

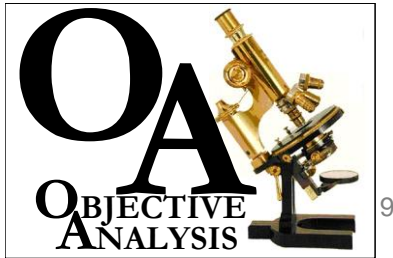


Flash Memory Summit

Emerging Memories Find New High-Performance Applications

Jim Handy, Objective Analysis

Tom Coughlin, Coughlin Associates





Flash Memory Summit

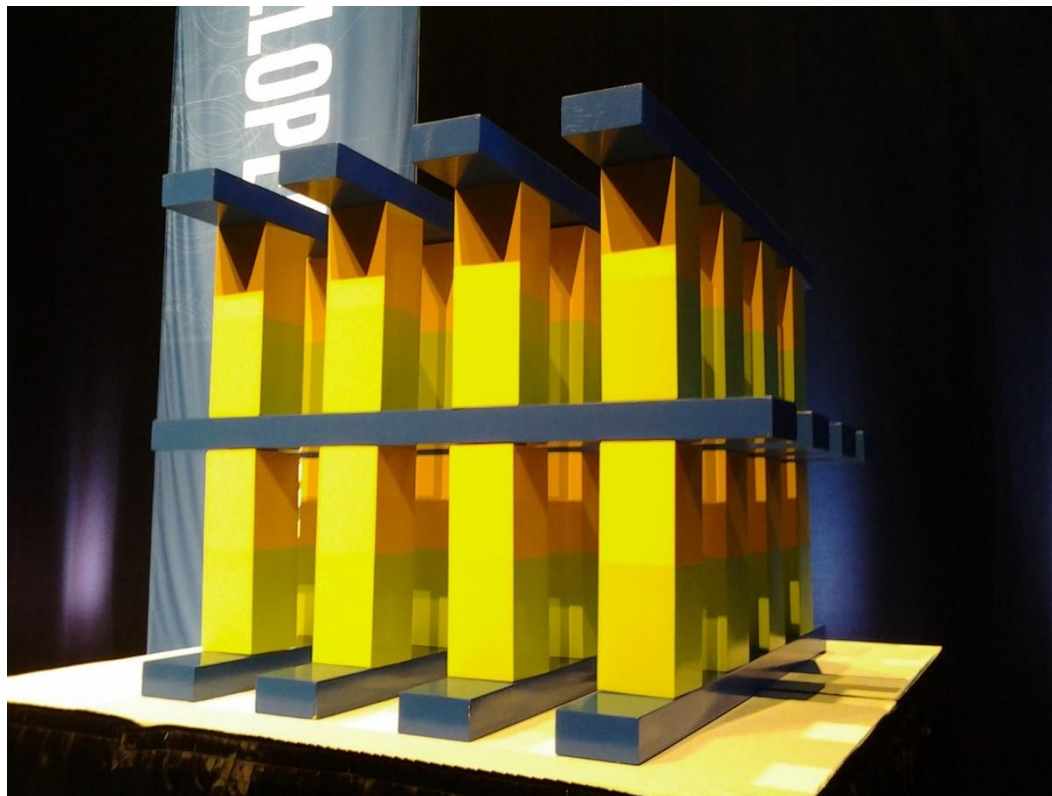
Emerging Memory Update by Type

- PCM/XPoint
- MRAM
- ReRAM
- FRAM
- Others



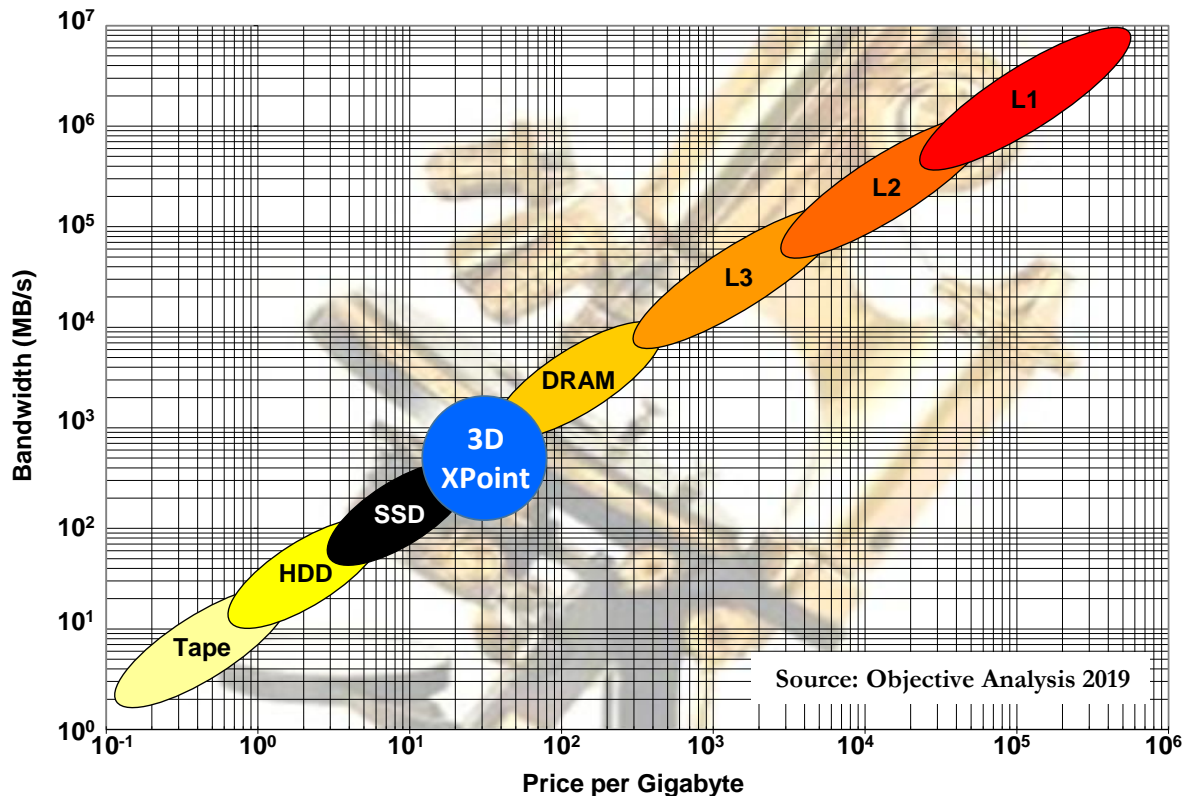
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PCM/3D XPoint



