SPIN MEMORY™

Defense and Aerospace Business

Accelerating MRAM for Strategic Applications

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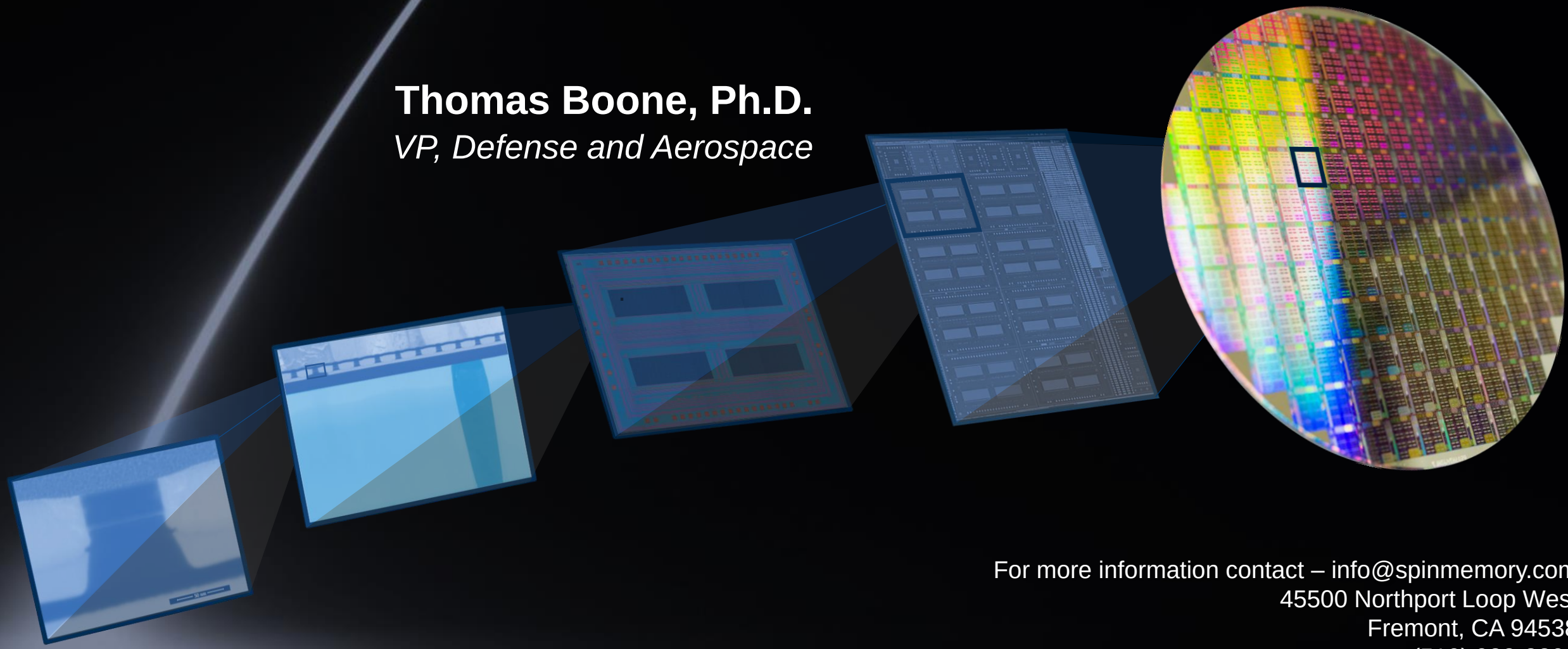

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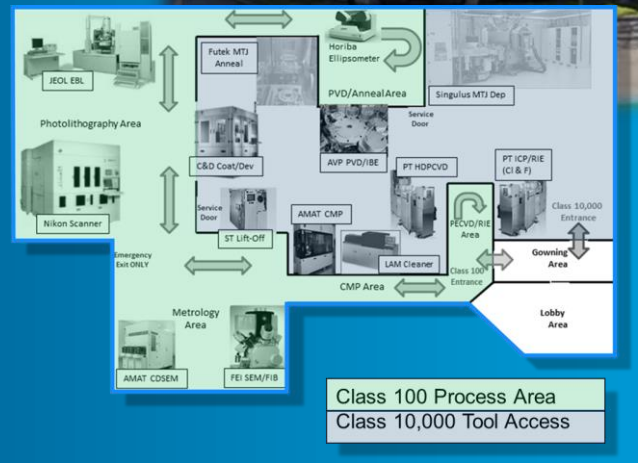
Spin Memory Corporate Overview

