

Emerging Memories Poised to Explode

The Long & Winding Road
to Persistent Memories

Live Webcast
December 11 2018
11.00PST

Today's Bearded Presenters



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- More information at <https://www.snia.org/forums/sssi>

About Your Presenters

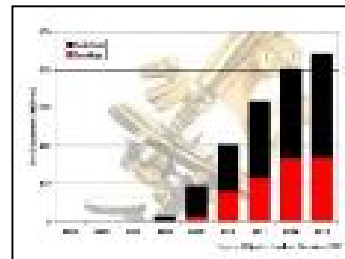
➤ Coughlin Associates

- ◆ Technical and Market Analysis
- ◆ Consulting
- ◆ Reports, Conferences and Newsletter

*Coughlin
Associates*

➤ Objective Analysis

- ◆ Profound analysts
- ◆ Reports & services
- ◆ Custom consulting



Outline

- Persistent Memory Types
- Market Drivers
- Support Requirements
- Outlook

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Persistent Memory Types

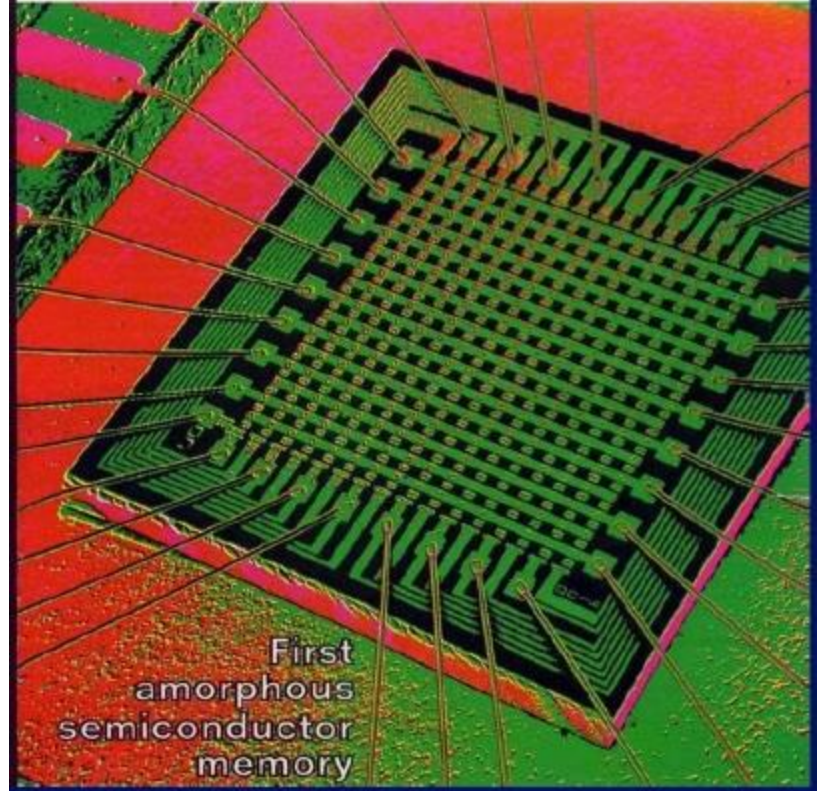
- PCM/XPoint
- MRAM
- ReRAM
- FRAM
- Others

3D XPoint: A Long Time Coming

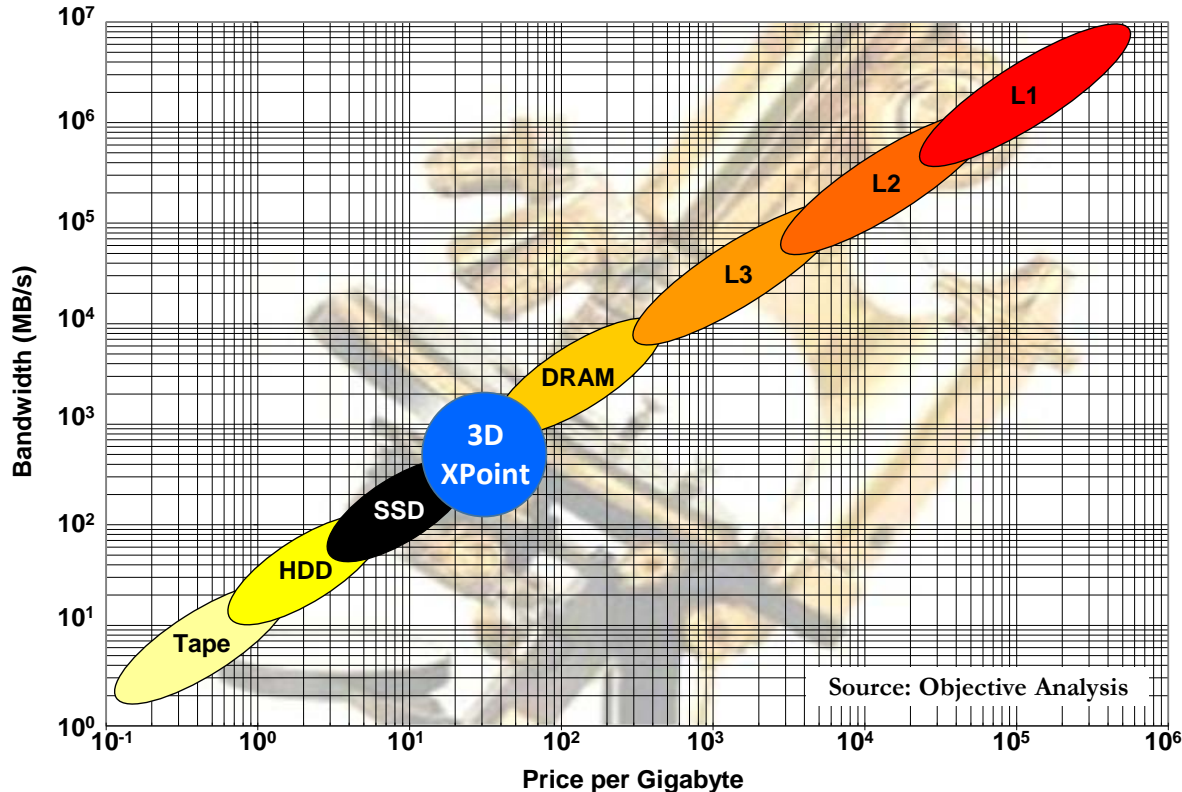
Amorphous semiconductors: jury still out 56
Designing low-noise bipolar amplifiers 82
The big gamble in home video recorders 89