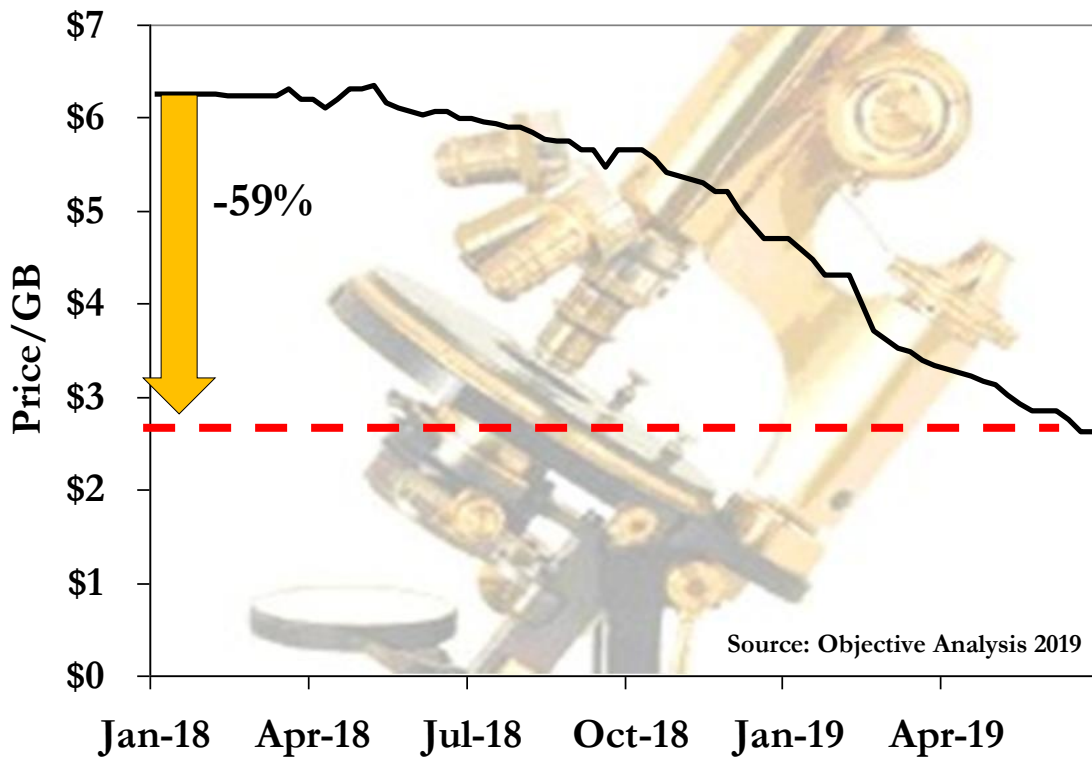


3D XPoint Must Be Priced Below DRAM Otherwise People will Just Buy DRAM





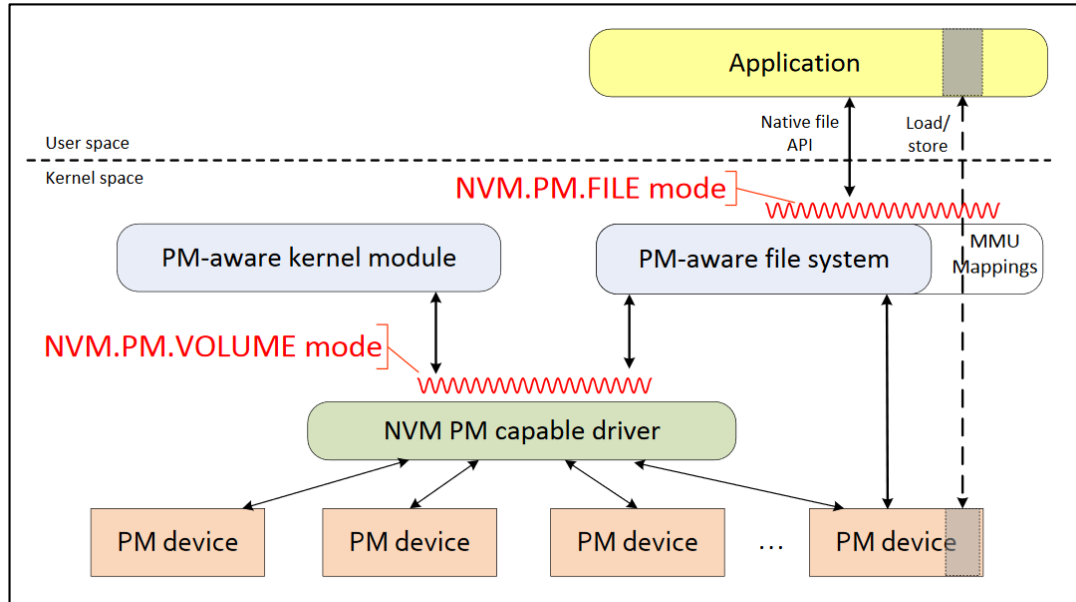
DRAM Prices are Collapsing





3D XPoint Needs Special Support

- SNIA's Nonvolatile Memory Programming Model
 - <https://www.SNIA.org/PM>