- US company located in Fremont, CA developing perpendicular spin transfer torque magnetic random access memory (pSTT-MRAM).
- Developing technology to provide embedded NVM, SRAM and ultimately DRAM
- Company owns a class 100 cleanroom "back-end" manufacturing facility
- World Class Team of US Citizen and US Persons including 10 PhD's
- Currently developing radiation hardened memory solutions to support U.S. Military and Space applications *STT-MRAM is inherently rad-hard!*

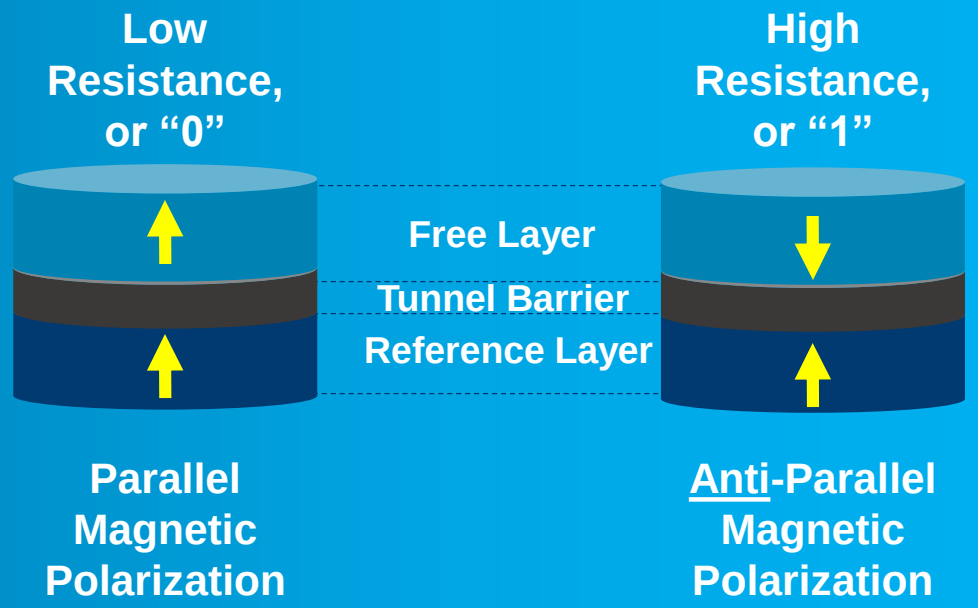
Spin Memory- Fremont, CA



What is STT-MRAM? A Class of Computer Memory.

- MRAM is *Magneto-resistive RAM*
  - Magnetic polarization sets ‘1’, ‘0’
- STT is *Spin Transfer Torque*
  - Electron spin sets Free Layer polarization
  - ST-MRAM using pMTJ is latest MRAM generation
- Bitcell uses 1 transistor + 1 MTJ
  - Very dense configuration
- Attributes:
  - Non-volatile
  - High-speed read and write
  - High endurance
  - Easy integration in BEOL – no impact on FEOL

Perpendicular Magnetic Tunnel Junction (pMTJ)



Spin Memory's Defense and Aerospace Value Proposition

NEED: US Government and DoD requires advanced Rad-Hard microelectronics memory for strategic and space applications.

APPROACH: STT-MRAM is intrinsically Radiation immune. Space Probe and Satellite applications. Targeting Trusted and Assured Foundries.

BENEFITS: Spin Memory's enabling STT-MRAM IP and resources including CONUS 200 mm Factory in Fremont, CA - 100% US Persons.

