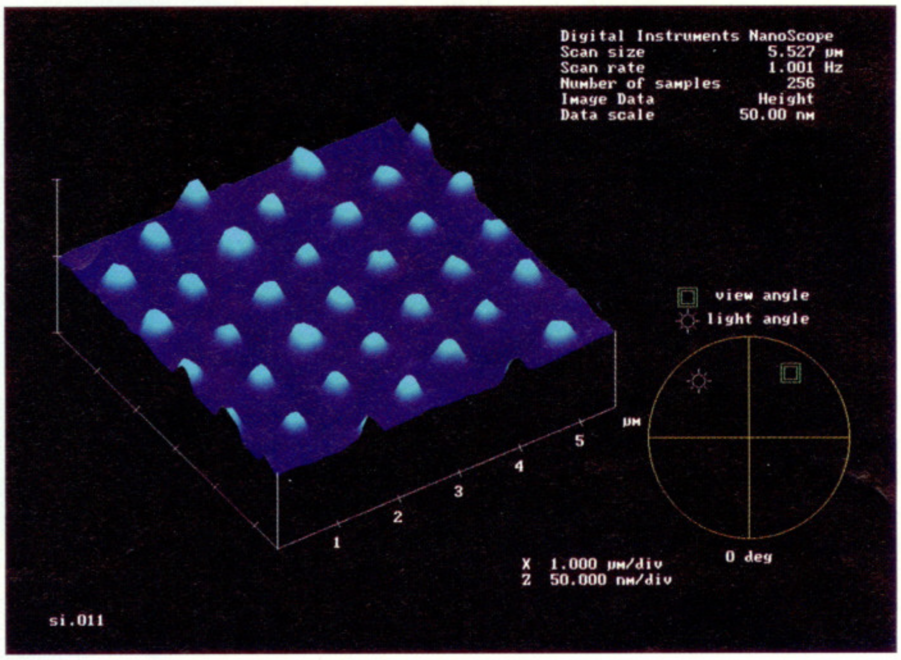
Exposing 1-µm-diameter polystyrene beads to 248-nm radiation from an excimer laser yields regular arrays of 260-nm-diameter silicon bumps. Courtesy of Sumei Huang.



undoped wafers with a latex suspension of the beads that they had diluted with deionized water. They allowed the water to evaporate, yielding a monolayer atop the silicon surface. They irradiated the regular hexagonal lattice of beads with a single, 23-ns-long pulse of 248-nm radiation from the laser, focused into a 25 × 5-mm spot of uniform intensity.

Half-transparent at 248 nm, the beads nearly completely melt and evaporate at laser fluences greater than 45 mJ/cm². Their brief presence during the exposure, however, leads to an enhancement in the optical near field where they come in contact with the wafer, so that even an incident fluence of 150 mJ/cm² results in a fluence at the contact point well above the 500- to 750-J/cm² melting threshold of silicon.

As a consequence, the silicon becomes molten, and the researchers suggest that competing thermal and chemical capillary forces result in a net inward flow. Moreover, because liquid silicon is more dense than solid silicon, there is an increase in volume at the melt spot as the material cools, and a bulge forms.

The researchers note that the technique enables the adjustment of the distance between the nanoscale bumps through proper selection of bead diameter to control the near-field enhancement. □

Daniel S. Burgess

Applied Physics Letters, April 18, 2005, 161911.

Painting Nanowires Yields High-Speed Circuits

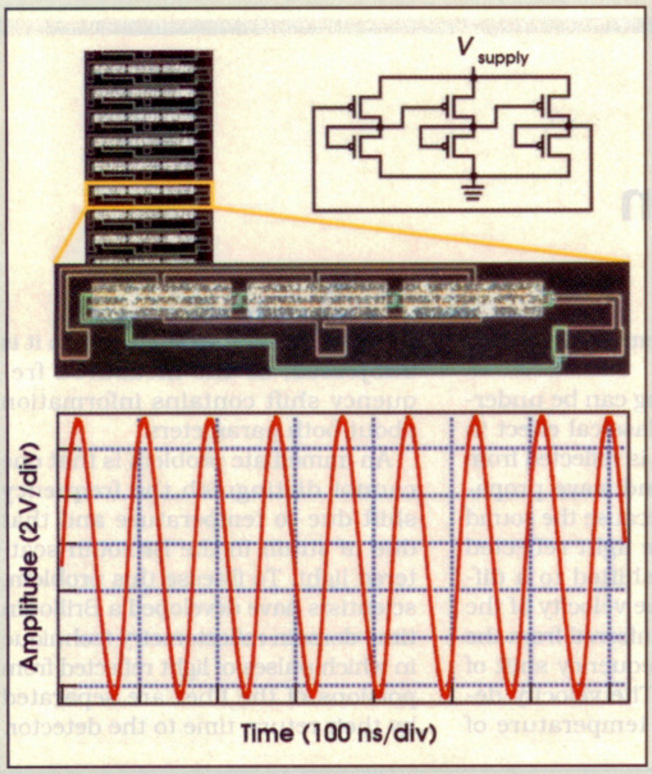
The production of circuits and processors from silicon substrates is expensive, and the required high-temperature fabrication process is not always compatible with a variety of materials. Researchers at Harvard University in Cambridge, Mass., have found an alternative: using nanowires to create electronic devices on glass and plastic from a solution. The technique eliminates the need for high temperatures in the production process.

