RESEARCH BULLETIN

IC Insights

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## Memory Alternatives Increasing in Number, Value

*Multiple choices offer some good, but often not enough for complete market replacement*

Memory manufacturers have put more effort into developing alternative solutions to DRAM and flash memory as the struggle to scale DRAM capacitors and flash memory storage cells nears the physical limitations using current process technologies. Consequently, alternative memory solutions featuring storage techniques other than a capacitor or floating gate are being considered (Figure 1). Several different specialty memories targeting specific end uses are currently available. Though none is likely to challenge volume products anytime soon, all hold at least the possibility of providing the characteristics that could make a universal memory including fast read and write with low power; non-volatility with very long data retention and cycle life; and small cell size.

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Magnetoresistive RAM (MRAM), Ferroelectric RAM (FRAM), and Phase-change RAM (PCRAM) are among the most talked about options to DRAM and flash memory. As noted in Figure 1, each technology has some decided advantages over current DRAM and flash memory options. However, each also has some drawbacks from a cost or technology standpoint.

Resistance (resistive) RAM ReRAM/RRAM is another possible solution. Fujitsu, Intel, Samsung, Sharp, and Spansion are working on this technology. These companies believe ReRAM will be 100x faster than flash, yet scale much better than other advanced memories like phase-change RAM or MRAM.

An option not listed in the chart but showing considerable promise is carbon nanotube (CNT) technology. This could be the answer for system memory near-term and complex logic farther out. Nanotube-based RAM (NRAM) cells are constructed using several CNTs suspended above a metal electrode. When a small voltage bias is applied to the tubes, they "sag" toward the electrode until making contact. At that point, the tubes are considered in the logic 1 state. When the voltage bias is removed, they pull back away from the electrode and the logic state becomes 0 once again. The benefits of NRAM include having the speed of SRAM, densities far exceeding DRAM, and lower power consumption than DRAM or flash. Also, it stands up well to harsh environments and scales well.

Additionally, the recent announcement of the "memristor"—the circuit element that improves in performance as you scale it down—to smaller sizes could be the technology breakthrough that memory suppliers hope for to create a universal memory.

IC Insights continues to believe that the memory market (particularly, DRAM) is evolutionary, not revolutionary. Memory suppliers will push all they can out of existing technology/architectures before having to move on to an alternative such as nanotubes, PCRAM, or MRAM. So far, no alternative memory offers such a compelling solution that makes it better than anything currently existing.

## Memory Alternatives

### *MRAM — Magnetoresistive RAM*

- Spin-momentum-transfer or just spin-transfer device to possibly add 20x density boost?
- Magnetic, rather than electronic, charges to store bits of data.
- Well-suited for embedded memory apps.
- Nonvolatile memory with fast read, write, and erase times. Considered a potential enabler of "instant-on" computer.
- Questions about scalability (density and current). Can cell size and production costs get close to DRAM, Flash?
- *Major Players: Crocus Technology, Freescale, Grandis, Honeywell, IBM, NEC, Renesas, Samsung, Spintron, Toshiba. (Casualties: Cypress, Union Semi, ST, Micron.)*

### *FRAM — Ferroelectric RAM*

- Durable nonvolatile memory with fast read/write access and low power requirements. Potentially useful in small consumer applications.
- Similar construction as DRAM, one capacitor and one (or two) transistors(s).
- FRAM cannot store nearly as much as DRAM or SRAM given same die size.
- Limited production, destruction read process, limited endurance.
- *Major Players: Fujitsu, Ramtron, Cells Semi.*

### *PCRAM — Phase-change RAM*

- Data stored by heating and changing the state of special material, "chalcogenide."
- Read operation takes place by determining high/low resistance state of memory cell. Write operation is triggered by ohmic heating with electric current.
- Current densities to 128Mb, faster write speed, potential to replace flash memory.
- Long-term outlook: good scalability and the possibility of multi-level cells.
- Considerable work yet to be done on technical side.
- *Major Players: Elpida, Hitachi, Hynix, IBM, NXP, Numonyx, Ovonyx, Qimonda, Renesas, Samsung, ST.*

### *Organic RAM*

- Triple-layer device composed of an embedded metal layer between two organic films. Retains data for weeks when the power is turned off. Said to be very fast compared to other NV memory and easily manufactured. Potential as embedded memory.

### *CBRAM — Conductive-bridging RAM*

- On/off states correspond to presence or lack of a conductive bridge between electrodes. Writing/erasing follows the formation and removal of the bridge; reading is done by measuring resistance between electrodes. DRAM-like cell size. Infineon, Micron exploring the technology.

Source: IC Insights, Qimonda

**Figure 1**

## Report Details

Additional details about the memory market through 2012 can be found in the 2008 edition of *The McClean Report,* IC Insights' complete analysis and forecast of the integrated circuit market. Packed with 400 tables and graphs, the report is available in three-ring binder, CD-ROM, and on-line formats, and also comes with free monthly updates by e-mail from March through November. A single copy of the report in CD-ROM or binder format is priced at $2,790. A bundled CD-binder set is priced at $3,285. An Internet access password is available as a $695 option. The report is also available under a multi-user corporate license for $5,990.

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