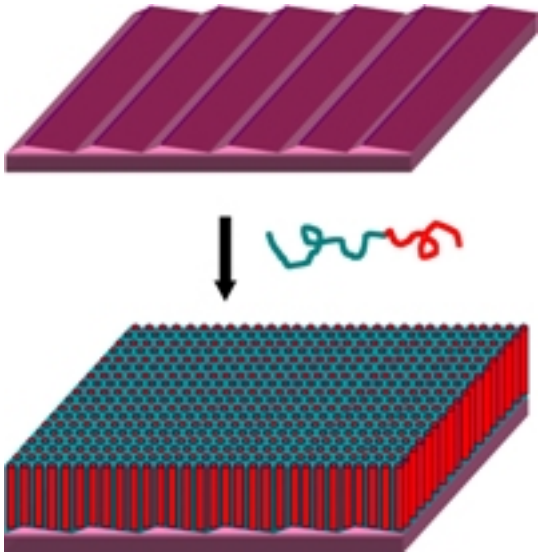
Crystalline Lattice May Revolutionize Memory



Researchers say a newly tested method for producing super dense, defect-free, thin polymer films is the fastest, most efficient method ever achieved and it may dramatically improve microelectronic storage capabilities, such as those in computer memory sticks.

In the February 20 issue of the journal *Science*, researchers at the University of Massachusetts Amherst and their colleagues at the University of California Berkeley report how they designed a new way to guide the self-assembly of the material used to store computer memory, layered block copolymers, and generate up to 10 times more storage space than similarly sized copolymers.

The researchers say they developed a defect-free method that can generate more than 10-terabit-per-square-inch copolymer where other efforts achieved at most one terabit per square inch. A terabit is an information storage unit equal to one trillion bits.

"We can generate nearly perfect arrays over macroscopic surfaces where the density is over 15 times higher than

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anything achieved before," said Thomas Russell director of the UMass Materials Research Science and Engineering Center. He co-led the research with Ting Xu, a member of the Department of Materials Science and Engineering at Berkeley. "We applied a simple concept to solve several problems at once, and it really worked out," Russell said.

The concept involved stacking atoms more closely together than previously thought possible to produce the highest density copolymer ever achieved, one capable of storing more information than previous copolymers. Researchers used surface ridges of a base crystal to guide the assembly very much like using the corrugations in cardboard to direct how closely marbles can be packed together.

For the copolymer's base layer, the researchers used commercially-available sapphire wafers, which start out flat. After heating them from 1,300°C to 1,500°C for 24 hours, the wafer's surface reorganized into a sawtooth topography with an inherent orientation. A thin copolymer film layer then was applied causing the underlying sawtooth corrugations to guide the film's self-assembly in a highly-ordered way to form an ultra-dense hexagonal, or honeycomb, crystalline lattice.

Additionally, by varying the annealing temperature, the scientists were able to change the angle and height of the sawteeth and the depth of the troughs between their peaks. The result enabled researchers to produce more densely packed troughs, which is where computer memory is stored.

The work was supported by the National Science Foundation and the Department of Energy's Office of Basic Energy Science.

"I expect this new method of producing highly ordered macroscopic arrays of nanoscopic elements will revolutionize the microelectronic and storage industries and perhaps others," said Russell.

He points out most previous efforts to create a well-ordered base material onto which electronic information is stored topped out at 15 nanometers for the smallest achievable pattern size. But "we've shattered that barrier and I think we can go farther," Russell said.

"This research by the teams at UMass Amerherst and Berkeley represents a significant breakthrough in the use of polymer self-assembly to create a high density of addressable locations in a thin film," said NSF program manager William J. Brittain. "Most significantly, the simple crystalline lattice used as the template may serve as a revolutionary step for a new generation of computer memory."

Photo courtesy of Dong Hyun Lee/UMass Amherst.

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