## Laser-Manipulated Iron Applied to Nanofabrication

In magnetism, model systems are required for understanding magnetic interactions and switching behaviors on the nanoscale. Fabrication and analysis of periodic nanostructures can therefore be useful in understanding phenomena such as magnetic photonic bandgaps or ultrahigh-areal-density materials for magnetic data storage. In the October 25 issue of *Applied Physics Letters* (p. 3842), G. Myszkiewicz and E. Jurdik from the group of Th. Rasing of Radboud University Nijmegen in The Netherlands have reported the fabrication and characterization of iron nanolines by atom optics, which is the interaction between an atomic beam and a far-off resonant laser standing wave. Atom optics allows for macroscopic, uniform arrays of well-defined periodic structures necessary for future magnetic data storage technology.

The iron nanostructures were grown by depositing an atomic beam of iron onto a glass–ceramic substrate through a one-dimensional optical standing wave tuned 200 MHz above the relevant optical transition in $^{56}$Fe. The optical forces applied to the $^{56}$Fe atoms propagating through the optical standing wave caused the atoms to migrate toward the regions of low light intensity. The process does not induce 100% modulation depth of the atoms so that the result is a background layer of deposited metal with a periodically-modulated line structure on top. The macroscopically "corrugated" surface is created with highly uniform Fe nanolines, which have a period of 186 nm, a full-width at half maximum of 95 nm, and a height above the background of 8 nm, as shown by atomic force microscopy (Figure 1). Approximately 8600 iron nanolines were created, each ~400 μm in length. Studies using magnetic force microscopy and magneto-optical Kerr measurements demonstrate ferromagnetic behavior with an in-plane easy axis that is independent of nanoline presence.

The researchers said that future work will involve engineering a material with periodically modulated magnetization, such as selective manipulation of iron during simultaneous deposition of another material, in order to create a nanostructure that is useful for data storage.

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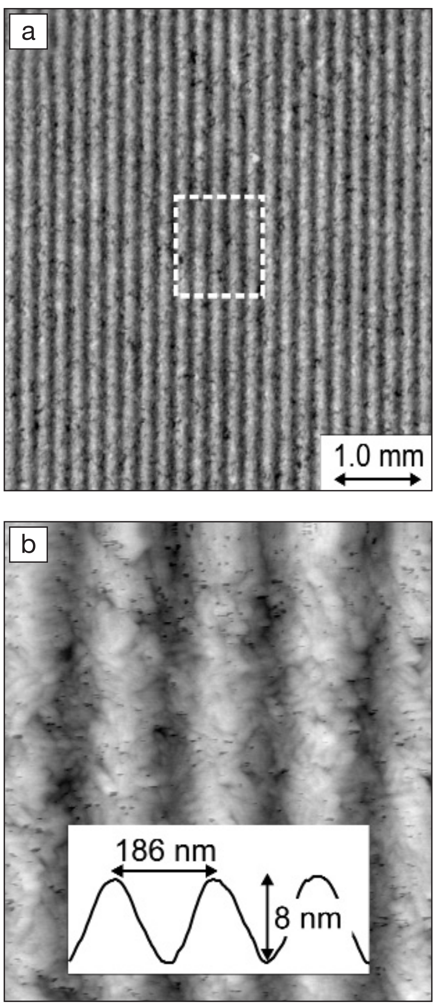


*Figure 1. Laser-focused nanolines of iron. Atomic force microscopy scans of (a) 5 μm × 5 μm and (b) 1 μm × 1 μm, corresponding to the surface area encapsulated in the white square in (a); inset is the structure profile averaged over 1 μm along the lines. Reprinted with permission from* Applied Physics Letters ***85*** *(17) (October 25, 2004) p. 3842. © 2004 American Institute of Physics.*

## High-Contrast Images of Semiconductor Chips Produced by Novel Microscopy Approach

A semiconductor integrated circuit (IC) chip is composed of metals, semiconductors, and dielectrics. In order to accurately identify the defect material in an integrated circuit, several microscopic imaging tools are available, but each has its advantages and drawbacks. V.J. Cemine and colleagues from the University of the Philippines have found that by combining confocal microscopy and optical-beam-induced current (OBIC) imaging, they are able to achieve high-contrast images of semiconductor and metal sites in integrated circuits. By using a semiconductor laser instead of a gas laser as the light source, they increased the efficiency and reduced the costs of this technique over others.

The OBIC imaging method can be used to generate two-dimensional images of the semiconductor sites in an IC because only semiconductors produce OBIC signals. A serious drawback with the OBIC images, though, is their poor resolution in the direction perpendicular to the chip surface, which makes images look similar even if they are taken at different depths. Confocal reflectance microscopy, on the other hand, yields high-contrast images, but metal and semiconductor sites are difficult to distinguish from each other because both materials exhibit relatively high reflectivity.

As reported in the November 1 issue of *Optics Letters* (p. 2479), the researchers acquired a pair of confocal and OBIC images simultaneously with the same focused beam by scanning the IC sample longitudinally relative to the stationary optical beam. The semiconductor laser used in these measurements is responsive to the reflected optical signals from the IC samples. This optical feedback mechanism helps to reduce threshold current and improve quantum efficiency of the laser. Three-dimensional distributions of semiconductor and metal sites in an IC are constructed by post-detection processing of image pairs taken at different depths.

"This is an inexpensive technique for high-contrast imaging of semiconductor and metal sites in an integrated circuit," said the researchers. "When combined with existing data sampling technologies employed in VCD players, rapid failure analysis of ICs can be performed economically."

SHIMING WU

## Protein Nanopatterning Technique Combines Nanoimprint Lithography and Molecular Self-Assembly

A major challenge for the development of bioengineered surfaces is the ability to immobilize proteins on scales ranging from the submicron to the nanometric. A critical criterion for biomolecular nanopatterns is the ability to deter nonspecific biomolecular binding, including nonspecific binding in the non-interactive areas of the pattern, to insure a low background signal. Patterning methods fall into two categories: serial and parallel. Serial techniques—like electron-beam writing, focused ion beam, and scanning probe-based lithography—are typically expensive and time-consuming but can generate virtually any type of pattern. Parallel techniques that produce regular, submicron patterns include microcontact printing, colloidal lithography, dip-pen nanolithography, and nanoimprint lithography (NIL). These methods are inexpensive compared to serial techniques but have substantially less pattern-shape flex-



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