SNIA SSSI | SOLID STATE STORAGE

What a Year It Was - and Where We Need To Go in Emerging Memory

Live Webcast
14 January 2020, 11:00 am PT/ 2:00 pm ET

Today's Presenters

Moderator:
Alex McDonald, Co-Chair

Presenter:
Tom Coughlin, President

Presenter:
Jim Handy, General Director

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Technologies We Cover:

- Solid State Storage
- Persistent Memory
- Computational Storage

Join Us in January and February 2020 for these exciting events:

SNIA 2020 PERSISTENT MEMORY HACKATHON

www.snia.org/pmhackathon

January 22, 2020
1:00 pm – 5:00 pm
Santa Clara, CA

Complimentary registration

February 4, 2020
9:30 am – 5:00 pm
Tel Aviv, Israel
As part of
SDC 20 SNIA EMEA

www.snia.org/pm-summit

January 23, 2020
8:30 am – 6:30 pm
Hyatt Regency Santa Clara

Keynote by Andy Bechtolsheim of Arista Networks
Complimentary registration

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Many Emerging Memory Types

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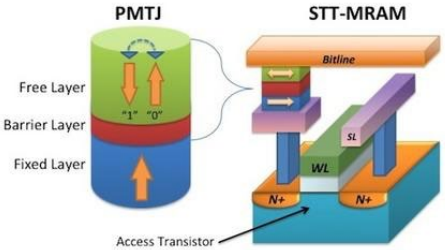
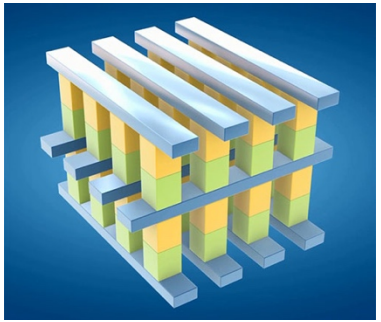
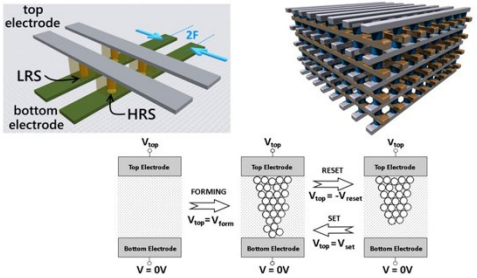
MRAM



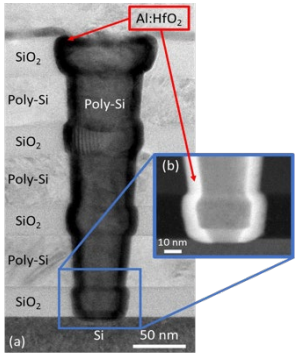
PCM



ReRAM



FRAM



They're All Persistent!

AND THEY'RE ALL IN OUR EMERGING MEMORIES REPORT

Agenda

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- SNIA Support Moves Ahead
- Optane DIMMs Arrive
- New MRAM types Emerge
- Business Conditions in Flux
- More Work is Needed

PM Needs Support

- Hardware (JEDEC, Others)
  - Supporting early development
  - Ongoing requirements
  - Form factors, interfaces
- Software support (SNIA, Others)
  - O/S support
  - Application program support

Hardware: Early Development

- Early groundwork has been helpful
  - NVDIMM-N
    - DRAM with flash backup
    - Deeply investigated in Objective Analysis NVDIMM Report
  - BIOS changes
    - How/when to boot without reloading memory?
  - New power fail signal brought to DIMM
- 3D XPoint Memory/Optane is driving HW changes
- Cadence now supports DDR4 MRAM for ASICs & FPGAs

Ongoing Hardware Requirements

- Nonuniform Memory Architecture: “NUMA”
- MMU redesign
- Faster CPU context switches needed
  - Use polling for now
- Updated DDR4 bus
  - Intel has developed proprietary DDR-T
    - “Transactional”
  - Support for non-deterministic access times