A McGraw-Hill Publication
September 23, 1970

Electronics

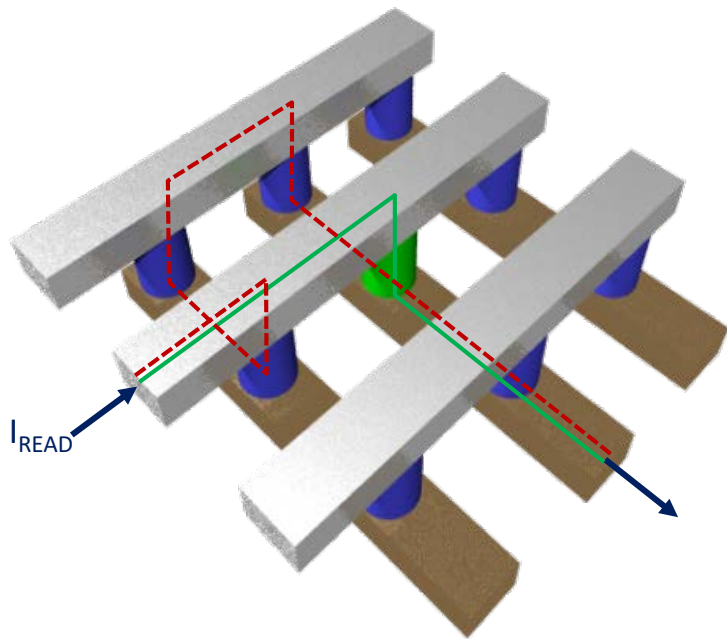


3D XPoint Must Cost Less than DRAM Otherwise People will Just Buy DRAM



Source: Objective Analysis

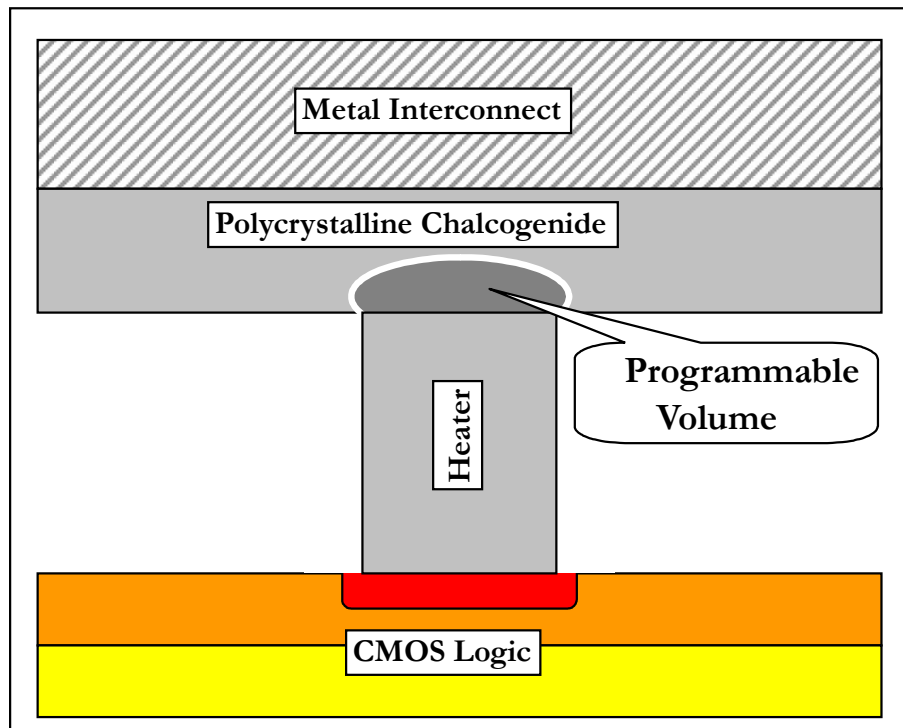
What is a Crosspoint?



- Small die area
- Stackable
- The ideal memory!

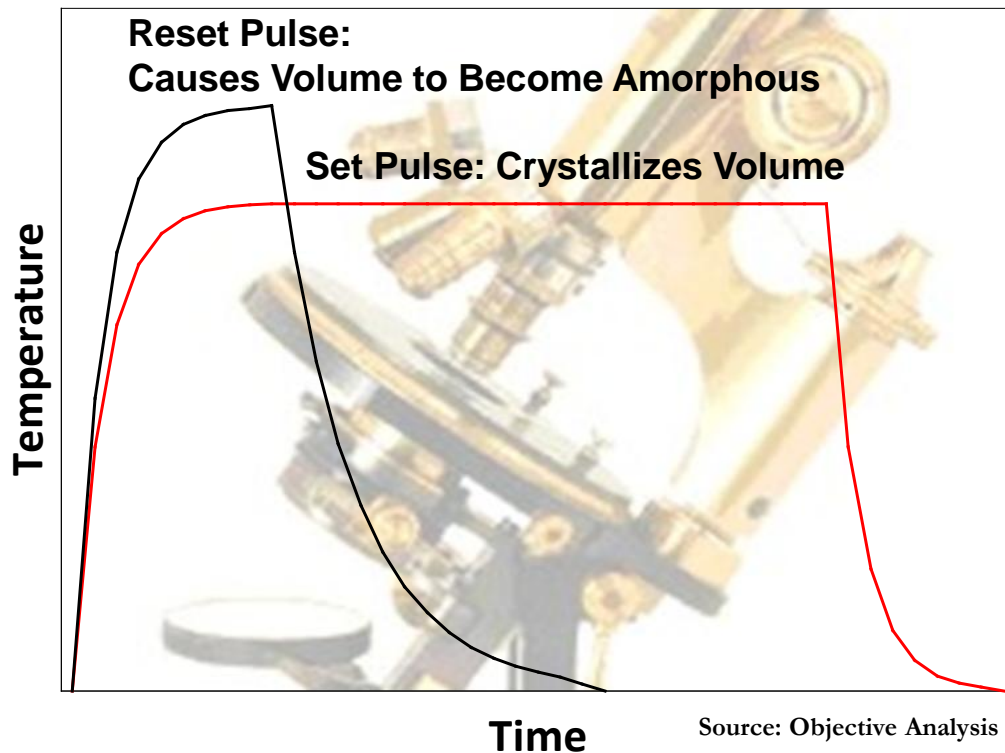
<https://TheMemoryGuy.com/emerging-memories-today-understanding-bit-selectors/>

