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COLLOQUIUM

The AAE Spring 2007 Colloquium Series

Mechanical Behavior of Polymeric Nanofibers Subject to Cold Drawing

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GRIS 180

ABSTRACT

This presentation will report on the effect of rate of cold drawing on the mechanical behavior of electrospun polyacrylonitrile (PAN) nanofibers with 200-500 nm diameters and lengths varying between 10-60 microns. The investigation was conducted using a novel MEMS-based mechanical property-testing platform that allowed for measurements at different drawing rates. The effective fiber mechanical response was elastic-nearly perfectly plastic for the three effective strain rates (0.025 s^{-1}, 0.0025 s^{-1}, 0.00025 s^{-1}) that were employed. The fiber strength was 90±30 MPa and the ultimate strain was 200±20%. The elastic modulus as determined from the slope of the unloading stress-strain curves was 7.6±1.5 GPa.

At all strain rates, the elastic modulus, fiber yield and ultimate strength increased with decreasing fiber diameter. The elastic modulus and the yield strength were insensitive to the fiber length, but the ultimate strain, although insensitive to the fiber diameter, it decreased significantly for the longer fibers. On the other hand, the effect of strain rate was not as uniform: The trends for strain rates 0.025 s^{-1} and 0.0025 s^{-1} were as expected: Increasing strain rate caused a decrease in ductility and an increase in the fiber strength. On the other hand, no appreciable dependence of the modulus of elasticity on the strain rate was observed. These trends were reversed in the tests conducted under 0.00025 s^{-1} strain rate: The yield and ultimate strength were consistently higher by almost a factor of two compared to the faster drawing rates. Similarly, at the slow strain rate the increased fiber strength was accompanied by enhanced ductility compared to faster strain rates. These initially conflicting trends were explained by electron microscopy imaging that pointed to two different rate dependent mechanisms of deformation that will be discussed in detail in this presentation.

Bio

Ioannis Chasiotis received his Ph.D. and M.S. degrees in Aeronautics with a minor in Materials Science from the California Institute of Technology in 2001 and 1998, respectively, and his Diploma in Chemical Engineering in Greece in 1996. From 2001 to 2004 he was an Assistant Professor of Mechanical and Aerospace Engineering at the University of Virginia. In 2005 he joined the Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign where he is also affiliated with the Beckman Institute for Advanced Science and Technology. His research focuses on experimental mechanics of thin films, MEMS/NEMS, and nanostructured materials and composites with emphasis on nanoscale deformation and failure.

An informal coffee & cookie reception will be held prior to the lecture at 2:30 p.m. in GRIS 390