Software: Operating System Support

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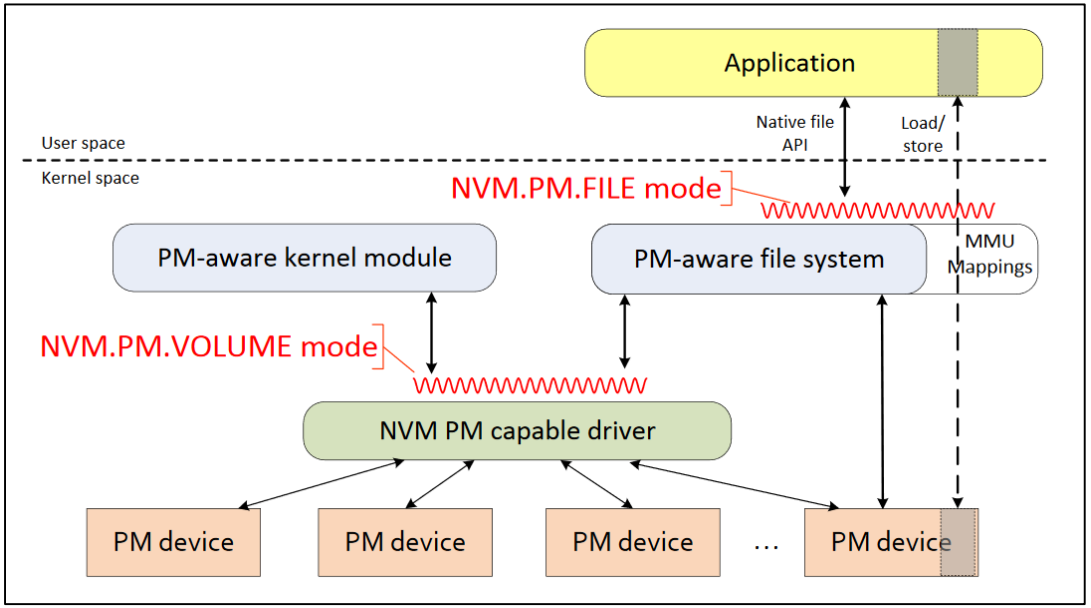
- SNIA's Persistent Memory Programming Model
  - https://www.SNIA.org/PM



SNIA's Persistent Memory Progress

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- 2019
  - PM Programing Hackathon and Workshops launched
  - Work on PM software interface specifications
    - Developed PMDK
  - Persistent Memory Summit
  - White papers
- Future
  - Define Remote PM Programming Model (i.e. RDMA)
  - Updates to current PM Programming Model

Application Program Support

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- PM is useless if its advantage is untapped
  - Persistence is unknown in most software
- This change will take some time
  - Closed systems can use it now
    - Hyperscale Data Centers, SANs
  - Open systems will evolve

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3D XPoint Must Be Priced Below DRAM

Otherwise People will Just Buy DRAM

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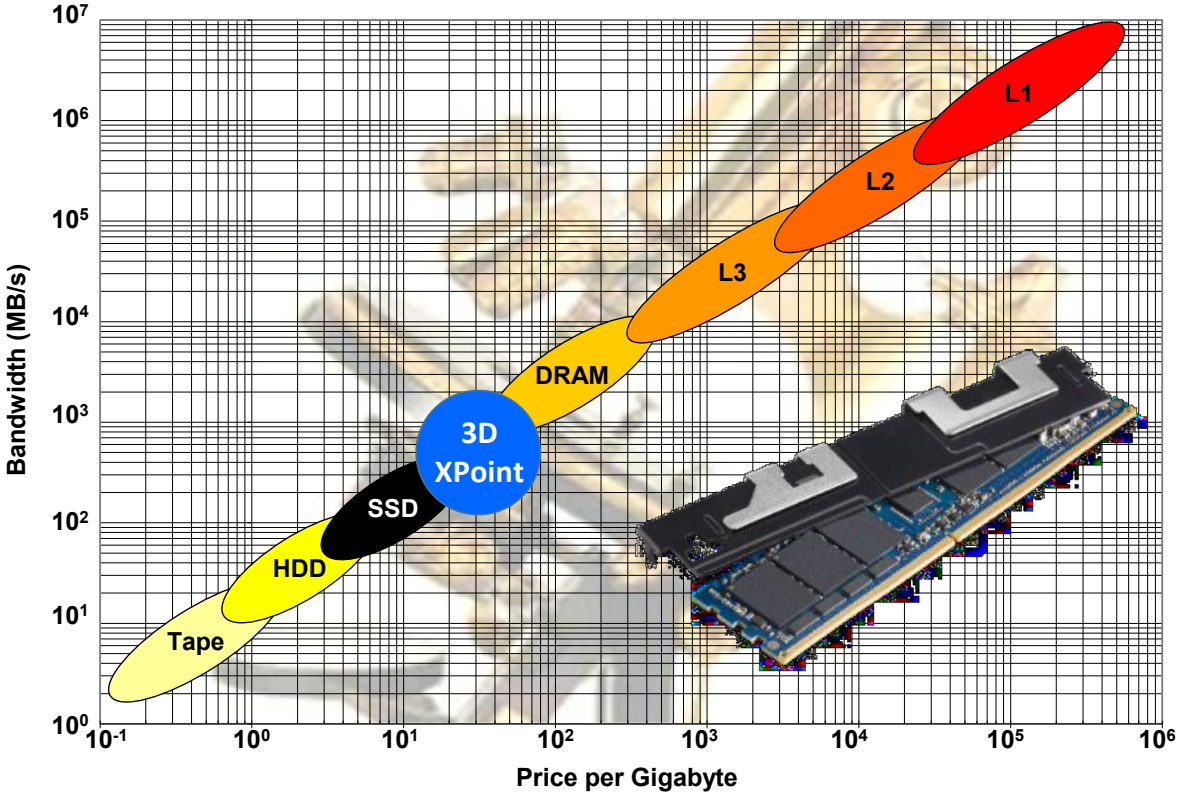

Optane Status

- Optane DIMMs are a key selling point for next-generation server “Cascade Lake” CPUs
  - Big performance benefit from Optane + CPU enhancements
- Optane SSDs gaining modest acceptance
  - NAND makers countering with fast SLC SSDs
- Covered in depth by Objective Analysis XPoint report
  - Details at end of slideshow