Phase Change Memory (PCM)



Source: Objective Analysis

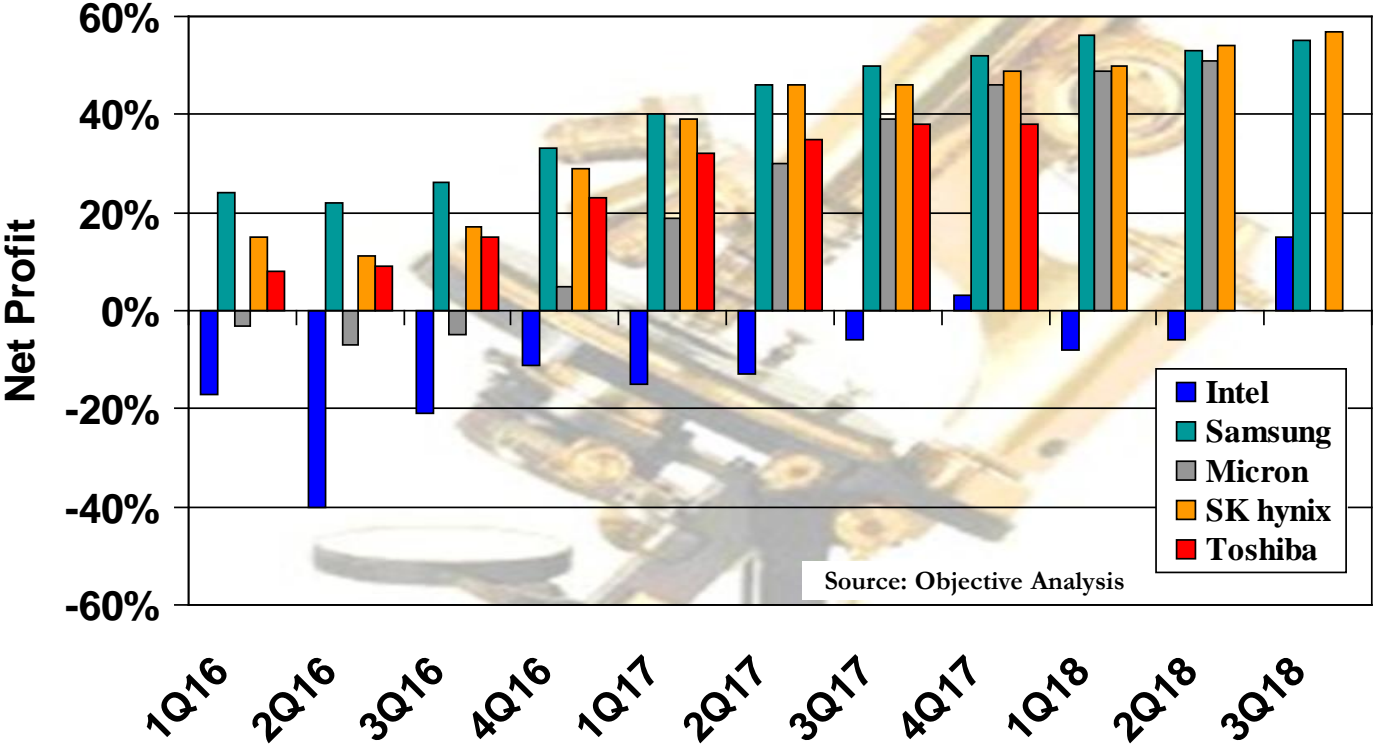
PCM Set/Reset Mechanism



NOR-Compatible PCM

- Shipped by both Samsung & Numonyx (Micron)
 - ◆ Both obsoleted it
- Well-understood materials
- Single current flow direction
 - ◆ Selector device is uncomplicated
- Today's markets:
 - ◆ Largely experimental & university projects

Intel Incurring XPoint Losses



Source: Objective Analysis

3D XPoint Report

➤ The Why, How, and When of 3D XPoint Memory

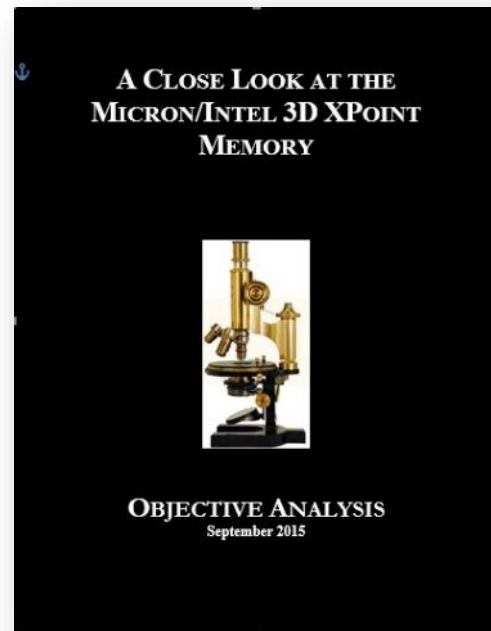
- ◆ Why Intel wants it
- ◆ How it fits into the memory hierarchy
 - › Impact on DRAM
- ◆ When will it sell in volume

