IMPACT PROFILE

RESEARCH AT THE UNIVERSITY OF MARYLAND

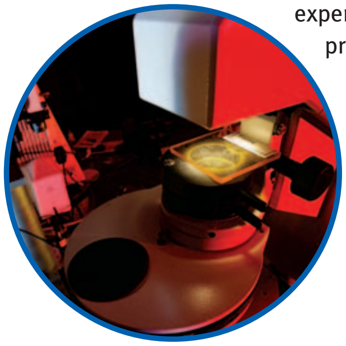
JOHN FOURKAS

New Chemistry for Micro Machines

The University of Maryland's John Fourkas works in the world of three-dimensional microscopic machines so tiny you can't see them. They do things like deploy airbags and make cell phones work. They may one day be used to deliver medication to a very specific area of the body or do magnetic resonance imaging from inside a single blood vessel.

So far, the micro technology of these minute structures has used silicon as the major construction material, which limits potential applications. Fourkas, a chemistry professor in the College of Chemical and Life Sciences, is changing that. He's finding ways to construct micro machines with a variety of materials and in mass quantities, discoveries that could pave

Micro Machines



the way for entirely new types of micro machines.

Fourkas and fellow researchers have invented a method that can incorporate a broad range of materials, including metal, into structures fabricated by multiphoton absorption polymerization, or MAP, a technique being developed by a number of groups around the world. MAP uses a laser to harden a special liquid to create microscopic 3-D structures that are composed of a material similar to plexiglass. "It's akin to the process that dentists use to harden composite fillings," says Fourkas, "except that the laser beam allows us to do the hardening on a point by point basis."

A major drawback of MAP, however, has been that it is limited to the creation of structures made only of plastic. "For many applications it is necessary to be able to include other materials as well," Fourkas explains. "The ability to incorporate materials other than plastic is a crucial step forward for multiphoton fabrication."

To demonstrate their technique, Fourkas and his team deposited metal selectively on specific regions of 3-D microstructures. By metal-coating a plastic coil fabricated using MAP, they were able to create and measure the properties of an inductor, a component used in electronic devices such as cell phones, that was a tenth as long as the diameter of a human hair. "Although we demonstrated the deposition of metal to make electrical devices, the same basic strategy will work with other materials, such as biomolecules or even glass," says Fourkas. "This should make it possible to create a whole new generation of microscopic sensors, actuators, and other devices."

Another challenge of micro technology is that the structures can be made only one at a time, an expensive proposition for commercial production. One of the problems, Fourkas says, is that the techniques are quite limited. "It's not just a matter of converting techniques we already have."

So Fourkas and his team have devised a way to reproduce their structures rapidly, an important step in making laser fabrication commercially viable. "We can mold a huge variety of structures. I think that will include moving parts," he says.

The research team is also developing ways to work with chemicals that are commercially available and that can be formed into shapes with low laser power, and to incorporate other materials into the process. Their aim is to do everything on a desktop—to program a computer to do the work—Fourkas says. The biggest breakthrough, he adds, was finding a way to reproduce structures with closed loops. "We were told that it was impossible to reproduce a three-dimensional structure with loops because the mold jams in the holes," he says. "We developed a way around this problem so that we can reproduce bridges and other structures with openings."

With their techniques, Fourkas and his team have created a remarkable array of intricate microscopic structures that resemble everything from a Japanese lantern to the word "HAIR," spelled out in three dimensions, one-five-thousandth of a millimeter high, on an actual human hair. And his laser technique doesn't damage biological structures.

Says Fourkas: "You might imagine building little devices on somebody's skin or on a blood vessel, or even in the long run on an individual cell. So you start thinking, 'Can I build microscopic devices that might be able to monitor what's going on in a biological tissue?'

"We have this ability to make any kind of structure that we'd like in any kind of geometry possible. It opens doors to new kinds of devices that just aren't possible with current kinds of technologies." —*Ellen Ternes*

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