



MRAM Developer Day 2018 MRAM Update

Barry Hoberman

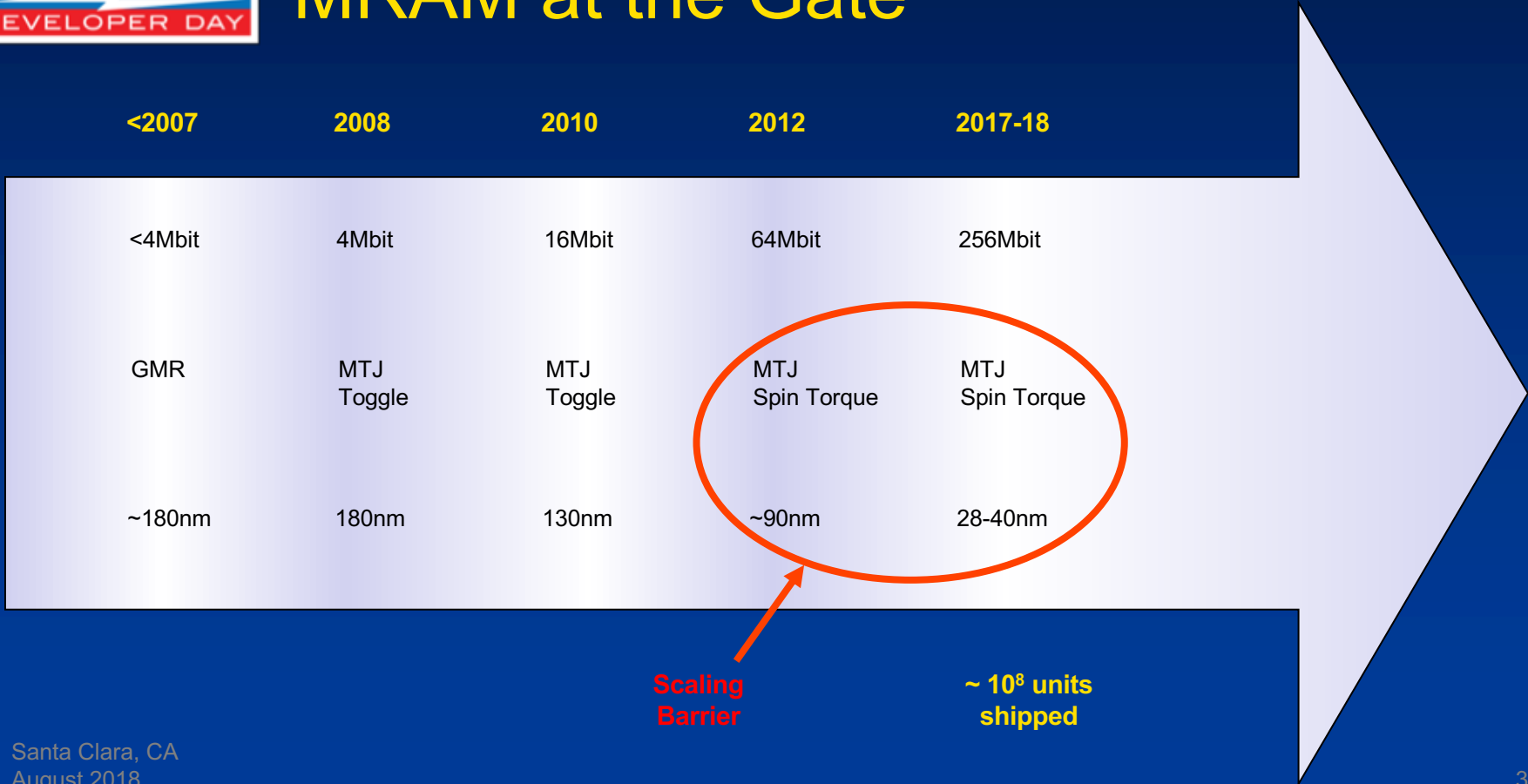


Disclaimer

- Observations and opinions...
- >35 years experience in wide variety of memory
- >12 years experience in MRAM
- 2012-2017 CEO/Chairman at Spin Transfer Technologies, Inc.
 - 2006-2012 Crocus Technology



