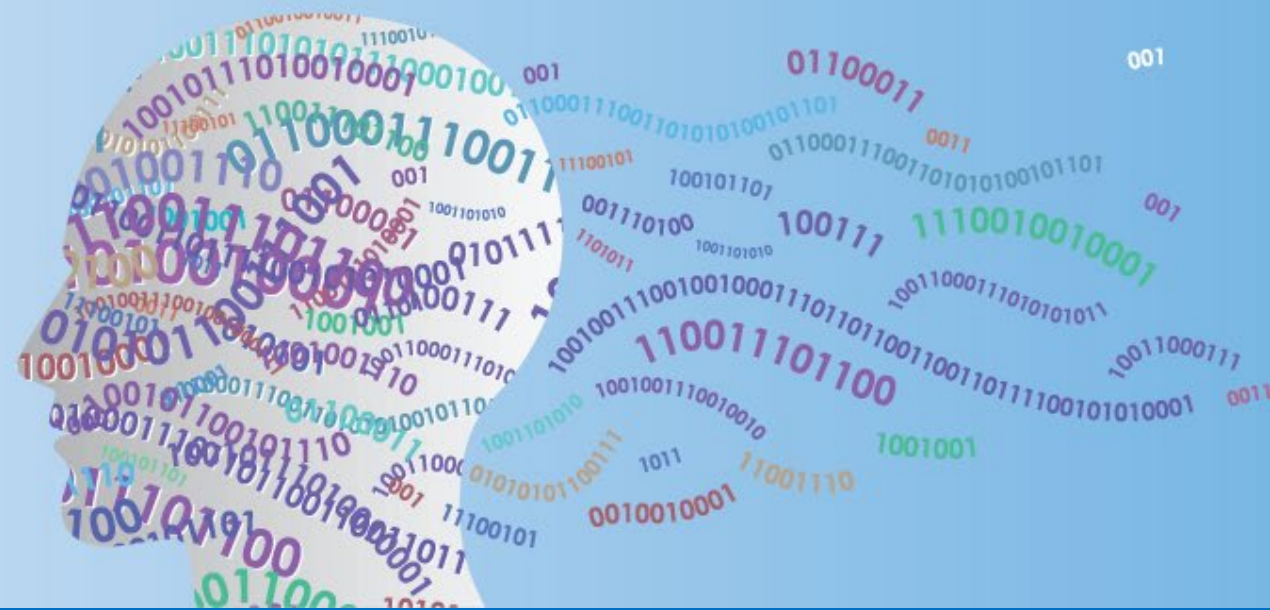




SNIA

PERSISTENT MEMORY + SUMMIT 2021 COMPUTATIONAL STORAGE

FROM DATACENTER TO EDGE : VIRTUAL EVENT
APRIL 21-22, 2021



Dynamic Trends in Nonvolatile Memory Technologies

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Jim Handy, Objective Analysis, www.Objective-Analysis.com

Outline

- Why Now?
- Changes to the Computing Model
- Emerging Memories 101
- Who's Producing It?
- Real Life Applications
- Outlook
- Conclusions
- References

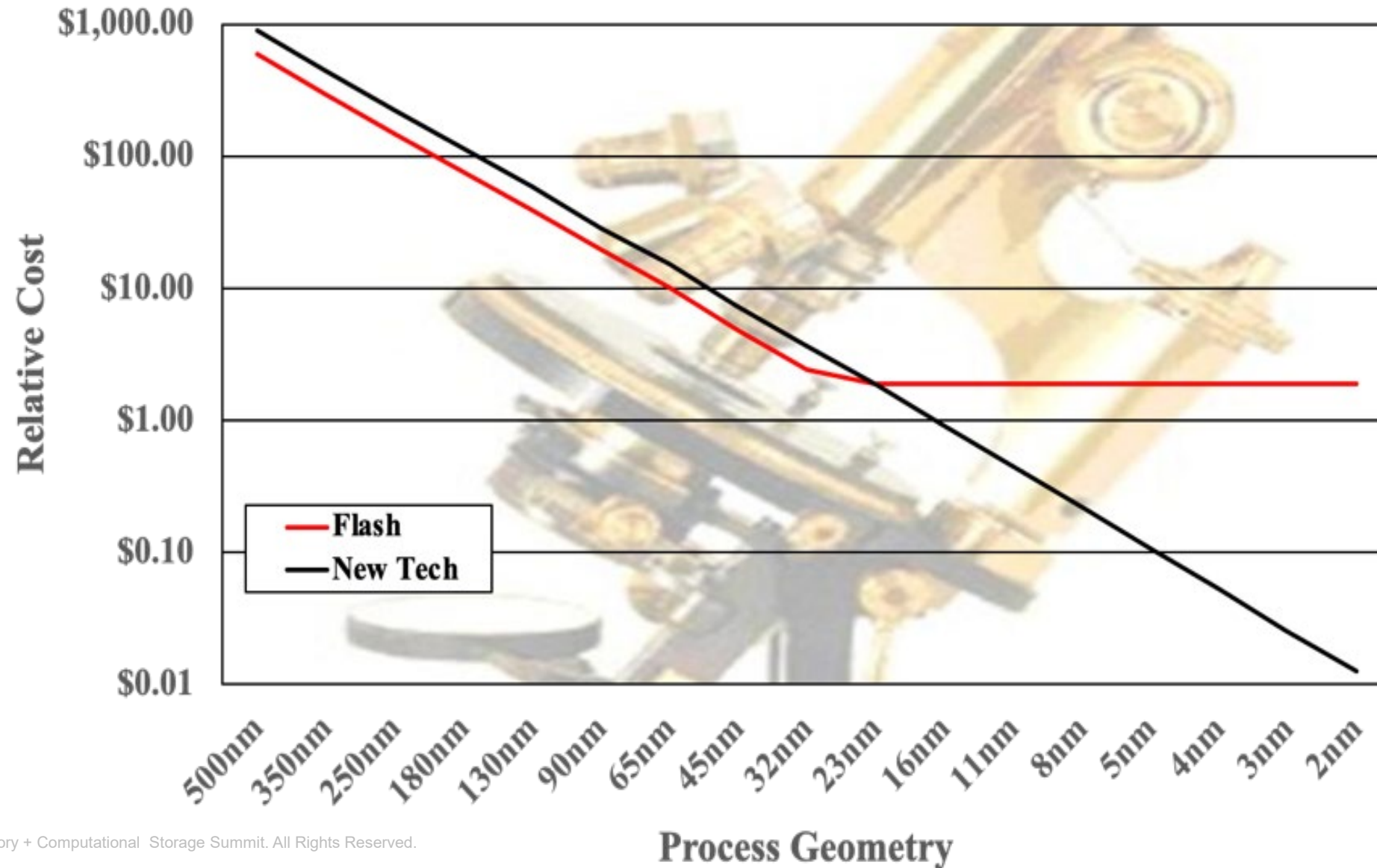
Why Now?



