Nanotechnology Highlight

Self-Assembling Copolymer Templates as a Route to Terabit Technologies

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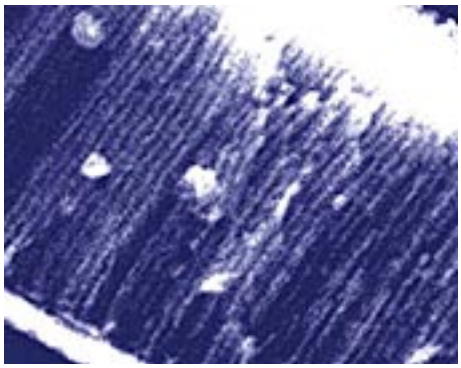
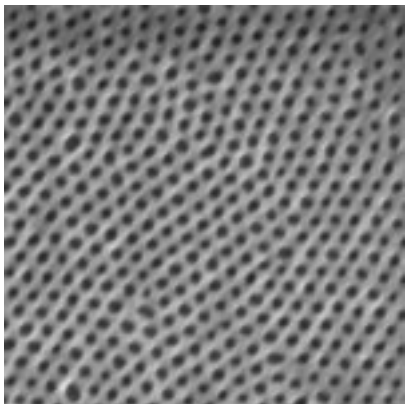
Imagine being able to store 25 full-length, DVD-quality movies on a disc the size of a quarter. That amounts to a data storage density of about 1.2 trillion bits per square inch. A recent development by researchers at the University of Massachusetts Amherst may provide a fabrication pathway to such future technology. Specifically, this group introduced a new technique for creating tightly-packed arrays of magnetic nanowires. The research is detailed in the Dec. 15, 2000 issue of the journal Science, and is funded by a National Science Foundation "Partnership in Nanotechnology: Functional Nanostructures" grant. Besides the UMass principal investigators, this work was performed by Thomas Thurn-Albrecht, Jorg Schotter, Gerd Kästle, and Nathan Emley of UMass, and T. Shibauchi, Lia Krusin-Elbaum, Kathryn Guarini, and Charles Black of the IBM T.J. Watson Research Center of Yorktown Heights, N.Y.



An electron micrograph showing a cross-section of an array of magnetic cobalt nanowires. Each wire is 14 nanometers in diameter -– 10,000 times thinner than the width of a human hair. *Prepared by M. Bal and A. Ursache, UMass Amherst.*

The fabrication technique relies on nanoporous polymer templates derived from the self-assembled nanoscopic array structure of cylindrical-phase poly(styrene)-poly(methacrylate) PS/PMMA copolymer films. An electric field is used to align the PMMA cylinders perpendicular to the substrate surface. UV irradiation, or alternatively an electron beam, facilitates the removal of the PMMA and the cross-linking of the PS. The resulting template resembles a highly-ordered honeycomb structure, with pores running from the surface of the film to the substrate underneath. Aided by the use of a surfactant, an array of cobalt metal nanowires is grown in the pores by electrochemical deposition. Figure 1 shows nanowires that are 14 nanometers in diameter, 500 nanometers long, and positioned on an array period of 24 nanometers. A considerably large magnetic coercivity is observed due to the small diameter of the wires. High-aspect-ratio magnetic elements, oriented perpendicular to the substrate surface, addresses the challenge of creating high-density media without giving in to the detrimental effects of superparamagnetism. The opportunity exists to tune the design the magnetic arrays in all three dimensions through manipulation of polymer molecular weight and electrodeposition parameters. This fabrication technique is quite versatile and can be used for fabricating other nanoscale array systems.



A top view of a nanoporous template derived from a PS/PMMA diblock copolymer film.

Relevant References:

1. "Ultrahigh-Density Nanowire Arrays Grown in Self-Assembled Diblock Copolymer Templates," T. Thurn-Albrecht, J. Schotter, G.A. Kästle, N. Emley, T.Shibauchi, L.Krusin-Elbaum, K.Guarini, C.T.Black, M. Tuominen and T.P. Russell, Science **290**, 2126 (2000).
2. "Nanoscopic Templates from Oriented Block Copolymer Films," T. Thurn-Albrecht, J. DeRouchey, C.M. Stafford, E. Huang, M. Bal, M. Tuominen, T. Russell, and C.J. Hawker, Advanced Materials, **12**, 787 (2000).
3. "Ultra-High-Density Magnetic Arrays: Fabrication by Electrochemical Deposition in a Nanoporous Diblock-Copolymer Template," M.T. Tuominen, T.P. Russell, T. Thurn-Albrecht, and J. Schotter, U.S. Patent (pending).