MRAM at the Gate





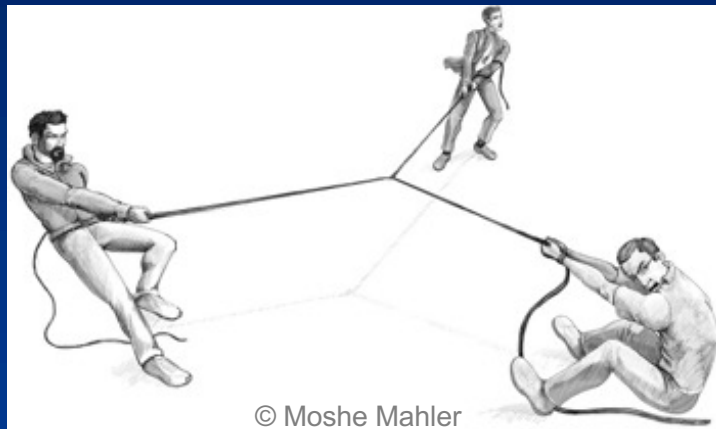
3rd Generation Constraint: STT MRAM 3-WAY Tug of War

Write Current

RETENTION

Write Voltage

ENDURANCE

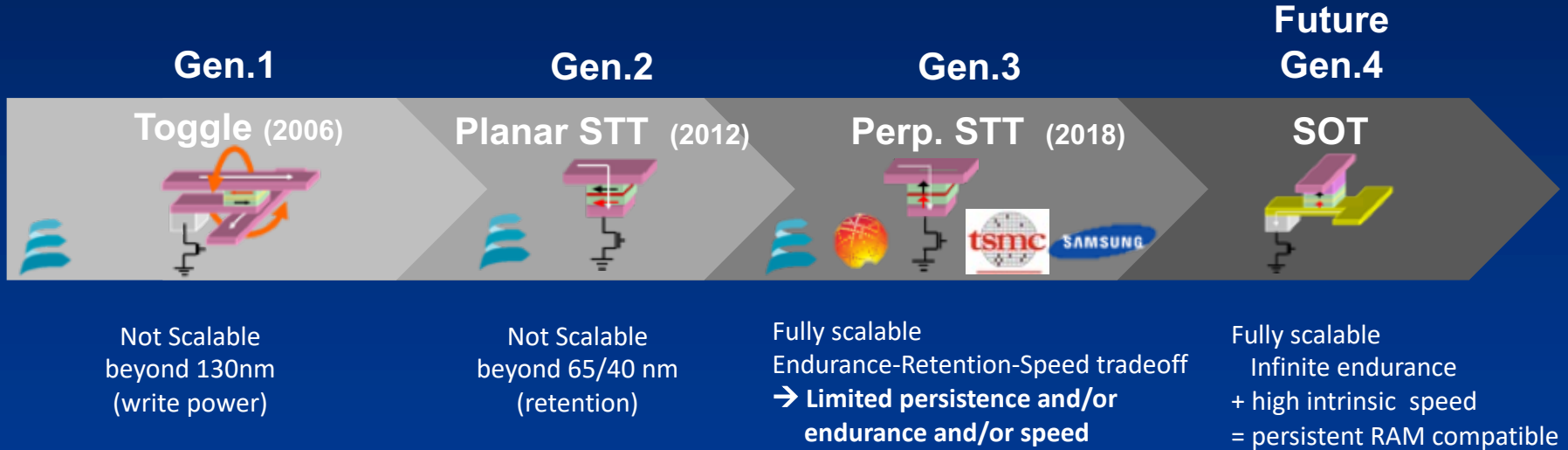


Write Pulse Width

SPEED

3rd generation STT MRAM cannot simultaneously provide speed, endurance, and retention for high speed SRAM application

