CHEMICAL PHYSICS

Magnetic Wires Promise Giant Step for Memory

The race to cram ever more data onto computer hard drives could soon be veering onto more interesting terrain. So far the track has been level: Hard drives store bits of data in tiny beams of magnetic material lying side by side on a flat disk. By continually shrinking those beams and improving the devices that read and record magnetic traces in them, computer engineers have boosted storage capacity nearly 100-fold over the past decade. In theory, they could pack in even more bits by standing the beams upright. But the leading technology for making dense arrays of magnetic posts requires chemicals corrosive to other disk materials and is limited to making posts of just one size. Now, a better way to make such an array may be at hand.

On page 2126, researchers at the University of Massachusetts, Amherst, IBM's T. J. Watson Research Center in Yorktown Heights, New York, and the Los Alamos National Laboratory in New Mexico describe a potentially cheap and simple method of creating porous plastic templates. By filling the pores with magnetic materials, they can make magnetic posts so small and close together that 10^{12} of them fit in a square centimeter. If each post could be addressed individually—a feat beyond the capability of today's read-write heads and likely a major challenge—disk drives would be able to store a terabit of data per square centimeter, a 300-fold improvement over current models.

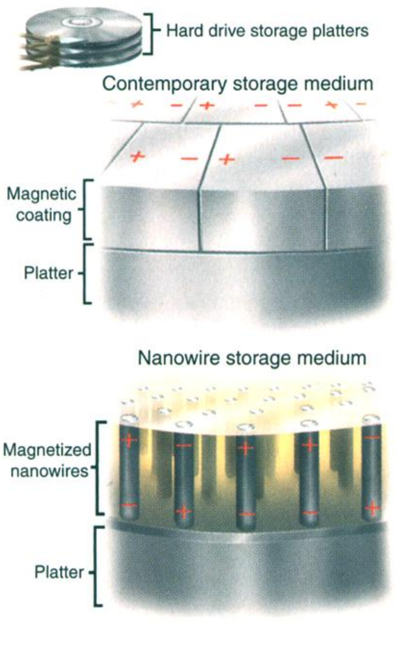
"I think it's going to be important," says Ivan Schuller, a physicist at the University of California, San Diego, who studies the properties of ultrasmall magnetic structures. And magnetic storage may be just part of the story, says Tom Russell, who led the University of Massachusetts portion of the team. By tweaking the recipe for the template's chemical precursors, he points out, one can create films with pores of different sizes. That may open the door for nanowire templates and arrays that serve as novel porous membranes for chemical separations or as tiny crucibles for controlling chemical reactions.

Currently, laboratories make the most densely packed arrays of tiny, parallel magnetic wires by chemically pitting a thin block of aluminum with tightly packed holes and then filling the holes with a magnetic material such as cobalt or iron. The trouble, Russell says, is that creating the holes requires caustic reactions that can wreak havoc on other components in computer circuitry.

To overcome that problem, Russell and his colleagues turned to two-part plastic molecules called copolymers. A copolymer molecule contains two portions sewn together in the middle, like a strand of spaghetti that is egg-flavored at one end and spinach-flavored at the other. When large numbers of copolymers are mixed together in solution, similar ends quickly crowd together. Researchers have long used this self-segregating property to make thin plastic films in which the copolymer halves arrange themselves into various patterns, including arrays of cylinders of one polymer component standing upright within the other. Those cylinders can then be hollowed out and filled with other materials to make things such as tiny magnetic posts. But such well-ordered films tend to be too thin to mold useful magnetic posts. And in thicker films the cylinders point in random directions.

Russell's team set out to orient those cylinders in thick films. Starting with two-part polymers made from standard plastic precursors, polystyrene and polymethylmethacrylate (PMMA), they deposited a thick layer over a surface. The polymers self-segregated into randomly oriented PMMA cylinders in a polystyrene matrix. The researchers then simply exposed the film to an electric field oriented perpendicular to the surface. Because the lowest energy state for each cylinder is to follow the path of the lines of the external field, the cylinders stood at attention like an army of tiny soldiers.

