Non-Volatile Memory Trends

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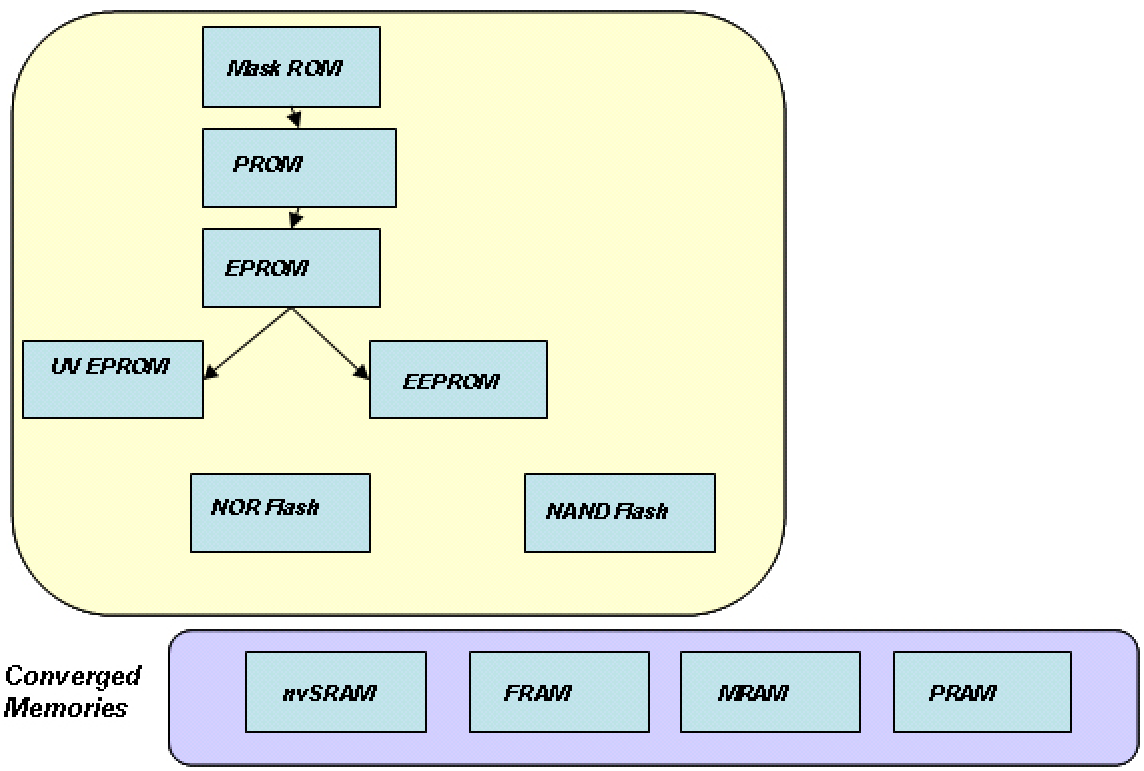
Executive Summary

This article focuses on emerging non-volatile memories and the differences between them. Some of these technologies are already in production and are extending their reach beyond niche applications. Convergence of key features of volatile and non-volatile memories is driving the trend in the development of these memories.

Introduction

Non-Volatile memories come in many different forms. Figure 1 shows the emergence of different non-volatile memories over time.

Figure 1: Emergence of non-volatile memories



Memory technology in the non-volatile space has evolved very quickly, driven by application needs. While many applications long ago only needed small amounts of boot code to be stored, some applications now need gigabytes of music and video data, which has brought about drastic changes in these memories. Non-Volatile Memories started with simple Mask Read Only Memories (ROMs), which evolved into Programmable ROMs and then into erasable PROMs. It's been more than 15 years since fast random-access NOR flash memory's initial public unveiling by Intel in 1988. NOR quickly gobbled up all of the memory sockets that EPROM had previously serviced, despite that EPROM technology was more than a decade and a half *more* mature. NAND flash memory is older than NOR— more than two decades old last year. Initially, NAND slowly ramped up its year-to-year incremental volume shipments, but of late it's been on a tear, primarily fueled by the success of the markets its unique attributes helped create, such as digital audio players, digital still cameras, USB memory sticks and solid state hard drives.

Volatile memories are typically very fast from a read and write standpoint, while non-volatile memories are typically slow from a write standpoint. Non-Volatile memories also suffer from an inherent limitation from a write standpoint, after a certain number of writes the memory hits its endurance limit and fails. An ideal memory would be one that would have be non-volatile, have a speed of access similar to SRAMs, have no limitations on read/writes and have very low power. This is the driving factor behind the development of the last generation of non-volatile memories.

None of the new memories succeed in all areas, but all of them make key advancements in at least some of these important memory characteristics. Attempts in this direction include nvSRAM, FRAM, Phase Change memory, etc.

nvSRAMs

The nvSRAM internally stores data when power is lost, with no battery required, and is a perfect fit for applications requiring continuous high-speed writing of data and absolute non-volatile data security. The nvSRAM has made good progress with the involvement of Cypress Semiconductor with long term nvSRAM promoter Simtek. The main advantage of FRAM over nvSRAM is its comparatively small die for a given array density and manufacturing lithography, but 4Mb nvSRAM devices are currently in development. This will provide tough competition to battery-backed memories, which have had significant issues with reliability and RoHS-compliance. The partnership of Cypress with Simtek to add a SONOS process module to Cypress's standard 130nm CMOS process will enable manufacturability of nvSRAM products greater than 4Mb. This will also allow SONOS applications in various mixed-signal and logic SoC products. This partnership transitioned the nvSRAM memory from a low-volume niche product to a high-volume, high-end memory and has had significant design wins with major industrial and computing applications.

FRAM

FRAM, which is the main competition to the nvSRAM, works on the concept of replacing the DRAM capacitor's dielectric with a ferroelectric material: either a Perovskite crystal, such as PZT (lead-zirconate titanate), or a layered Perovskite, such as SBT (barium-strontium titanate).

MRAM

MRAM, which stands for Magnetoresistive Random Access Memory, combines a magnetic device with standard silicon-based microelectronics to obtain the combined attributes of non-volatility, and unlimited read and write endurance.

PRAM

PRAMs are memories that operate on changing the properties of certain materials that can go from a crystalline state to an amorphous state by applying heat. Table 1 provides a comparison of different non-volatile memory technologies.

Table 1. Performance, reliability and power consumption of three non-volatile memory technologies

Parameters	Measurement	nvSRAM	FRAM	MRAM
Performance	Access Time (ns)	15 – 25	100 - 150	35
Reliability	Years of Retention	20	10	10
Current / Power	Active @ 100 ns (mA)	20	22	30
	Typical Standby (uA)	750	20	9000

While nvSRAMs works on the concept of one-to-one pairing of a non-volatile bit and a fast SRAM bit in each memory cell, in system operation, the ICs behave exactly as standard fast SRAMs that can be easily interfaced to existing microprocessors and microcontrollers. When IC power is disrupted or lost, the event is detected and, in one quick array write, every SRAM bit is saved into non-volatile (in under 13ms) using the saved energy in a small capacitor. Data is automatically recalled from non-volatile to SRAM once power is restored. The nvSRAM architecture allows infinite read/writes and access times down to 15ns. The products exceed 20-year data-retention ratings in all specified temperature ranges (communications, industrial, military, etc.). They also eliminate unreliable batteries from the system design while offering the smallest board space area and bills-of material.

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