COMPETITION: Legacy Toggle MRAM, RRAM, FRAM, CRAM. Less upfront cost, but lack in performance of perpendicular STT-MRAM

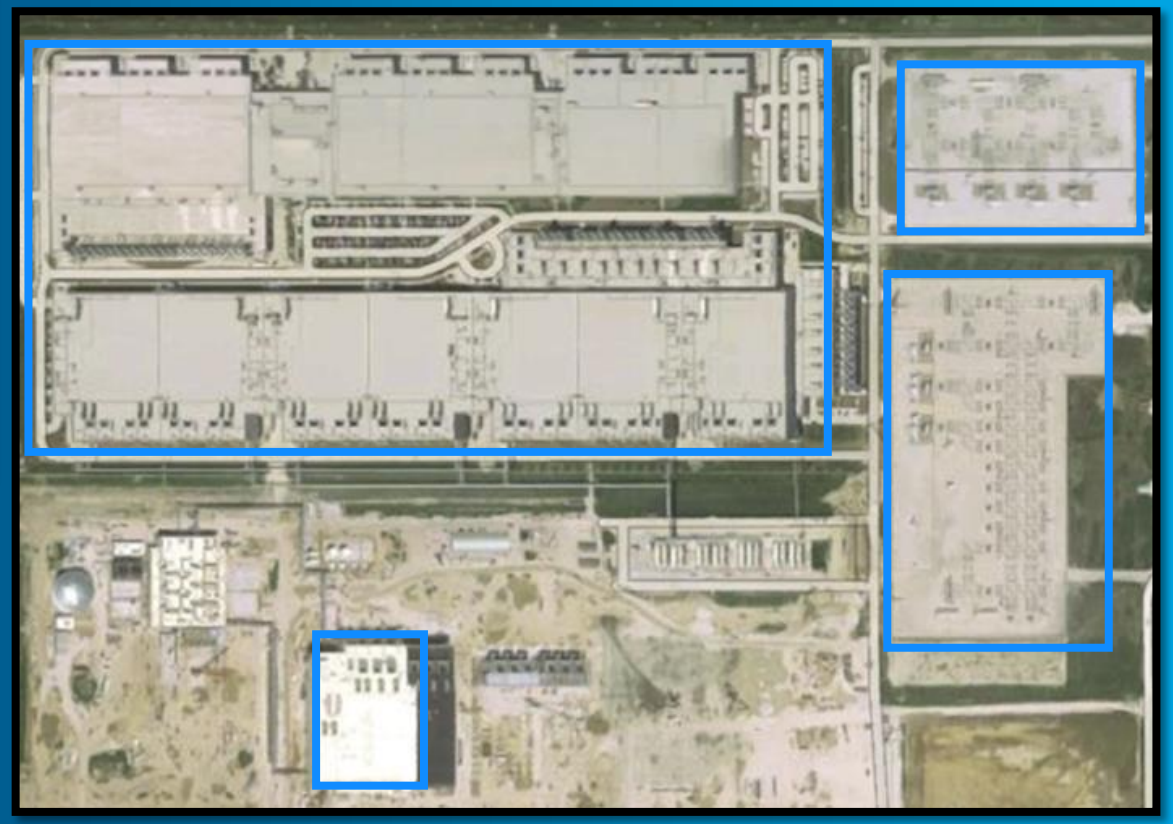
Space-Based Systems Need a New Memory

	SRAM	DRAM	NOR	NAND	ReRAM	MRAM
Non-Volatile	No	No	Yes	Yes	Yes	Yes
Read/Write Speed	High	High	Slow	Slow	Slow	High
Read/Write Power	Low	Low	High	Low	Low	Low
Stand-by Power	High	High	Low	Low	Low	Low
Cost (Cell Size)	High	Low	Low	Low	Low	Low
Endurance	High	High	Low	Low	Low	High
Retention	No	No	High	High	High	High
Scalable < 16nm	No	No	No	No	Yes	Yes
Non-Charge Based	No	No	No	No	Yes	Yes
Radiation Tolerant	**No**	**No**	**No**	**No**	**Yes**	**Yes**

