Nanomaterial May Be Future of Hard Drives

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Materials become magnetized when their internal magnetic grains, which usually point in different directions, align in a strong enough magnetic field. How much a material’s grains resist
aligning is known as its coercivity. A familiar bar magnet, for example, has high coercivity, with its typically constant north-south poles. Other substances, such as iron and nickel, have low coercivity, meaning they can change their orientations more easily.

Coercivity isn’t just about a magnet’s composition; it also depends on its temperature. Usually, a magnet’s coercivity changes gradually as its temperature rises or falls. But the new nanomaterial shows this isn’t always true. To make the material, a team led by physicist Ivan Schuller at the University of California, San Diego, deposited an ultrathin 10-nanometer layer of nickel onto a 100-nanometer-thick wafer of a substance called vanadium oxide. The scientists then cooled the mixture and ramped up a magnetic field until the nickel’s grains started to flip. This process allowed the scientists to measure the material’s coercivity at temperatures down to negative 153°C.

After most temperature changes, the material’s coercivity budged only slightly. But between negative 88°C and negative 108°C, its coercivity jumped up five times, making it much more resistant to changing its magnetic orientation. Its coercivity then plummeted to half its maximum value as the scientists further lowered the temperature to negative 123°C, meaning the material’s grains again became easier to flip. The dramatic spike in coercivity—far larger than that seen in any other material over a similar temperature range—excited the researchers, who reported it at this week’s American Physical Society meeting in Denver. The work also appears in Applied Physics Letters. This is what we physicists like to do—look at things that are huge effects, that are fantastic effects,” Schuller says.

Even though nickel has the flippable magnetic grains, Schuller thinks a change in vanadium oxide’s internal structure is what causes the combined material’s coercivity spike. Vanadium oxide’s atoms take on one arrangement above negative 88°C and another below negative 123°C. Between the two temperatures, however, the material contains blocks with both arrangements. That mixed structure makes it harder for the overlying nickel’s grains to flip en masse, Schuller says.

While potential applications are still a ways off, Schuller thinks his team’s finding could someday lead to a new kind of temperature-controlled computer memory. Computers encode information in tiny magnetic components, and to be stable these components must not realign easily. But the magnets must also be able to flip quickly under certain conditions, so that memory can be rewritten. Schuller envisions that a hard drive based on his finding would keep its memory elements at a high-coercivity temperature most of the time, and heat them slightly for rewriting. This would be a huge improvement over current heat-assisted magnetic recording devices, whose elements must be heated hundreds of degrees by laser.

“I was a bit surprised” at the large coercivity spike the team found, says Dan Dahlberg, a physicist at the University of Minnesota, Twin Cities. “It’s not what you would expect.” But Dahlberg is not excited enough about the material to start studying it himself. He notes that any viable heat-assisted memory technology would need to operate near room temperature, not at the frigid temperature where the coercivity of Schuller’s material spikes. (Schuller says his team has produced a material with a coercivity spike closer to room temperature and is planning to publish this result.)

Still, Dahlberg says, it can be hard to predict whether a new discovery will lead to applications down the road. “To say something will never end up in technology … is a very dangerous thing.”
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