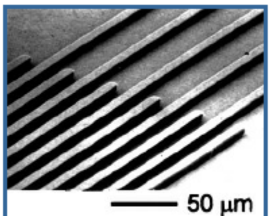
materials update

Stamping out nanostructures

There is increasing interest in the use of non-lithographic patterning techniques for the fabrication of both micro- and nanoscale devices. By reducing the number of expensive and time-consuming lithographic steps required, these techniques allow the commercial production of such devices to be more efficient and cost effective.

18 July 2002

Ed Gerstner



Scanning electron microscope image of an elastomer stamp, coated with layers of gold and titanium, before transfer.

Microcontact printing is one approach that is particularly useful in applications where conventional lithography is inappropriate. It is an analogous process to rubber-stamp printing, which involves the transfer of self-assembled monolayer inks from patterned elastomer stamps. This, and other patterning techniques, are becoming increasingly important in areas such as biotechnology, organic electronics and fibre optics. But the resolution of these techniques is limited because they usually involve a number of etching and postpatterning deposition steps. In *Applied Physics Letters* this week, Yueh-Lin Loo and colleagues extend the concept of microcontact printing to nanoscale dimensions in an additive process they refer to as nanotransfer printing.

Instead of transferring sacrificial resists that act as a template for the patterning of subsequent materials by etching and lift-off, nanotransfer printing involves the transfer of final metallic structures directly onto a substrate's surface. The process involves evaporating an appropriate metal onto the surface of a patterned stamp material, which can be either soft (such as an elastomer) or hard (such as the metal alloy GaAs) depending on the application. The evaporated metal is then simply pressed onto the surface of a substrate. Bonding between the metal and the substrate occurs following chemical reactions involving hydroxyl groups between the two surfaces. Although this therefore requires the use of materials that spontaneously form surface oxides, virtually any type of metal can be patterned so long as an appropriate intermediate layer, such as titanium, is used.

Using this technique, the authors demonstrate the effective patterning and transfer of gold/titanium bilayers onto plastic substrates with feature sizes approaching 100 nm, and edge resolution of less than 15 nm. They also use it to form the drain and source contacts of semiconducting polymer transistors with electrical characteristics, which are comparable to transistors patterned by conventional lithography.

Although the accuracy of this technique for registering multiple layers of patterns has not yet been determined, the authors expect it to be similar to that of nanoindentation. Even so, the speed, low cost and simplicity of this technique could prove useful in the development of commercial nanoscale devices.

Additive, nanoscale patterning of metal films with a stamp and a surface chemistry mediated transfer process: Applications in plastic electronics
YUEH-LIN LOO, ROBERT L. WILLETT, KIRK W. BALDWIN & JOHN A. ROGERS
We describe a method for contact printing metal patterns with nanometer features over large areas. This nanotransfer printing (nTP) technique relies on tailored surface chemistries to transfer metal films from the raised regions of a stamp to a substrate when these two elements are brought into intimate physical contact. The printing is purely additive, fast (math15 s contact time), and it occurs in a single processing step at ambient conditions. Features of varying dimensions, including sizes down to ~100 nm, can be printed with edge resolution better than 15 nm. Electrical contacts and interconnects for high-performance organic transistors and complementary inverter circuits have been successfully fabricated using nTP.

Applied Physics Letters **81,** 562–564 (15 July 2002)
| article |

Related articles:

News:
Imprints offer Moore
20 June 2002

Highlight:
Embossing nanostructures
20 June 2002