



Flash Memory Summit








Challenges & Strategies for Mass Adoption of Emerging Non-Volatile Memory

Simone Bertolazzi, Ph.D.

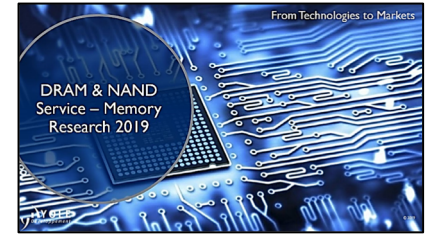
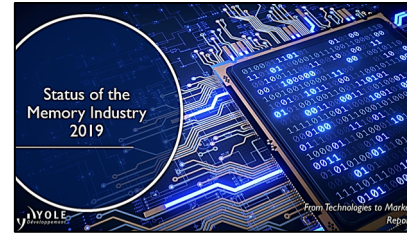
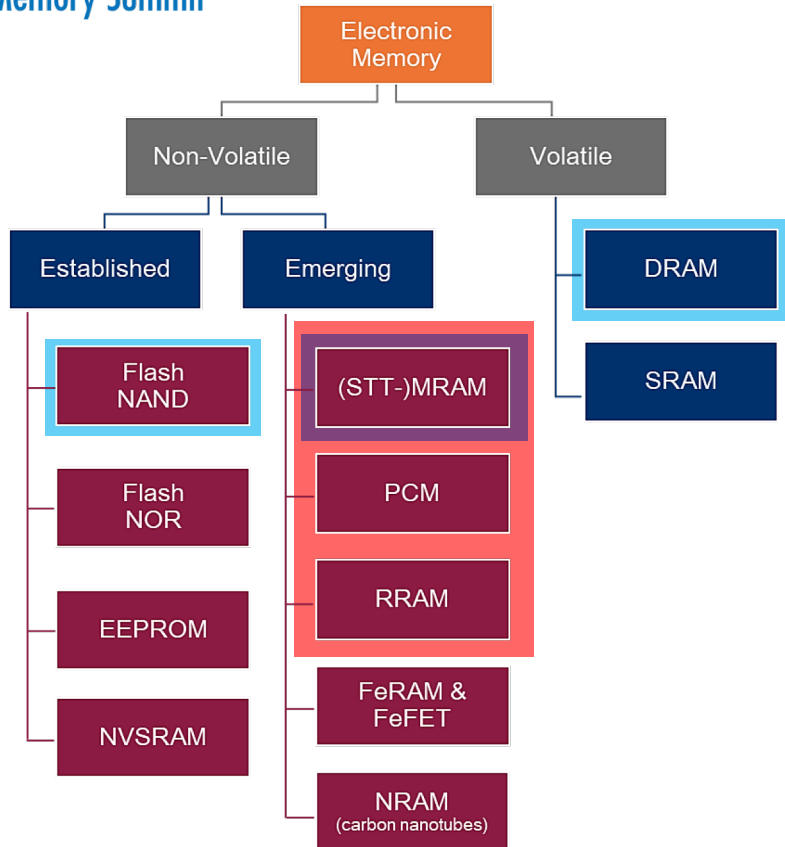
Technology and Market Analyst, Yole Développement


About Yole's Memory Team


<p>Walt Coon VP of NAND and Memory Research</p> 	<p>Mike Howard VP of DRAM and Memory Research</p> 	<p>Simone Bertolazzi, Ph.D. Technology & Market Analyst Memory</p> 	<p>Ivan Donaldson VP of Yole Finance</p> 	<p>Emilie Jolivet Division Director Semiconductor & Software</p> 
<p>Experience: 20 years in Memory</p>	<p>Experience: 15 years in Memory</p>	<p>Experience: 8 years in Emerging Semiconductors and Devices</p>	<p>Experience: 14 years in Semiconductor Industry Strategy, Business Development, and IR</p>	<p>Experience: 9 years in Equipment, Manufacturing, Processing</p>
<p>At Yole: NAND</p>	<p>At Yole: DRAM</p>	<p>At Yole: Emerging Memory</p>	<p>At Yole: Manages all services and relationships for global financial clients</p>	<p>At Yole: Embedded Technologies, 3DIC & Manufacturing</p>



