Center for Laser and Plasma for Advanced Manufacturing (CLPAM)

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Extending Damage Limits of Hydraulic Systems in Military Aircraft

Titanium tubing provides the critical arteries of hydraulic systems in military aircraft. The tubing is comprised of thin-walled tubes capable of withstanding high pressures in the range of 5,000 psi. Research at the Center for Lasers and Plasmas for Advanced Manufacturing (CLPAM) at the University of Virginia has helped in assessing the ability to expand the damage limits of the tubing; that is, how much sustained damage can be safely tolerated.

Example of military aircraft Osprey which uses Ti alloy tubings for hydraulic controls of the aircraft.

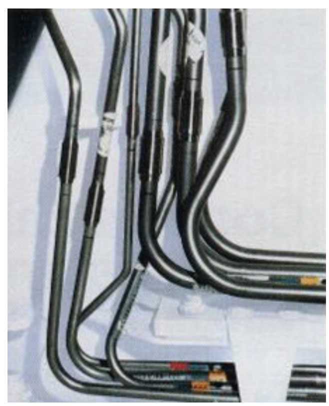

Image of hydraulic tubings made of Ti alloy used in military and commercial aircrafts.

Economic Impact: Research has demonstrated that there were additional margins in some areas that translated into expanded damage limits. Expanding the damage limit can reduce maintenance man-hours and reduce operational support costs. As a result of this work, aircraft are performing much better from a maintainability standpoint. This should result in considerable savings to the military over the next 15-20 years. Knowing the structure damage limits under realistic operating conditions can avoid the premature failure of components. The premature failure can cause loss of life and failure of aircraft. For these reasons, this work enhances safety and is having large economic impacts. After this work, other agencies such as the Air Force are looking into damage limits of Ti tubings used in military aircrafts.

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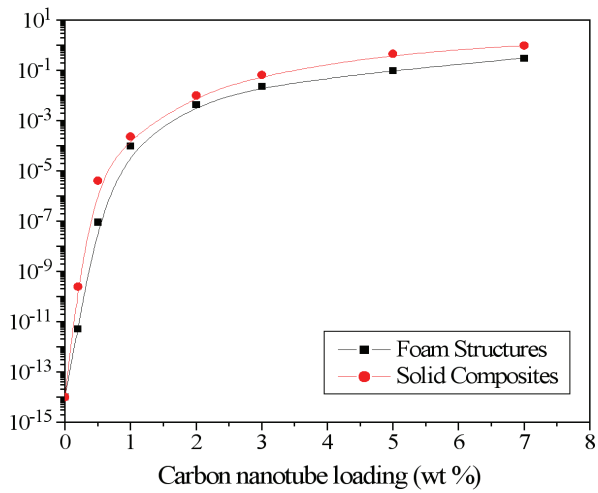
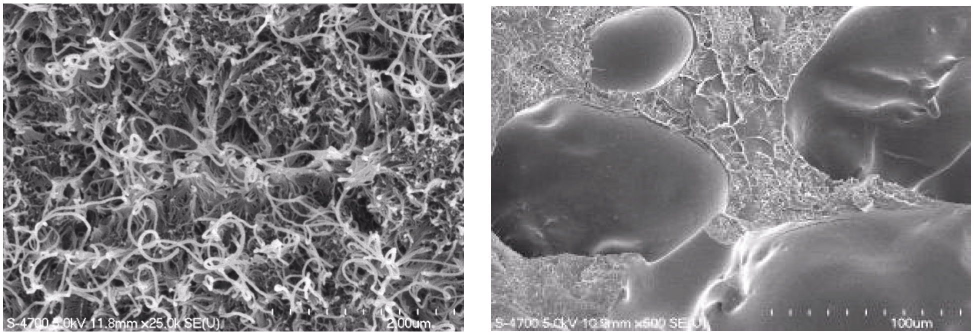
Ultra Lightweight Structures Using Carbon Nanotubes

Ultra lightweight materials capable of electronic conduction are needed by National Aeronautics and Space Administration and the military. Ultra lightweight electrically conducting materials would provide structures for Electromagnetic Interference (EMI) Shielding applications for commercial and space applications, development of advanced sensors, lower cost canopy for aircrafts, lightening protection, electronic packaging, printed circuit boards etc. Research at the Center for Lasers and Plasmas for Advanced Manufacturing (CLPAM) at the University of Virginia has shown that ultra lightweight electrically conducting materials can be obtained by incorporation of lightweight carbon nanotubes in polymeric materials.