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Existing MRAM Types: Toggle & STT

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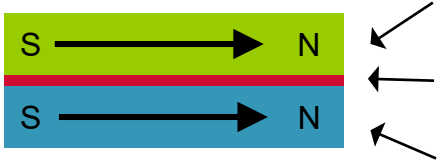
Toggle Mode

"Reset"



"Free" magnetic layer

Tunnel barrier

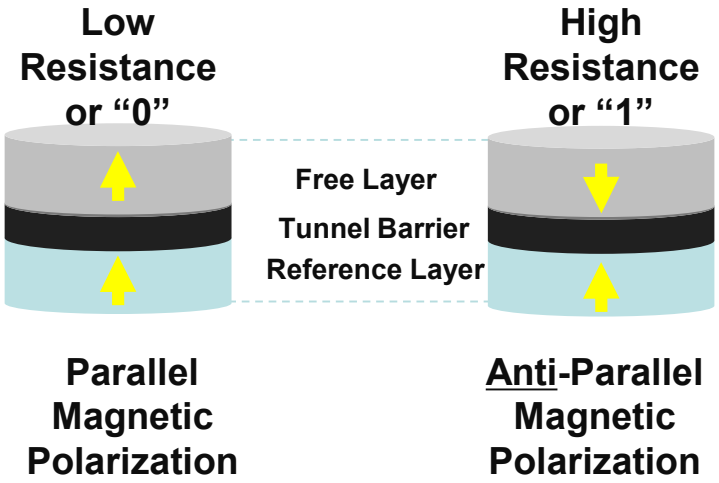
"Fixed" magnetic layer

Magnets aligned = Low resistance: "0"

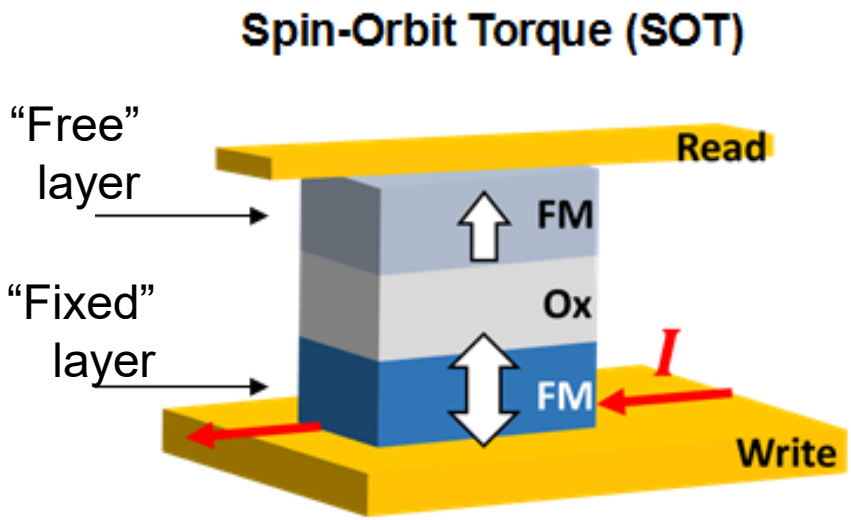
"Set"

Magnets unaligned = High resistance. "1"

Spin Transfer Torque (STT)



New: Spin-Orbit Torque MRAM (SOT)



- Higher reliability in-plane current
- Faster than STT – As fast as SRAM

MRAM Status

- MRAM cache is in certain new IBM SSDs as well as some RAID controllers
- Spin Memory introductions:
  - Precessional Spin Current
  - Endurance Engine Technologies
- Everspin still sole supplier of stand-alone MRAMs
  - Over 123 million units shipped
  - Avalanche is sampling
- Today's markets: Space, high-uptime systems, caches and buffers

Embedded MRAM on SoCs

- Support from all major semiconductor foundries for embedded MRAM:
  - Samsung
  - Intel
  - TSMC
  - GLOBALFOUNDRIES
  - UMC
- This will increase the volume to lower costs
- New tools are needed for MRAM, driving capital equipment spending