To hollow out those cylinders, the researchers exposed their film to ultraviolet



Raw bits. Nanowires cast in plastic molds might lead to computer drives packed with 300 times as many magnetic domains capable of storing information.

ILLUSTRATION: CAMERON SLAYDEN

ScienceScope

Thinking Strategically Canadian researchers will soon get a chance to share their visions of a "strategic investment." The new Canadian Institutes of Health Research last week launched plans to give each of its 13 newly appointed scientific directors (for a list, see sciencenow.sciencemag.org/cgi/content/full/2000/1206/4) $3.5 million annually to spend on strategic research. That has triggered a debate on exactly what to fund.

Genetics institute director Roderick McInnes, for instance, says the focus should be on cutting-edge science, while Jeff Reading, head of the Aboriginal People's Health institute, wants to emphasize research addressing social needs, such as reducing suicide among aboriginal teens. Infection and Immunity director Bhagirath Singh envisions using the money as leverage to attract research partners from industry and academe.

The directors agree that canvassing the science community for their ideas will be essential. "The biggest fear that scientists have is that some director is going to propose his pet project ... and that's it," says Cancer institute director Philip Branton. The spending plans are due 1 April.

Mehr, Bitte Germany's top basic research organizations are bemoaning a "disappointing" science budget for 2001. Research leaders said this week that planned increases won't be enough to sustain some innovative programs—or keep pace with other leading nations.

At the Max Planck Society, the nation's premier basic research agency, spending will rise 3% next year, to about $800 million, says president Hubert Markl. That's well short of the requested 5.2% budget hike, so the society may scale back new "international research schools" and other efforts to promote interdisciplinary partnerships, he says.

Markl and Ernst Ludwig Winnacker, head of the DFG basic-research granting agency—which will also get a 3% increase to about $1 billion—warn that Germany is falling behind the United States. To keep pace, both men vowed to push for more "substantial" raises in the 2002 budget. Markl is aiming for at least 5% more, while Winnacker hopes for as much as a 10% boost.

Contributors: David Malakoff, Andrew Lawler, Wayne Kondro, Robert Koenig

light, which breaks apart the PMMA and forges links between neighboring polystyrene molecules holding them in place. The result was a polystyrene matrix honeycombed with tiny tubes, which the team filled with cobalt. By changing the size of the copolymer components, "we can control the size of the cylinders [and nanowires] from 13 to 130 nanometers," Russell says.

Although the researchers have yet to test the magnetic properties of individual cobalt posts, they say the array as a whole shows promising characteristics. One is unusually high coercivity, or magnetic resistance, a trait that suggests cobalt nanowire arrays may be better than standard magnetic media at holding their magnetization when subjected to heat or other random fluctuations.

Russell notes that the team is pushing ahead with other applications as well. Silicon-filled holes may be useful as tiny electron storage devices for other types of computer memory. Cylinders lined with particular compounds may form membranes that let certain chemicals pass through while blocking others. The researchers also are teaming up with other groups to use the holes to trap large membrane proteins, the better to decipher their three-dimensional structure. If even one of these uses pans out, plastic templates with nanosized pores could have a big future. —**ROBERT F. SERVICE**

AGING RESEARCH

Old Flies May Hold Secrets of Aging

Sensible people know better than to believe in pills that promise perpetual youth or weight loss without dieting. But then Stephen Helfand isn't known for always being sensible. Seventeen years ago, he left a lucrative career as a neurologist at a prominent Boston hospital to search for aging genes in fruit flies, a task many considered hopeless at the time. Yet, as he and his colleagues at the University of Connecticut Health Center in Farmington demonstrate on page 2137, there's lots to be learned by departing from the norm.

Helfand's team has discovered a gene that, when altered, can double the average life-span of fruit flies and may one day lead to that long-awaited miracle pill. "This [gene] provides optimism that it may, indeed, be possible to manipulate active life-span beyond the constraints that ordinarily apply in natural evolution," says Seymour Benzer, the geneticist at the California Institute of Technology in Pasadena who in 1998 discovered a different fruit fly aging gene, dubbed *methuselah* (*Science*, 30 October 1998, p. 856).

