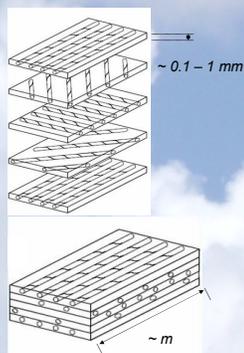


Nano-Engineered Composites

Using nanotechnology to improve aerospace composite materials

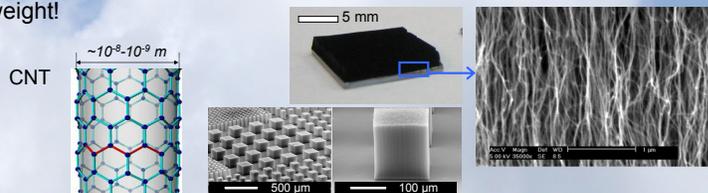
What is a composite?

Composites combine two or more materials to take advantage of each component's properties. Typical aerospace composites are made by layering aligned carbon fibers embedded in a polymer matrix resulting in high mass-specific strength (i.e., light and strong) and stiffness along the fibers, which is critical for aerospace structures. Mechanical properties between layers and other multifunctional properties, however, need further improvement.



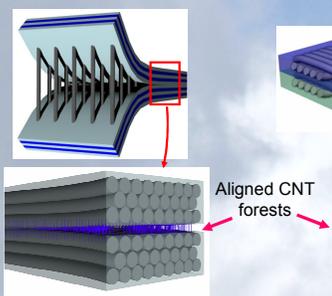
What is a carbon nanotube (CNT)?

A carbon nanotube is a nano-sized hollow tube of carbon atoms. The strong bonding between carbon atoms and molecular structures provide unique properties, CNTs are mechanically strong and stiff, and conduct electricity and heat. More importantly, CNTs are light, 1/10 the density of metals. CNTs can improve composite properties, while adding minimal weight!



Hierarchical Materials - Use aligned CNTs growth to reinforce and tailor existing advanced composites

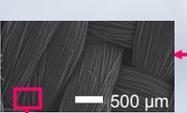
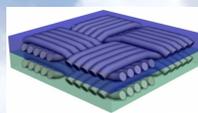
Nanostitching



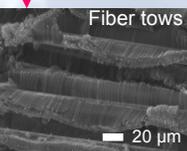
Aligned CNTs extend between fibers and plies provide mechanical reinforcement. With electrically conductive CNT networks, structures can be protected against EM interference or even lightning.

Fuzzy Fiber Reinforced Plastics

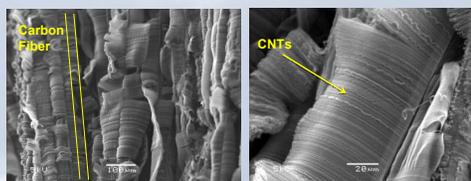
Woven cloth



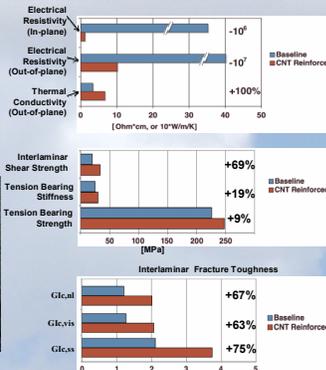
Finished Laminates



Implementation on carbon fibers 2 cm

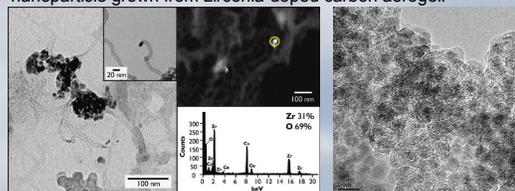


Composite property improvements of Fuzzy Fiber Reinforced Plastics made with alumina fiber



Discovering Non-metallic Catalysts and New CNT Growth Mechanisms

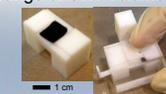
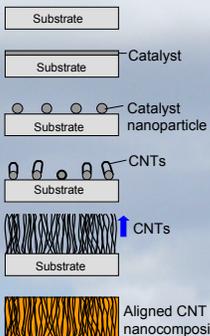
First proven case of nonmetal catalysts: Zirconia catalyst nanoparticle grown from zirconia-doped carbon aerogel.



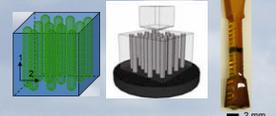
Fullerene cage structures encasing zirconia nanoparticles in pyrolyzed ZrO₂-doped carbon aerogel.

Polymer and Ceramic Matrix Nanocomposites

Mechanical Densification to yield a range of CNT volume fractions



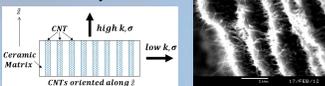
Anisotropic Constitutive Relation Determination



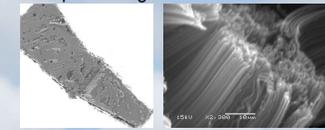
Electrical and Thermal Transport



Tunable Ceramic Nanomaterials with controlled CNT morphology to engineer electrical and thermal conductivity, while maintaining modulus, hardness, and stability.



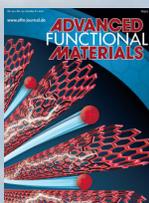
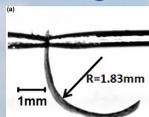
Aligned CNT growth on ceramic surfaces for unique coatings



Optimal Electrodes for Ionic Actuators/Sensors via Nanoengineering

Aligned CNTs at varied volume fractions

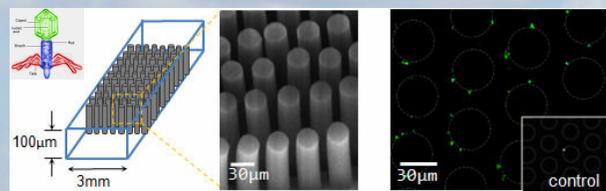
Ion transport through particles vs. aligned CNT forests



Liu et al., Adv. Func. Mat., 2010.

Applications Beyond Aerospace: Biomedical

Permeable CNT elements can isolate bioparticles, such as cancer cells and viruses. They are being developed for quick and low-cost diagnostics.



Chen et al., Small, 2011. Fachin et al., JMEMS, 2011.