, mainly because of the experimental challenges at the nanoscale.

Understanding the mechanics of nanowires and the processes involved with relevant nanofabrication processes is necessary to fully utilize their scientific and technological uniqueness. In this presentation, we will discuss two issues:

(i) In-process residual stress development in nanowires due to the fluid loading effects of nanowire-based fabrication processes. We will show how stress gradients appear across the diameter due to fluid loading and discuss the implications on fabrication of future nano-devices.

(ii) Mechanical characterization of nanowires. Specifically, we will present a MEMS test bed and specimen preparation techniques for uniaxial loading of nanotubes and nanowires. The technique is capable of loading and measuring forces with nano-Newton resolution and displacement with nanometer resolution. The advantage of the proposed technique is that it is independent of the chemistry and structure of specimen material and hence can be applied to any type of nanostructural materials. The MEMS device is also capable of performing coupled electromechanical and thermomechanical studies of nanoscale materials. Unusual properties, for example enhanced fracture strain of about 6-8%, will be discussed for ZnO nanowires. The implications on nanosensors (ZnO is also a piezo-ceramic material with very large coupling coefficient) development will be discussed.