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Silicon nanocrystals may replace traditional flash memory
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Freescale Semiconductor Inc said yesterday it had manufactured what it claims is the first 24-megabit-memory chip based on silicon nanocrystals.

The new type of memory technology is faster, denser and cheaper than conventional flash memory, Freescale said.

The result may be smaller, cheaper stand-alone memory used in cell phones, smart phones and PDAs.

The technology may find its first application in replacing conventional embedded flash memory, which is expected to reach its scaling limit, or smallest size, during the next four years. Embedded flash memory is widely used in wireless baseband gear and car microcontrollers.

Silicon nanocrystal memories fall into a new class of memory technologies called thin-film storage. Freescale said its new 24-Mbit-nanocrystal memory represents a major step toward replacing traditional flash memories.

Semico analyst Jim Handy said this type of storage is a "promising alternative" to traditional embedded NOR memory. And it may indeed lead to faster, cheaper memory, Handy said.

Essentially, Freescale's technology seeks to help the chip industry keep pace with Moore's Law on the memory front.

Conventional floating gate-based memories require a fairly thick oxide surrounding, so they can be charged with voltage from the MOSFET, or metal-oxide semiconductor field-effect transistor. Without the oxide surroundings, the charge would wander off. But its thickness requires a typical plus- or minus-9 volt charge. In order to program these cells at high voltages, relatively large peripheral logic devices are needed.

Simply thinning down the oxide surrounding is problematic because it contains inherent defects, which may cause the voltage to leak.

"So there's an inability to scale the size of your memory module," explained Bruce White, Freescale's manager of advanced materials, memories and interconnects.

To get around this problem, Freescale has reduced the voltage level by essentially breaking the floating gate into tiny silicon nanocrystals. The silicon blocks measure just 5-nanometers in diameter. (The width of a strand of human hair measures roughly 80,000.)

By replacing a chunk of silicon typically used in a floating gate with silicon nanocrystals, Freescale can effectively thin down the oxide surroundings. If the charge becomes exposed to one of the oxide surrounding's defects, then just one nanocrystal would be removed. The rest of the nanocrystals would retain their charge, White said.

Using nanocrystals enables Freescale to thin those surrounding oxides down by roughly a factor of 2, he said. And it can reduce the required charge from plus- or minus-9 volts to plus- or minus-6 volts at the 90-nanometer manufacturing node, he said.

Of course, by making the memory half the size doesn't mean the total silicon used in a mobile device would half, but memory can currently represent a substantial fraction of the silicon die, White said.

The nanocrystal method also has additional advantages for embedded memory.

"It also allows you to communize a lot of the process steps required to build this memory with high performance logic," White said.

Typically, a conventional floating gate would require 11 additional masking steps to embed the memory into a logic process during manufacturing. Silicon nanocrystals would require just four additional masking steps, White said.

He declined to quantify the manufacturing cost savings but said they would be "significant."

Because Freescale's new method used largely the same type of materials, such as silicon and silicon dioxide, there is an opportunity to reuse current manufacturing process technologies, White said.

The memory was made at Freescale's Austin facility using 90-nanometer CMOS technology. But White said the Texas-based company hopes to begin production in its upcoming 65-nanometer manufacturing node in 2008.

While the nanocrystal method was developed to benefit Freescale, "There are opportunities to license the technology," White said.

Freescale has been on the nanocrystal trail for some time. It first demonstrated a 4-Mbit-nanocrystal-memory device in late 2003.