NANO HIGHLIGHT
Carbon Nanotubes: Active *in situ* Sensing of Strain and Damage in Advanced Composite Materials

NSF NIRT Grant 0304506
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Recent research by members of the NSF-NIRT team has revealed a means to detect and identify damage within advanced composite materials using a network of carbon nanotubes, which act in a similar manner as human nerves. Composite materials are typically layers of high-performance fibers, such as carbon, glass or Kevlar®, embedded in a plastic resin matrix. These traditional composites have inherent weaknesses because the plastics surrounding the fibers are far less strong than the fibers. Weak spots result near the interface areas and particularly where pockets of resin exist.

Because carbon nanotubes, with diameters of several nanometers (10^{-9} m), are much smaller than conventional fibers, with diameters around 5-20 μm (10^{-6} m), they are able to penetrate areas in between the bundles of fibers and layers of the composite, in the plastic-rich areas (Figure 1). By embedding conductive nanotubes uniformly throughout the composite material, a network is formed in the plastic matrix that is capable of monitoring the health of composite structures. If a microscopic crack forms it breaks the pathway of the sensors and the response can be measured using electrical techniques [2]. Figure 2 shows the deformation / resistance response for a composite tested in tension. Sharp steps in resistance show the accumulation of damage in the composite due to the development of microcracks. The technique is very sensitive to the onset of internal damage.

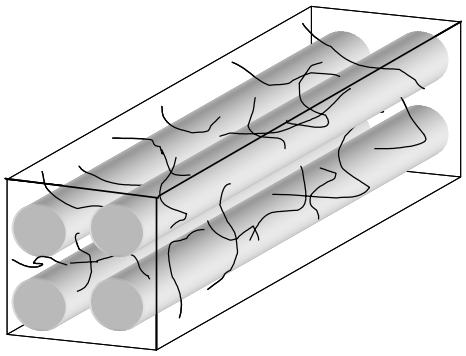

Figure 1. A 3-D schematic showing carbon nanotubes surrounding an array of conventional micron-sized fibers in an advanced composite for in situ sensing.

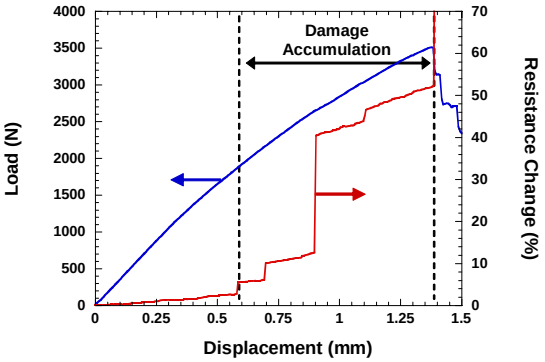

Figure 2. Load-displacement and resistance curves for a composite tested in tension with embedded nanotubes as in situ sensors

The results of this research have important implications both in the laboratory, where engineers and scientists are trying to predict the life-span of composite materials, and in industrial applications, where nanotubes could be utilized as a tool for monitoring the health of composite structures that are used in of a variety of applications, including commercial aircraft.

References

[1] For further information about this project link to <**http://www.me.udel.edu/chou/nirt**>
[2] Erik T. Thostenson and Tsu-Wei Chou "Carbon Nanotube Networks: Sensing of Distributed Strain and Damage for Life Prediction and Self-Healing," *Advanced Materials*, 2006. **18**(22): 2837-2841.