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Finite element simulation and characterization of nanostructured textiles

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Abstract

The behavior of a single-walled carbon nanotube complex structures, representing idealized woven cells of single-walled CNTs, is investigated using a spring-based finite element model. Each nanotube is idealized as a spring structure with carbon atoms represented by nodes and interatomic forces, simulated by linear translational and torsional springs. The contact between interweaved nanotubes is due to van der Waals forces, which are responsible for keeping the nanotextile together. These interactions are also simulated by appropriate nonlinear springs. Numerical tests under uniaxial and biaxial tension, pure shear and bending on a single cell of the nanotextile, have demonstrated that the overall stiffness depends strongly on nanotube geometric parameters.

***Key words**: Carbon nanotubes, Nanotextile, Finite element method, Material characterization*

Carbon nanotubes (CNTs) are the stiffest and strongest known fibers, with remarkable electronic and conductive properties and many other unique characteristics. Development of CNT-based textiles could demonstrate their unique structural and conductive properties. Such materials (Sawhney *et al.*, 2008; Li and Ou, 2008; Zhao and Yuan, 2008) could lead to lighter proof clothing, wiring for aircraft and more efficient power-transmission lines, thus contributing to designing lighter and more efficient land, air or marine vehicles. CNT composite fibers have already been produced in a laboratory, using a coagulation-based spinning method (Dalton *et al.*, 2003), making possible the spinning of a reel of a 100 m long nanotube-gel fiber, which when solidified can be weaved into a textile. To explore the full potential of such an achievement, researchers should focus their efforts on developing computer simulation tools for modeling and evaluating the properties and behavior of such structures and ultimately for designing efficient textiles, that would exploit in full the unique characteristics of CNTs.

In this paper, complex structures, representing idealized woven cells of single-walled CNTs, are investigated using the finite element (FE) method, which was successfully implemented in the past for modeling the

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