Memory Technologies



 Focus of Yole's NAND and DRAM Market Monitors (published every quarter)

 Focus of MRAM Technology and Business 2019 and Emerging Non-Volatile Memory Report (updated every year)

Outline

- **Overview of the Memory Market**

 - Established and Emerging Memory Market Trends

- **Emerging Non-Volatile Memory**

 - Technology Overview: STT-MRAM, PCM and RRAM

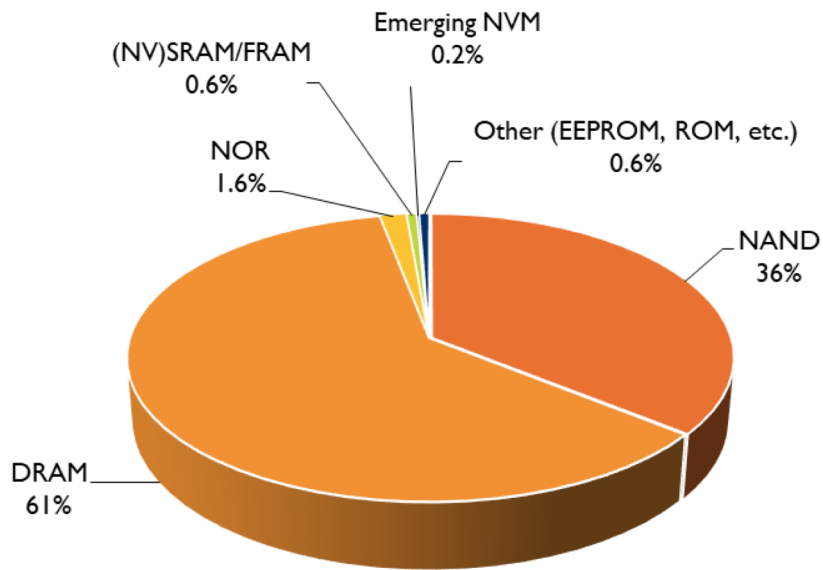
 - Market Projections by Applications

- **Players & Strategies for Mass Adoption of Emerging NVM**

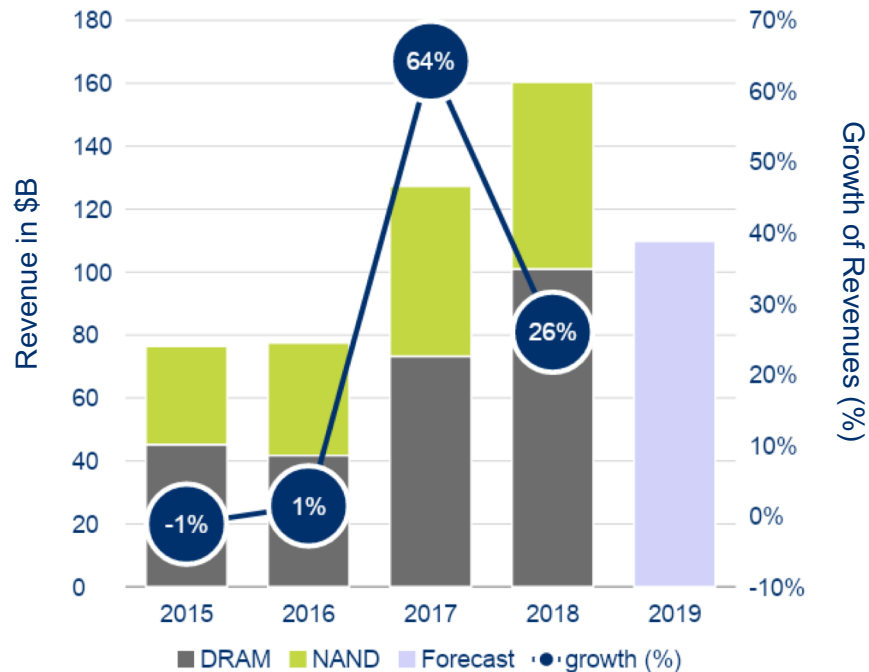


Stand-Alone Memory Market - Overview

- In 2018, NAND and DRAM account for ~97% of the stand-alone memory market (~\$160B).