Four Generations of Production MRAM



SOT solves STT shortfalls for RAM applications



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



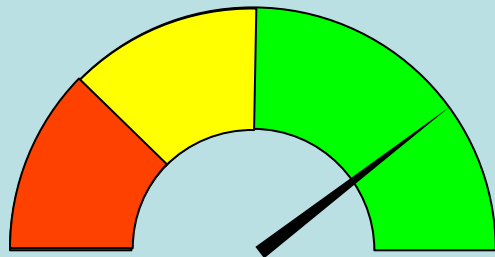
Production Equipment Availability

- 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

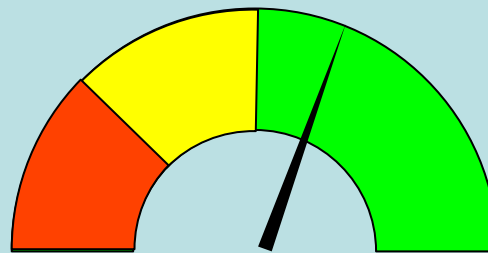


Emerging Memory Technology

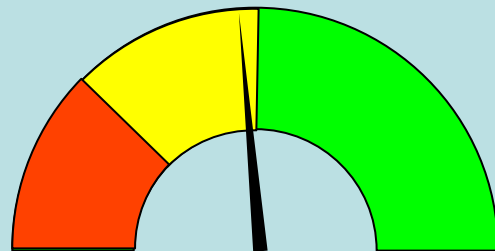
Market/Production Momentum



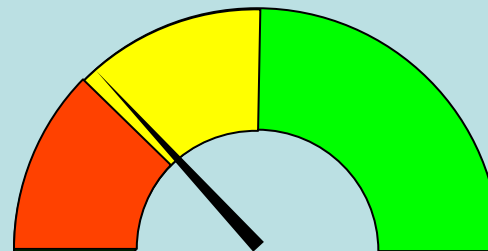
MRAM



PHASE CHANGE



ReRAM



NANOTUBE



Discrete MRAM in Storage

'The Low Hanging Fruit'

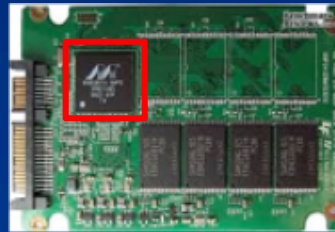
RAID systems

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



'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



'High Impact' MRAM Application Promise

Top 10 List – Near Term Impact Predictions

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



Editorial

Why new chip memory is so hard...

- Practical equipment/manufacturing barrier
 - Production fabs don't do development and cost \$5-10 billion
 - Full development today requires >\$200 million
 - New physical structures 'manufacturability' isn't known till late in development cycle
 - Multi-dimensional 'chicken & egg' situation
- Takeaway: It's HUGE that leading CMOS foundries have installed production equipment, invested in processes, and are on the threshold of MRAM production



(More) Editorial

Why new chip memory is so hard...

- Matching new technology manufacturing yield/performance curve to design expectations
 - Combining well-known CMOS yield characteristics with ambiguous and optimistic 'new device' yield statistics is hard
 - Cross-functional engineering teams universally underestimate

- Takeaway: Teams that focus on bridging both the 'yield curve gap' with margin and the 'cross-functional interdependency gap' will win in this emerging market



Free-format slide title



Free-format slide title



Some Notes about this template

- The first action you should take is to save this presentation
 - You have opened a design template (.pot)
 - Need to save as .ppt
- A master exists for:
 - Slides
 - Handouts - default is 3 to a page
 - You can print a different number, but no guarantees about appearance



Some Notes about this template

- The first action you should take is to save this presentation
 - You have opened a design template (.pot)
 - Need to save as .ppt
- A master exists for:
 - Slides
 - Handouts - default is 3 to a page
 - You can print a different number, but no guarantees about appearance



Free-format slide title