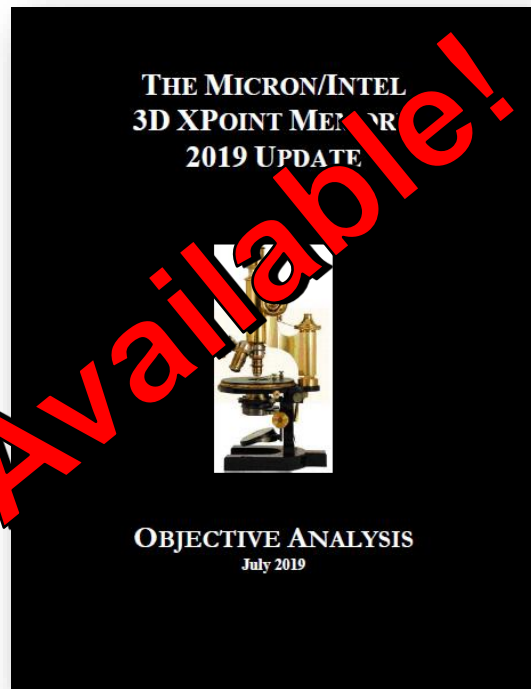
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3D XPoint Report

- 2019 Update from Objective Analysis
- The Why, How, and When of 3D XPoint Memory
 - Why Intel wants it
 - How it fits into the memory hierarchy
 - Impact on DRAM
 - When will it sell in volume
- Detailed Forecasts

