

STT-MRAM: Emerging NVM

Dr. Rajiv Y. Ranjan Co-founder & CTO

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Emerging Memory: Hierarchical Positioning



•STT-MRAM targeted for DRAM, Storage-class-Memory •Embedded STT-MRAM: for SRAM, e-Flash and e-DRAM

avalanche technology

Emerging Memory / Target Markets

- SRAM: Scaling below 20nm will cause increase cell size and leakage– L2/L3SRAM(embedded)
 - STT-MRAM is the Leading candidate
 - Microprocessor, SOCs, Mobile SOC; Security applications; IOT
- DRAM: Scaling Challenge < 1Xnm Stand alone and embedded
 - STT-RAM is the leading candidate
 - Performance and low cost
- NOR Flash: Legacy; > \$2B TAM
 - STT-MRAM, ReRAM



Avalanche At-A-Glance

- Advanced Perpendicular MTJ (pMTJ)
 - Low write current (<100uA) @50ns pulse @55nm 32/64MBit Device (Achieved 50uA @2ns pulse @2X nm)
- Disruptive and Fundamental IP (185)
- Embedded and Discrete MRAM Solution
 - Storage, Telecom
- World Class Fab partners
 - 300mm Advanced Technology Nodes
- ✤ 32/64Mb SPI NOR/NvSRAM STT MRAM Silicon
 - CS Select Customers (Storage and Telecom)
- 1 Gb DDR4 STT MRAM Design





32/64Mb SPI/NvSRAM



Enabling STT MRAM through pMTJ



Highly scalable to 1x nm: low write current (<50 μ A/0.3V) with sustainable high thermal stability Δ >100

Excellent write performance (sub ns)

High TMR ~200% (targeting 250 % in near future)

Thermally stable TMR up to 400° C > 60 min \rightarrow compatible with standard CMOS (embedded)

High Endurance> 10¹⁶ cycles and Rad Hard

Excellent Manufacturability & low cost (<1x nm)

pMTJ stack can be tailored for different applications through speed and cell size optimization

300 mm BEOL Integration: Scalable to 1x nm

- Advanced BEOL integration scheme developed and matured (40-50 nm) in worldclass foundry
- Low cost adder with one single MTJ etch mask
- Scalable (<1xnm) MTJ BEOL integration process flow (portable to other IDM/foundry)
- MTJ thermally stable up to 400°C, compatible with embedded applications
- Note MTJ below M1 as shown. Portable between any 2 metal layers









55nm pMTJ SPI NOR/NvSRAM STT-MRAM

Current offerings with highest performance compare to Flash, EEPROM, FRAM, ...



Avalanche Quad SPI SPSRAMTM



10X Faster Program compared to SPI NOR FLASH and Byte Alterable

Avalanche Quad SPI SPMEM based on proprietary pMTJ delivers faster program time (<32us per page), very high endurance (> 100 million) and 20 Years retention @85°C

<u>Key Features</u>

32Mb 55nm STT-MRAM Technology Dual/Quad SPI Interface (108MHz) Byte Alterable (No Erase) Fast Write > 3MB/s Endurance > 100 Million Writes Retention 20 Years at 85C Industrial Temp -45C to 85C

Applications

Raid Storage Power fail storage Setup box and LCD display Digital consumer applications



Fastest and Largest Density NvSRAM achieving 50MB/s Write and Read throughput

Avalanche Quad SPI SPMEM based on proprietary pMTJ delivers SRAM speed (50MB/s), very high endurance (>1 Billion) and 20 Years retention @85°C

<u>Key Features</u>

32Mb 55nm STT-MRAM Technology Dual/Quad SPI Interface (100MHz) No wait write Fast Read & Write > 50MB/s Endurance > 1 Trillion Writes Retention > 20 Years at 85C Industrial Temp -45C to 85C

Applications

Internet of Things (IOT) Automotive Crash Recorder Digital consumer application Smart Meters



AvRAM[™] – Ideal Embedded Memory

SOC With Multiple Memories



1.0X

AvRAM[™] Technology Delivers Cost and Performance Benefits

- Smaller Die Size due to Smaller Cell Size
- Simplified System Architecture at sub nano-second performance
- Low voltage CMOS process; Low power consumption (Zero Leakage)
- Modular Integration with 1X CMOS design node and beyond



