Center for Lasers and Plasmas for Advanced Manufacturing (CLAM)

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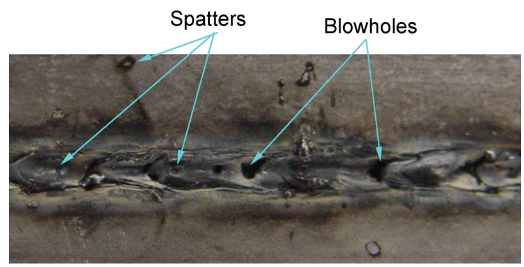
Center website: http://www.nsf.gov/eng/I/UCRC/directory/lam.jsp

Hybrid Laser – UltraLight Steel Auto Body (ULSAB) Project



Research at the Center for Lasers & Plasmas for Advanced Manufacturing (CLAM) has made it possible to reduce the weight of vehicles and improve the fuel efficiency and safety. More and more galvanized steels high-strength steels are being used in the automotive industry. All (100%) of the ULSAB-A VC body structure is made of high strength steel (HSS), with over 80 percent being AHSS steels (dual phase steels take 74% among the AHSS steels). This breakthrough impacts outer body panels, inner panels, underbody, bumpers, impact beams, and reinforcements and more. Previous methods required the pre-processing and post-processing actions and are costly to be used in the practice.

This new welding procedure combines the laser welding with the gas tungsten arc welding (GTAW) used as a preheating source has been successfully developed to lap join the galvanized dual phase steels in a gap-free configuration. GTAW leads the laser beam at the specific distance to preheat the work pieces. Under the controlled heat input from the GTAW, zinc coating at the top surface is burned and the metal oxides are generated at the top surface of pieces. Under these welding conditions, a stable "keyhole" is produced, which provides a channel for the highly pressurized zinc vapor to be vented out. Productivity efficiency is being dramatically increased by this new welding procedure in comparison with the other methods for welding of galvanized steels in a gap-free lap joint configuration.

> **Economic Impact:** Current practice for laser welding of Zn-coated steel sheet in the automotive industry is to provide a slight gap between the two sheets to be welded. The gap allows for the zinc vapor to escape. Problems associated this gap drive additional process costs for each and every such joint. Therefore, significant savings can be achieved by enabling a zero-gap laser weld condition.

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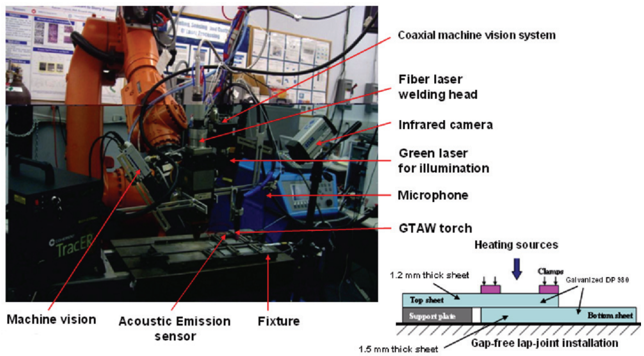

Experimental setup for hybrid GTAW preheating-Laser welding of galvanized steels in a gap-free lap joint configuration.

Sample of the gap-free lap joints from the hybrid GTAW preheating-laser welding in galvanized dual phase steels.

Field Portable Welding of Titanium Tubes

Welding titanium tubes in military aircraft is an exceedingly critical and very difficult task. Ordinarily this process is accomplished by manufacturing in super clean operational environments using high-skilled personnel. The U.S. military not only would like to develop the capability to perform welding of titanium tubes aboard ships and into austere, remote areas, but it would also like to avoid using some of the chemicals traditionally used to clean titanium tubes prior to welding. Working with the Center for Lasers and Plasmas for Advanced Manufacturing, the U.S. military has demonstrated that surfaces of titanium tubes can be successfully cleaned using lasers instead of caustic and environmentally harmful chemicals, thus successfully removing the oxidation layer and any contaminants on the outside of the tube. This laser technology provides a very accurate method of controlling the depth of oxide removal in welding. Now that the feasibility of this approach has been demonstrated work is underway to package the system in a portable, maintainable system for deployment in the field.