Preliminary data suggest that the protein encoded by this gene, called *Indy* for "*I'm not dead yet*," transports and recycles metabolic byproducts. Helfand thinks that defects in the gene, two copies of which exist in each fruit fly, can lead to production of a protein that renders metabolism less efficient; as a result the body functions as if the fruit fly were dieting, even though its eating habits are unchanged. As such, the discovery provides a "clear genetic link between metabolism and the rate of aging," comments Tomas Prolla, a geneticist at the University of Wisconsin, Madison. The work may lead to a better understanding of how metabolism plays into aging. It may also illuminate why worms, fruit flies, and rodents, at least, live longer on a spartan diet.

Antiaging protein. Dark staining indicates that *Indy* genes are active in the fat bodies of fruit flies, the right place to alter metabolism.

Helfand came upon *Indy* by accident. In mutant strains of fruit flies produced for a different experiment, he and Connecticut's Blanka Rogina noticed that some lived longer than usual. Working with Connecticut's Robert Reenan, they first did some experiments to make sure that a mutation in *Indy* and not some other factor was indeed conferring longevity on these flies. It was. They determined that fruit flies carrying one good copy and one defective copy of *Indy* lived the longest, averaging 70 days versus the usual 37—"quite impressive extension of life-span," notes Judith Campisi, a cell and molecular biologist at Lawrence Berkeley National Laboratory in California. With two altered copies of the gene, flies live only about 20% longer than the norm.

The Connecticut team tracked down other mutant strains with defects in the *Indy* gene, culling some from their own stocks and those of colleagues. They eventually came up with five different mutant versions of *Indy*, one copy of which always made the fruit fly live much longer. They chose the name based on a quip in the movie *Monty Python and the Holy Grail*.

In each mutant, *Indy* seems to extend life-span without exacting any other costs from the fruit fly. In tests, individuals belonging to the *Indy* strains flew just as well, ate just as much, and courted each other with as much vigor as did their shorter lived counterparts. They started reproducing at the same age, laid as many eggs, and even continued to reproduce long after other flies had stopped—suggesting they retained their youthful vitality.

Indy codes for a protein that resembles a sodium dicarboxylate cotransporter, a membrane protein found in many organisms, from bacteria to mammals, including humans. In mammals, dicarboxylate cotransporters show up in cells in the digestive tract, placenta, liver, kidney, and brain, where they transport metabolic intermediates across the cell membrane. In the fruit fly, the gene "is right at the places you'd like it to be" to serve a similar function, Helfand notes: It is active in fat bodies—which function as the liver in insects—the midgut, and in cells called oenocytes, which appear to store glycogen and be involved in metabolism. "Perhaps it's altering the nutrients, either their utilization or absorption, or making intermediate metabolism slightly less efficient," he suggests. "Either way, it may be the genetic equivalent of caloric restriction."

Given these data, the *Indy* mutants could prove a gold mine to aging researchers, says Prolla, as they may help clarify antiaging mechanisms. He'd like to see what happens to the life-span of flies that have both a mutation in *Indy* and one in genes that alter the fly's ability to deal with oxidative stress, another putative cause of aging. If those flies lived even longer, "it would suggest that there are in fact many routes for intervention in the aging process," Prolla adds.

Despite their enthusiasm, aging researchers stress that much work remains. "The genetic evidence is strong, but there is some biochemistry that needs to be done to show that this really works the way they say it does," says Campisi. Researchers have not studied cotransporters extensively in humans, except those in the kidney. So exactly how they work in, say, the gut of humans or flies remains unclear. Researchers must also find out how the protein works in different mutant strains.

But Helfand is hopeful. The *Indy* protein's location and nature suggest that eventually, "it may be possible to design a drug that can extend life," he suggests. "The drug may very well work with weight control, too." And that sounds like a chance even sensible people might be willing to take.

—**ELIZABETH PENNISI**

CREDIT: B. ROGINA *ET AL.*