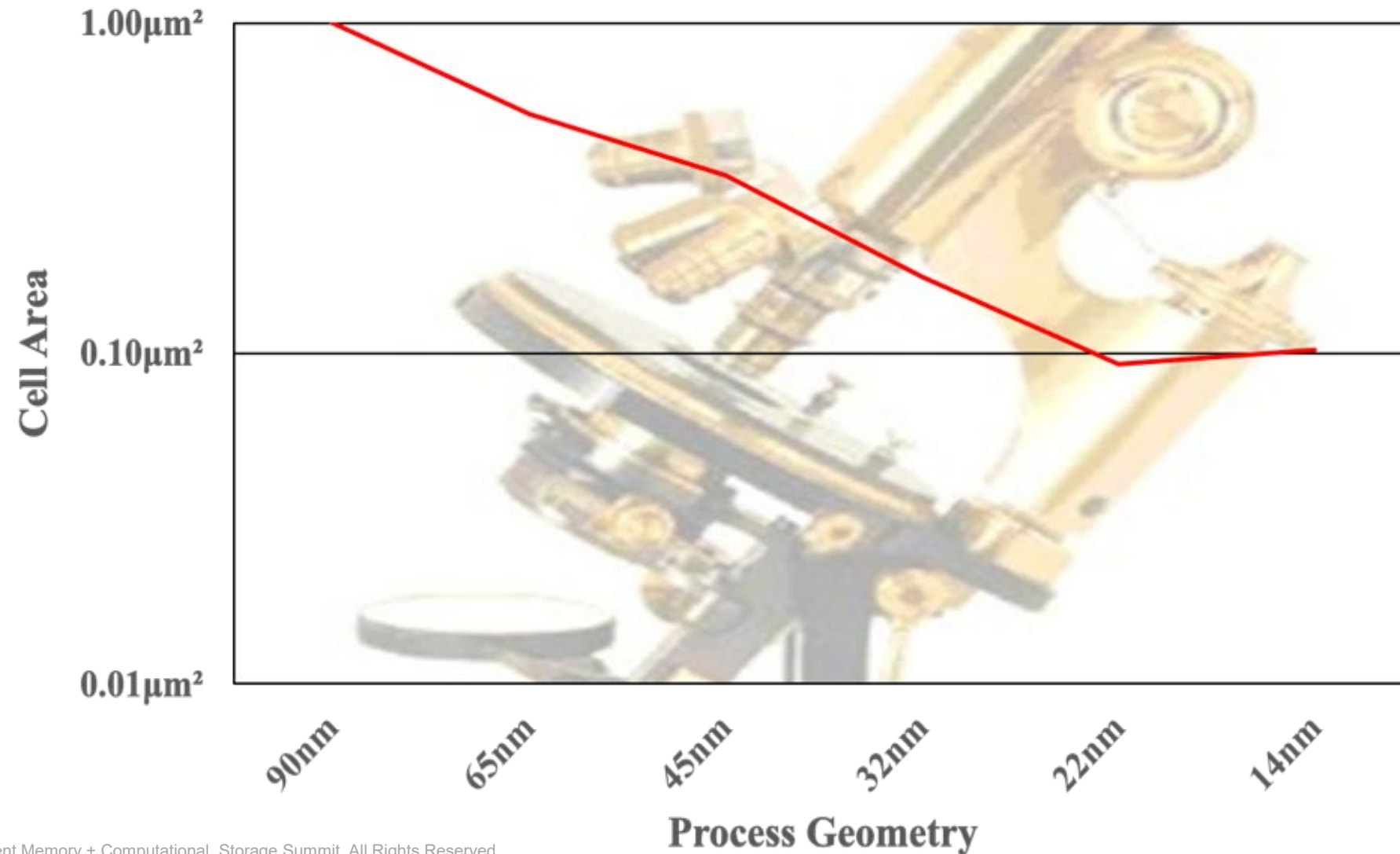
Why Emerging Persistent Memories are Necessary

- Flash can't scale with process advances
 - NAND flash went 3D at 15nm
 - NOR scaling stops with FinFET
 - 28nm & smaller processes need something new
 - SRAM scaling may stop at 14nm
- In addition, low power high density non-volatile memory is needed for embedded and data center applications

