TECHNOLOGY MILESTONES

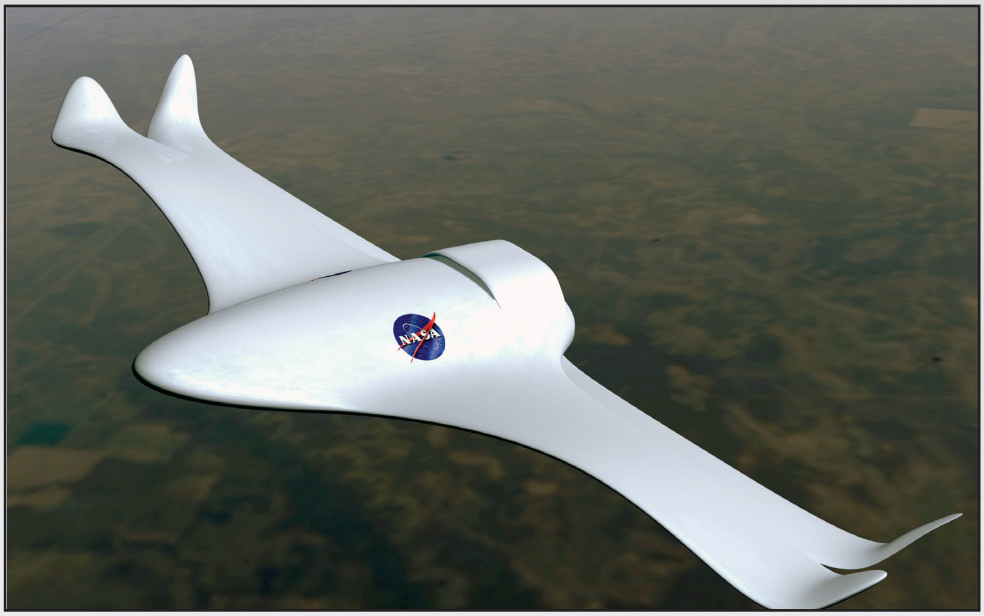
Nanocomposites May Allow Morphing Material Applications

A team from the Air Force Research Laboratory is investigating a new series of stimuli-responsive nanocomposites, which change their mechanical properties when exposed to electric fields and electromagnetic radiation. The mechanical morphing of the new materials is the result of synergistic interactions between the nanofiller and the polymer matrix. The team established a coherent material-performance relationship for electric-field actuation, enabling evaluation and optimization for various structural morphing applications.

This research was the first to clarify the role of carbon nanotubes in electrostrictive polymer nanocomposites (PNCs), thereby focusing subsequent development in the community. It provides a rational basis for the design of PNC-based devices and establishes limits on conductive nanoparticle-filled PNCs for mechanical actuators. It will enable an assessment of the manufacturability of the materials and their use in various Air Force applications.

Lightweight, mechanically adaptive materials are desirable for a broad array of technologies, from medical stents to deployable telescopes and morphing air vehicles. They are crucial for morphing systems including Remotely Piloted Aircraft, low-profile munitions, satellites, and automatic target recognition sensor arrays. However, inadequate temperature stability, cyclability and controls limit their use in some applications. Researchers recognize polymer nanocomposites (PNCs) as a solution to this, but actuation and mechanical adaptivity were not well understood. A realistic assessment of their impact, durability prediction and performance optimization was needed.

Researchers assembled a multi-disciplinary team to investigate the mechanism of electric field actuation in PNCs. They developed predictive mechanical models which showed that PNC electrothermal actuation does not depend on the composition of the nanofiller, but only on the resultant macroscopic conductivity of the PNC. This establishes the rationale for nanofiller selection, amount of nanofiller addition, and processing methods to control morphology.



An artist's rendering of the 21st Century Aerospace Vehicle, nicknamed the Morphing Airplane, shows advanced concepts NASA envisions for an aircraft of the future. Mechanically adaptive materials may help produce future aircraft with morphing capabilities. (AFRL Image)

These findings enable optimization of mechanically adaptive PNCs. They prove that performance is primarily determined by the macroscopic characteristics of the PNC, such as electrical conductivity, heat capacity, and sample dimensions, rather than by the type of nanoparticle used to promote conductivity. It also establishes limits on conductive nanoparticle-filled PNCs for mechanical actuators. It will help focus efforts on next-generation adaptive materials and provides a rational basis for design of PNC-based devices.

For additional information on this technology contact AFRL/RX techinfo@afrl.af.mil, (937)255-6469. To receive more information about AFRL, visit the Homepage at www.wpafb.af.mil/afrl. (RX-11-20_05-11) ***Materials and Manufacturing/Discovery***