



Flash Memory Summit

Flash Memory Summit 2018 MRAM Update

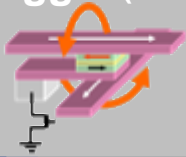
Barry Hoberman



Four Generations of Production MRAM

Gen.1

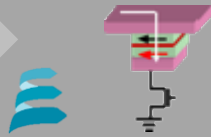
Toggle (2006)



Not Scalable
beyond 130nm
(write power)

Gen.2

Planar STT (2012)



Not Scalable
beyond 65/40 nm
(retention)

Gen.3

Perp. STT (2018)



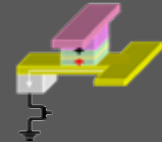
Fully scalable
Endurance-Retention-Speed tradeoff
→ **Limited persistence and/or
endurance and/or speed**

256Mbit at
threshold of mass
production

Embedded NVM
on threshold of
production in 22-
28nm CMOS

Future Gen.4

SOT



Fully scalable
Infinite endurance
+ high intrinsic speed
= persistent RAM compatible

SOT solves STT
shortfalls for RAM
applications



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Manufacturing Ramp at Foundries

- Samsung, TSMC, Global Foundries in ramp up in 22-28nm insertions
 - In logic processes as ‘embedded memory’ in SOC
- STT-MRAM introduction primarily as ‘roadmap substitution’ for embedded NOR Flash replacement
 - Plus some use as ‘pseudo’ RAM
 - Compromises on speed, endurance, retention
 - Production starts 2018-2019
- STT-MRAM not applicable as general purpose embedded SRAM replacement



Production Equipment Availability

- Essential 300mm tools with suitable wafer throughput and technical capability reaching availability
 - Applied Materials, TEL, Canon/Anelva
 - Magnetic film deposition and etch are principle requirements
- Yield and other process control converging on manufacturable, but not yet equal to incumbent memory types



Discrete MRAM in Storage

'The Low Hanging Fruit'

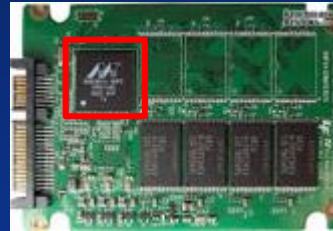
RAID systems

5-10+ memories per RAID system controller
\$100-1000 per system
5M+ units/year



SSD / HDD controller

R/W cache, Logical/Physical Address Table, etc...
\$1-4 per drive
\$50-100 per system in high end storage system
500M+ units per year



"Front End" multi-Gb buffer

in mission critical high performance SSD
1-2 memories per drive
\$10-20 per drive
150M units per year



Critical mission: 'Protect Data in Flight'

Requires: Speed and Endurance of DRAM, with instantaneous power-off data retention



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'High Impact' MRAM Application Promise

Top 10 List

1. >1 Million IOP SSD
2. Unified Memory (XIP) Microcontroller
3. Persistent Cache for Mobile CPU
4. Big-Capacitor-Free Performance SSD
5. SOC Embedded SRAM Replacement
6. SOC Embedded Flash Replacement
7. 'High Training Rate/Low Training Energy' NVM Memory for AI
8. Persistent Cache for Storage System
9. Rad Hard High Density Flash Replacement
10. 'High Endurance' Flash Gap



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'High Impact' MRAM Application Promise

Top 10 List – Near Term Impact Predictions

1. >1 Million IOP SSD
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