NOR Flash Scaling Ends at 28nm



SRAM's In Trouble Too

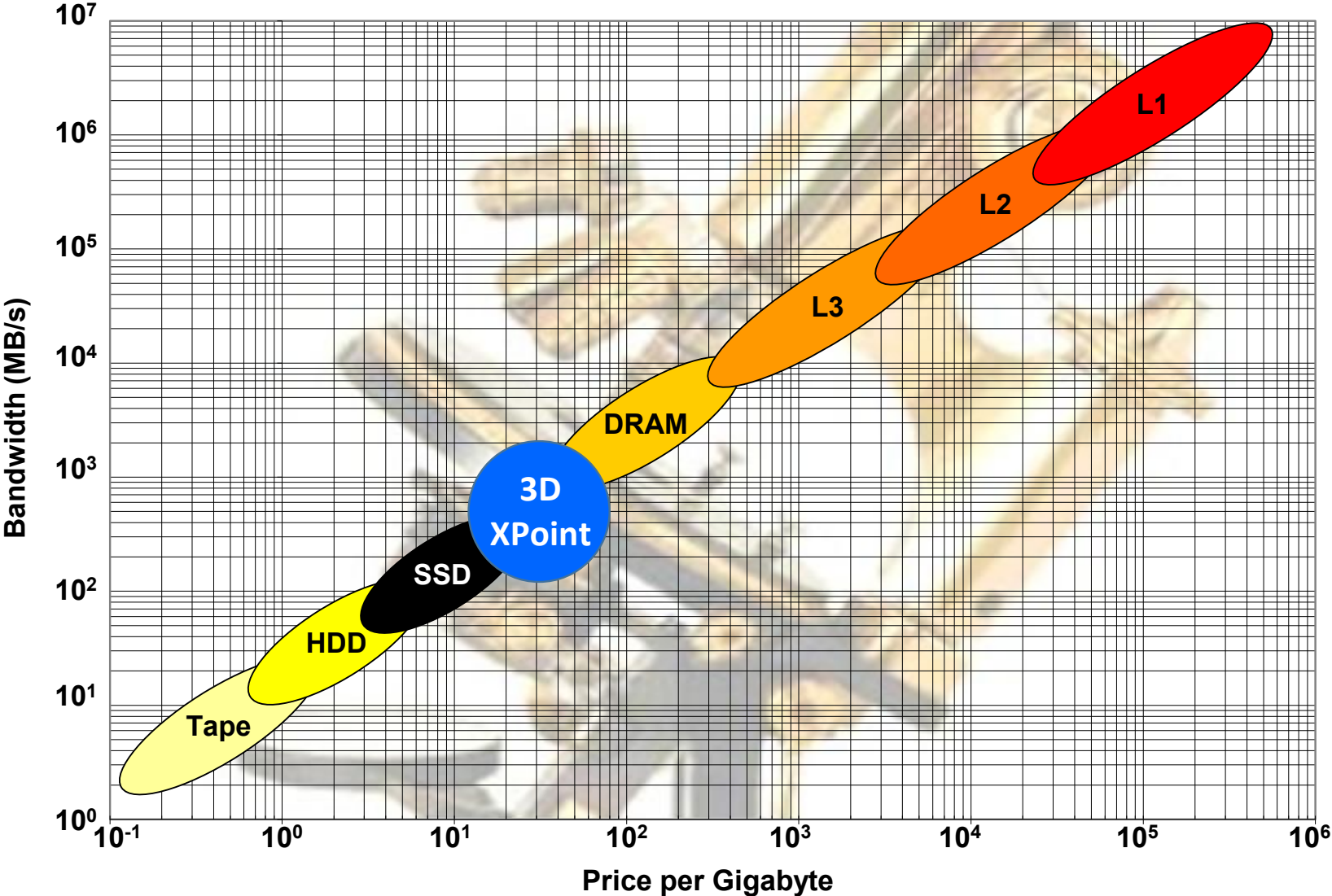


Changes to the Computing Model

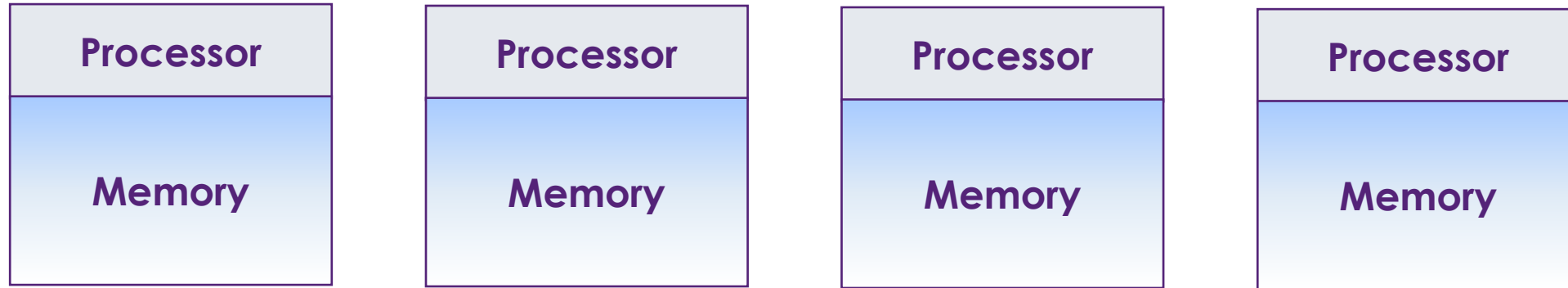
Enabling the use of Emerging Memories



Key Issue: Pricing!