<https://Objective-Analysis.com/reports/#XPoint>

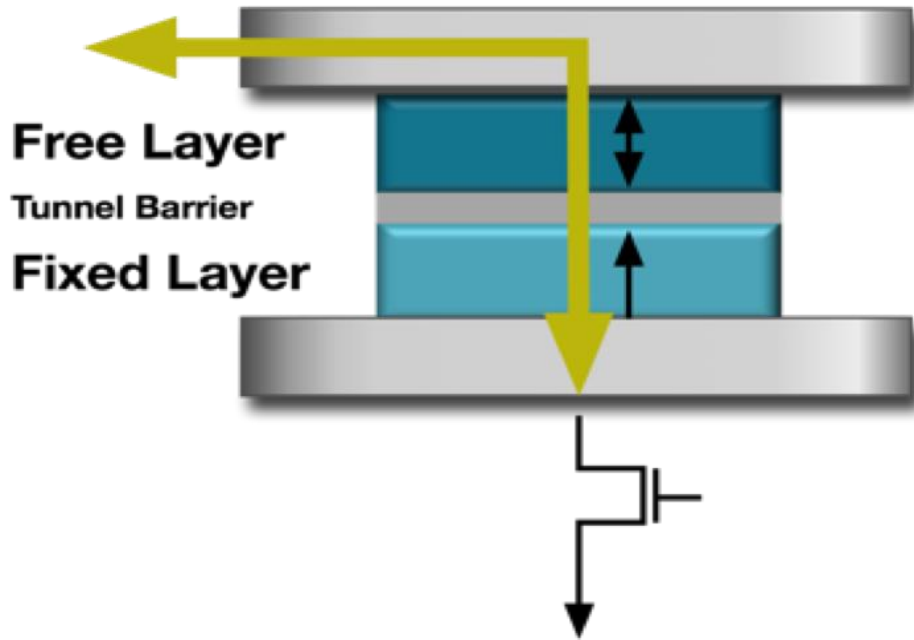
Now Available!





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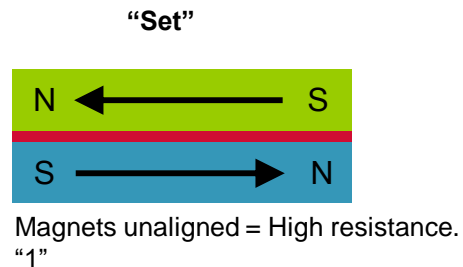
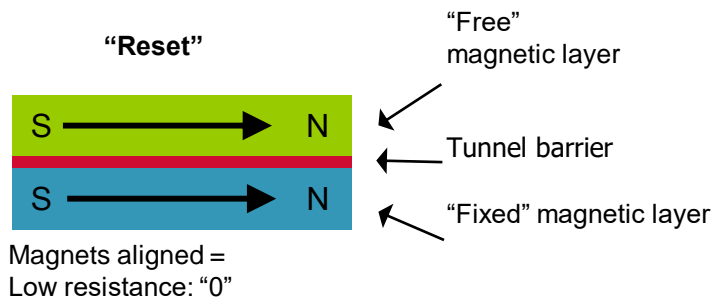
Magnetic RAM: MRAM



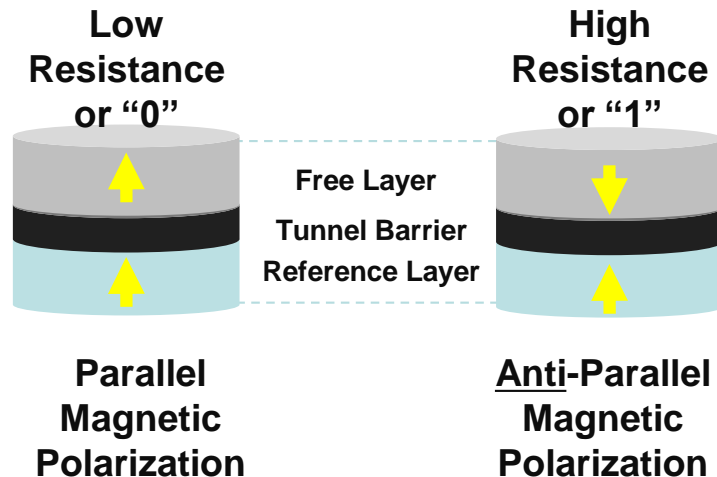


Two MRAM Types

Toggle Mode



Spin Transfer Torque (STT)