MRAM Capital Spending Up

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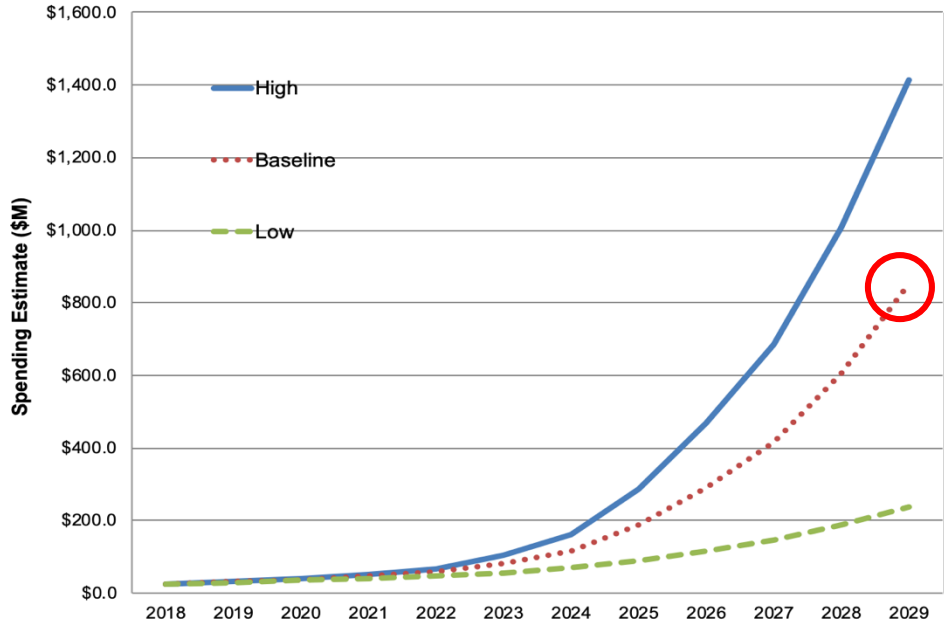
MRAM Production Equipment Spending, 2018-2029



>$800 Million!

2019 Emerging Memories Ramp Up, Coughlin Associates and Objective Analysis, 2019

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Who Wants Persistent Memory?
1) If it Costs MORE than DRAM

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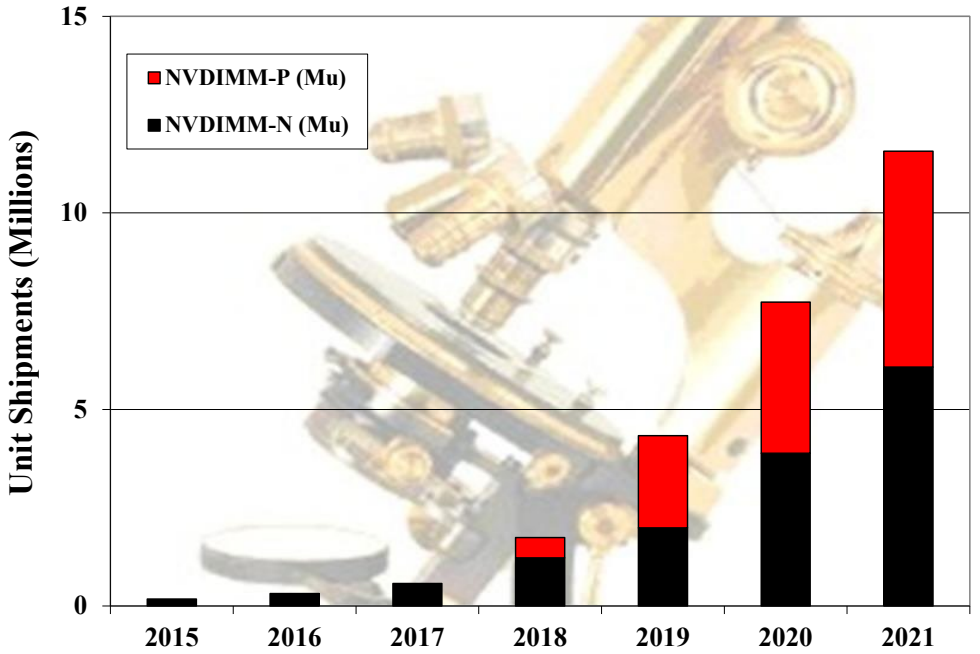
- That's NVDIMMs!
  - Early adopters:
    - High-availability systems
    - Financial databases
    - Some hyperscale applications
- MRAM DIMMs are also interesting (faster but more expensive)



