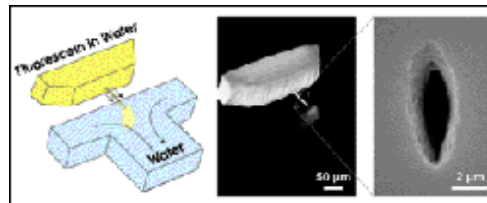




Femtosecond Laser Brings 3-D to Microfluidics

Microfluidic devices have submillimeter channels designed to control the flow of very small volumes of liquids, offering the promise of providing highly capable biological assays for such applications as bedside clinical diagnostics. Traditional microfluidics are molded in a polymer substrate, but molding is inherently a two-dimensional process, which limits the complexity of inexpensive devices.

Femtosecond laser manufacturing can add unique capabilities to microfluidic systems. This section of a microfluidic device has two channels molded with traditional techniques, connected by a 1- μm -diameter channel



fabricated with 27-nJ pulses from a femtosecond laser. Flow through the microcapillary can be verified by observing the transfer of fluorescein-dyed water from one channel to the other. The left image shows the device schematically, the center is the fluorescence microscopy image, and the right is a cross section of a 1- μm microcapillary produced with the laser. Courtesy of Chris B. Schaffer.

Researchers at the University of California, San Diego, in La Jolla have demonstrated a femtosecond laser manufacturing technique that can produce microcapillaries with complex three-dimensional geometries. The investigators, in [the Groisman Microfluidics and Kleinfeld Neurophysics laboratories](#), begin with a polydimethylsiloxane (PDMS) substrate in which they form channels by pressing it into a patterned mold. They bond a glass coverslip to the PDMS, creating a top to the molded channels. Those are standard 2-D microfluidic construction techniques.

But then they expose the PDMS to 100-fs pulses of 800-nm radiation from a laser operating at 1 kHz. The laser system consists of a 10-W CW green laser that pumps a femtosecond laser oscillator, both from Coherent. Pulses from this oscillator are amplified to higher energy in a home-built chirped pulse amplifier, which is pumped by a Coherent Q-switched Nd:YAG green laser. Focusing the light through a 1.0-NA Olympus water-immersion microscope objective creates a small ablation region, the size and geometry of which depends upon the pulse energy, which varies from 550 to 17 nJ.

Translating the substrate at 100 $\mu\text{m}/\text{s}$ while illuminating with a pulse train creates a connected string of ablated regions: a microcapillary. Debris

from the ablations tends to clog the channel, but if ethanol flows into the ablated regions, the debris is carried away. After the machining is completed, a final rinse in hydrofluoric acid stabilizes the microcapillaries. Without that rinse, capillaries smaller than 5 μm in diameter clog quickly.

Since optimizing the process parameters, the researchers have explored the capabilities of the technique. In one set of experiments, which they reported in the May 16 issue of *Applied Physics Letters*, they manufactured straight channels with diameters ranging from more than 10 to less than 1 μm . By combining transverse and axial motion, they created a 3-D spiral microcapillary.

They connected two 50- μm molded channels with a 1- μm -diameter microcapillary constructed using the femtosecond laser technique. By creating a pressure difference between the two larger channels, they trapped a 5- μm polystyrene bead and held it against the opening of the microcapillary while liquid flowed through the channel, an approach that could be used to immobilize a living cell while exposing it to a variety of environmental changes.

Chris B. Schaffer, the lead researcher on the project, said that the small feature sizes and the ability to manufacture in three dimensions will enable not only more dense integration of microfluidic channels for lab-on-a-chip devices, but also the fabrication of channel geometries that offer new functionalities. Although femtosecond lasers add such unique capabilities, they can be relatively expensive. The costs are coming down, but for now, he said, the key is to use standard techniques to mold as much of the device as possible and to use laser fabrication only where necessary.

Schaffer will continue the work in his new Biophotonics Engineering Laboratory at Cornell University in Ithaca, N.Y., where he will take a faculty position in January. ■

by Richard Gaughan

Contact: Chris B. Schaffer, University of California, San Diego, La Jolla;
e-mail: **E-mail:** cschaffer@ucsd.edu.



© 1996-2005 Laurin Publishing. All rights reserved.
Photonics.Com is Registered with the U.S. Patent & Trademark Office.
Privacy Policy | Terms and Conditions of Use
Reproduction in whole or in part without
permission is prohibited.
webmaster@laurin.com