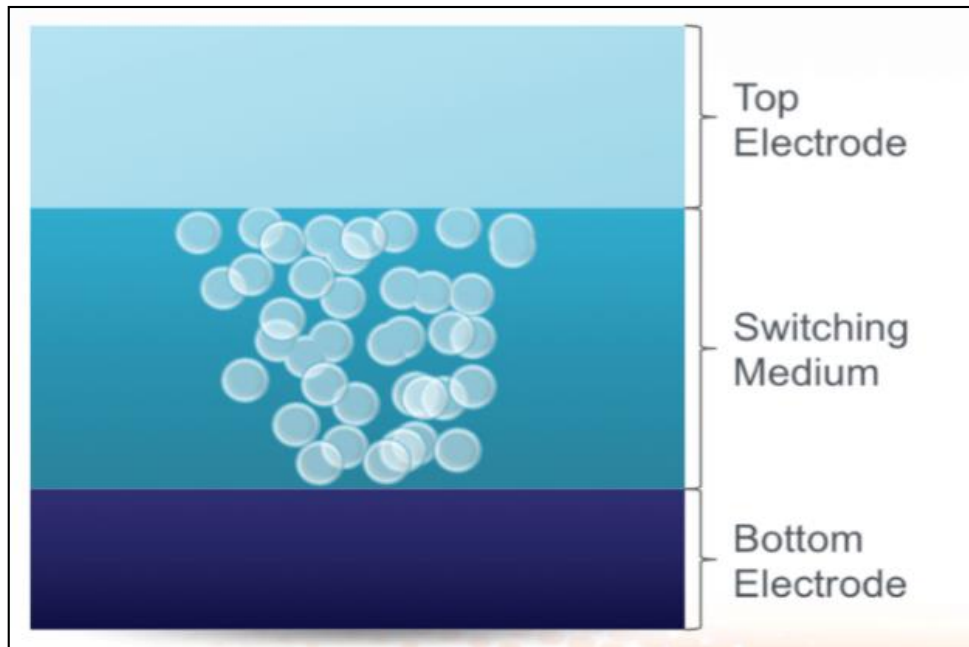
MRAM Status

- IBM SSD uses MRAM for SSD cache
- Spin Memory (formerly Spin Torque Technologies) launches Precessional Spin Current & Endurance Engine Technologies
- Growing foundry support: All majors sampling, two shipping
- Everspin still sole supplier of stand-alone parts
 - Over 110 million units shipped
 - Avalanche sampling
- Today's markets: Space, high-uptime systems



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Resistive RAM: ReRAM





Many Variants of ReRAM

- CMOx
- CBRAM
- PCM
- Memristor
- Carbon nanotubes

All use the value of a resistance to represent a “1” or “0”



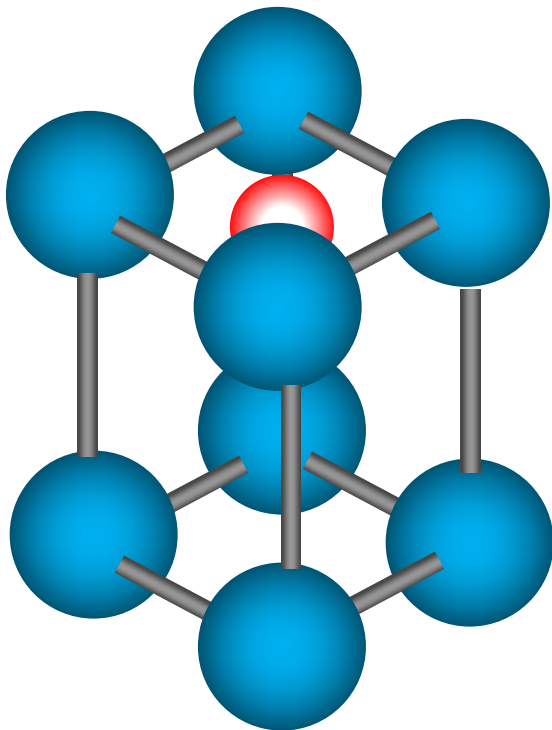
Two ReRAM Types in the Lead

- **SiO₂-based**
 - Crossbar, Weebit Nano
 - Positioned as the memory for neural networks
 - Not yet in volume
- **Metal filament**
 - Adesto
 - Production volumes



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Ferroelectrics: FRAM





FRAM Status

- Ramtron (Now Cypress)
 - Sole supplier of stand-alone FRAM
 - PZT – Lead Zirconium Titanate
- Other renditions:
 - Thinfilm, organic FRAMs
 - Symetrix IP provider
- New HfO₂ approach from NamLab, Dresden
 - Uses well-understood materials (Hafnium Oxide)
- Today's markets:
 - RFID, other low write current applications

