Emerging Memories
Poised to Explode
The Long & Winding Road
to Persistent Memories

Live Webcast
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Today’s Bearded Presenters

Alex McDonald
SNIA SSSI Co Chair
NetApp

Tom Coughlin
Coughlin Associates

Jim Handy
Objective Analysis
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  - Provides education, performs market outreach, and influences & promotes standards.

- Technical Work Groups (TWGs) and Special Interest Groups (SIGs)

- More information at https://www.snia.org/forums/sssi
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  • Reports, Conferences and Newsletter

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  • Profound analysts
  • Reports & services
  • Custom consulting
Persistent Memory Types
Market Drivers
Support Requirements
Outlook
Outline

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

- PCM/XPoint
- MRAM
- ReRAM
- FRAM
- Others
3D XPoint: A Long Time Coming
3D XPoint Must Cost Less than DRAM Otherwise People will Just Buy DRAM
What is a Crosspoint?

- Small die area
- Stackable
- The ideal memory!

https://TheMemoryGuy.com/emerging-memories-today-understanding-bit-selectors/
PCM Set/Reset Mechanism

Reset Pulse: Causes Volume to Become Amorphous

Set Pulse: Crystallizes Volume

Source: Objective Analysis
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
Toggle MRAM

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

“Reset”

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Magnets aligned = Low resistance: “0”

“Free”

“Fixed”

“Set”

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Magnets unaligned = High resistance. “1”
STT MRAM

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

Perpendicular Magnetic Tunnel Junction (pMTJ)

- Low Resistance or “0”
  - Parallel Magnetic Polarization
  - Free Layer
  - Tunnel Barrier
  - Reference Layer

- High Resistance or “1”
  - Anti-Parallel Magnetic Polarization
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
FRAM Status

Ramtron (Now Cypress)
- Partnered with Fujitsu for high-volume applications
- PZT – Lead Zirconium Titanate.

Other renditions:
- Thinfilm, organic FRAMs
- Symetrix

New HfO$_2$ approach from NamLab, Dresden
- Uses well-understood materials (Hafnium Oxide)

Today’s markets:
- RFID, other low write current applications

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ReRAM

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/
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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Support Requirements

- **Hardware support**
  - Supporting early development
  - Ongoing requirements

- **Software support**
  - O/S support
  - Application program support
Hardware: Early Development

- 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](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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Outlook

- 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

String Stacking

- 2013: 24 Layers
- 2014: 32 Layers
- 2015: 48 Layers
- 2016: 64 Layers
- 2017: 96 Layers
- 2018: 128 Layers
- 2019: 192 Layers
- 2020: 256 Layers
- 2021: 384 Layers
- 2022: 512 Layers

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Commodity Price Cycle

- Manufacturers Over Invest
- Prices Collapse
- Manufacturers Under Invest
- Prices Stabilize
- Shortage
- Oversupply

Source: Objective Analysis
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

DRAM

Source: Objective Analysis, 2018
Emerging NVM market could exceed $6B by 2023!

Emerging Memories: Poised to Explode
Coughlin Associates/Objective Analysis
Resources

Emerging Memories: Poised to Explode

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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