New Memory Prices Will Move Past Established Technologies

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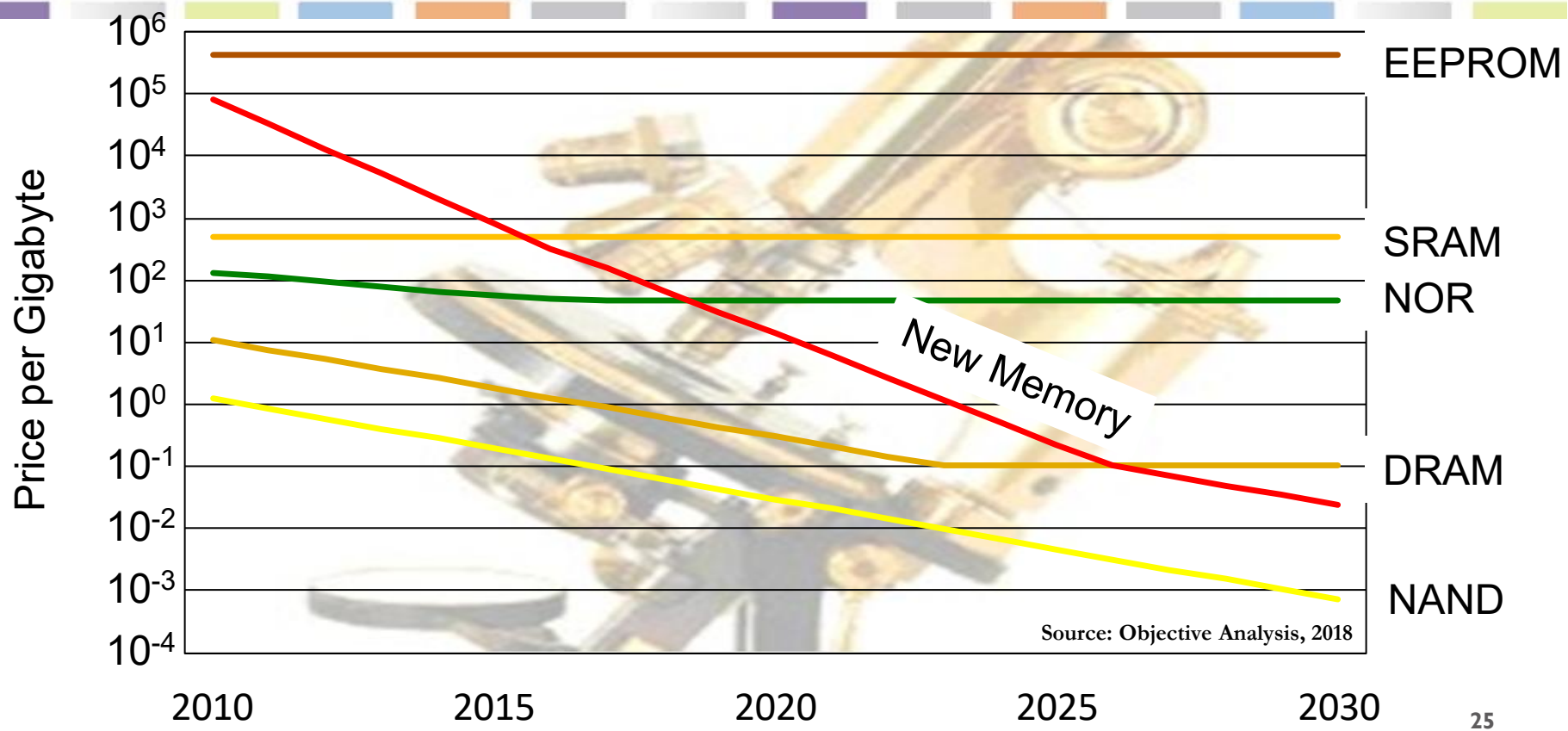