Avalanche STT-MRAM Architectural Roadmap



Avalanche STT-MRAM Architectures Enable Expanded Markets



THANK YOU

46600 Landing Parkway - Fremont CA 94538 - T: 510| 897-3300 - F: 510| 438-0143 - www.Avalanche-Technology.com



TECHNOLOGIES The MRAM Company

MRAM Into the Mainstream

SNIA NVM Summit Jan 20, 2016

Everspin- The Only Company to Deliver MRAM

□ Private, VC funded, spinout from Freescale in 2008

- Delivering our first generation MRAM products with 7 years of consecutive growth and 60M units shipped at 50% gross margin
- Second generation product (Spin Torque) provides the opportunity for explosive growth. We are partnered with GLOBALFOUNDRIES to bring products on 300mm manufacturing to our customers

□ Establishing MRAM as the leading emerging memory technology



Data Instantly Stored, Instantly Available





Confidential Information

<100ns Latency with ST-MRAM : A New Storage Tier



- Write Buffer/Cache for enterprise storage chassis & applications
 - Enables consumer class SSDs to become main storage platform
 - Enables the use of lower endurance TLC
- PCIe NVMe over fabrics without interrupting processors or disrupting CPU caches
 True distributed and shared storage
- Metadata storage and file system journal
- Persistent memory/storage for SDS
 HW support for SW RAID
- At speed data logging and persistent scratchpads



Persistent DRAM – Closing the Computation and Storage Performance Gap without Batteries or Capacitors

ST-MRAM is the only emerging memory technology to provide the speed and endurance needed for the 1st tier in enterprise class storage systems

	Characteristics*				Requirements		
	ST-MRAM	3D Xpoint	Resistive RAM	Low Power CBRAM	SSD Buffer	RAID Buffer	Server Write Cache
Supplier	Everspin	Intel/Micron	Crossbar	Adesto			
Latency R/W	10ns / 20ns	50ns / 1us	100ns / 100us	50ns / 1us	<100ns	<80ns	<70ns
Endurance	10 ¹⁰ - 10 ¹²	10 ⁶ - 10 ⁷	10 ⁵ - 10 ⁶	10 ⁵	10 ⁹ -10 ¹¹	10 ¹¹	10 ¹¹ -10 ¹³
Interface	DDR3/DDR4	Proprietary	Flash Like	SPI	DDR3/4	DDR3/4	DDR3/4
Status	Shipping 64Mb	Sampling	R+D	Production			
Density	Gb	64Gb+	Tb potential	64Mb	256Mb-4Gb	1Gb-4Gb	1Gb-8Gb

*Everspin estimate, supplier data



Confidential Information

ST-MRAM ... Scaling Beyond eFLASH and eSRAM Intrinsic Limits!

eMRAM is the Solution for Embedded Memory 28nm & Beyond

- eFLASH and eSRAM are technologylimited at 40nm, 20nm, respectively.
- eSRAM is larger than the minimum logic transistor size.
- eMRAM bit cell tracks to the minimum logic transistor size starting with 28nm.
- A 28nm eMRAM MTJ can be applied in any CMOS technology (e.g. 40nm).





ST-MRAM is the Emerging Memory Ready to Use

MRAM production experience and know-how

- 300mm production with GLOBALFOUNDRIES = Quality and Quantity
 - Everspin branded products first targeted to enterprise storage
 - Embedded MRAM for consumer, industrial, automotive and IOT SoC products
- MRAM brings value as more than just memory
 - Persistent DRAM in write intensive storage applications
 - Versatility as embedded memory : Compute, Code, Capture all-in-one
- □ Card-based MRAM to allow for early adoption via reference designs
 - Ecosystem in place compatible with FPGAs and many controller IP products

Moving MRAM into the Mainstream





THANK YOU

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STORAGE INDUSTRY

Convergence of Storage and Memory Developing the Needed Ecosystem

JANUARY 20, 2016, SAN JOSE, CA



David Eggleston



VP Embedded Memory

Emerging Embedded Memory



Embedded Memory: Requirements





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SNIA **Embedded Memory: Customer Usage** Solid State Storage Initiative MCU Automotive IoT Compute Storage 68 HDD and SSD

ADAS Engine Control Infotainment Battery monitoring Vision systems Navigation Smartcards
Set-top boxes
White goods
Industrial Controls
Touch sensorsWearables
Intelligent sensors
Gateways
Smart TVs
Smart Cities

Fast caches Persistent memory Server processors Network processors

storage controllers

Storage arrays

NV buffers/tiers

NV caches







Embedded Memory: Time Horizon SNI Solid State Storage Initiative MCU Automotive IoT Storage Compute ^{IN 20 MIN} 68 <u>eMRAM</u> Sooner <u>eFlash</u> Later Retention Efficiency Speed

Embedded Memory: Customer Usage









GLOBALFOUNDRIES Embedded Memory Solving your product challenges for the hyper-connected world.