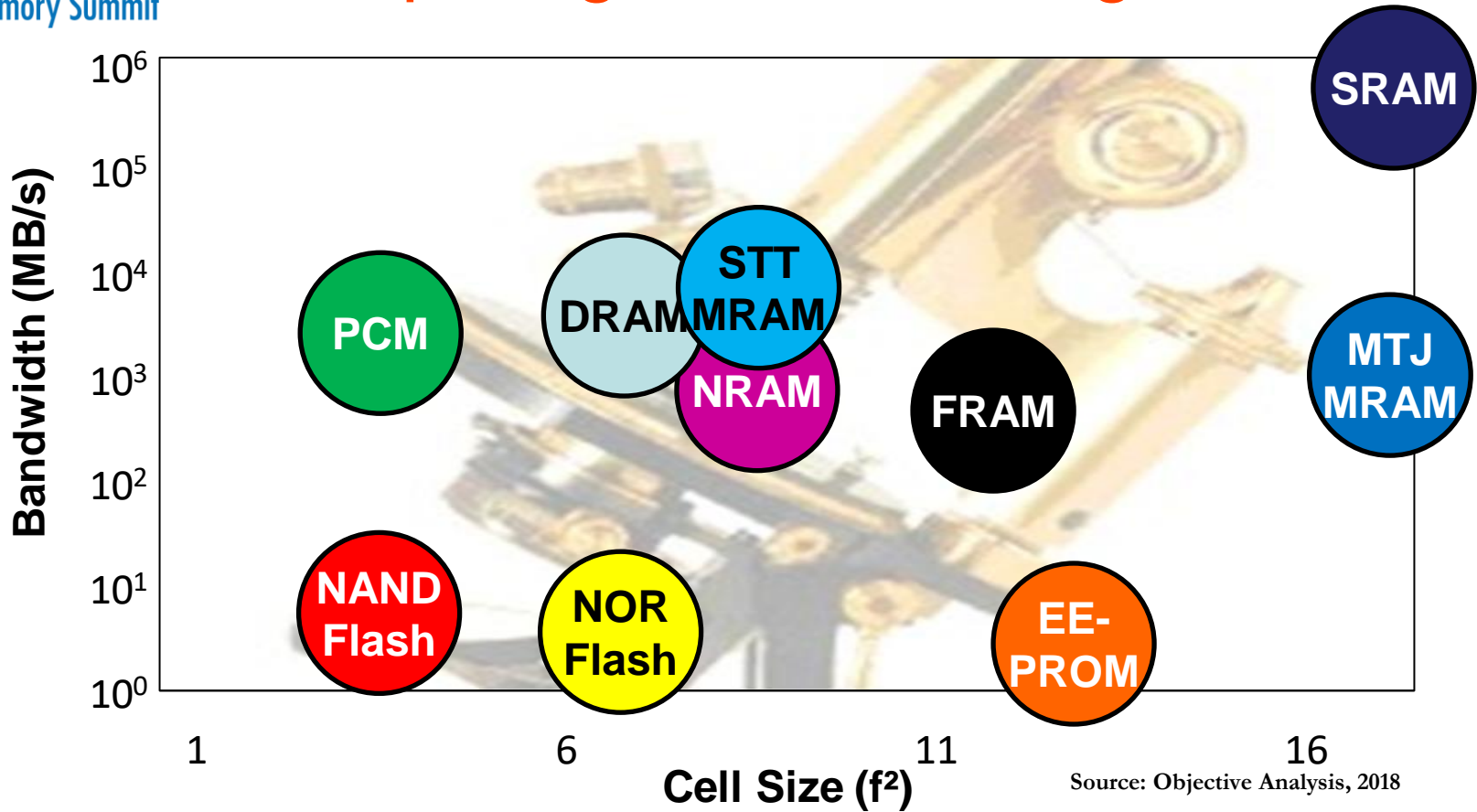


All New Memories Share Some Attributes

- Small single-element cell
 - Supports small/inexpensive die and 3D stacking
 - Promises to scale past DRAM & NAND flash
- Write in place
 - No “Block Erase”
 - More symmetrical read/write speeds
- Nonvolatile/Persistent
 - These can all be used as Persistent Memory: “PM”