Who Wants Persistent Memory?
2) If it Costs LESS than DRAM

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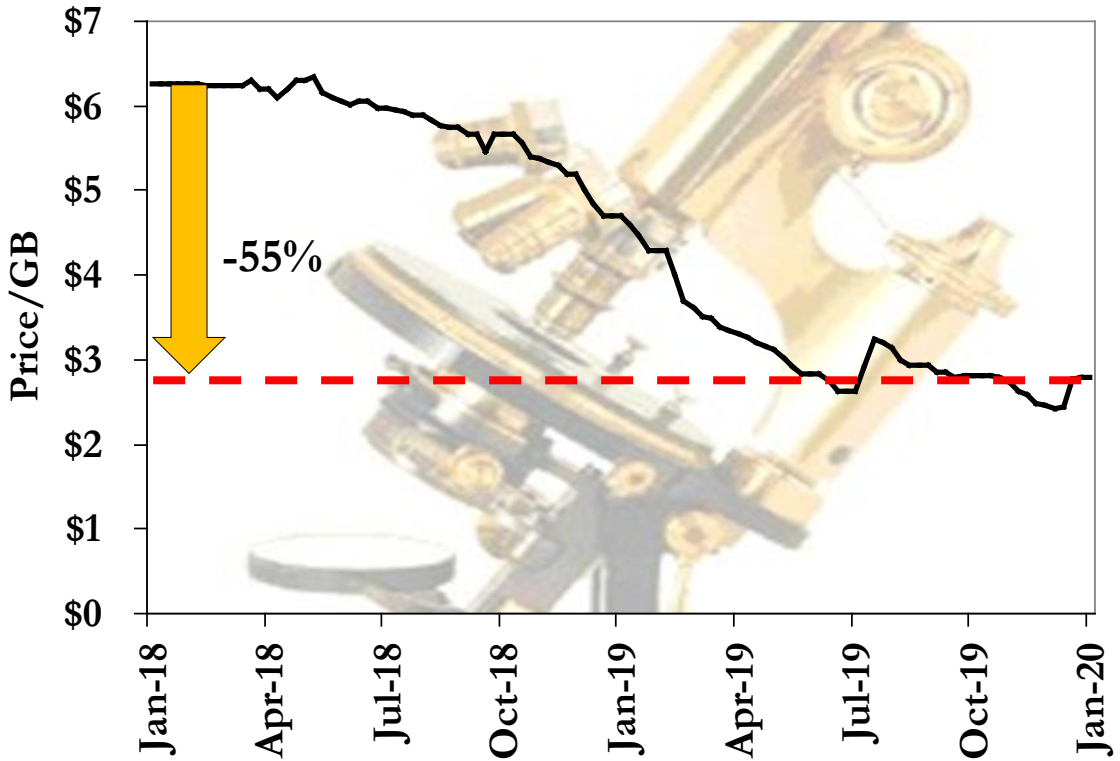
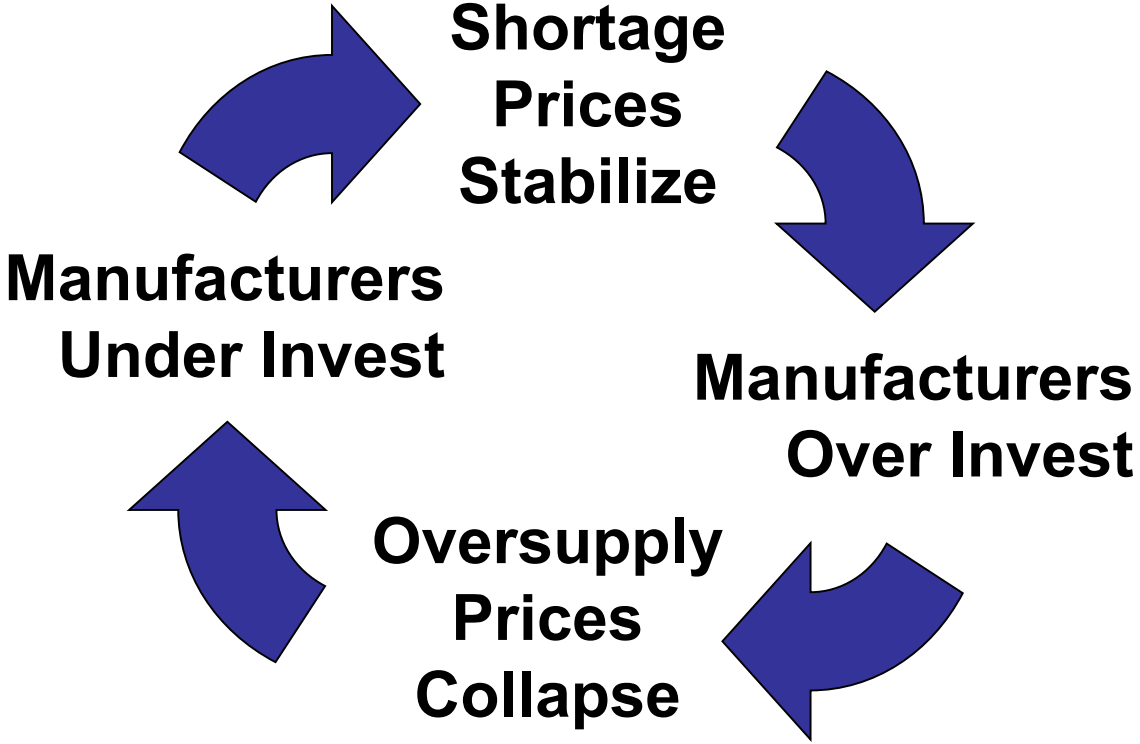
- That's 3D XPoint!
  - Everybody will want it!
  - It improves cost/performance
    - Persistence is of secondary importance
  - This will drive its success
    - Persistent apps come later

Meanwhile, DRAM Prices Collapse



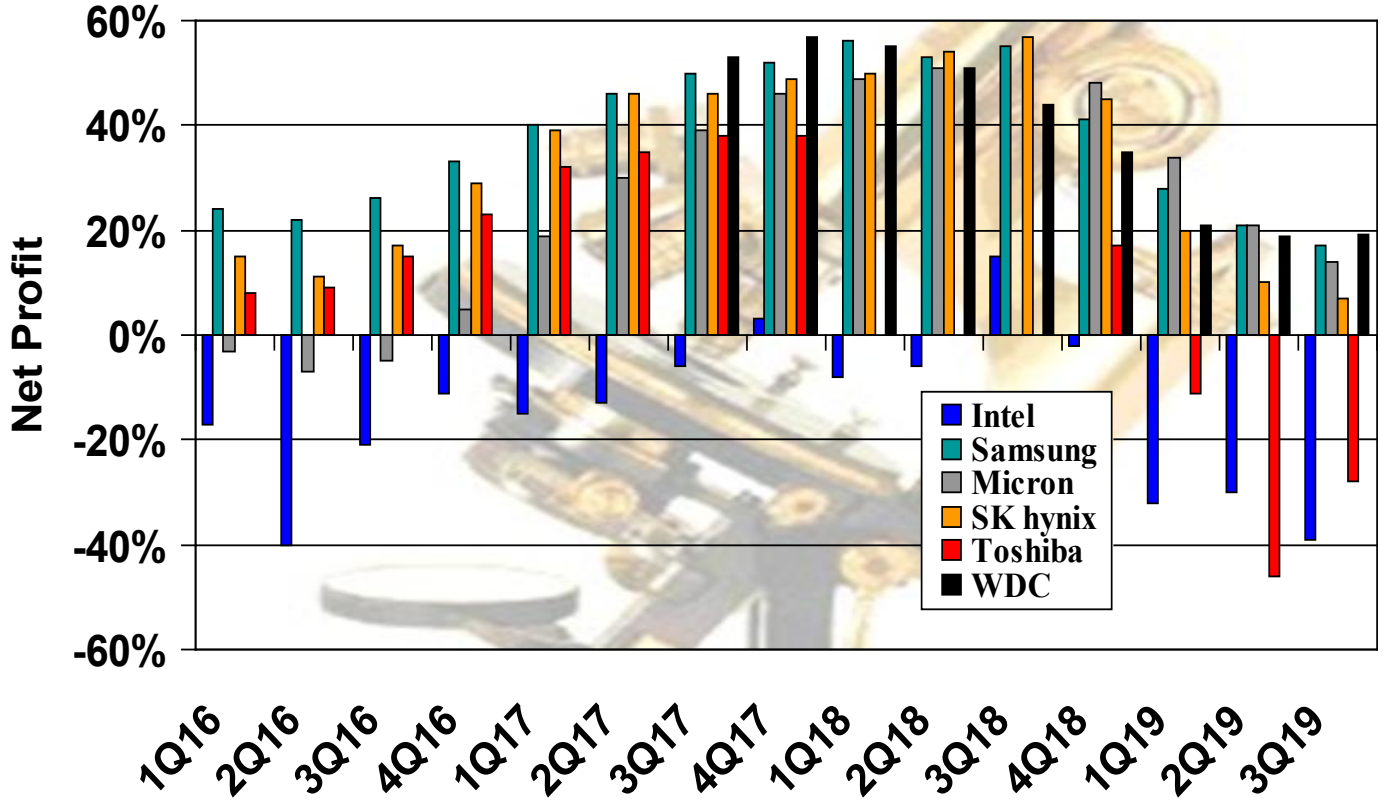
Commodity Price Cycle at Work!



