

Process Technology

MRAM

Overview

Magnetoresistive random access memory (MRAM) is a revolutionary memory technology that can potentially replace today's semiconductor memory technologies. The increasing capability of electronic devices to bring new features to the palm of your hand, such as real-time video, is driving a growing need for increased memory performance, requiring greater memory capacity and the integration of multiple memory options. MRAM has the potential to be a "universal memory." It can be a single memory solution for multiple memory options within one chip—enabling faster, lower power, less expensive solutions for next-generation electronic products.

Nonvolatile memories, such as hard disk and Flash, store instructions and data from operating systems and individual programs, and transfer them to the processor when needed. This transfer can become a bottleneck and hinder the processor performance. MRAM stores this same information, but with the capability to deliver it directly to the microprocessor without creating a bottleneck.

MRAM is expected to offer other significant performance advantages over existing memory technologies. It is expected to have better write characteristics because it does not require high-voltage programming while Flash memory does. It could eliminate the lengthy boot-up times for computers and other electronic devices.

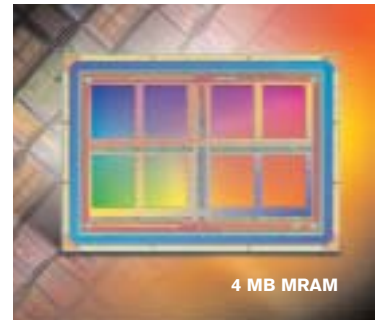
MRAM is expected to substantially reduce the battery power drain for portable electronic devices because it does not require the background refreshing of DRAM.

Because MRAM is readily integrated with conventional complimentary metal-oxide semiconductor (CMOS) processes, single-chip solutions can considerably reduce the cost of current multichip memory/processor applications.

Freescale Semiconductor's MRAM cells are based on a single transistor and a single magnetic tunnel junction (MTJ) structure. The MTJ structure consists of a layer of insulating material between two electrodes of magnetic material. One electrode is a fixed ferromagnetic layer that creates a strong pinning field to hold the magnetic polarization of the layer in one specific direction. The other ferromagnetic layer is free to rotate and hold polarization in one of two directions.

When the pinned and free layers have the same polarization, the MTJ cell will have a low resistance state. When they are antiparallel, the MTJ cell has a high resistance state. When reading the MRAM cell, a current flows, or tunnels, from one magnetic layer to the other magnetic layer through the insulator, and the resistance state is detected.

Integrating the MTJ above the bit-select transistor achieves a small cell size and provides an extremely cost-competitive memory solution. The fast read and write speed combined with virtually unlimited read and write cycles will enable MRAM to meet the system requirements currently requiring Flash, DRAM and SRAM.

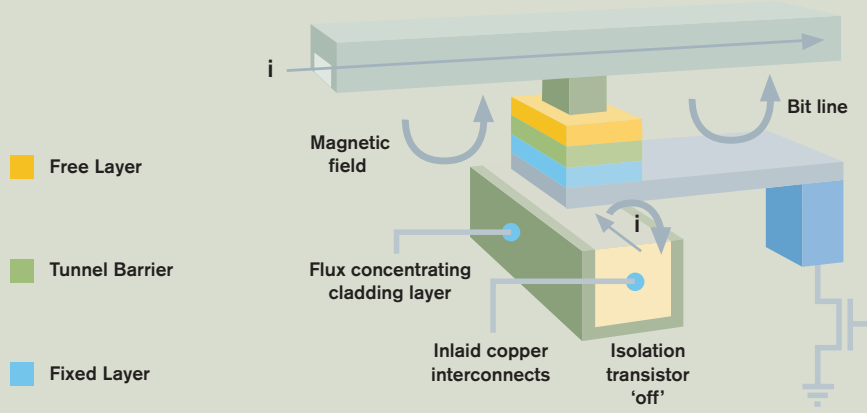


Milestones and Availability

MRAM leads the race to become the industry's choice for the next-generation memory technology. Freescale has demonstrated a 4 MB (256K x 16) toggle MRAM device based on a 0.18-micron five-level metal CMOS process technology with fast access times and copper interconnects. This is a significant advancement since Motorola's (now Freescale Semiconductor, Inc.) June 2002 demonstration of a 1 MB MRAM using 0.60-micron technology. The memory uses unidirectional programming currents with isolated write and read paths and balanced current mirror sense amplifier.

MRAM could initially enter the market in applications that require speed, data reliability and low power. The innovative memory technology is suited for applications that value the ability to do high-performance writes with unlimited read-write endurance and low write energy without battery backup. Freescale is on track to achieve its goal of MRAM product sample availability in 2004.

1-MTJ/1-TRANSISTOR MEMORY CELL



Technology Licensing

Freescale's embedded MRAM technology is a key element of a research and development partnership with STMicroelectronics and Philips. This alliance among three top semiconductor manufacturers provides an accelerated path for next-generation MRAM development, contributing to broader and faster market acceptance. Further recognizing MRAM's potential, Honeywell recently licensed Freescale's MRAM technology for military and aerospace applications.

Freescale continues to build its MRAM patent portfolio with more than 90 U.S.-issued patents to its name. Freescale* recently received multiple patents for its unique approach to information storage. These patents cover all aspects of the bit cell structure, programming method and circuit

design. The discoveries harness the magnetic characteristics of the technology and make MRAM easier to manufacture.

Freescale has solved the three most fundamental challenges facing MRAM implementation—bit selectivity, data retention and scaling. The improved bit selectivity allows writes anywhere in the memory without disturbing other bits in the array. The superior data retention allows stable, long-term storage of information. Scaling to smaller geometries allows designers to pack more cells into a smaller area, resulting in lower cost.

Licensees of Freescale MRAM technology enjoy access to this intellectual property as well as access to new applications and markets enabled by MRAM technology.

COMPARISON OF EXPECTED MRAM FEATURES WITH OTHER MEMORY TECHNOLOGIES

	SRAM	DRAM	Flash	MRAM
Read Time	Fast	Moderate	Moderate	Moderate-Fast
Write Time	Fast	Moderate	Slow	Moderate-Fast
Nonvolatile	No	No	Yes	Yes
Refresh	N/A	Yes	N/A	N/A
Minimum Cell Size	Large	Small	Small	Small
Low Voltage	Yes	Limited	No	Yes

Learn More: For more information about Freescale products, please visit www.freescale.com.

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*The Semiconductor Products Sector of Motorola, Inc. became Freescale Semiconductor, Inc. in 2004.

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