Determination of Mechanical Properties by Indentation in Nanoscale Metallic Wires using Atomic Force Microscopy (AFM)

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Abstract

The primary goal of this research is to determine the mechanical properties of Ni and Au nanowires. Research in this field is critically important because the properties of these wires below 200 nanometers in diameter remain unknown. It is expected that the traditional bulk material property laws do not hold true on the nanoscale. For example, research has shown that both high strength and low temperature ductility are exhibited in metallic nanowires, as opposed to observations made on the same metallic bulk materials. Progress on my project has been made through the use of solid modeling, finite element analysis (FEA), scanning electron microscopy (SEM), and atomic force microscopy (AFM). The first step toward finally determining the properties of Ni and Au nanowires was to characterize the AFM probe. This probe is custom made with a sapphire cantilever and a diamond, cube corner tip, and was characterized in two steps, starting with imaging the probe using SEM as well as AFM with a special test grating. The second part of the characterization was to model the probe using SolidWorks, and then to determine the cantilever's natural frequency with the built in FEA. After completion, the second step was to model the contact of the nanoindentation, which is currently in progress and being refined. This contact is most closely a non-linear elastic-plastic relationship. Third, calibration of the AFM was required to validate results in the future. Achieving success in the prior three steps will result in the smallest error in results for the final step of nanoindentation, which will be used to determine the mechanical properties of Ni and Au nanowires. Developing a specific procedure for the calibration, but additionally for the four steps will set an industry standard in determining the mechanical properties of metallic nanowires using AFM.