➤ Forecasts by application

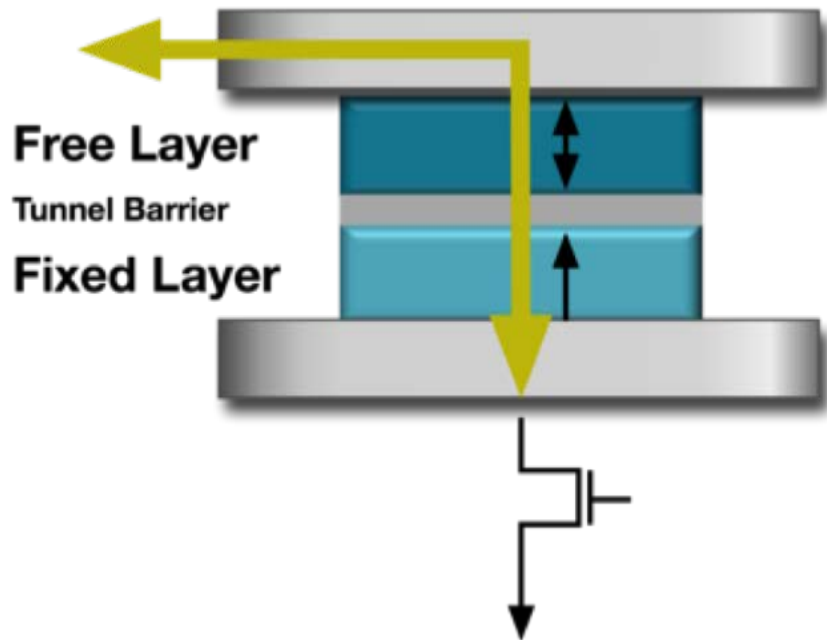
- ◆ NVMe SSD
- ◆ DIMM format

➤ Available for online purchase:

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

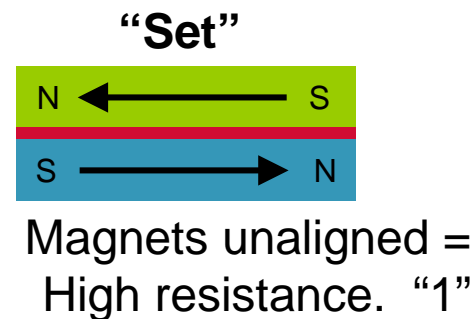
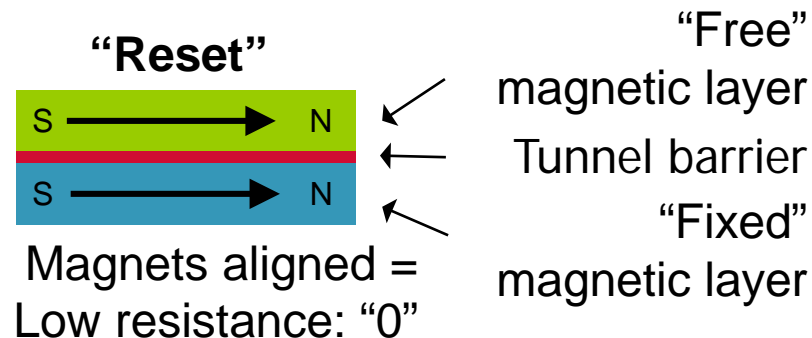


MRAM



Toggle MRAM

- Offshoot of HDD head design
 - ◆ Magnetic tunnel junction: “MTJ”
- Magnetism determines tunnel barrier resistance
- Before STT there were scaling issues

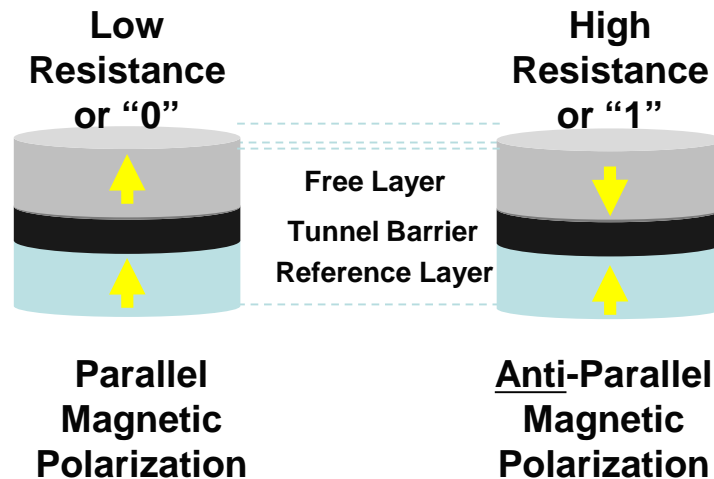


STT MRAM

- Solves scaling issues
- Being adopted in foundries
 - ◆ For embedded memories: SoCs
- Discrete memories will come later



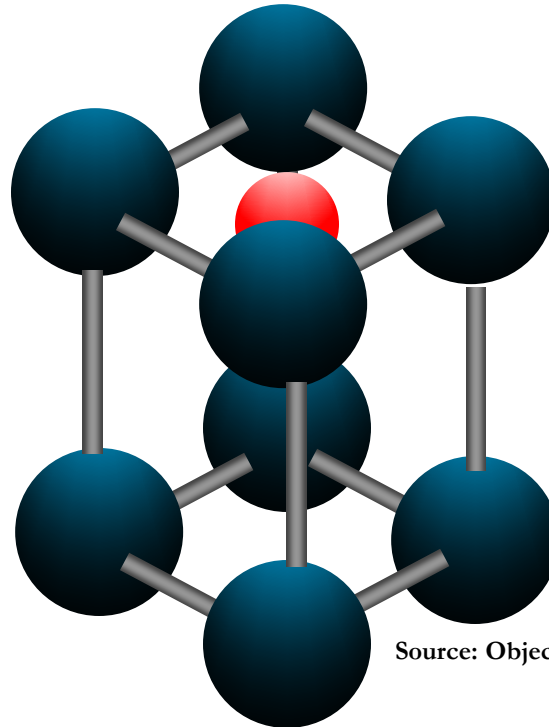
Perpendicular Magnetic Tunnel Junction (pMTJ)



