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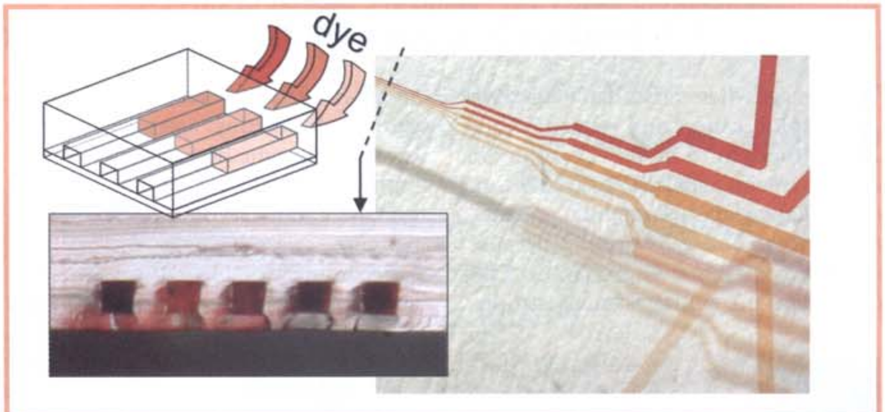
Photolithography goes with the flow

Many of today's microfluidic devices and other biochips are manufactured using photolithography. This process involves etching a shape using an opaque mask to selectively illuminate a thin photosensitive layer with UV light. Although this method works, three-dimensional microstructures require multiple steps, the masks are permanent and the method can expose the photosensitive layer to UV light only in an on or off fashion.

Researchers at the University of Washington in Seattle may have a solution to these problems. They have developed gray-scale photolithography using changeable microfluidic masks, which could lead to easier fabrication of miniaturized fluidic devices, tissue engineering scaffolds and other structures.



University of Washington researchers have developed a changeable gray-scale photomask using the transparent rubber PDMS and food-coloring dyes. The photomask could be used to make microfluidic devices and may be useful in other biological research.

Other gray-scale photolithography techniques have been too expensive, too slow or too limited for widespread use. Albert Folch, assistant professor of bioengineering at the university, said that the key enabling technology behind his method is soft lithography, a family of techniques based on molding the transparent rubber polydimethylsiloxane (PDMS).

In their approach, Folch and his colleagues create a changeable mask by first using a traditional mask to form a structure of raised bars on a silicon wafer. They produce a series of valleys by flowing PDMS over the surface and then lifting it off. They bond the replica to a 10-μm-thick sheet of PDMS, creating a series of channels through which dye can be injected.

This microfluidic photomask is placed on a photosensitive layer, and by changing the dye concentration and color, the exposure of the photoresist under the various channels can be tailored — even though the light source itself is a constant. As a consequence, structure height can be adjusted. Filling an area with a dye that is opaque to the UV light can even alter the layout of the structure without requiring a new mask. The researchers easily constructed a microfluidic device with varying microchannel heights — a difficult task with conventional photolithography.

This gray-scale approach is not perfect.

There are, for instance, constraints on the sizes and shapes it can produce. Filling or flushing the dye in the mask may be difficult for applications that need narrower, longer or more intricate channels than those in the demonstration mask.

The researchers say that the technique could have biological applications outside of biochips. The masks could be used to expose cultured, living cells to varying degrees of light from complete darkness to full illumination using a single constant source. What's more, this light pattern could be quickly changed at will.

"The selective exposure of cells to light is an application of great interest to cell biologists," Folch said. This research will also be helped by the characteristics of the base material.

"PDMS is biocompatible, so we could culture the cells on the photomasks themselves," he added. □

Hank Hogan

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