High-Precision Multimode Ultrasonic Liquid Applicator

One of the core engineering competencies at LLNL is the precise fabrication of complex assemblies at the millimeter scale or smaller. The broader concept of mesoscale manufacturing—the fabrication of millimeter-scale assemblies using combinations of dissimilar materials, and having features on the micrometer or nanometer scale—has been identified as one of LLNL's key areas of enabling technology. To advance the state of the art in this area, we are reducing to practice novel approaches to the construction and assembly of increasingly more challenging objects.

Applications include the adhesive assembly of laser targets for the National Ignition Facility and other experiments (Fig. 1), and the application of biochemical solutions and other liquids to biosensors and microfluidic devices. These uses require the ultra-precise application of nanoliter or picoliter quantities of special liquids to specific locations.

Traditionally, the application of liquid adhesives to laser targets and other small objects is done manually, using single camel hairs as paintbrushes. We are using a new approach, a combination of commercially available specialty inkjet components, and custom-engineered hardware, to build new equipment that uses inkjet techniques to apply tiny droplets of different liquids to complex parts.

Project Goals

The project goals include the construction of two complete systems: one specialized for target fabrication, to be located in LLNL's target fabrication facilities, and a more general purpose system, to be located in LLNL's Microfabrication Laboratory.

Relevance to LLNL Mission

Mesoscale manufacturing is a core technology supporting LLNL missions in stockpile stewardship, high-energy-density physics, and national and homeland security. This project advances capabilities and tools for mesoscale manufacturing.

FY2005 Accomplishments and Results

The inkjet techniques used in this project are fundamentally the same as

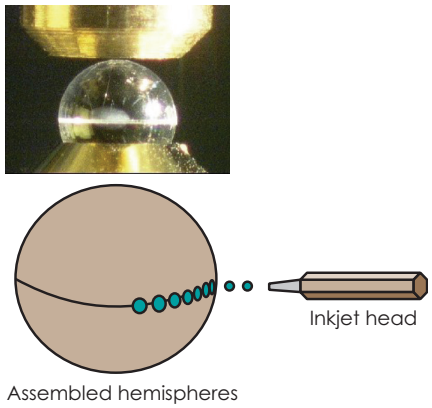

Figure 1. Representation of an application of liquid adhesive: the adhesive joining of the hemispherical halves of laser targets for the National Ignition Facility.

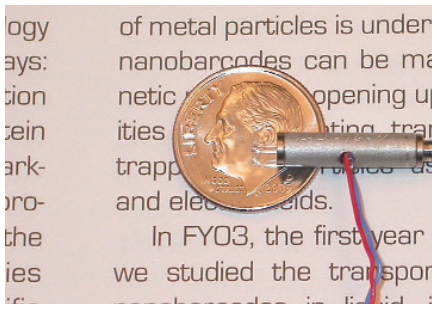

Figure 2. Typical inkjet device used in the project. The "business end" of the device is a tiny glass nozzle that generates droplets as small as 10 μm in diameter.

For more information contact
George M. Dougherty
(925) 423-3088
dougherty9@llnl.gov

those used to generate high-quality printed material. A typical inkjet device used in the project is shown in Fig. 2.

Tests were conducted to verify that the inkjet methods being considered are indeed capable of "printing" individual droplets of custom liquids such as low-viscosity adhesives. These tests involved deposition onto various substrate materials as well as bond lines between small plastic parts, and confirmed that the method would work. The droplets generated in this way are less than a quarter the width of a human hair. The results of one such test are shown in Fig. 3.

We then turned to two new systems at LLNL. For the target fabrication system, close cooperation with the target fabrication community was essential. Working with their engineers and technicians, a system was created that mates directly to the existing target assembly station, and can be attached and removed as required. The ultrasonic inkjet tip is located on a long probe that allows it to approach a small target being held within the vertical fixturing of the assembly station. A computerized motion controller manipulates the probe, and a special compact microscope mount allows the operator to view the deposition process.

The general-purpose system is similar in capability but very different in form. This system has an open geometry that allows excellent access to a wide range of substrates, and a 2-D computerized linear stage that enables either the precise placement of individual droplets or the large-area printing of complex patterns. The general-purpose system, installed in the Microfabrication Laboratory and available for use, is shown in Fig. 4.

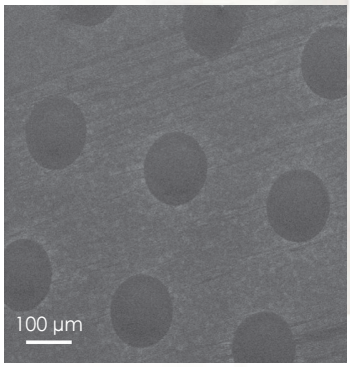

Figure 3. Scanning electron microscope image showing part of a large array of spots made by depositing individual droplets of low-viscosity adhesive onto a hydrophilic polished glass substrate.

Figure 4. General-purpose ultrasonic inkjet system in LLNL's Microfabrication Laboratory.