Nanoscale computer memory retrieves data 1,000 times faster

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Scientists from the University of Pennsylvania have developed nanowires capable of storing computer data for 100,000 years and retrieving that data a thousand times faster than existing portable memory devices such as Flash memory and micro-drives, all using less power and space than current memory technologies.

Ritesh Agarwal, an assistant professor in the Department of Materials Science and Engineering, and colleagues developed a self-assembling nanowire of germanium antimony telluride, a phase-changing material that switches between amorphous and crystalline structures, the key to read/write computer memory.

Fabrication of the nanoscale devices, roughly 100 atoms in diameter, was performed without conventional lithography, the blunt, top-down manufacturing process that employs strong chemicals and often produces unusable materials with space, size and efficiency limitations.

Instead, researchers used self-assembly, a process by which chemical reactants crystallize at lower temperatures mediated by nanoscale metal catalysts to spontaneously form nanowires that were 30-50 nanometers in diameter and 10 micrometers in length, and then they fabricated memory devices on silicon substrates.

“We measured the resulting nanowires for write-current amplitude, switching speed between amorphous and crystalline phases, long-term durability and data retention time,” Agarwal said.

Tests showed extremely low power consumption for data encoding (0.7mW per bit). They also indicated the data writing, erasing and retrieval (50 nanoseconds) to be 1,000 times faster than conventional Flash memory and indicated the device would not lose data even after approximately 100,000 years of use, all with the potential to realize terabit-level nonvolatile memory device density.

“This new form of memory has the potential to revolutionize the way we share information, transfer data and even download entertainment as consumers,” Agarwal said. “This represents a potential sea-change in the way we access and store data.”

Phase-change memory in general features faster read/write, better durability and simpler construction compared with other memory technologies such as Flash. The challenge has been to reduce the size of phase change materials by conventional lithographic techniques without damaging their useful properties. Self-assembled phase-change nanowires, as created by Penn researchers, operate with less power and are easier to scale, providing a useful new strategy for ideal memory that provides efficient and durable control of memory several orders of magnitude greater than current technologies.

“The atomic scale of the nanodevices may represent the ultimate size limit in current-induced phase transition systems for non-volatile memory applications,” Agarwal said.

Current solid-state technology for products like memory cards, digital cameras and personal data assistants traditionally utilize Flash memory, a non-volatile and durable computer memory that can be erased and reprogrammed electronically. Data on Flash drives provides most battery-powered devices with acceptable levels of durability and moderately fast data access. Yet the technology’s limits are apparent. Digital cameras can’t snap rapid-fire photos because it takes precious seconds to store the last photo to memory. If the memory device is fast, as in DRAM and SRAM used in computers, then it is volatile; if the plug on a desktop computer is pulled, all recent data entry is lost.

Therefore, a universal memory device is desired that can be scalable, fast, durable and nonvolatile, a difficult set of requirements which have now been demonstrated at Penn.

“Imagine being able to store hundreds of high-resolution movies in a small drive, downloading them and playing them without wasting time on data buffering, or imagine booting your laptop computer in a few seconds as you wouldn’t need to transfer the operating system to active memory” Agarwal said.

Source: University of Pennsylvania

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