2012 R&D 100 50th ANNIVERSARY

HIGH-PERFORMANCE METAL COATINGS HAVE EXCEPTIONAL BOND STRENGTH

A photonic method called high-velocity laser-accelerated deposition (HVLAD) produces protective coatings with ultrahigh-strength, explosively bonded interfaces that prevent corrosion, wear, and other modes of degradation in extreme environments. Developed by Lawrence Livermore in collaboration with Curtiss-Wright Surface Technologies – Metal Improvement Company, HVLAD leverages high-power pulsed laser technology developed for laser inertial-confinement fusion research as well as key components of laser peening technology.

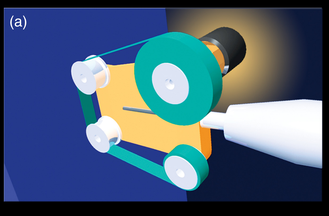
How It Works

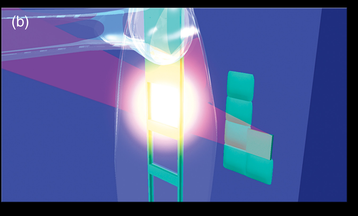
A high-intensity laser pulse is focused onto an advancing filmlike target material, which is covered by a thin layer of water that serves as a tamper. The laser pulse generates a high-temperature plasma and with it very high pressure that shears out a patch of the filmlike material, accelerating it to hypersonic velocities. The accelerated patch hits the substrate at an oblique angle, where the high-impact velocity induces plastic shear flow at the film–substrate interface, resulting in the mixing of target and substrate materials at the interface. Exceptionally strong interfacial bonds are created that approach the ultimate tensile strength of the substrate.

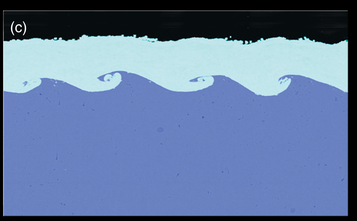
Conventional thermal and cold-spray coatings have bond strengths on the order of only 680 atmospheres (10,000 pounds per square inch), while the HVLAD-bonded materials have ultimate tensile strengths of about 6,800 to 34,000 atmospheres (100,000 to 500,000 pounds per square inch).

Industrial Applications

Application of the HVLAD technology can be beneficial in a variety of industries. For example, HVLAD coatings could make possible the use of high-temperature materials in fossil-fuel, solar thermal, and nuclear power plants, leading to an increase in efficiency. Increasing the operating temperature of an energy conversion system from 325°C to 900°C could lead to a 20-percent gain in efficiency. Another application could involve coating a thin layer of titanium on conventional ship hulls made of steel as a cost-effective means of corrosion prevention. These protective coatings and cladding with high-integrity interfacial bonds are capable of extending the operating life of valuable equipment in the aerospace, marine, and energy arenas.







(a) For high-velocity laser-accelerated deposition (HVLAD), a special head is adapted to a laser-peening device and associated robotics. (b) Patches of high-performance corrosion-resistant film are accelerated and bonded to a substrate in a controlled process. (c) A scanning electron microscope image shows a heat and corrosion resistant tantalum coating on a copper substrate. The tantalum was accelerated at the copper substrate, and the shear forces at the interface caused the mixing of the two materials, resulting in an exceptionally strong interfacial bond. This coating was produced at room temperature and pressure, with no special process equipment other than the laser. (Renderings by Clayton Dahlen.)

Livermore development team for HVLAD: Alexander Rubenchik (left) and Joe Farmer.

Lloyd Hackel of the Curtiss-Wright Surface Technologies – Metal Improvement Company

Lawrence Livermore National Laboratory

For more information: www.llnl.gov

Prepared by LLNL under Contract DE-AC52-07NA27344. LLNL-POST-XXXXXX