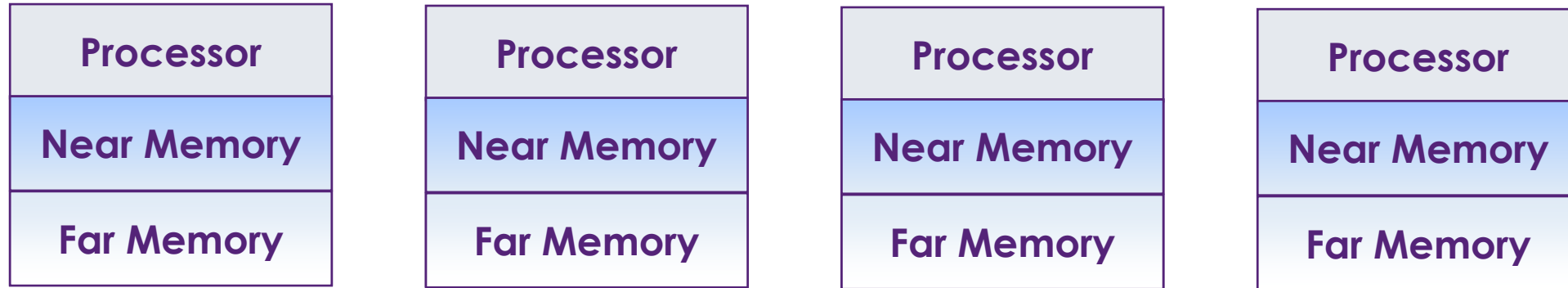


Moving from a von Neumann to a Memory-Centric Compute Model



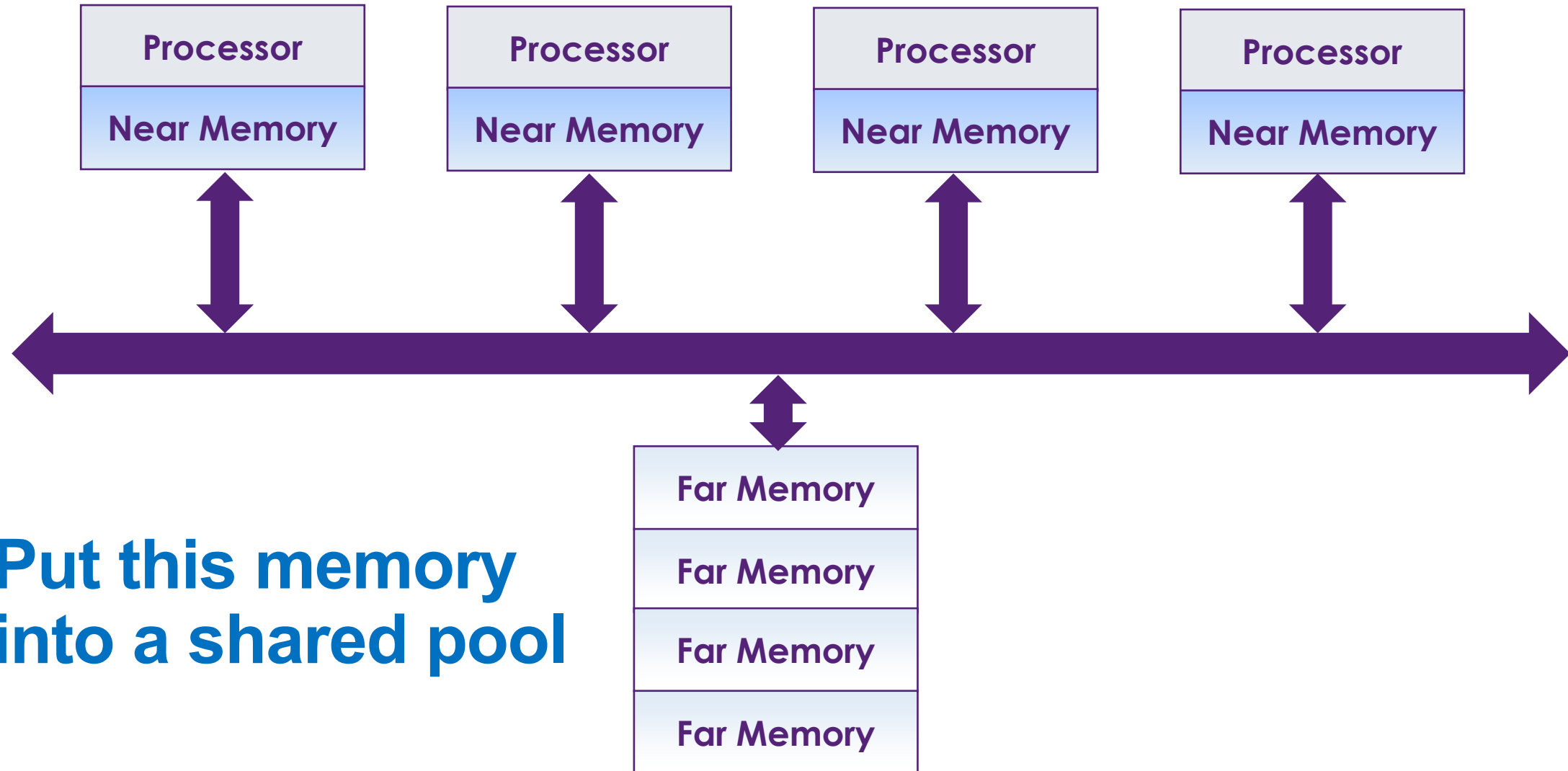
Classical von Neumann Model

Moving from a von Neumann to a Memory-Centric Compute Model



Divide off some of the memory

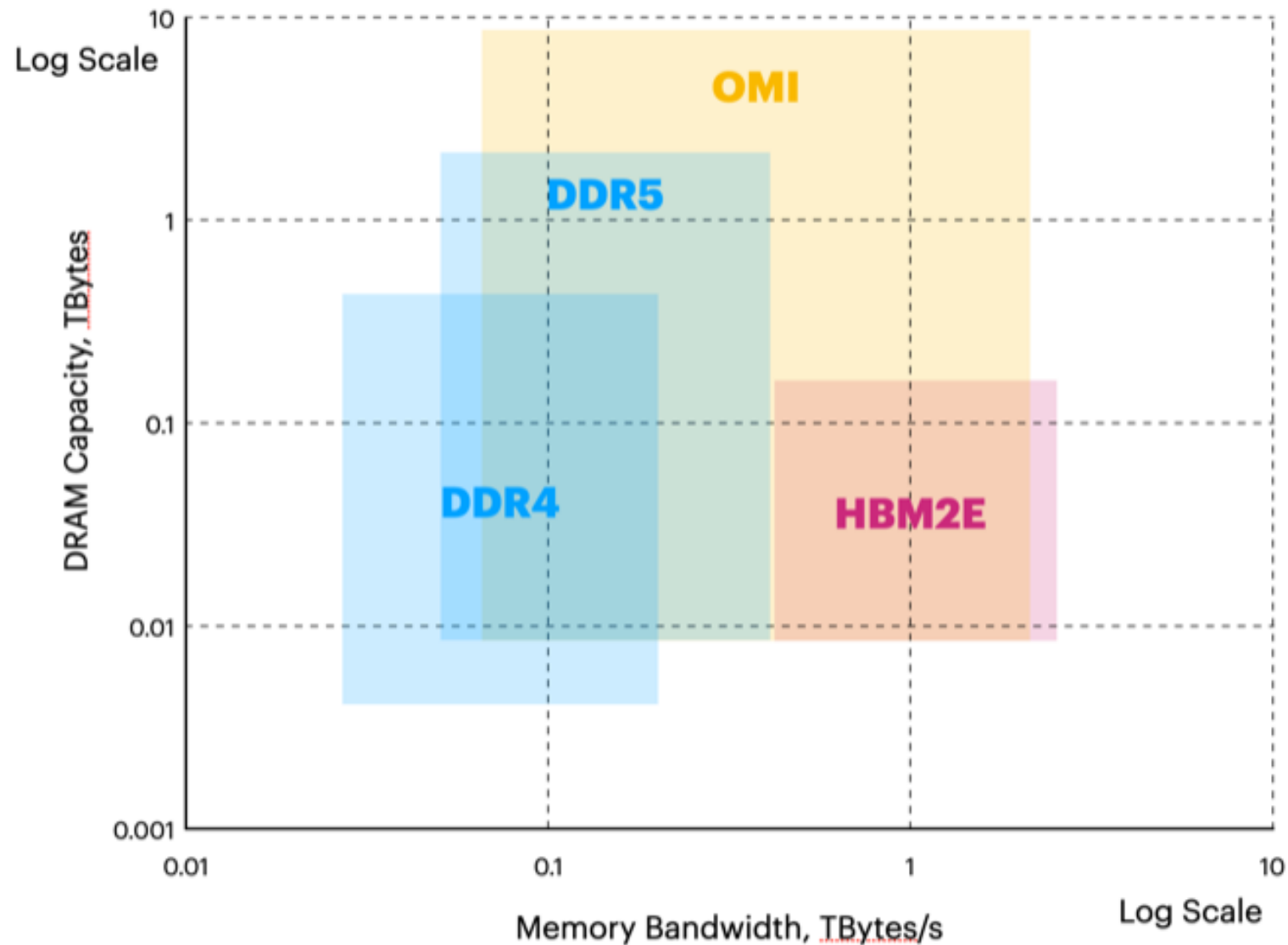
Moving from a von Neumann to a Memory-Centric Compute Model