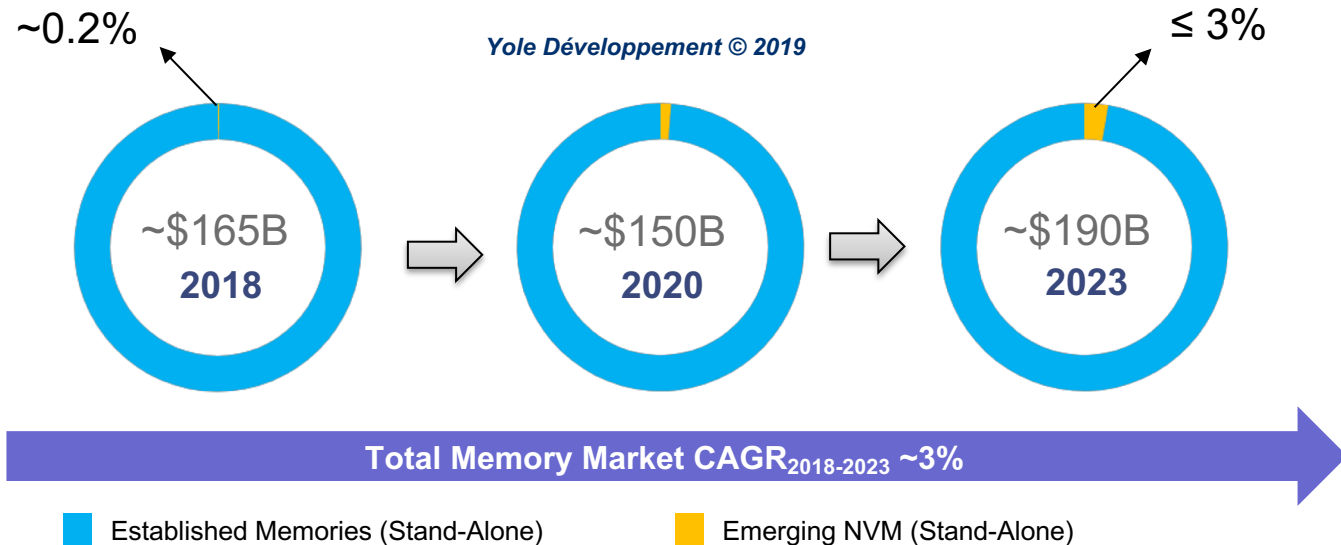
Total Stand-Alone Market in 2018 ~ \$165 billions





Emerging NVM Market - Overview

- The emerging NVM market (**PCM**, **MRAM** and **RRAM**) is gaining significant momentum, but will remain below 3% of the total stand-alone memory market.