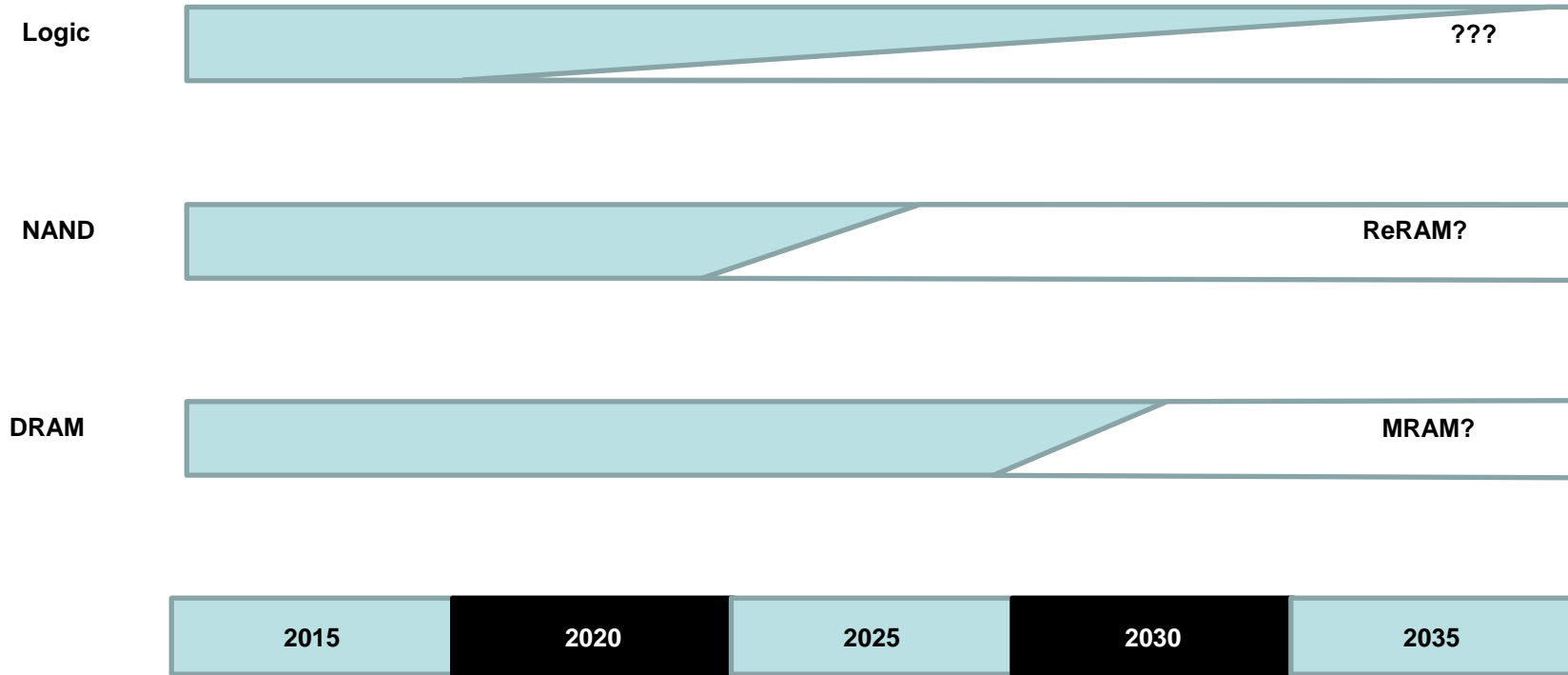
Comparing the Technologies





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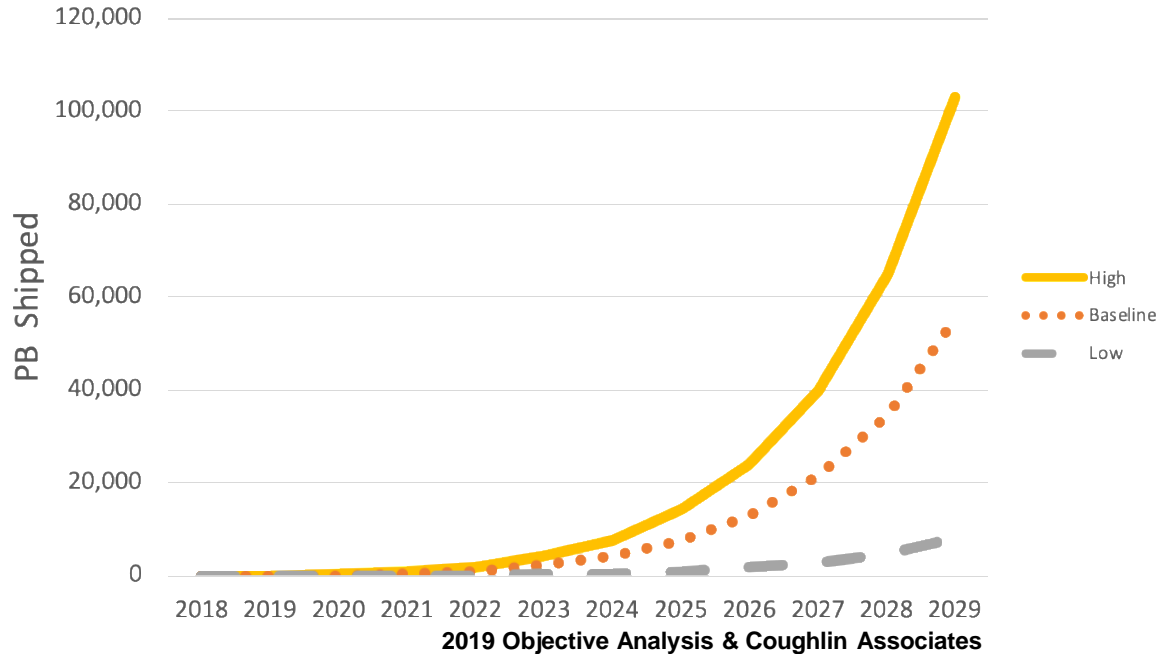
Timeline for Change



Source: Objective Analysis, 2019



Emerging Memory PB Forecast



Could exceed \$37B by 2029!



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New Emerging Memory Report

- Coughlin Associates/Objective Analysis
- Examines Emerging Memory Ecosystem
 - Technologies (PCM, ReRAM, MRAM, FRAM...)
 - Companies
 - Markets
 - Support requirements
- Forecasts Emerging Memory consumption
 - Embedded Emerging Memories
 - Discrete Emerging Memories
- 172 pages, 30 tables, 125 figures

NOW Available!



<http://www.tomcoughlin.com/techpapers.htm>
<https://Objective-Analysis.com/reports/#Emerging>



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Summary

- Emerging Memories Making Good Progress
 - Still hard to determine the frontrunner
- Support requirements being well addressed
- Many issues confront the market



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Questions?



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Coughlin Associates

- Technical and Market Analysis
- Consulting
- Reports and Newsletter
 - Emerging Memories Poised to Explode: Emerging Memory Report
 - Digital Storage in Media and Entertainment
