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Novel Platform for Fabricating and Testing Ultra-high Volume Fraction Aligned-CNT Nanocomposites

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A technique to fabricate high volume fraction vertically-aligned (VA-)CNT nanocomposites using biaxial mechanical densification of VA-CNT forests [1] followed by capillarity-induced wetting [2,3] with unmodified complex thermosets is developed. High volume fractions [4] (up to 22%), approaching posited theoretical limits where inter-CNT spacing approaches characteristic lengths of the polymer chains can be obtained by using these technique . SEMs and WAXS analysis are used to confirm the CNT alignment degree and distribution in thenanocomposites [4]. Differential Scanning Calorimetry and Thermal Gravimetric Analysis were used to evaluate the thermal behavior of the composite with different CNT volume fractions. Experimental results show multi-functional enhancement includes interlaminar shear strength (69% by 1% CNT volume fraction) and electrical conductivity (by the factor of 10^6 to 10^8 with 13% CNT volume fraction) [5] Thermal conductivity measured by depositing a 100-nm Al layer on the CNT-composite surface and using a pump-a-probe technique is enhanced much with the VA-CNTs in nanocomposites. Nanoindentation is used to explore the effective modulus increase due to the VA-CNTs, indicating improvement of 3X at 16% volume fraction of CNTs vs. the pure thermoset polymer. The Off-Lattice Monte Carlo simulation [6] is utilized to model the effects of interfacial thermal boundary resistance (TBR) between the CNT-polymer and CNTs on the heat flow in different orientations of CNTs dispersed in the polymers. The effects of CNT orientation, touching degree, weight fraction and CNT-polymer TBR on the effective conductivity of the nanocomposites are quantified. AC electrical impedance measurements up to 40 MHz are obtained for the nanocomposites as a function of volume fraction along the CNT axis and perpendicular to this axis, demonstrating highly non-isotropic mechanical and other physical properties of the unique VA-CNT nanocomposites.

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