MRAM Status

- Once considered a DRAM replacement
- Only one chip supplier: Everspin
 - ◆ Over 70 million units shipped
 - ◆ Converting from toggle bit to STT
 - ◆ Partnership with Global Foundries for 300 mm wafers
 - › GF to engage embedded market
- Others trying to get in
 - ◆ Avalanche, Samsung, Spin Transfer, TDK, Toshiba, TSMC, UMC
- Today's markets: Space, high-uptime systems

Ferroelectrics: FRAM



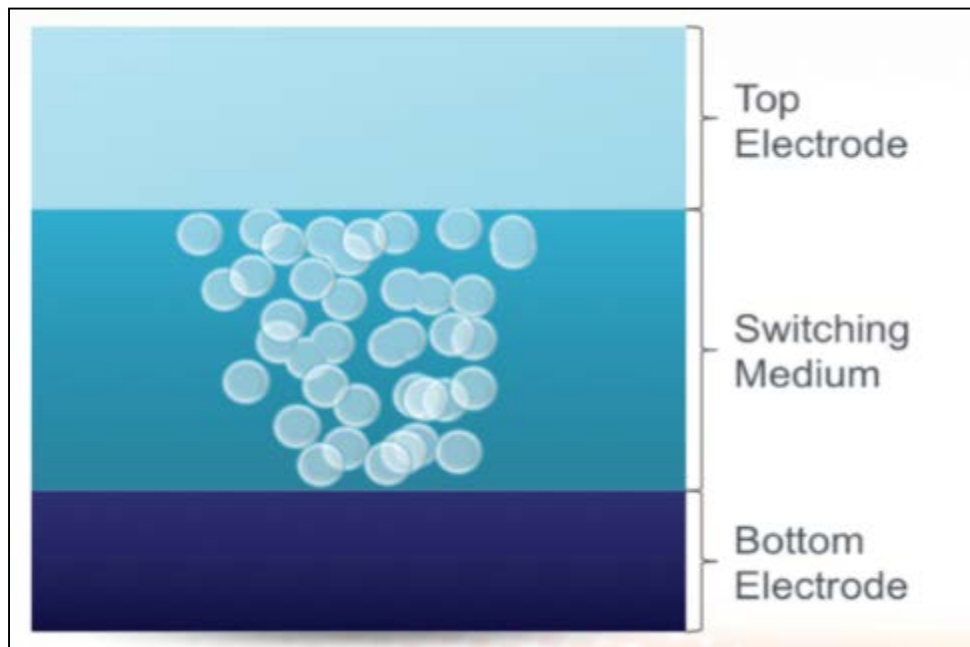
Source: Objective Analysis

- Ramtron (Now Cypress)
 - ◆ Partnered with Fujitsu for high-volume applications
 - ◆ PZT – Lead Zirconium Titanate.
- Other renditions:
 - ◆ Thinfilm, organic FRAMs
 - ◆ Symetrix
- New HfO₂ approach from NamLab, Dresden
 - ◆ Uses well-understood materials (Hafnium Oxide)
- Today's markets:
 - ◆ RFID, other low write current applications

- What it is depends on who you ask
 - ◆ PCM
 - ◆ Memristor
 - ◆ CMOx
 - ◆ CBRAM
 - ◆ Carbon nanotubes

What *IS* a ReRAM?

- Any memory with a resistive bit



All Have Something In Common

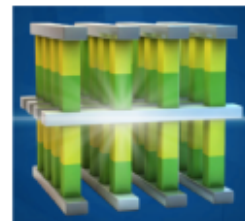
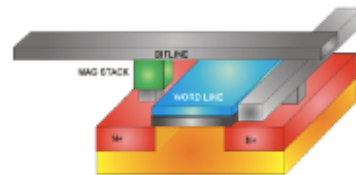
- Small single-element cell
 - ◆ Some use diode select mechanism
 - ◆ Promise to scale past DRAM & NAND flash
- Nonvolatile
- Write in place
 - ◆ No “Block Erase”
 - ◆ More symmetrical read/write speeds
- New materials

New Persistent Memory Report

- Coughlin Associates/Objective Analysis
- Examines the PM Ecosystem
 - ◆ Technologies (PCM, ReRAM, MRAM, FRAM, +)
 - ◆ Companies
 - ◆ Markets
 - ◆ Support requirements
- Forecasts PM consumption
 - ◆ Embedded PM
 - ◆ Stand-alone PM
- Available for online purchase
 - ◆ <https://TomCoughlin.com/tech-papers/>

