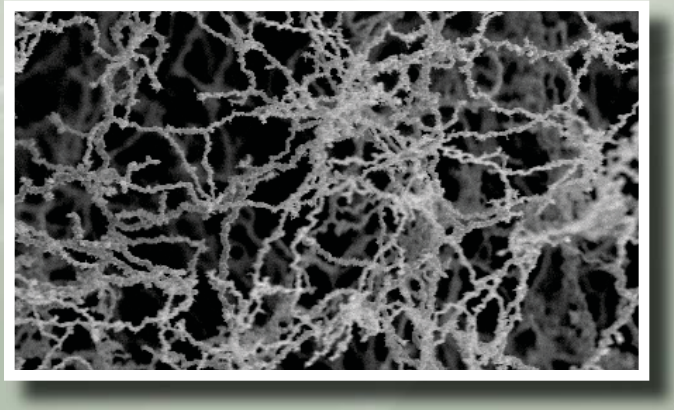
Nickel Nano-Strands for Aircraft Lightning Strike Protection and Electro-Magnetic Shielding

Accomplishment: Electrically conductive structural composites, polymers, paints, adhesives and ceramics have been produced by adding nickel nanostrands that are 100-150 nanometers in diameter and up to a millimeter in length. Manufacturing processes have been established to apply these new materials to a range of military applications.

Impact: Significant protection from lightning strike damage, required for all-weather aircraft operation, has been demonstrated in component-level testing of composite structures with nickel nanostrands. Conductive polymers using nickel nanostrands are being validated for shielding of electronic components from electromagnetic pulses, saving 150 pounds per aircraft over the current metal shielding. Electrically conductive coatings using nickel nanostrands are now fielded in other critical DoD applications.



Motivation and Approach: Commercial aircraft are struck by lighting 1-2 times a year, and all-weather operation required for military aircraft increases the chance of a lightning strike. Graphite/epoxy composites are widely used in aircraft skins and structures but do not have good electrical conductivity due to the composite ply architecture and low breakdown current (the current at which a material no longer conducts electricity) of graphite fibers. The high current (200,000 amps) and voltage (750,000 volts) of a major lightning strike vaporizes the epoxy resin and destroys the graphite fibers, producing significant structural damage. The electromagnetic pulse can also damage critical electronic components in the aircraft. Structural composites are presently protected by adding metal meshes or foils that add significant cost and weight, are damaged by corrosion, and are difficult to repair. Electronics are shielded with metal boxes that add up to 150 pounds per aircraft.

Polymers, including epoxy, are usually non-conductive, but adding only a small volume fraction of nickel nanostrands provides a conductive path due to the nanometer-sized diameter and the millimeter-sized length. Addition of only 2% by volume of nickel nanostrands doubles the electrical conductivity of a graphite/epoxy structural composite. In this accomplishment, nickel nanostrands were developed at Metal Matrix Composites Company, LLC and were characterized and incorporated into conventional structural composite processing and manufacturing at the Materials and Manufacturing Directorate. Techniques were established to produce conductive polymeric surface films by integrating nickel nanostrands into spray painting, wet coating and brushed gel coatings. Nickel nanostrands have also been added to adhesives, thermoplastics and ceramics. A wide range of applications have been identified and are under development and certification testing or have already been inserted into fielded applications.

Team: Research at the Materials and Manufacturing Directorate is led by Max Alexander, with significant contributions from Dr. Jennifer Chase Fielding, Heather Dowdy and Brandon Black. Manufacturing and engineering contributions were funded by an Air Force Small Business Innovation Research (SBIR) program with the Metal Matrix Composites Company, LLC and Eclipse Composite Engineering.