Memory Interconnect Types

- CXL for “Far Memory”
 - Pools heterogeneous memories
 - Mixed latencies and data rates
- Gen-Z to connect storage boxes and racks
- The DDR interface will stay with us for “Near Memory”
 - DDR good for smaller systems
 - HBM fast but restrictive and costly
 - OMI for both high speed and large capacities

Approaches to Near Memory

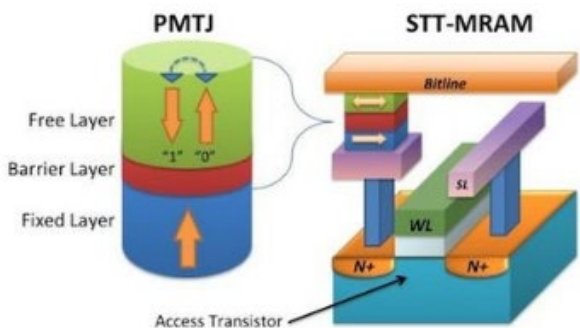


Emerging Memories 101

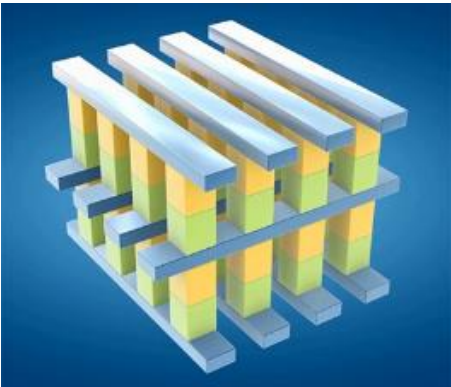


Candidates for Persistent Memory

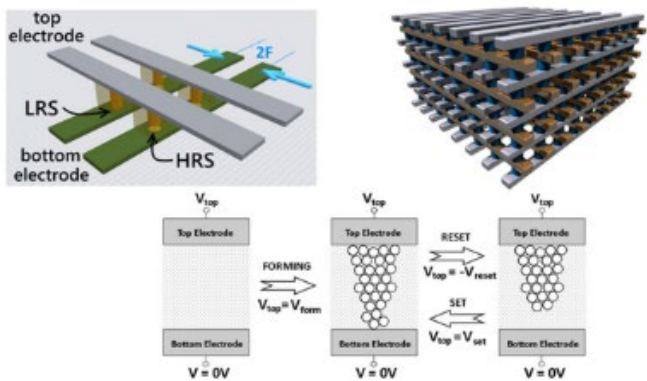
MRAM



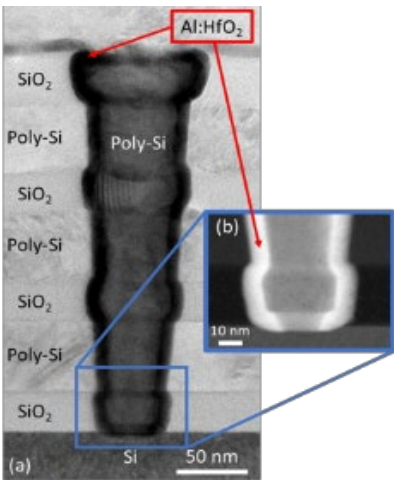
PCM



ReRAM



FRAM



- Everspin
 - Over 120M chips shipped
 - Partnership with Global Foundries
 - Used in IBM's FlashCore modules in Storwise and FlashSystem arrays
- Renesas (Formerly IDT)
 - 8Mb, SPI
- Leading foundries starting to ship
 - GlobalFoundries
 - TSMC
 - Samsung
 - Others



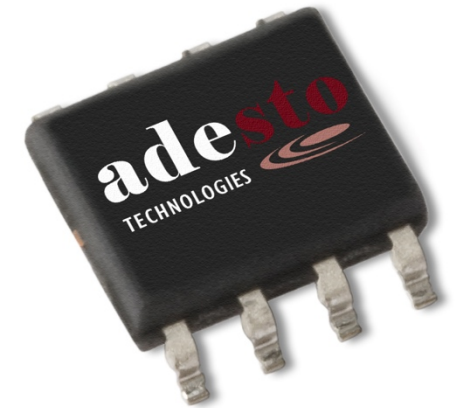
Source: TechInsights

PCM (3D XPoint)

- The second-oldest emerging memory (1970)
- Intel Optane products
 - NVMe shipped in 2017
 - DIMMs in 2018
- Micron Abandoning 3D XPoint
 - Selling Lehi fab

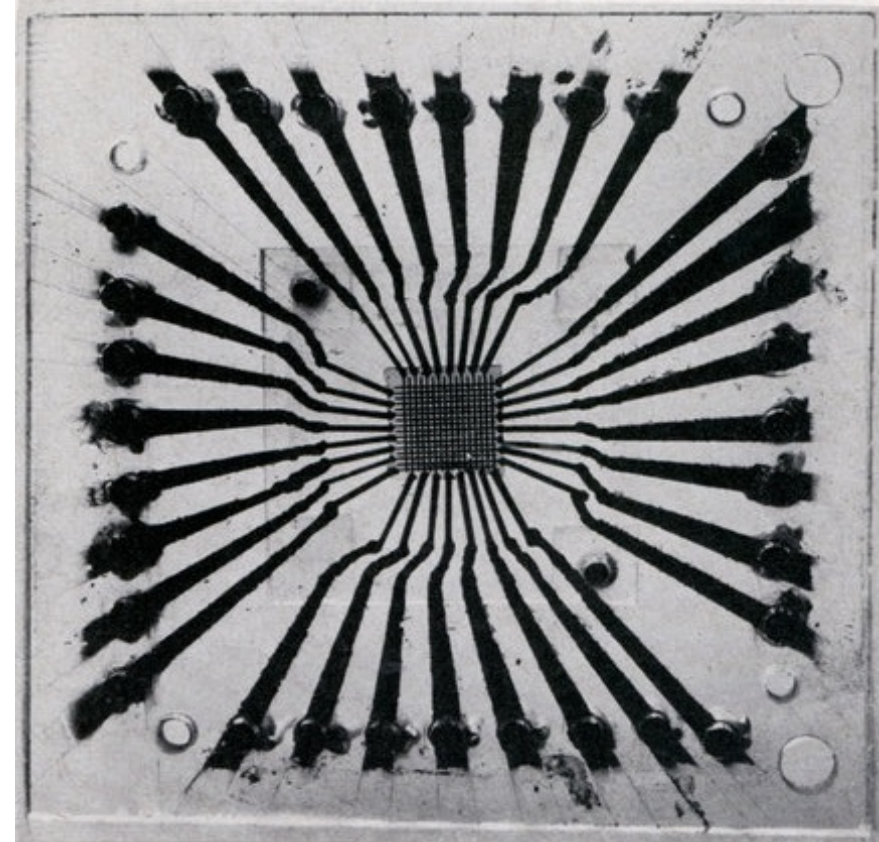


- Adesto has shipped CBRAM chips for several years
 - Dialog Semiconductor acquired Adesto June 2020
 - Will license CBRAM technology to GLOBALFOUNDRIES
 - GF will first offer as an embedded, option on its 22FDX platform
 - GF Plans to extend to other platforms.
- Cerfe Labs (Arm spin-out)
 - Correlated electron materials (CeRAM)
 - Licensed from Symetrix.
- Others (Mitsubishi, Fujitsu, Panasonic, Winbond, Honeywell,...)
- Foundry support (GLOBALFOUNDRIES, TSMC, others)