Lead researcher Charles M. Lieber explained that the group set out to show that these high-performance nanowire-laced solutions can literally be painted onto any material to make fast circuits and processors that rival those made in billion-dollar fabrication lines today. Using single-crystal silicon nanowires as the semiconductor, the team went beyond the limits of traditional silicon semiconductor processing because the nanowires could be manipulated using a liquid solution and then spread onto any substrate.

Nanowires could be used in applications that must be shock-resistant, lightweight, flexible and/or curved.

To test the method, the scientists used nanowire thin-film transistors to generate fully integrated inverters and ring oscillators on glass substrates. The ring oscillators comprised three inverters in series, with a feedback loop completing the ring. The integration was entirely on the chip, with no external wiring.

They found that the output voltage of the ring oscillators was stable



High-frequency nanowire ring oscillators can use glass, plastic or other materials as a substrate. In this optical image of a nanowire ring oscillator on glass (shown with the corresponding circuit diagram), the patterned nanowire film appears white (top). In tests, the device exhibited 11.7-MHz oscillation (bottom), 20 times faster than that of those made using alternative low-temperature fabrication techniques. ©Nature Publishing Group.

and self-sustained. The devices performed 20 times faster — up to 11.7 MHz — than those made at low temperatures using organic semiconductors, which, at best, operate in the 100-kHz regime.

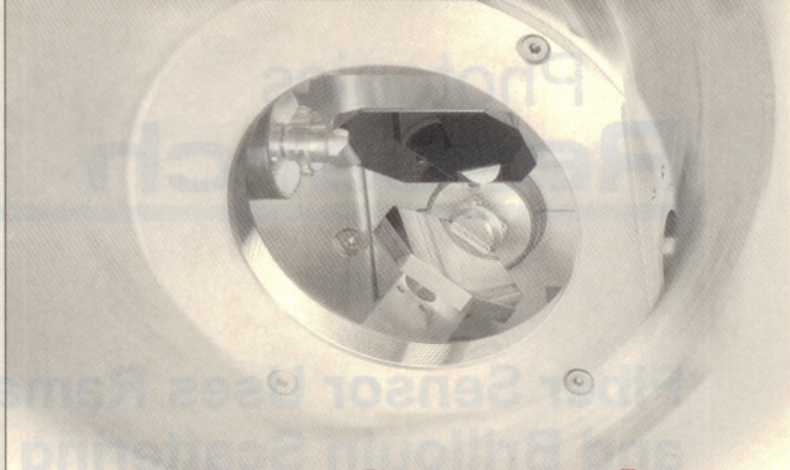
One challenge to the design is that supply voltages of 35 V or more are required to achieve stable oscillations. Lieber said that, through device design and choice of materials, more complex devices may be built with lower voltage requirements. Recently, for example, the scientists operated ring oscillators at 15 V with a similar design but with improved nanowires. Using improved dielectrics, Lieber expects to decrease this to below 10 V.

The next step is to further optimize the structures to enable higher device frequencies, possibly leading to microwave-frequency oscillators on flexible plastics. These could be used in applications that must be shock-resistant, lightweight, flexible and/or curved. Their low cost may make them appropriate for mobile applications or for inexpensive, throwaway electronics such as a disposable computer or a flexible color display that can be sewn into clothes or packaged goods.

Lieber also indicated that the potential exists for sophisticated photonics, such as nanowire-based LEDs, on plastics or other substrates. □

Anne L. Fischer

Nature, April 28, 2005, p. 1085.



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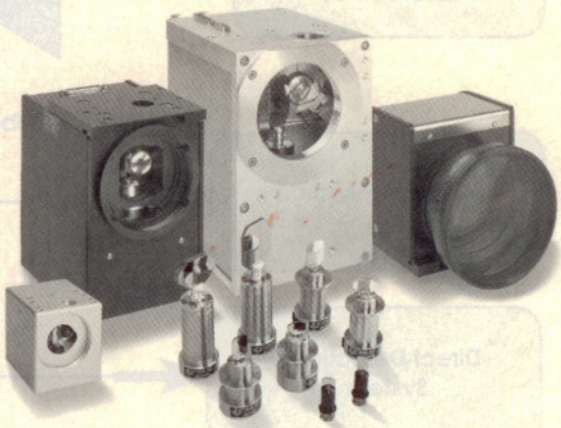

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