This graph shows that polymers are insulators, that is, they do not conduct electricity. By adding few carbon nanotubes, polymers become more valuable for electromagnetic shielding.

Research has demonstrated that the weight of the nanotubes can be further reduced by conversion to foam structures. Density of 0.56 gm/cm^3 was obtained. These kinds of flexible conductive composites may be used for typical antenna systems, lightning-protected aircraft composite panels, avionics line replaceable unit (LRU) enclosures, connector gaskets, electrostatic and space charge dissipation materials, and different types of electronic pressure sensitive switches or sensors. The University of Virginia has received a US patent (Patent # 8,424,200) on this technology due to its large commercial and defense application potentials.



Figures show the presence of carbon nanotubes in polymers and their interconnectivity which give rise to electrical conduction. Carbon nanotubes are in nm dimensions. The right image shows micron scale air pockets which reduce the weight of structures.

Economic Impact: Increasing amounts of electromagnetic signals are emanated from variety of electronic components. If they are not adequately shielded from external noise these electromagnetic signals may cause interference of nearby equipment. For example cell phones need to be protected from external static noise in order to receive clear voice signals. Electronic shielding of many components is therefore essential. Lightweight electrically conducting nanocomposites will find applications for shielding of military components, biomedical instruments, and of instruments used in daily life such as cell phones, computers, laptops, radio, CD players, etc. The economic impact of lightweight electrically conducting nanocomposites is substantial but is difficult to quantify. The lightweight structures are highly important to energy savings in transportations and in communications.

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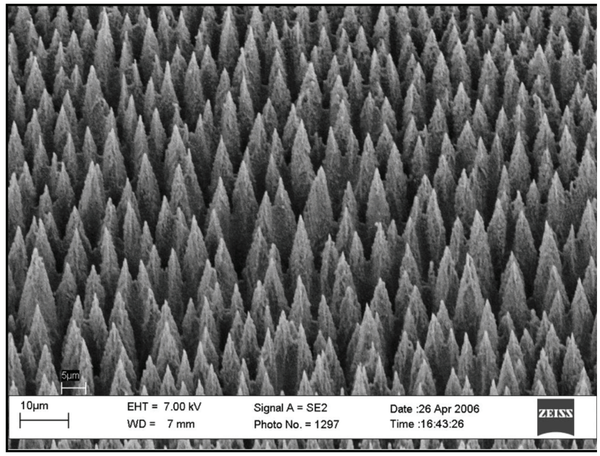
Laser Texturing of Surfaces and Commercial Applications

Laser processing provides a unique method of modifying materials surfaces by depositing large amounts of energy onto the surface of a material in a tightly controlled manner. Research at the Center for Lasers and Plasmas for Advanced Manufacturing (CLPAM) at the University of Virginia has helped to develop enhanced textured surfaces on metals and semiconductors. The laser treatment causes pillars to form on the treated surface. These pillars provide for greater light absorption for solar energy conversion, enhanced light detection, improved tissue growth for body implants, higher catalytic activity, and better heat sinks.



The figure shows the surface of materials after the laser process. This surface has similarity with lotus leaves where water does not wet the surface. Such non-wetting properties of materials' surfaces have applications for anti-icing (avoids buildup of ice for aircrafts, dish antenna, etc.), and corrosion protection.

This research is leading to the formation of a new high technology company for commercial products and defense applications. Because of its large commercial and defense application potentials, the University of Virginia has filed an industry supported patent application. This technology can be used for solar energy applications for efficient trapping of sun light incident at different angles. Microtextured surfaces can be used for anti-icing applications.

Economic Impact: The costs to the US military related to corrosion are estimated to exceed one-quarter trillion dollars per year. Ice buildup is also a major problem for commercial and military aircrafts, blades for wind energy generation, refrigeration systems, and outdoor antennas. The annual anti-icing market is estimated to be $250 million. The US Navy's yearly bio-fouling cost to is estimated as $2.1 billion. It is therefore reasonable to assume that the economic impacts of having surfaces that more effectively repel water would be huge. Laser microtextured materials will play important roles in various markets. Another important market where these surfaces could play an important role is in renewable energy and nuclear power generation. For these reasons, the economic impacts of this technology for key industries and for the nation are substantial but difficult to quantify precisely.

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