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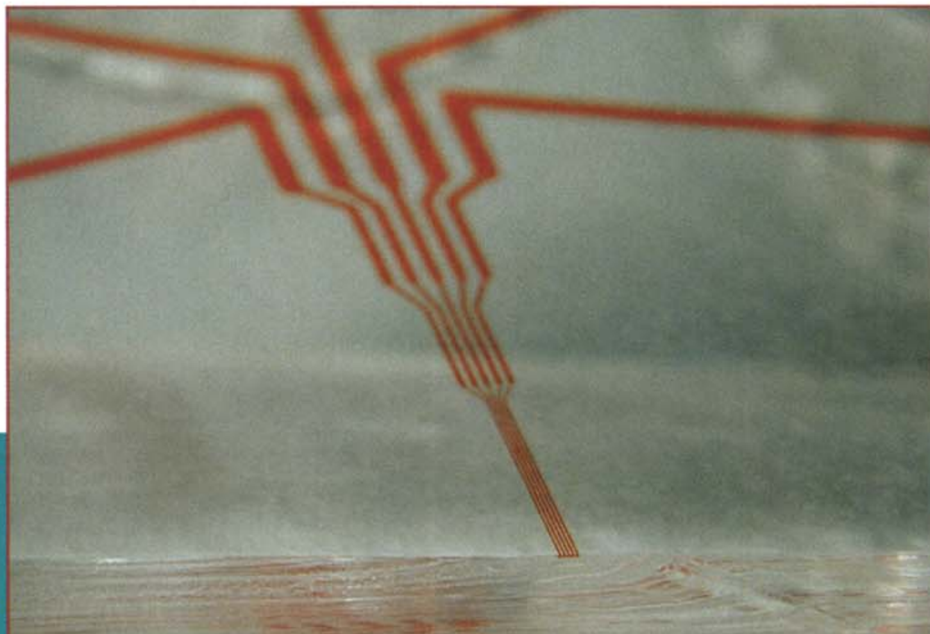
Soft Lithography Enables Gray-Scale Process

As might be expected of the workhorse of digital circuit production, traditional photolithography is an either-or process. A line is formed where the exposing radiation shines through the mask, or there is a space where it is blocked by chrome. All lines are the same height for a given layer of film, and all spaces the same depth. Although this is fine for today's semiconductors, it does not work well for three-dimensional microstructures.



Microfluidic photomasks built using transparent rubber, microchannels, and dye could be useful for gray-scale photolithography.

Albert Folch, an assistant professor of bioengineering at the University of Washington in Seattle, has developed an approach for gray-scale photolithography using changeable microfluidic masks that could be employed to fabricate miniaturized mechanical or fluidic devices, optical elements, tissue engineering scaffolds and other structures. Although such gray-scale techniques already exist, they so far have been too expensive, too slow or too limited for widespread use. The new work could change that.

According to Folch, the key enabling technology for the process is soft lithography, a family of techniques that involve the molding of the transparent rubber polydimethylsiloxane. The researchers begin by micropatterning a silicon wafer using conventional photolithography, producing a series of lines and spaces. Next, they create a replica of this pattern by flowing polydimethylsiloxane over the surface and lifting off the transparent rubber. They bond this replica to a 10-µm-thick sheet of the material, forming a series of channels through which a suitable dye can be injected. They call this a microfluidic photomask.

In practice, the photomask is placed on a silicon wafer coated with conventional photoresist. By changing the dye concentration and color, the exposure of the photoresist under the various channels can be tailored to the desired effect — even though the light source is uniform. As a consequence, the user can adjust the height of the structure. Also, changing the characteristics of the dye in the channels controls the layout.

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To demonstrate the technique, Folch and his colleagues have constructed a device with varying microchannel heights. This is difficult to do with conventional photolithography but proved easy with the new method.

Research and development in microfluidic photomasks continues. "We want to work, pending funding, on automating this process for manufacturing masks and on combining the photomasks to stimulate live cells," Folch said. □

Hank Hogan

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