Nanotube memory flashes past silicon

16:14 05 February 2009 by **David Robson**
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Although carbon nanotubes have long been believed to be perfect for making faster, smaller computer memory prototype devices have so far proved too sluggish for practical use.

Now a new design that is 100,000 times faster than previous efforts has blasted through that barrier, paving the way for nanotube flash memory to be a part of future electronic and computing devices.

The device stores a single digital bit on each nanotube, using a very simple setup.

Each tube is laid flat on a silicon wafer and attached to two electrodes that run an electric current along its length. A third, "gate", electrode is separated from the tiny tube by a thin insulating layer and is used to write the data.

To do this, the gate lets pass a quick burst of electricity which causes a lasting build-up of charge to be created in a layer of insulating material between the electrode and the nanotube.

The charge, signalling a digital 1, can be detected because it alters the current passing between the other two electrodes. Writing a 0 requires sending a second pulse via the gate electrode to wipe out the stored charge.

That charge will persist for long periods – enough for the memory to be maintained when a device is switched off, in the same way as flash memory devices such as USB sticks or flash cards in cellphones and cameras.

Silicon beater

Most previous carbon nanotube devices used silicon dioxide as the insulating layer. But loading that material with charge takes several milliseconds, an age in memory terms. Existing flash memory takes just microseconds to perform the same operation.

But the new device, developed by Päivi Törmä at Helsinki University of Technology and colleagues from the University of Jyväskylä, both in Finland, has closed that gap by using a different insulating material.

They coated the gate electrode in a thin layer of hafnium oxide, which is very sensitive to changes in voltage and has a porous structure that helps it to capture charge.

In tests, the new device could store and erase data in just 100 nanoseconds – a dramatic improvement over previous prototypes and even faster than commercial flash memory.

Faster to come?

"It's pretty amazing considering it has not gone through any optimisation or refining process," says Törmä. "What actually sets the 100 nanosecond limit is not the nanotube memory, but our experimental setup, so it might be able to work at even higher speeds – we just don't know yet."

The device managed to withstand 18,000 operations, which is a reasonable lifetime for a memory device, she adds.

Hurdles remain

The next challenge is to join an array together into a working memory chip, as the

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team has so far only tested single carbon nanotube elements. And although they have only proved capable of "remembering" data for several days after the power is cut, the team are confident this can be extended.

Andrea Ferrari, who works on nanoelectronics at the University of Cambridge, calls the work a "significant advance". He adds that the findings could resuscitate interest in these carbon devices after slow writing speeds have deterred some researchers.

"It's the first step to putting carbon nanotube devices back on the map," he says. However, Ferrari points out there will still be hurdles in manufacturing the nanotubes at high densities on memory chips on a large commercial scale.

Manipulating large numbers of nanotubes into position is not easy compared to the sophisticated, high-volume silicon manufacturing processes used to make the memory in today's devices. But new techniques, such as transporting them using electric fields, are developing fast.

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