Economic Impact: This technology will have economic impact in two ways. First, it reduces the use of toxic chemicals for surface oxide removal. Second, it lowers the cost of sample preparation prior to welding. It also is a portable system that has military and commercial applications.

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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 (LAM) 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. Expanding the damage limit can reduce maintenance man hours and reduce operational support costs.

Research results have demonstrated that there were additional margins in some areas that translated into expanded damage limits. 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.

Economic Impact: 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.

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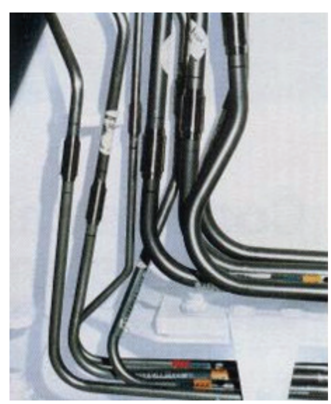
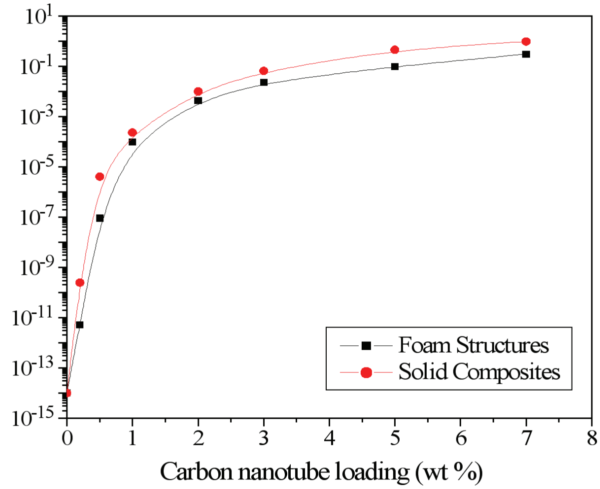


Ultra Lightweight Structures Using Carbon Nanotubes



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 (LAM) 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. 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 filed a patent application on this technology due to its large commercial and defense application potentials.

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. 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 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.

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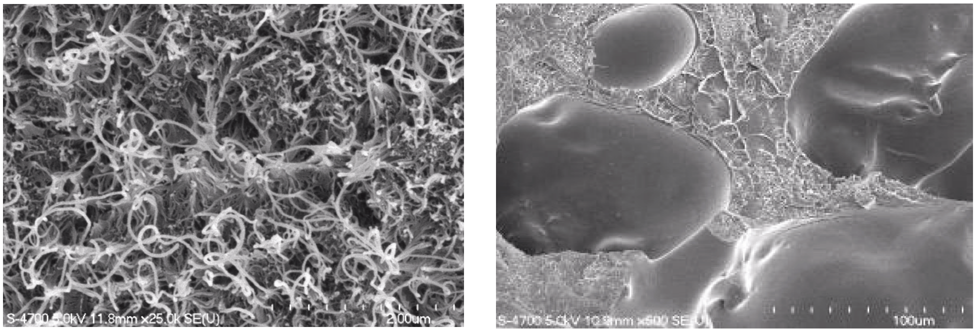
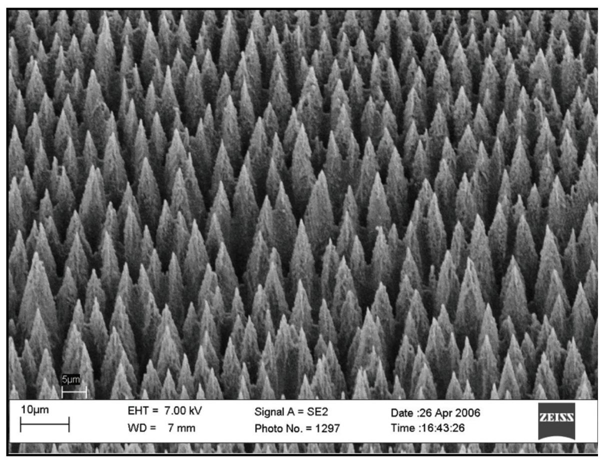


SEM images of CNT nanocomposite.

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 (CLAM) 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. 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:** Ice buildup is a major problem for commercial and military aircrafts, blades for wind energy generation, refrigeration systems, and outdoor antennas. 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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