

## Announcing the Final Examination of Ying Sun for the degree of Doctor of Philosophy

Time & Location: November 13, 2009 at 2:00 PM in 40 307

Title: Mechanical Properties of Carbon Nanotube/Metal Composites

Carbon nanotubes (CNTs) captured great attention worldwide since its discovery in 1991. CNTs were considered as the stiffest and strongest material owing to their perfect atomic arrangement and intrinsic strong in-plane sp<sup>2</sup>-sp<sup>2</sup> covalent bonds between carbon atoms. In addition to mechanical properties, CNTs also have showed exceptional chemical, electrical and thermal properties. All these aspects make CNTs promising candidates to develop novel multi-functional nanocomposites.

How to utilize CNTs as fillers to develop advanced nanocomposites still remains as a challenge, due to lacks of fundamental understanding on both material processing in nanometer scale and resultant material properties. A new model and theoretic equations were developed to investigate the effect of controlling parameters on resultant mechanical properties of carbon nanotubes composites. The new theory can be used to guide development of advanced composites by using carbon nanotubes as well as any nano-fibers, with any matrices (ceramic, metal, or polymer). Our study already showed that the effect of carbon nanotubes dimension and concentration fit the theoretic curve very well.

Metallic carbon nanotubes (both SWNTs and MWNTs) composites have been developed by using a novel electrochemical co-deposition process. Copper and nickel matrices composites were developed by using pulse-reverse electrochemical co-deposition. Uniaxial tensile tests results showed that more than 300% increase in strength than pure metal has been achieved. For example, the ultimate tensile strength of Ni/CNTs composites reaches as high as about 2GPa. These are first time experimental results ever reported so far. The results are mainly attributed to the good interfacial bonding between CNT and metal matrices and good dispersion of carbon nanotubes within the matrices. Experimental results have also shown that the strength is inversely dependent on the diameter of carbon nanotubes.

In addition to the mechanical strength, carbon nanotubes reinforced metallic composites are excellent multifunctional materials in terms of electrical and thermal conduction. . The electrical resistivity of carbon nanotubes/copper composites produces electrical resistivity of about 1.0~1.2 x10<sup>-6</sup>ohm-cm, which is about 40% less than the pure copper. The reduced electrical resistivity is attributed to the good interface bonding between carbon nanotubes and metal matrices, realized by the electrochemical co-deposition.

Along with the study of carbon nanotubes composites, a study of effects of nanometer sized metal like copper on mechanical strength was also carried out. Nano-crystallized copper was synthesized by using electro-chemical deposition. Ordered pattern of nanometer (as small as 10nm) Cu grains was formed and the mechanical properties were investigated. Results showed that the tensile strength is inversely proportional to the Cu grain size.

Major: Materials Science and Engineering

Educational Career:

Bachelor's of Materials Science and Engineering, 1999, Jilin University

Master's of Materials Science and Engineering, 2002, Shanghai Institute of Ceramics, Chinese Academy of Sciences

Committee in Charge:

Quanfang Chen, Chair, MMAE

David Nicholson, MMAE

Kevin Coffey, MMAE

Jiyu Fang, MMAE

Lee Chow, Department of Physics

Approved for distribution by Quanfang Chen, Committee Chair, on September 1, 2009.

The public is welcome to attend.