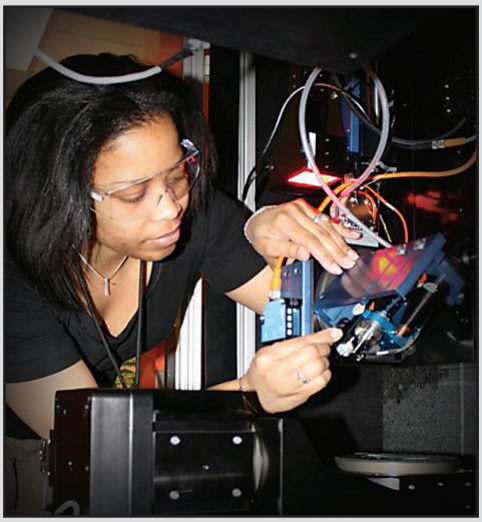
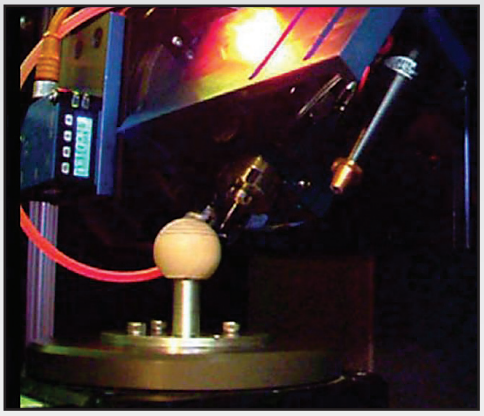
Lab Gets It "Write" With Novel Manufacturing Methods



AFRL uses direct-write (DW) manufacturing to create new structures and integrated materials. Pictured is a researcher employing Mesoscale Maskless Material Deposition (M3D), one of many DW techniques enabling the three-dimensional deposition of functional materials directly onto a material surface. (AFRL image)



AFRL's most recently demonstrated DW method entails M3D, which employs aerodynamic focusing (as pictured) to deposit chemical precursor solutions and/or colloidal suspensions directly onto material surfaces. (AFRL image)

In leveraging direct-write (DW) manufacturing methods—most recently, one known as Mesoscale Maskless Material Deposition (M3D)—AFRL materials experts are promoting advances in new metamaterial structures and multifunctional, hybrid materials. Like other DW methods, M3D provides a means for three-dimensional deposition of functional materials directly onto a material surface. Because it enables both active and passive functional devices to be fabricated directly onto structural parts and assemblies, this capability will benefit a wide range of systems—increasing the functionality; simplifying the design; and reducing the size, weight, cost, number of components, and time to market of products such as radio frequency devices, displays, packaging batteries, antennas, and sensors.

DW refers to a manufacturing process that adds components and subsystems to surfaces by printing them on a material. It encompasses a range of viable techniques, including ink jet, microspray, quill, pen, aerosol, pulsed laser evaporation, and laser direct etching methods. For instance, the micropen system can write lines from 50 μ to greater than 1 mm wide on virtually any surface. Among the many and varied materials that can be deposited via these DW methods are ceramics, metals, polymers, biological systems, nanomaterials, and hybrid materials with viscosities from 1 to 5,000 cP (centipoise). The width of the deposited material ranges from 5 to 150 μ.

M3D, the type of DW currently undergoing demonstration at AFRL, is a computer-aided-design-driven, maskless DW technique that uses aerodynamic focusing for the high-resolution deposition of chemical precursor solutions and/or colloidal suspensions. In completing this process, the M3D system focuses, deposits, and patterns an aerosol stream of the deposition material onto a planar or nonplanar substrate using three modules. The system can write on conformal structures and over large areas. The M3D equipment at AFRL is unique in that the deposition head is positioned on a six-degrees-of-freedom robotic arm, a configuration enabling deposition onto large, irregular surfaces.

To date, the Department of Defense and AFRL have demonstrated some success in using DW to develop technologies for structurally integrated antennas. Traditionally, antenna elements and arrays are mounted to aircraft exterior surfaces and require a structural enclosure to improve aerodynamics and provide protection from the elements. Different approaches to the structural integration of antennas and other sensors have undergone demonstration with varying levels of success. A Defense Manufacturing Science and Technology program, for example, demonstrated the DW integration of a very-high-frequency antenna element onto a secondary structural component via the Mesoplasma Thermal Spray technique.