FRAM

- The oldest emerging memory (1955)
- The highest-shipped emerging memory
- Finding new life with new materials

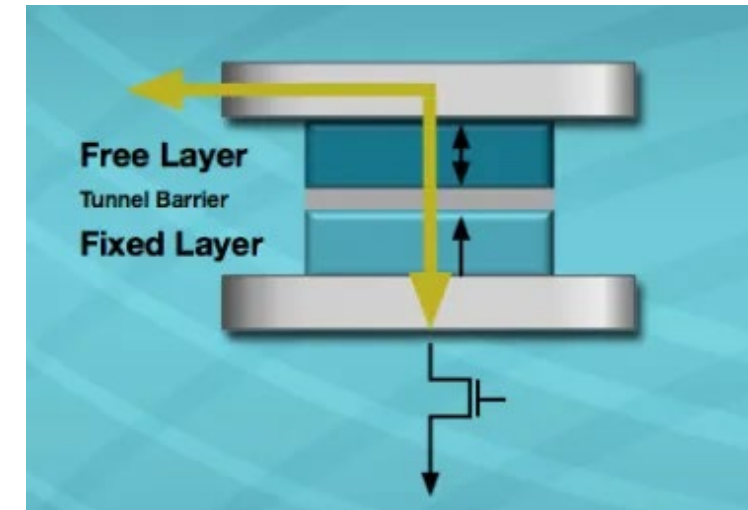


Who's Producing It?

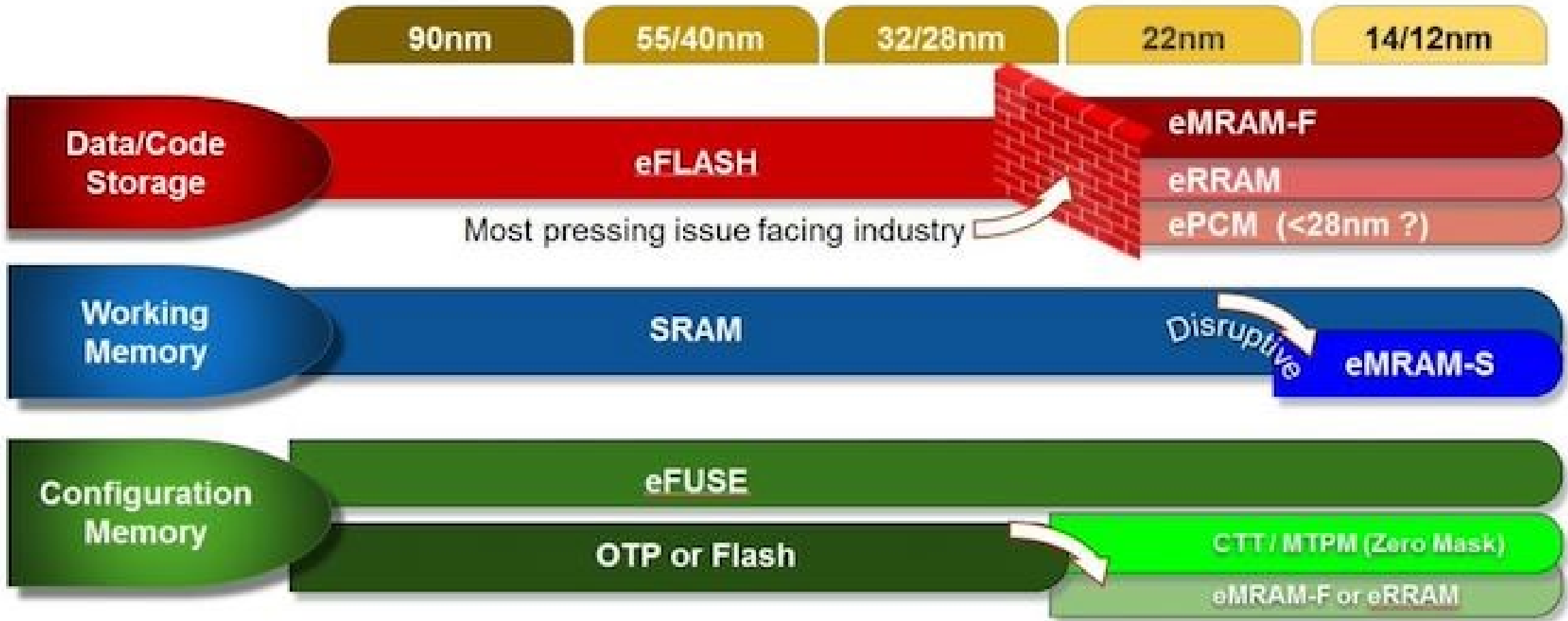


Major Chip Foundries Offer MRAM, FRAM, and ReRAM Options

- TSMC, Samsung, GLOBALFOUNDRIES, UMC, TI, ...
- STT-MRAM, FRAM, & ReRAM today
- SOT-MRAM and other MRAM technologies later on
 - Could compete against lower level cache (faster) SRAM
 - Possible DRAM alternative for higher performance at lower power