Enormity of Modern Data Centers

Modern data centers are increasingly becoming the world's largest facilities.
(aerial photos on same approximate scale)

Pentagon – Washington DC



Google Data Center– Council Bluffs, IA

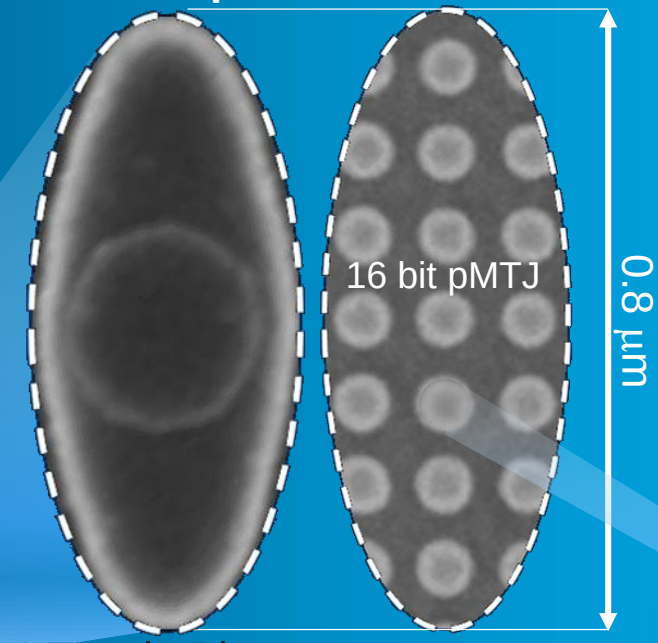
AT&T Stadium – Arlington, TX

Legacy RH Toggle MRAM vs. advanced STT-MRAM

Toggle MRAM

- Toggle is 16-20x larger than pMTJ
- Toggle-MRAM uses simple etch process
- Limited to 130nm+ CMOS Nodes
- Reticle Limited to 16Mb

Top Down View

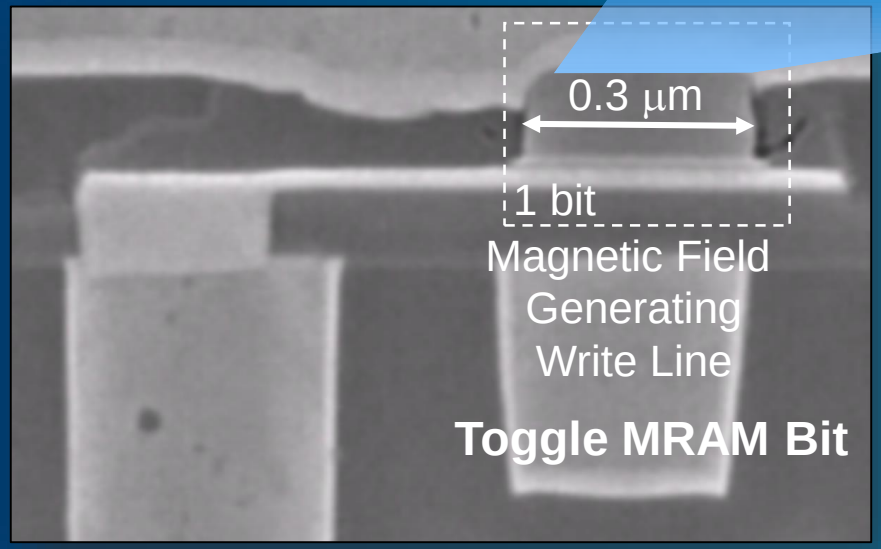


This side-by-side comparison illustrates that nearly 2 Bytes of STT-MRAM data fits in the same area as 1 bit of Toggle-MRAM

