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Experimental Uniaxial Tensile Characterization of One-Dimensional Nickel Nanowires

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Abstract : Metallic nanowires with sub-micron and hundreds of nanometer diameter have a diversity of applications in nano/micro-electromechanical systems (NEMS/MEMS). Characterizing the mechanical properties of such sub-micron and nano-scale metallic nanowires are tedious; require sophisticated and careful experimentation to be performed within high-powered microscopy systems (scanning electron microscope (SEM), atomic force microscope (AFM)). Also, needed are nanoscale devices for placing the nanowires; loading them with the intended conditions; obtaining the data for load–deflection during the deformation within the high-powered microscopy environment poses significant challenges. Even picking the grown nanowires and placing them correctly within a nanoscale loading device is not an easy task. Mechanical characterizations through experimental methods for such nanowires are still very limited. Various techniques at different levels of fidelity, resolution, and induced errors have been attempted by material science and nanomaterial researchers. The methods for determining the load, deflection within the nanoscale devices also pose a significant problem. The state of the art is thus still at its infancy. All these factors result and is seen in the wide differences in the characterization curves and the reported properties in the current literature. In this paper, we discuss and present our experimental method, results, and discussions of uniaxial tensile loading and the development of subsequent stress–strain characteristics curves for Nickel nanowires. Nickel nanowires in the diameter range of 220–270 nm were obtained in our laboratory via an electrodeposition method, which is a solution based, template method followed in our present work for growing 1-D Nickel nanowires. Process variables such as the presence of magnetic field, its intensity; and varying electrical current density during the electrodeposition process were found to influence the morphological and physical characteristics including crystal orientation, size of the grown nanowires1. To further understand the correlation and influence of electrodeposition process variables, associated formed structural features of our grown Nickel nanowires to their mechanical properties, careful experiments within scanning electron microscope (SEM) were conducted. Details of the uniaxial tensile characterization, testing methodology, nanoscale testing device, load–deflection characteristics, microscopy images of failure progression, and the subsequent stress–strain curves are discussed and presented.

Keywords : uniaxial tensile characterization, nanowires, electrodeposition, stress-strain, nickel
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