TSMC MRAM Roadmap



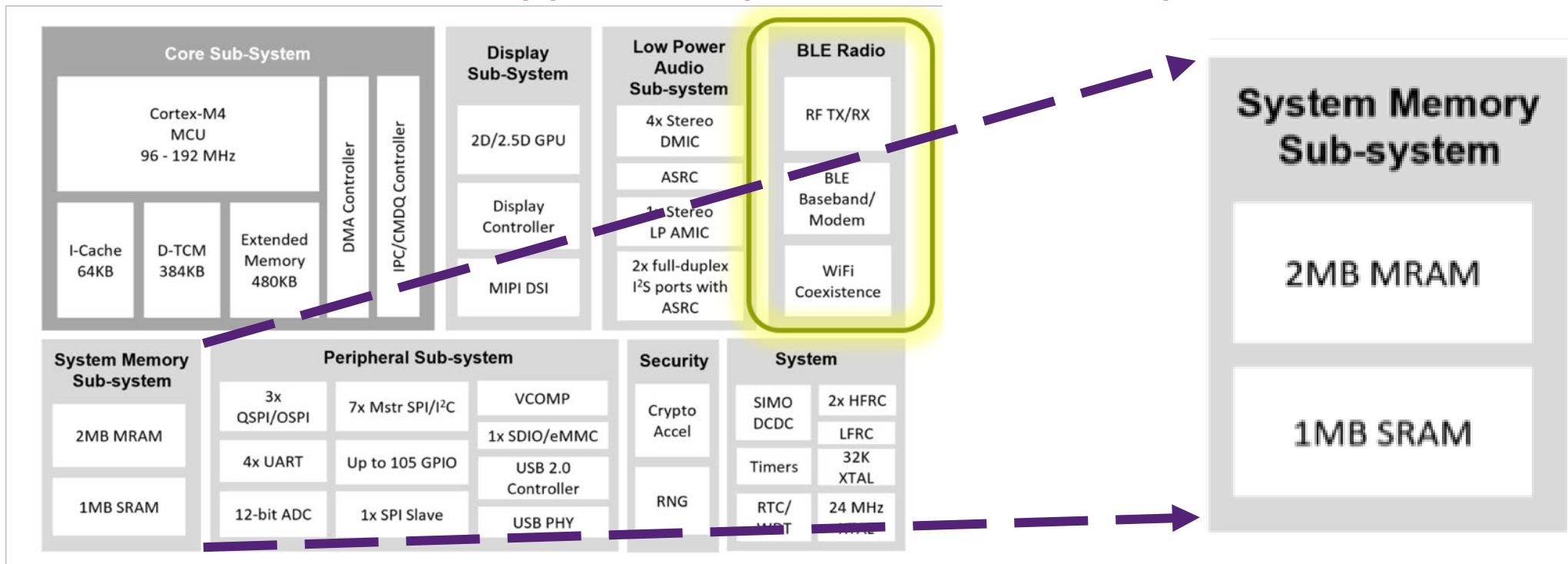
Real-Life Applications

It's Here Now!



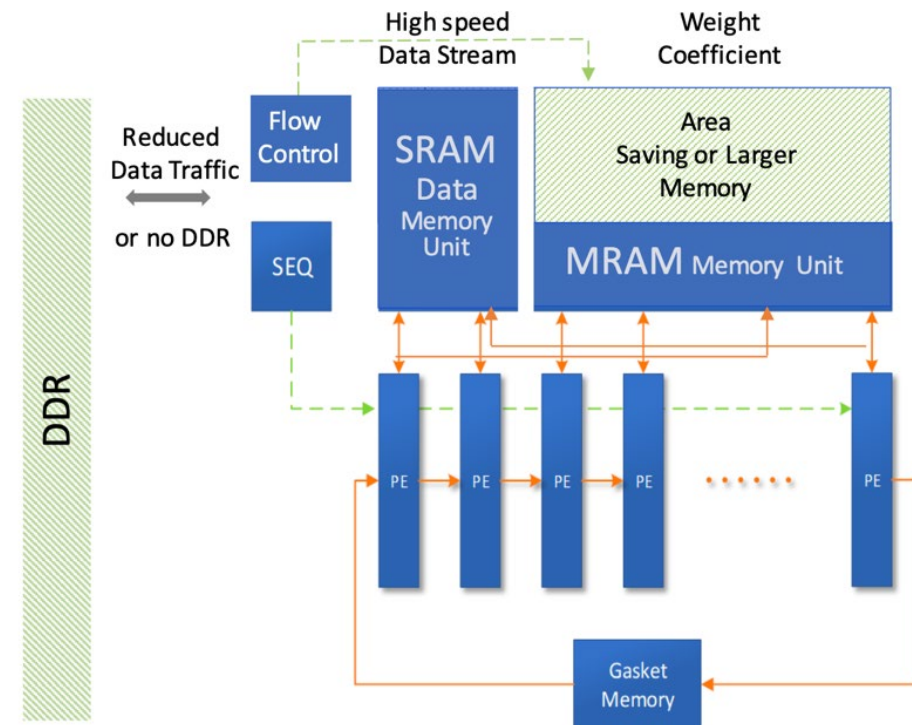
MRAM IoT SoC – Ambiq Apollo

- SoC for intelligent endpoint IoT devices
- Ultra-low battery power
- Serves as both an application processor and a coprocessor



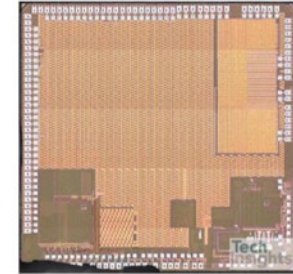
MRAM DNN Accelerator Chip – NuMem

- Used by NASA
- 1-32 processing engines, 32-1024 ALUs per chip
 - Efficient for matrix multiplication, convolution, etc.
- Radiation hard, high endurance MRAM
 - Nonvolatility reduces energy requirements
- Numerous Applications:
 - Sensor fusion for super resolution
 - Terrain Mapping for Depth and Terrain Classification
 - Navigation systems: Object Detection & Tracking



MRAM GPS Receiver – Sony

- CXD5605 GPS Receiver
- Used in Huawei GT 2 Smartwatch
- 8Mb Embedded MRAM
- Samsung 28 FD-SOI Process



