SEMICONDUCTORS / MEMORY

NEWS

Flash Memory Survives 100 Million Cycles

A little heat lets flash beat typical 10 000-cycle limit

By YU-TZU CHIU / DECEMBER 2012

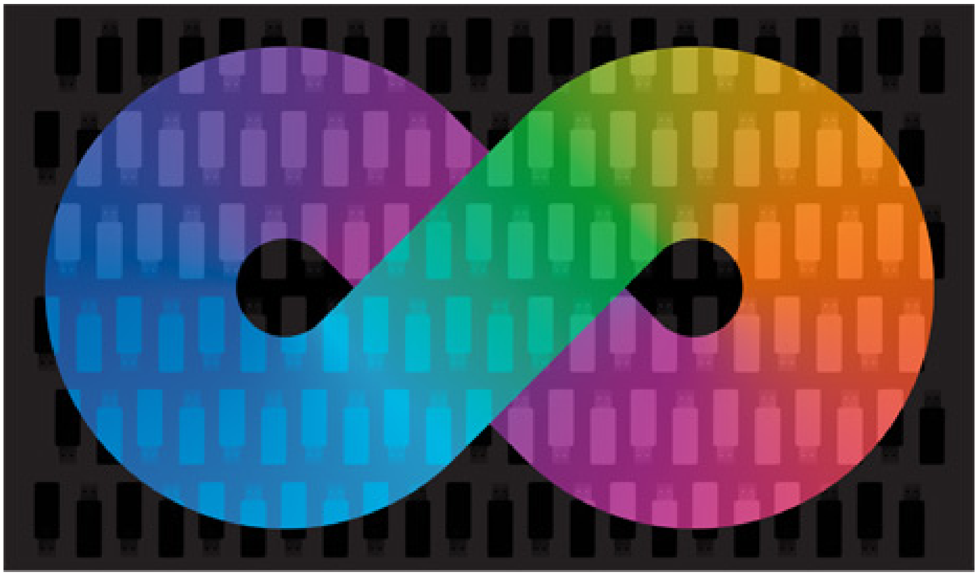

Illustration: Brandon Palacio; Original Images: iStockphoto

In the world of memory chips, flash is king. But it's not perfect. It wears out after being programmed and erased about 10 000 times. That's fine for a USB dongle that you'll probably lose in a year, but not ideal for the solid-state drives of server farms. And the same problem keeps manufacturers from using flash to replace other types of computer memories. This month, at the 2012 IEEE International Electron Devices Meeting, engineers from Macronix plan to report the invention of a self-healing NAND flash memory that survives more than 100 million cycles.

What's more, that may not even be the real limit. "We do not know what would eventually cause the device to fail, since we have not seen the end-of-life signals yet," says Hang-Ting Lue, a project deputy director at Macronix, which is located in Hsinchu, Taiwan. To test for 1 billion cycles would take several months, he says.

The key to superlong-lasting flash lies in stealing some tricks from an up-and-coming memory technology that some hope will eventually push flash aside.

A flash memory cell looks like an ordinary CMOS transistor: source and drain regions with a channel of silicon between them, a layer of insulation above the channel, and the gate above that. The major difference is a layer of material called a floating gate, which is embedded inside the transistor's gate insulation. The bit is stored in that layer when electrons are driven to "tunnel" through the insulation and get stuck in the floating gate. Erasing the bit requires driving the electrons out again.

But these write-erase cycles degrade the insulation, and eventually the cell will fail. To compensate for this weakness in solid-state drives, designers have to adopt elaborate schemes to ensure that no particular set of bits is overwritten too often. Annealing would heal the damage, but the thinking was that it could be done only by heating the whole chip for hours at around 250 °C.

