Microelectromechanics

In their report "Design and fabrication of topologically complex, three-dimensional microstructures" (26 June, p. 2089), Rebecca J. Jackman *et al.* point out the wide range of potential applications in microelectromechanical systems (MEMS) and other miniature devices that will require the fabrication of small three-dimensional (3D) structures. We have explored another method for generating micron-scale, 3D structures with the use of a variant of photolithography with electroplating (*1*). In this technique, a photo-sensitized gel is exposed through a gray scale mask, cross-linking the gelatin in proportion to exposure. The resistance to ionic transport through the gelatin increases with cross-linking. Therefore, on electroplating through the gelatin, the gray scale of the original optical mask is translated into thickness variations on the final surface; that is, darker areas on the optical mask lead to thicker electrodeposits. The method provides a convenient additive method for generating 3D surface relief.

John C. Angus
Uziel Landau
Department of Chemical Engineering, Case Western Reserve University, Cleveland, OH 44106–7217, USA

References

1. J. C. Angus, U. Landau, S. H. Liao, M. C. Yang, *J. Electrochem. Soc.* **133**, 1152 (1986).

Response

The fabrication of microstructures is one of the most pervasive of modern technologies. Almost all microfabrication is now based on photolithography and its dependent technologies, and the dominance of this family of technologies is genuinely remarkable. Photolithography is intrinsically planar, although it can, with difficulty, be induced to produce certain types of nonplanar structures. The development of flexible, economical methods that would have the power of photolithography, but would build 3D microstructures, would open the door to a host of applications in microfluidic systems, MEMS, optical devices, and structural systems. Angus and Landau correctly emphasize the potential of the field of 3D microfabrication and provide an elegant example of another approach to the fabrication of microstructures having 3D character.

George M. Whitesides
Department of Chemistry and Chemical Biology, Harvard University, Cambridge, MA 02138, USA. E-mail: gwhitesides@gmwgroup.harvard.edu

Federal Research Priorities

In his thoughtful and pointed editorial "Making the case for federal support of R&D" (12 June, p. 1671), Franklin D. Raines poses five fundamental questions regarding such support for academic research and development (R&D). Most of these questions have been asked repeatedly, over at least the 25 years I have followed the issue, without much response from the scientific community. Nevertheless, the questions have clear-cut answers.

How large a scientific enterprise does the United States need? One criterion sets a floor: Enough university-based research to train the scientists called for by an increasingly technology-based industry. This amount is much less than current federal support. A different criterion—enough to make the United States competitive with other countries—is not useful: most federally funded R&D does not translate quickly into proprietary advantage. And increasing the pool of mankind's knowledge should be collaborative, not competitive. One sensible criterion would be to allocate a small, relatively stable fraction of the U.S. Gross National Product.

How can we set priorities in the nation's R&D enterprise? Raines's call for the scientific community to help set fund-