EMERGING MEMORIES POISED TO EXPLODE

An Emerging Memory Report



COUGHLIN ASSOCIATES
San Jose, California
July 2018

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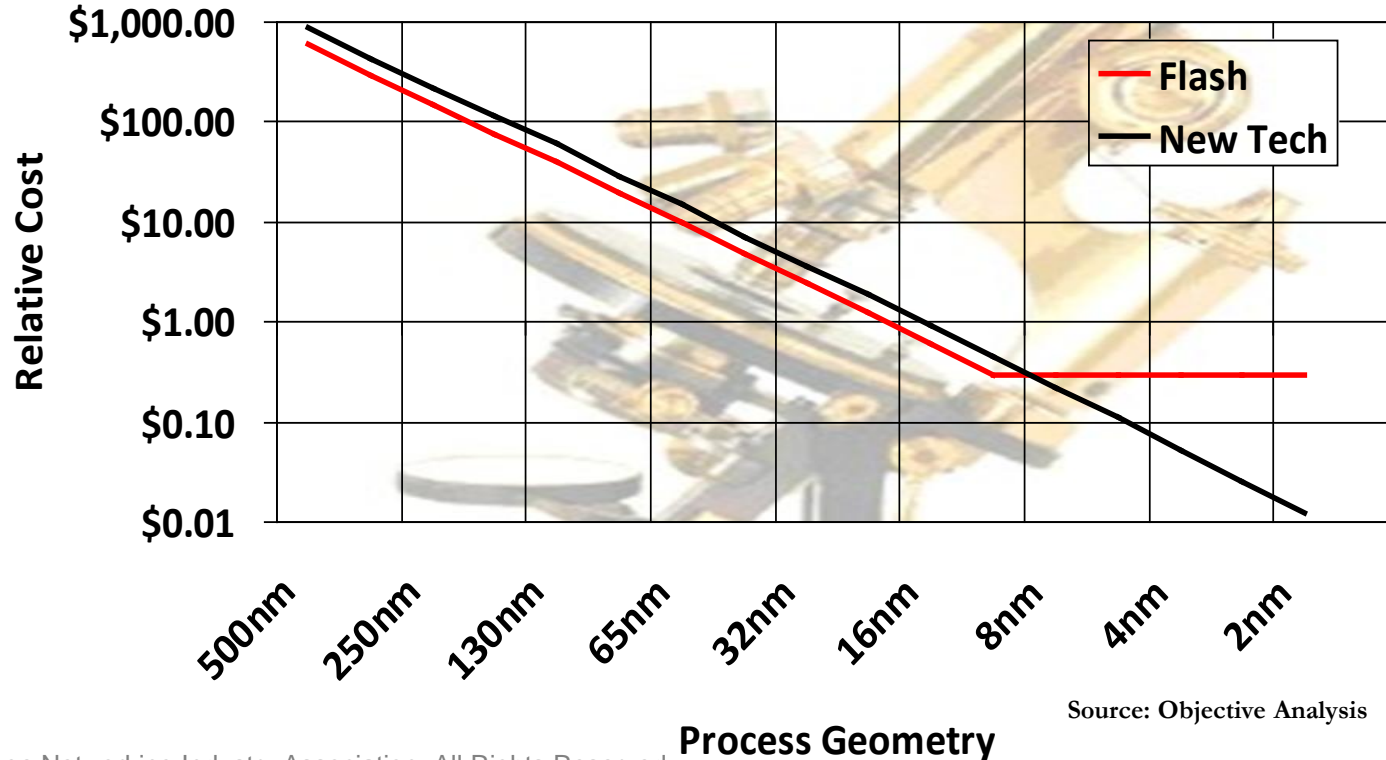
Outline

- Persistent Memory Types
- **Market Drivers**
- Support Requirements
- Outlook

Market Drivers

- PM vs. RAM
- PM in SoCs
- The economies of scale

The Vision: Replace Existing Technologies



Source: Objective Analysis

What Dictates Memory Cost?

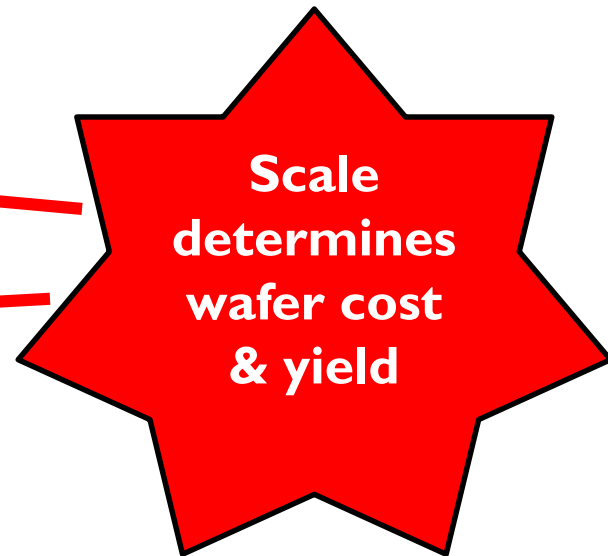
➤ Cost per megabyte depends on:

- ◆ Wafer cost
- ◆ Megabytes per wafer
- ◆ Yield

➤ Megabytes per wafer driven by bit size

- ◆ Shrinking bits allow cost reductions
- ◆ Manufacturers shrink processes to drive this

This is Moore's Law in Action!



The Same is True of All Memory Technologies

There can be no price advantage
without comparable scale

Outline

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➤ Hardware support

- ◆ Supporting early development
- ◆ Ongoing requirements

➤ Software support

- ◆ O/S support
- ◆ Application program support

- NVDIMM-N
 - ◆ DRAM with flash backup
- BIOS changes
- New signals to DIMM
 - ◆ Indicates power fail

