

**MATERIALS ENGINEERING
SEMINAR**

“Strengthening Mechanisms in Nanostructured Materials”

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ABSTRACT

Understanding the behavior of materials with nanoscale features is important because of both the size of engineering devices and the internal microstructure of more bulk materials. Many electronic components have been miniaturized in recent years to attend the high demand of technology development. Similarly, new stronger bulk metallic materials use nm-scale grain sizes or precipitates to increase their strength over more conventionally processed alloys. Nanoscale testing also offers a route for mechanical behavior understanding at the microscale. Nanoindentation has been used to find structure-properties relationships of nanostructured materials due to its high load depth resolution and versatility of the test. Nanoindentation can be used to find hardness and modulus of the materials, important characteristics to evaluate mechanical performance. An introduction to strengthening mechanism and generalities of nanoindentation is shown as a preamble for this presentation.

This thesis explores how traditional strengthening mechanisms for bulk materials, can be applied to nanomaterials and how the microstructure could be tailored to achieve the desired outcomes on the specific materials studied. The first one is the study of mechanical properties of Nanometallic Foams (NMF) and its relationship with the nanostructure. NMFs of pure copper, CuNi and CuZn alloys were fabricated and tested to find the predominant structural and chemical parameters of the mechanical properties. Research on how to control and tailor the structural parameters of NMF with viscosity of the precursors is shown as well. The relative density was the most predominant parameter among the structural parameters studied. However, when relative density parameter is isolated, NMF are more susceptible to strengthen by second phase precipitation instead of solid solution. The solid solution strengthening mechanism was validated with MD simulation and agrees with the experimental findings that showed the addition of Ni atoms to Cu have a moderate effect on the mechanical properties. The second example presented shows the strengthening effect of precipitates in nanometallic multilayer. The precipitation was achieved by aging treatment. High-temperature nanomechanical testing is also presented. The third and final example shows how the second phase precipitation and dispersion strengthening of lead-free solder SAC 305 compares between samples aged for nine years at body temperature and an accelerated aging treatments.

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