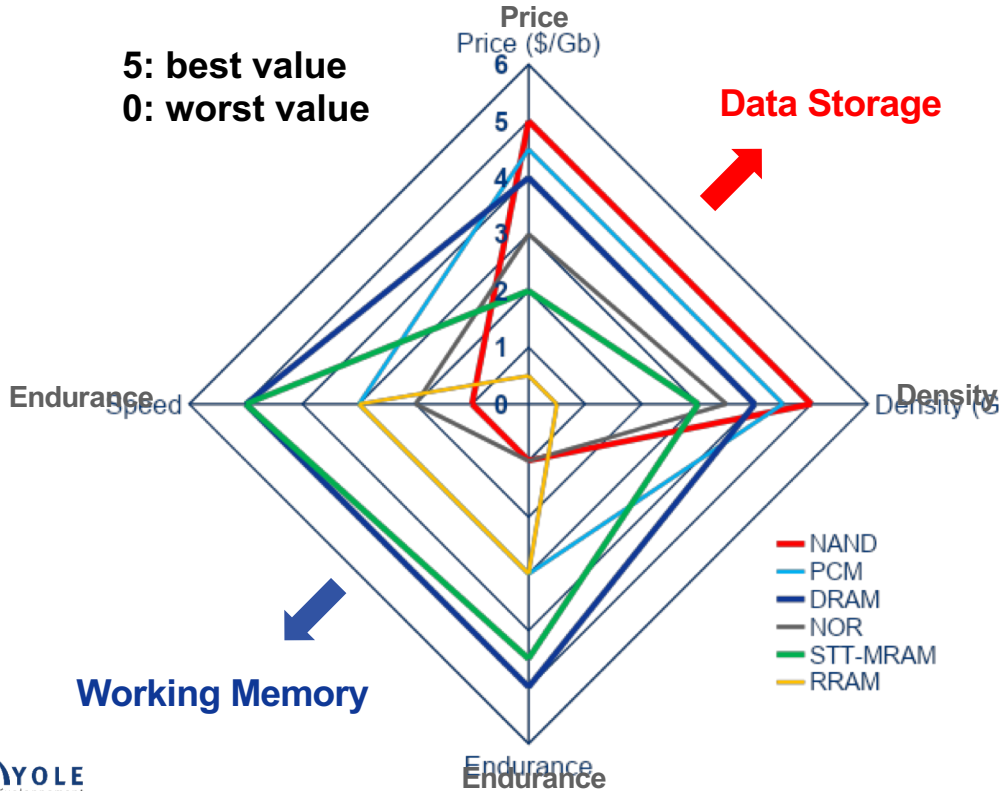


Source: "Emerging NVM" and "Status of the Memory Industry" Reports by Yole

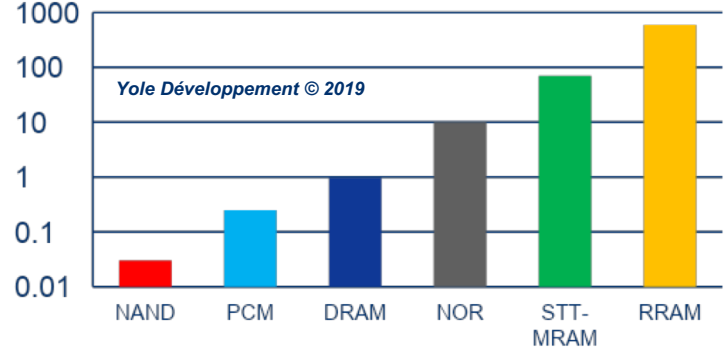


Memory Technology Comparison

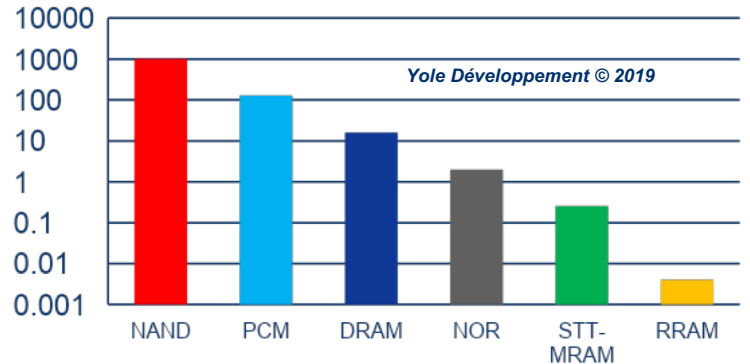
2018 stand-alone commercial products performance



Price position in 2018 (\$/Gb)



Density position in 2018 (Gb)



