Nanotechnology Highlight

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Caltech, Agere Systems scientists develop technique to shrink memory chips

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Researchers at the California Institute of Technology and Agere Systems, formerly known as the Microelectronics Group of Lucent Technologies, have developed a technique that could result in a new generation of reliable nanoscale memory chips. This research could lead to smaller, less expensive cellular phones and digital cameras.

The research development, announced December 13 at the International Electron Devices Meeting, applies to a type of memory called "flash" memory, which continues to store information even when the devices are turned off. This information could include personal phone directories in a cellular phone or the pictures captured by a digital camera. In a typical cellular phone, there are 16 to 32 million bits of data stored on a silicon flash memory chip. Each bit of data is stored in a part of the flash memory chip called a "cell." As the size of silicon memory chips decreases, the chips are more and more difficult to make leakproof, resulting in the loss of stored date.

Using an aerosol technique developed at Caltech, the researchers formed memory cells by spraying silicon nanocrystals through a bath of high-temperature oxygen gas. The end result was memory cells comprised of silicon on the inside with a silicon dioxide outer shell. The silicon nanocrystals store the electrical charge, whereas the insulating silicon dioxide shell makes the nanocrystal memory cells more leakproof.

"As compared to conventional flash memories, these silicon nanocrystal memories offer higher performance, simpler fabrication processes, and greater promise for carrying memory miniaturization to its ultimate limit," said Harry Atwater, professor of applied physics and materials science at Caltech and project director.

To overcome the potential leakage problem, Atwater and Richard Flagan, McCollum Professor of Chemical Engineering, and their students at Caltech, and colleagues Jan de Blauwe and Martin Green at Agere Systems developed a method to break up each memory cell into 20,000 to 40,000 smaller cells. Therefore, even if several of the smaller cells spring a leak, the vast majority of the charge will not be lost and the bit of data stored in the whole memory cell will be retained.

The aerosol approach has several advantages over the conventional lithographic techniques used to make today's flash memory cells. Because it requires fewer steps, it is less expensive and takes less time to produce. In addition, the aerosol approach will allow researchers to continue making smaller and smaller devices.

So far, the researchers have created extremely robust flash memory cells. For instance, they have charged and dissipated a single cell one million cycles without significant degradation, whereas with traditional silicon chips, 10,000 cycles is considered satisfactory. While these research results are promising, it is premature to predict if or when the technology will be commercially implemented.

In addition to Atwater and Flagan, other members of the Caltech nanocrystal memory team are postdoctoral scholar Mark Brongersma, and graduate students Elizabeth Boer, Julie Casperson, and Michele Ostraat.

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