How Does This Impact PM?

- Persistent memory competes against established technologies
  - E.g. 3D XPoint must be cheaper than DRAM
  - MRAM takes up less space on die than SRAM
- A DRAM collapse undermines XPoint pricing
  - Even though XPoint is sole-sourced!

Big XPoint/Optane Losses For Intel



New Memory Shipment Growth

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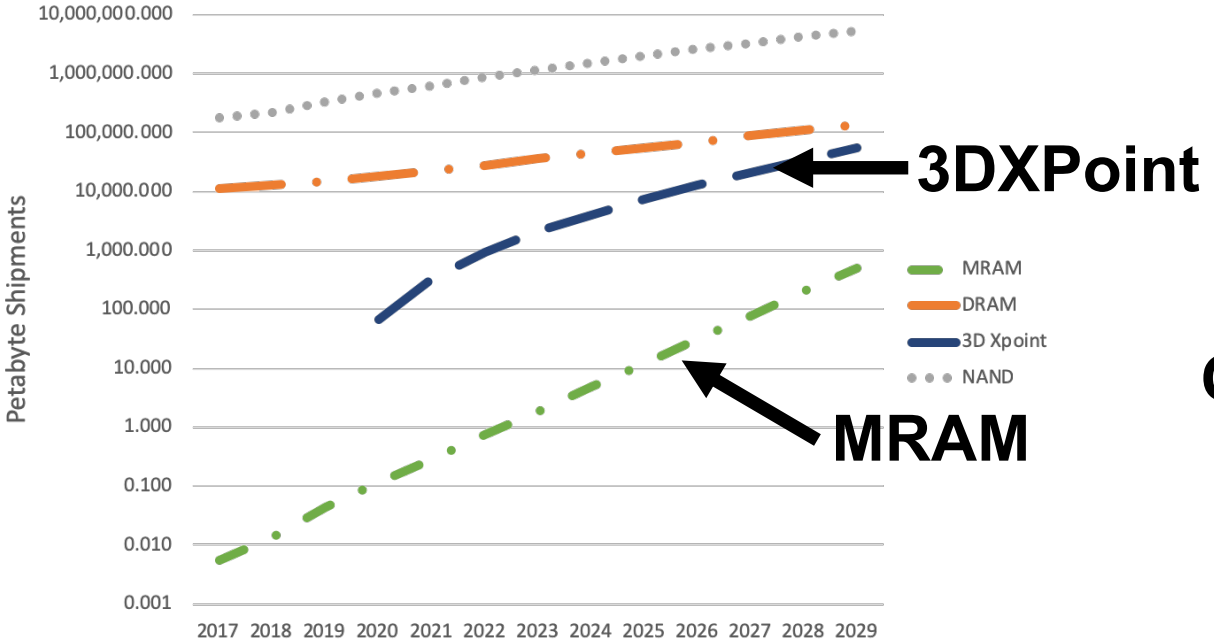
Memory Petabyte Shipments 2018-2029



Over $37B by 2029!

2019 Emerging Memories Ramp Up, Coughlin Associates & Objective Analysis, 2019

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Taking PM to the Max

- Application support for PM
- Additional open-source libraries to support PM (PMDK)
- PM hardware support outside of Intel
- Drive cost reductions by ramping production volume
- Standardize Remote PM protocol
- Buy our reports!

QUESTIONS?