 - Digital Storage Technology Newsletter
- Conferences
 - Storage Visions Conference, October 22-23, 2018 at the Hyatt Regency Hotel in Santa Clara, CA
 - Creative Storage Conference, May 2019 in Los Angeles



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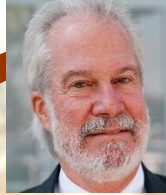
Emerging Memory/AI Workshop

Stanford University, 29 August 2019

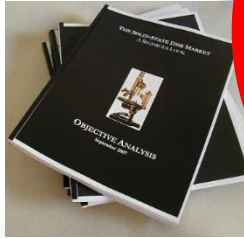
- One-day workshop
- All emerging memories:
 - MRAM, ReRAM, PCM, etc.
- Various AI applications
- Register at
 - <https://EMAI19.sites.Stanford.edu>



OBJECTIVE ANALYSIS

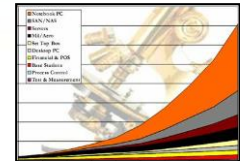
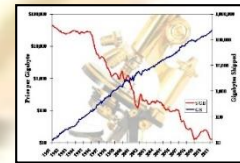
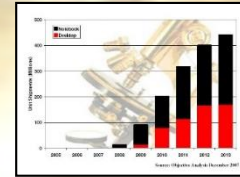


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OBJECTIVE ANALYSIS

Semiconductor Forecast Accuracy

Year	Forecast	Actual
<u>2008</u>	Zero growth at best.	-3%
<u>2009</u>	Growth in the mid teens	-9%
<u>2010</u>	Should approach 30%	32%
<u>2011</u>	Muted revenue growth: 5%	0%
<u>2012</u>	Revenues drop as much as -5%	-2.7%
<u>2013</u>	Revenues increase nearly 10%	4.9%
<u>2014</u>	Revenues up 20%+	9.9%
<u>2015</u>	Revenues up ~10%	-0.2%
<u>2016</u>	Revenues up ~10%	1.1%
<u>2017</u>	Revenues up ~20%	22%
<u>2018</u>	Strong start supports 10+% growth	14%
<u>2019</u>	Semiconductors down -5%	TBD