NVDIMM Report

- Explains the NVDIMM markets

- ◆ NVDIMM-N
- ◆ NVDIMM-P

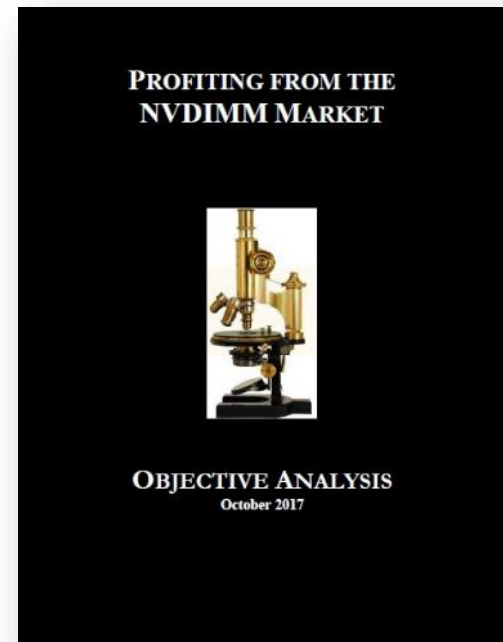
- Vendor profiles

- Support requirements

- Market forecast

- Available for online purchase

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

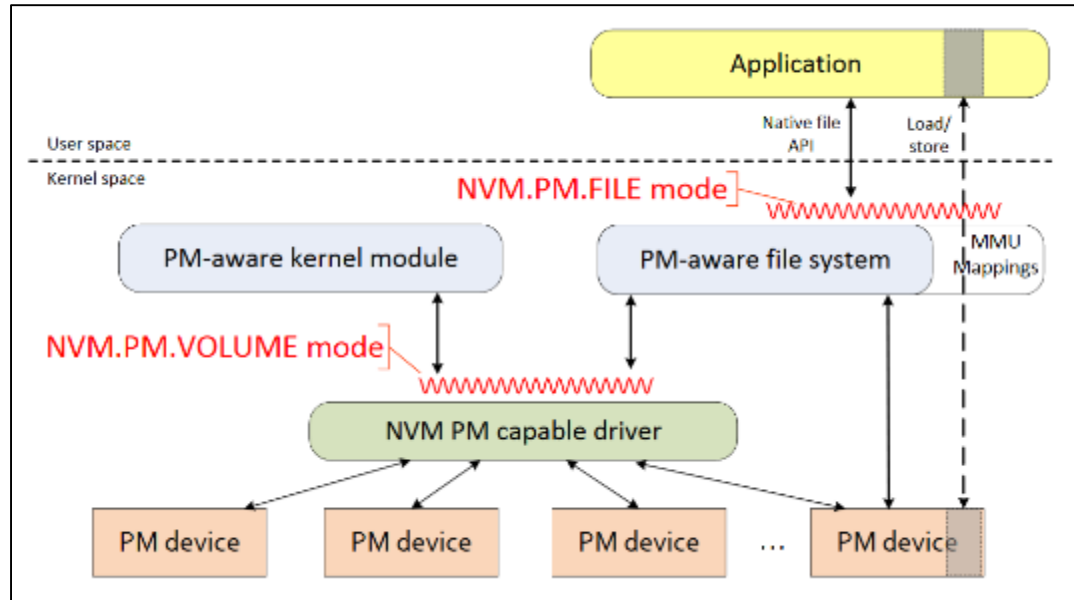


Ongoing Hardware Requirements

- Nonuniform Memory Architecture: “NUMA”
- MMU Redesign
- Faster context switches needed
 - ◆ Use polling for now
- Updated DDR bus
 - ◆ Support for non-deterministic access times

➤ SNIA's Persistent Memory Programming Model

- ◆ <https://www.SNIA.org/PM>



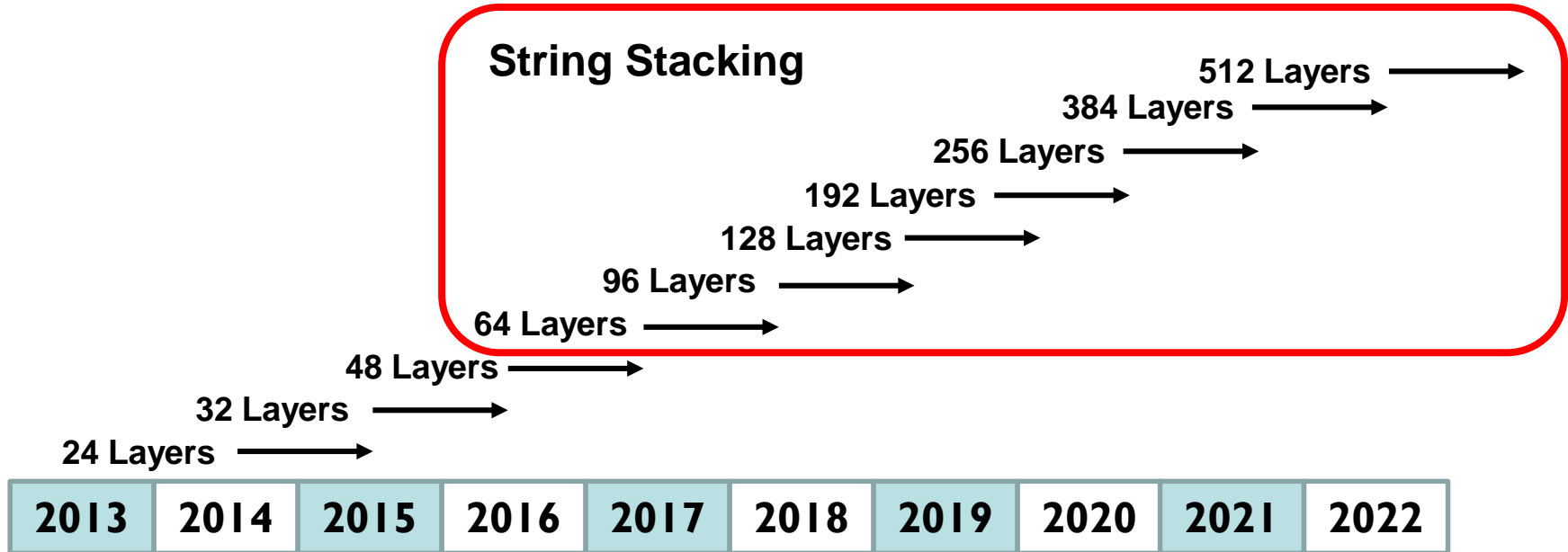
- PM is useless if its advantage is untapped
 - ◆ Persistence is unknown by most software
- This change will take some time