Source: TechInsights



Other Emerging Memory Products

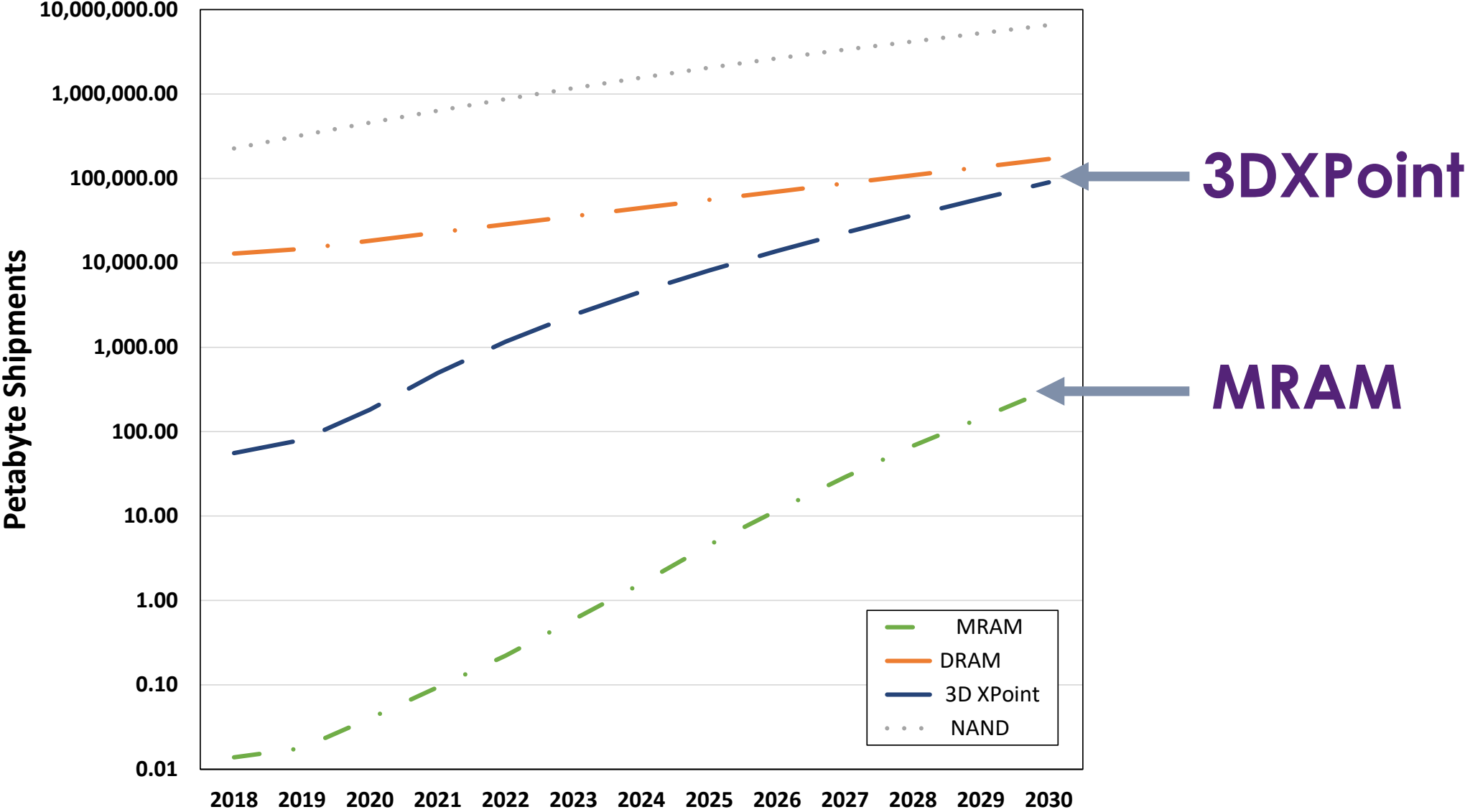
- NXP MRAM MCU
- STMicro PCM MCU
- TI FRAM MCU
- Fujitsu FRAM MCUs



Outlook



Growth in New Memory Shipments

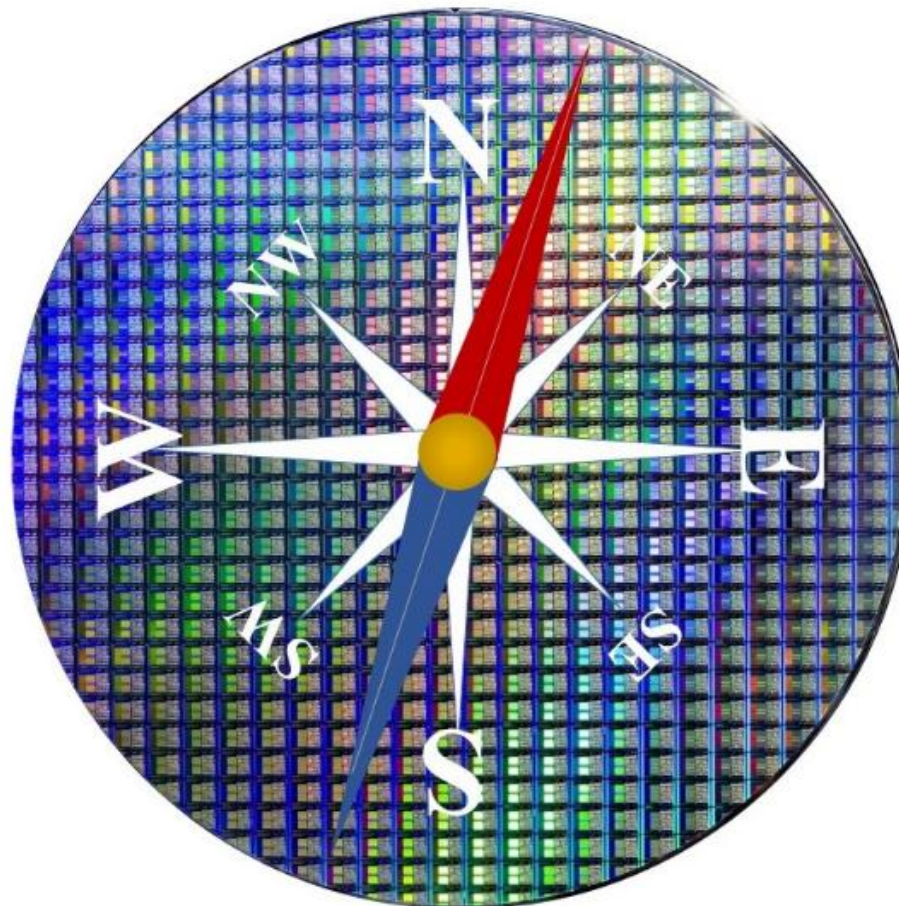


Summary

- NOR flash and SRAM have stopped scaling
- New non-volatile memory types will fill the void
- This will lead to new memory-centric computer architectures
- The storage/memory hierarchy will change
- There are four leading candidates: MRAM, PCM, ReRAM, and FRAM
- Leading foundries already support these new memories
- New memories are in use today
- MRAM and PCM revenues should exceed \$36B by 2030

New Report: Emerging Memories Find Their Direction

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*Coughlin
Associates*

Now Available!

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

References

- Emerging Memories Find Their Direction, Coughlin Associates and Objective Analysis, <https://tomcoughlin.com/tech-papers/>
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- Computer Express Link 2.0 Specification: Memory Pooling, CXL BrightTalk, March 23, 2021

Thank you

Please visit www.snia.org/pmsummit for presentations