Macronix engineers saw a solution in a competing technology, phase change RAM. In PCRAM, a bit is stored in a material called a chalcogenide glass, which can be either conductive or insulating. The bit's material switches between those states when briefly heated in a particular way. According to Lue, Macronix researchers noticed that heating the glass to its melting point had a kind of healing effect on their PCRAM. (They reported those results at the IEEE International Reliability Physics Symposium in April 2012.)

Macronix engineers figured that a similar trick wo[...] memory chip to include tiny onboard heaters that could anneal small gro[...] quite a few changes. The biggest one, says Lue, was altering the gate electrode so that it could carry current to heat the memory cells. That alteration, which included the addition of diodes, took up so much space that the Macronix team had to devise a new architecture for its memory arrays to squeeze it all in, he adds.

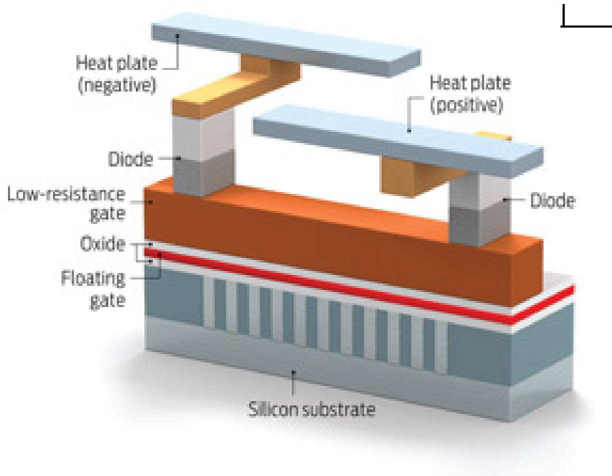

Illustration: Emily Cooper

HOT STUFF: Current flowing through the memory cells' gate heats and heals the oxide layers.

The modified structure enables current to pass through the transistor's gate to generate pulses of heat a few milliseconds long. Researchers found that temperatures exceeded 800 °C but that the hot spot was restricted to the area near the gate. The chips were able to heal themselves through this onboard annealing to the point that even after 100 million cycles, the researchers claim, the memories held data well.

You might think all this heating would be bad for battery life. The "refreshing" does require a substantial amount of power, Lue concedes, but the annealing can be done infrequently and one sector at a time, while the device is inactive but still connected to the power source. "It's not going to drain your cellphone battery," he says.

The experimental memory yielded another surprise: The heating allowed faster erasing, something that was thought to be independent of temperature. "Further down, this may evolve into a 'thermally assisted' mode of operation that gives both better performance—such as the faster erasing—and better endurance flash memory," Lue says. Faster erasing could eventually result in flash taking over from dynamic RAM, the volatile but fast computer memory, but it would take a lot to get there. "Flash is not a random access memory, and the architecture will need to be completely different," he says.

Lue says Macronix intends to capitalize on the self-healing flash breakthrough, but he would not give details about how and when. He was more forthcoming about when the flash industry should have worked in this technology. "It took a leap of imagination to jump into a completely different regime…very high temperature and in a very short time," says Lue. "Afterward, we realized that there was no new physics principle invented here, and we could have done this 10 years ago."

This article originally appeared in print as "Forever Flash."

6 comments

Randy Chung • 4 months ago

I wonder if this technique could be used to make IC's used in spacecraft more radiation tolerant?

Nimbekka Ktrc → Randy Chung • 3 months ago

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techau • 3 months ago

Heard about this on Security Now.. That's awesome news. Can't wait till it hits the market.

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Neil Rieck • 3 months ago

Back in the day, Stanford R. Ovshinsky developed a EEROM memory where a bit was stored by shifting a channel (I thought it was silicon) from a crystalline state (low resistance) to an amorphous state (high resistance). IIRC, one state required a short burst of 5-15 pulses while the other required a single long pulse. I never learned the underlying physics but now wonder if there was some heating effect to move the channel back into the crystalline state.

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Shankrammaktrc • 3 months ago

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Ujjappa Banakar • 3 months ago

So good one.......

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