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Coughlin Associates
Data Storage Consulting

OBJECTIVE ANALYSIS
Semiconductor Market Research

Emerging Memory Report

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- 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

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

Now Available!

Thanks for Watching Our Webcast

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- And check out these additional resource links:
  - SNIA Persistent Memory Summit videos and presentation slides
  - SNIA Educational Library resources on Persistent Memory
  - SNIA SSSI blog
  - SNIA Persistent Memory activities
    - NVM Programming Technical Work Group
    - SNIA Persistent Memory and NVDIMM Special Interest Group
    - SNIA Persistent Memory Programming Tutorial and Hackathon Program

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Additional Materials

Coughlin Associates

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- Technical and Market Analysis
- Consulting
- Events
- Reports and Newsletter
  - Emerging Memories Ramp Up: Emerging Memory Report
  - Digital Storage in Media and Entertainment Report
  - Digital Storage Technology Newsletter

Tom Coughlin
President

Objective Analysis

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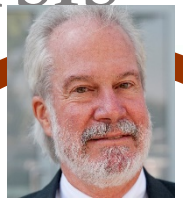
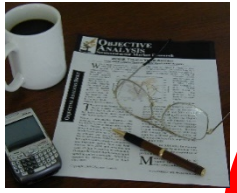
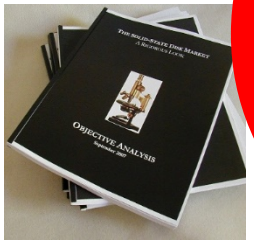


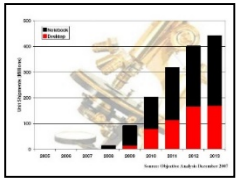
Profound Analysts

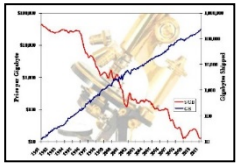


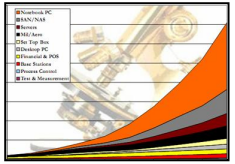


Reports & Services

Custom Consulting







Objective Analysis
Semiconductor Forecast Accuracy

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

NVDIMM Report

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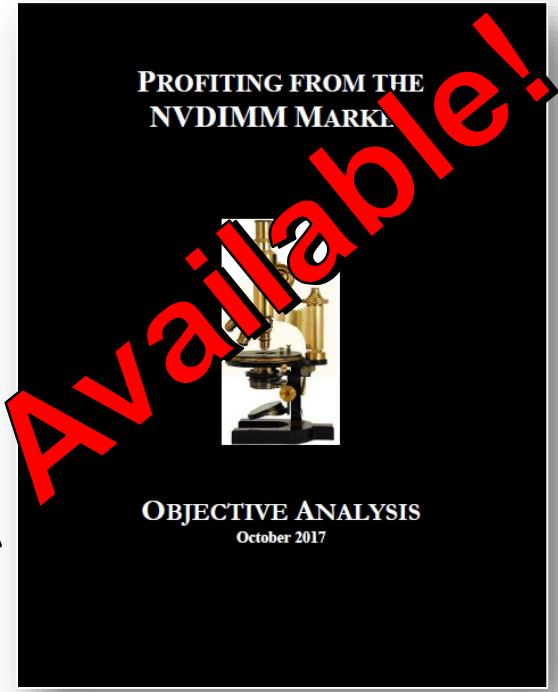
- Objective Analysis
- Explains the NVDIMM markets
  - NVDIMM-N
  - NVDIMM-P
- Vendor profiles
- Support requirements
- Market forecast



Now Available!

https://Objective-Analysis.com/reports/#NVDIMM

3D XPoint Report

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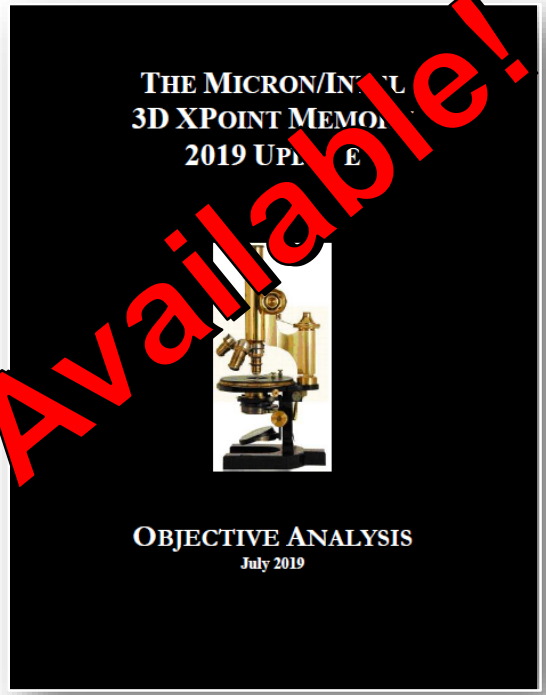
- 2019 Update from Objective Analysis
- The Why, How, and When of 3D XPoint Memory
  - Why Intel wants it
  - How it fits into the memory hierarchy
    - Impact on DRAM
  - When will it sell in volume
- Detailed Forecasts



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