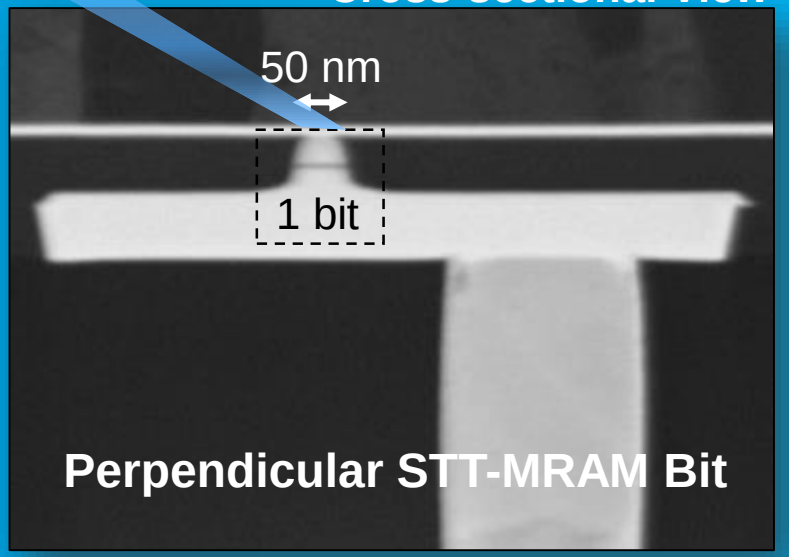
Perpendicular STT-MRAM

- 20x Density of Toggle
- Ion Mill Etch to preserve MgO
- Scales to 3nm CMOS
- Path to 8Gb w/ 1xnm CMOS

Cross-sectional View



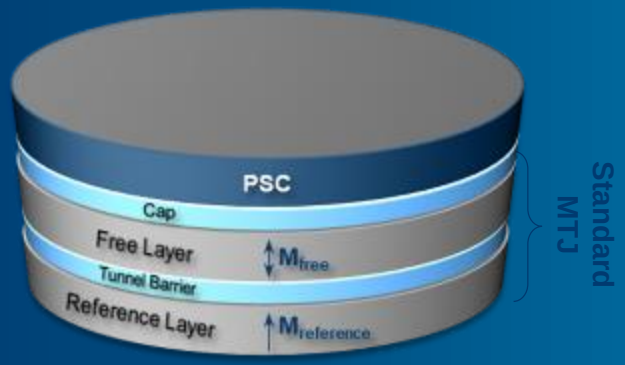
Cross-sectional View



Spin's Patented IP Engineers MRAM to Challenge DRAM/SRAM

Enhanced Retention Time

Magnetic Bit

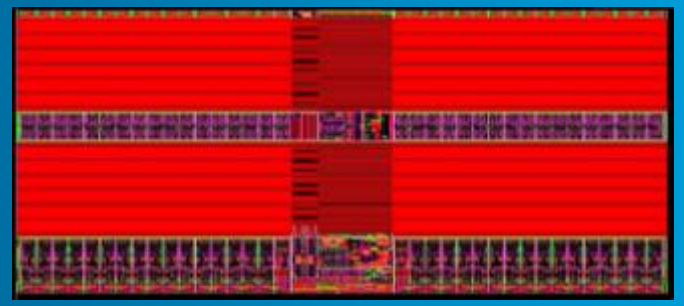


PSC Structure

- Demonstrated increase MRAM Memory retention by 1,000 times
- Enables high-density memory designs
- Technology remains intrinsically rad-hard

Endurance Boost

Engine/Design

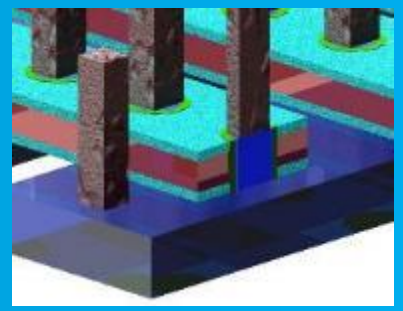


Endurance Engine:

- Demonstrated increases endurance of MRAM 100,000 times.
- Enables 10ns access times
- Corrects hard/soft errors from radiation
- Built-in health monitoring

Density Increase

CMOS Selector Technology



Selector:

- Enables MRAM to compete in cost with DRAM by increasing density.
- Can be used for all emerging memories: FeRAM, ReRAM, etc.
- Eliminates "RowHammer"