Researchers improve memory devices using nanotech

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Arizona State University's Center for Applied Nanoionics (CANi) has a new take on old memory, one that promises to boost the performance, capacity and battery life of consumer electronics from digital cameras to laptops. Best of all, it is cheap, made from common materials and compatible with just about anything currently on the market.

"In using readily available materials, we've provided a way for this memory to be made at essentially zero extra cost, because the materials you need are already used in the chips — all you have to do is mix them in a slightly different way," said Michael Kozicki, director of CANi.

The research was conducted in collaboration with Research Center Jülich in Germany. It was published in the October 2007 issue of the journal *IEEE Transactions on Electron Devices* in the article "Bipolar and Unipolar Resistive Switching in Cu-doped SiO2." The team included Christina Schindler, on loan from Germany to CANi, Sarath Chandran Puthen Thermadam of CANi, Kozicki, and Rainer Waser of the Institute for Solid State Research and Center for Nanoelectronics Systems and Information Technology in Jülich.

For some time now, conventional computer memory has been heading toward a crunch — a physical limit of how much storage can be crammed into a given space. Traditional electronics begins to break down at the nanoscale — the scale of individual molecules — because pushing electronics closer together creates more heat and greater power dissipation. As consumer electronics such as MP3 players and digital cameras shrink, the need for more memory in a smaller space grows.

Researchers have been approaching the problem from two directions, either trying to leapfrog to the next generation of memory, or refining current memory. CANi took both approaches, amping up performance via special materials while also switching from charge-based storage to resistance-based storage.

“We’ve developed a new type of old memory, but really it is the perfect memory for what’s going to be required in future generations,” Kozicki said. “It’s very low-energy. You can scale it down to the nanoscale. You can pack a lot of it into a small space.”

CANi was also able to overcome the limitations of conventional electronics by using nanoionics, a technique for moving tiny bits of matter around on a chip. Instead moving electrons among charged particles, called ions, as in traditional electronics, nanoionics moves the ions themselves.

“We’ve actually been able to move something the size of a virus between electrodes to switch them from a high resistance to a low resistance, which is great for memory,” Kozicki said.

Most memory today stores information as charge; in the binary language of computers, this means that an abundance of charge at a particular site on a chip translated as a “one,” and a lack of charge is translated as a “zero.” The problem with such memory is that the smaller its physical size, the less charge it can reliably store.

Resistance-based memory, on the other hand, does not suffer from this problem and can even store multiple bits on one site. Moreover, once the resistance is set, it does not change, even when the power is switched off.

CANi's previous high-performance resistance-change memory has been licensed to three companies, including Micron Technology and Qimonda, and has attracted the attention of Samsung, Sony and IBM. However, it used some materials, specifically silver and germanium sulfide, previously unused by industry and therefore required new processes to be developed.

The real advancement of CANi's newest memory is that researchers discovered a way to use materials already common in chip manufacturing. Although "doping" — mixing silicon with small amounts of conductive materials such as boron, arsenic or phosphorus — has been common practice for years, copper in silicon dioxide was largely unheard of. In fact, it was strictly avoided.

"People have actually gone to great lengths to keep the silicon oxide and the copper apart," Kozicki said. "But in our case, we are very interested in mixing the copper with the oxide — basically, so that it would become mobile and move around in the material."

"Because it can move in there, we can make a sort of nanoscale switch," he added. "This very, very small switch can be used in memory applications, storing information via a range of resistance values."

Industry has already shown interest in the new memory and, if all goes well, consumers could see it on the market within a few years.

"What it means is we could replace all of the memory in all sorts of applications — from laptops to iPods to cell phones to whatever — with this one type of memory," Kozicki said. "Because it is so low energy, we can pack a lot of memory and not drain battery power; and it's not volatile — you can switch everything off and retain information. What makes this significant is that we are using materials that are already in use in the semiconductor industry to create a component that's never been thought of before.”

Source: Arizona State University