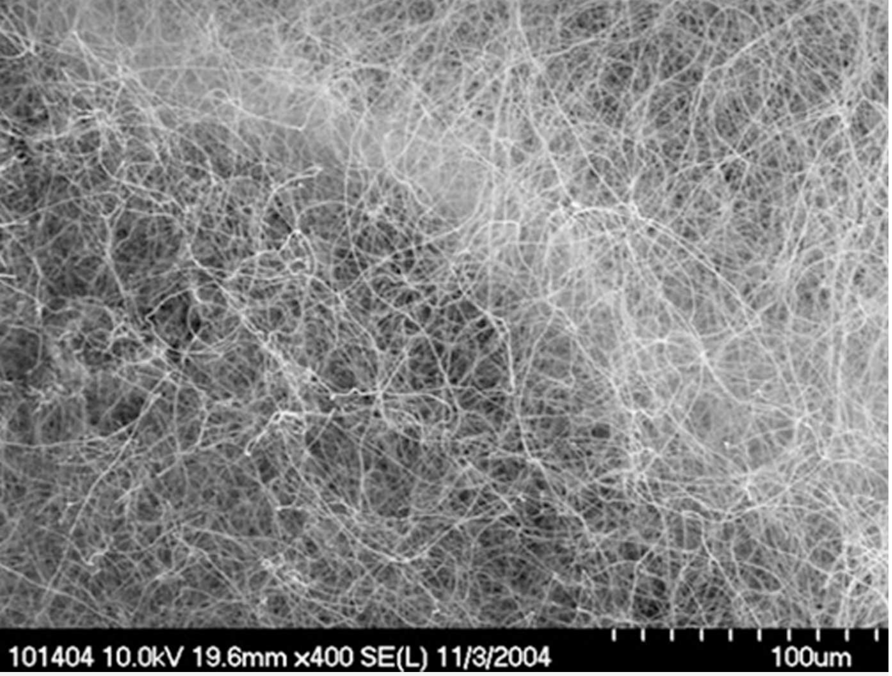

National Aeronautics and
Space Administration

Materials and Coatings

Resistive Heating Method for Higher Performing Carbon Nanotube Composites

A new process for fabricating carbon nanotube composites offers improved load transfer between carbon nanotubes and an engineering matrix

NASA's Langley Research Center scientists have developed a process for fabricating carbon nanotube (CNT) structural nanocomposites that brings CNT-based composites closer to realizing their potential for structural applications. Conventional methods fail to properly wet CNTs within the epoxy matrix, due to high resin viscosity, resulting in poor infiltration and reduced load transfer between the CNTs and matrix. The NASA process, resistive heating assisted epoxy infiltration (RHAEI), uses the CNTs electrical resistance to generate heat which reduces epoxy resin viscosity, for greater CNT wetting and adhesion. Mechanical properties are significantly improved compared to conventional methods. NASA's process has been demonstrated to offer 50% improvement in strength and elastic modulus, with mechanical properties competitive with structural carbon fiber composites.

BENEFITS

- Offers effective load transfer between CNTs and matrices for structural materials
- Reduces processing time from hours to minutes, and eliminates the need for a high temperature autoclave facility
- Makes mechanical properties of the epoxymodified CNT sheets or yarns competitive with those of currently available carbon fiber composites and CNT/polymer composites
- Applicable to high viscosity resin systems not limited to carbon nanofillers or epoxies
- Closed loop control through the use of AC and/or DC voltages and monitoring tools to facilitate delivery of desired levels of power
- Compatible with state-ofthe-art structural fabrication processes - such as vacuum assisted resin transfer molding and additive manufacturing

technology solution

THE TECHNOLOGY

Carbon nanotubes show promise for a wide range of structural applications due to their outstanding mechanical, electrical and thermal properties. However, taking advantage of these properties requires fabricating them in composite form, i.e., CNTs embedded in a solid matrix material and comprising at least 50% of the composite. Mechanical properties of CNT-reinforced nanocomposites have not yet lived up to expectations. This is partly due to poor CNT/matrix wetting which leads to ineffective load transfer. Load transfer is compromised by inadequate CNT concentrations, resulting from high viscosity (due to aggregation of CNTs) and poor wetting of the CNTs in the resin matrix. NASAs invention addresses the need to create strong and stable adhesion between CNTs, and between CNTs and the matrix, through improved infiltration of the CNTs by the epoxy resin.

Resistive heating-assisted epoxy infiltration (RHAEI) involves application of a low voltage to reduce resin viscosity for improved resin infiltration, followed by a higher voltage for rapid curing. With improved wettability and adhesion of the epoxy on the CNTs, the resulting CNT-reinforced composite offers a 50% improvement in mechanical performance compared to those manufactured with conventional thermal curing. Using CNT tapes for reinforcement, tensile properties of ~700 MPa/g/cc specific strength and ~70 GPa/g/cc specific modulus have been attained.

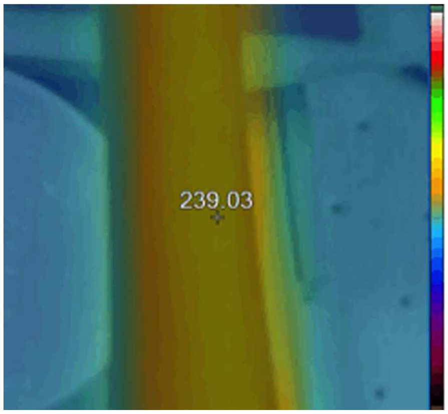

FIGURE 1 - 2-D infrared image with a representative temperature (Celsius) during resistive heating assisted infiltration and cure (RHAIC) process.

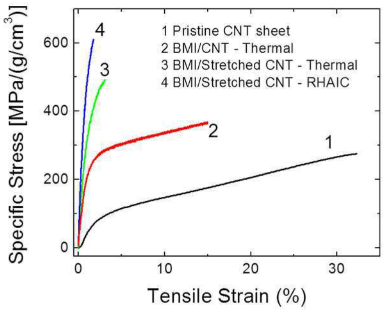

FIGURE 2 - Representative stress-strain curves of the pristine CNT sheet and processed BMI/CNT sheet nanocomposite fabricated by thermal cure and RHAIC.

APPLICATIONS

The technology has several potential applications:

- Aerospace airframe components
  - -- lightweight structural materials
  - -- lightning protection for aircraft
- Construction & Assembly - lightweight, flexible structures
- Defense - lightweight armor
- Mechanical design - thermal management
- Electrical Design - electromagnetic shielding for motor vehicles, solar energy
  facilities, blankets, helmets, etc.

PUBLICATIONS

Patent Pending

More Information

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