Outline

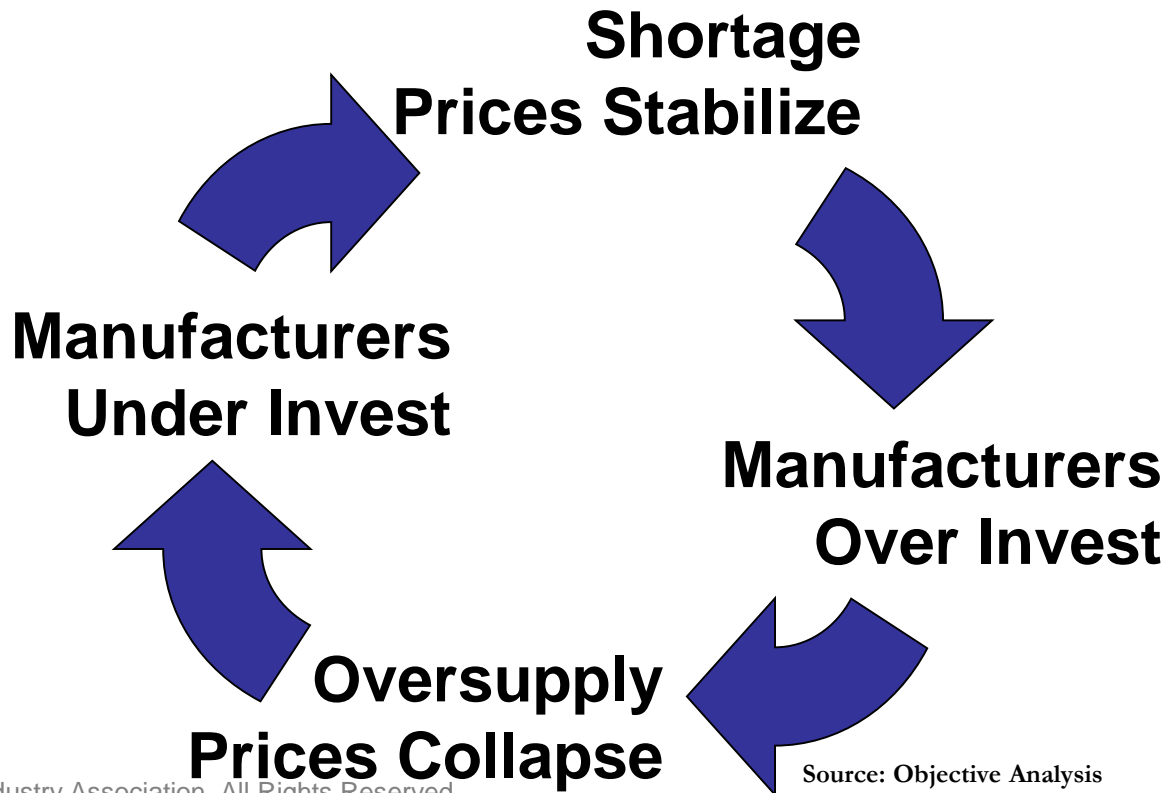
- Persistent Memory Types
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- Nothing works in a vacuum
 - ◆ PM is a part of the greater memory ecosystem
 - ◆ The memory market swings wildly
- Foundry processes will have a huge impact

3D NAND Layers will Continue to Increase



Commodity Price Cycle

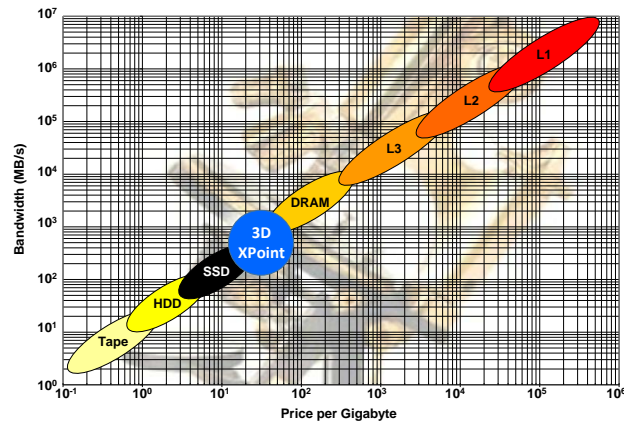


What Drives the Current Cycle?

- 2018 price collapse
 - ◆ Supply-driven overcapacity
 - ◆ Largest-ever price-cost gap
- Prices collapse to cost in early 2019
 - ◆ Will hug cost curve until next shortage
 - ◆ China's market entry will extend the oversupply

Impact to PM?

- Persistent memory competes against established technologies
 - ◆ Example: 3D XPoint must be cheaper than DRAM
- A DRAM collapse will create an XPoint collapse
 - ◆ Even though XPoint is sole-sourced!



Timeline for Change

Logic

???

NAND

ReRAM?

DRAM

MRAM?

2015

2020

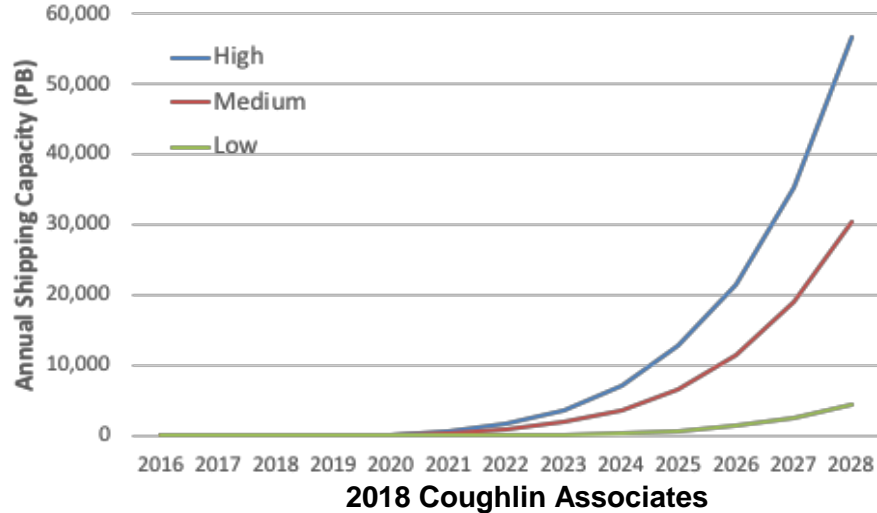
2025

2030

2035

Source: Objective Analysis, 2018

High, Low and Baseline PB Emerging Memory Shipments



Emerging NVM market could exceed \$6B by 2023!

Emerging Memories: Poised to Explode
Coughlin Associates/Objective Analysis
<http://www.TomCoughlin.com/tech-papers.htm>

- Emerging Memories: Poised to Explode
 - ◆ <http://www.TomCoughlin.com/tech-papers.htm>
- Profiting from the NVDIMM Market
 - ◆ <https://Objective-Analysis.com/reports/#NVDIMM>
- A Close Look at the Micron/Intel 3D XPoint Memory
 - ◆ <https://Objective-Analysis.com/reports/#NVDIMM>
- The Memory Guy blog
 - ◆ <https://TheMemoryGuy.com>
- SNIA SSSI
 - ◆ <https://www.snia.org/forums/sssi>

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- A full Q&A from this webcast, including answers to questions we couldn't get to today, will be posted to the SNIA SSSI blog: <http://sniasssiblog.org/>
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Thank You!