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Manufacturing of Ordered Carbon Nanotube Assemblies

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Abstract

While carbon nanotubes (CNTs) are known for their outstanding properties, manufacturing of large scale assemblies of CNTs with compelling performance is challenging due to limited understanding and control of the CNT network density, order and mechanics. We developed new processes to build highly-ordered CNT assemblies, using vertically aligned (VA) CNT forests as a starting point, relying on understanding the structure-mechanics relationship in CNT forests and the interaction of CNTs with liquids. Capillary forming enables the integration of VA-CNT in applications ranging from microsystems to micro-architectured composites. Elasto-capillary interactions result from shape-directed capillary rise during solvent condensation; followed by evaporation-induced shrinkage of as-grown CNTs. The heterogeneous strain evolution during the liquid-solid interface shrinkage cause 3-D geometric transformations of CNTs. Guided by modeling and in situ experimentation, a portfolio of CNT micro-architectures including straight, bent, folded and helical profiles, are fabricated demonstrating superior mechanical and electrical properties to microfabrication polymers (25 GPa modulus and 10^4 S/m conductivity).

Second, in pursuit of new multifunctional lightweight composites, continuous CNT yarns and sheets are produced by mechanical rolling and capillary assisted joining. The yarns' mechanical stiffness, strength and electrical conductivity can be tuned by engineering the morphology of CNT network.