NANOHOUR

Wednesday, October 18, 2006
3:00 PM, Beckman Institute - Room 3269

Processing and Characterization of Multiscale Hybrid Composites

Piyush R. Thakre, working with Prof. Dimitris C. Lagoudas, Materials Science and Engineering Program, Department of Aerospace Engineering, Texas A&M University

Aerospace industry demands the design of lightweight structures with inherent durability, damage tolerance and multifunctionality for high performance vehicles. Polymer matrix composite laminates are now commonly used in aerospace fields due to their lighter weight, superior mechanical properties and ability to be molded into complex shapes. To ensure continuity of successful application of composite structures to aerospace vehicles, it is necessary to develop new material systems that meet the demanding requirements. Some of the recent investigations are focused on assessing the possible applications of nanoparticles like carbon nanotubes in conventional composites for structural applications or multi-functional applications.

Present work focuses on selective placement of single walled carbon nanotubes (SWCNTs) in woven carbon fabric-epoxy matrix composites. Vacuum assisted resin transfer molding (VARTM) process has been used for the processing of these multiscale hybrid composites (MHCs) because of its several advantages over conventional resin transfer molding and autoclave process and also due to its ease of scalability. Selective placement of pristine and functionalized nanotubes has been achieved through spraying process. Functionalized nanotubes have been used to achieve better dispersion and bonding characteristics.

Composite laminates contain nanoscale reinforcements as SWCNTs, micron size fibers and macro scale laminae. Multiscale nature of the composite requires advanced characterization at multiple scales along with the conventional characterization to understand the effect of the presence of nanotubes. Conventional testing methods like short beam shear tests and double cantilever beam tests have been performed to characterize the macroscale behavior of the composites. The presence of functionalized nanotubes showed a distinct behavior in crack propagation and fracture surfaces with respect to the base material. To discern this behavior and understand physical phenomenon at nano and micro scale, requires advanced characterization techniques like Raman micromechanical tests, nanoindentation and high resolution microscopy.

AND

Multiscale Modeling of Carbon Nanotube Sprayed Carbon Fiber Composites via Micromechanics

Gary D. Seidel working with Prof. Dimitris C. Lagoudas, Materials Science and Engineering Program, Department of Aerospace Engineering, Texas A&M University

Carbon nanotube reinforced polymer composites are attracting much interest as multifunctional materials. Two key issues which have emerged in such composites are the adequate dispersion of carbon nanotubes within the polymer matrix and good adhesion between the carbon nanotubes and surrounding matrix. Efforts to address both issues from a processing point of view have identified chemical functionalization of carbon nanotubes as one solution, leading to an increased importance of the interphase region between carbon nanotubes and the surrounding matrix. Differing forms of carbon nanotube functionalization affect both interphase thickness and how the material properties within the interphase vary through the thickness. The interphase region in these composites can therefore be modeled as a functionally graded material.

Recently, molecular dynamics simulations have revealed the presence of a functionally graded interphase even in non-functionalized carbon nanotube reinforced polymer matrix composites. Because it involves a representation of the atomistic structure, molecular dynamics simulation is well-suited to predicting properties at this local scale. In the molecular dynamics simulations, the density variation can be determined from the molecular structure of the polymer chains packing around the nanotube. This information can then be used in the multi-layered composite cylinders model to examine the effect of the interphase on the elastic properties of carbon nanotube reinforced composites. A multi-scale model can, therefore, be established, which utilizes the atomistic details from the MD and incorporates them into the micromechanical model.

An example of such a multi-scale model is found in the production of CNT-sprayed carbon fiber composites in which carbon fiber laminae are sprayed with CNTs. This introduces a graded interphase at the carbon fiber length scale where the gradation is a result of the variation of CNT volume fraction away from the carbon fiber surface. In the present work, the multi-layered composite cylinders model is used to model a functionally graded interphase region with continuous and with an increasing number of piecewise continuous subregions in discerning the potential impact of nanocomposite coatings in traditional composite materials.

Coffee and cookies will be served.
http://nanohour.beckman.uiuc.edu