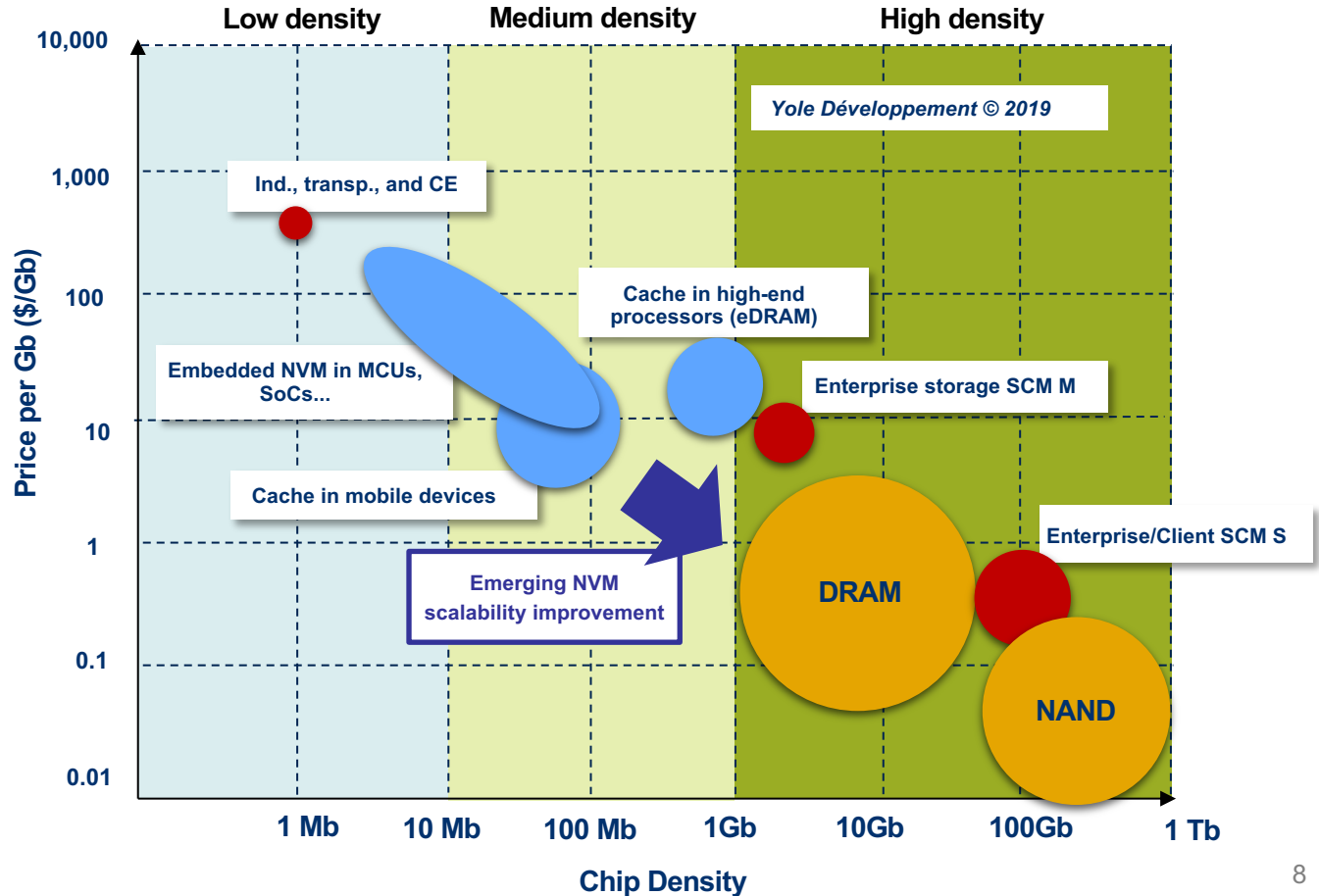


Opportunities for New Memories

- Embedded NVM
- Stand-alone NVM
- Mainstream memory

Bubble size corresponds to the total accessible market (TAM) size

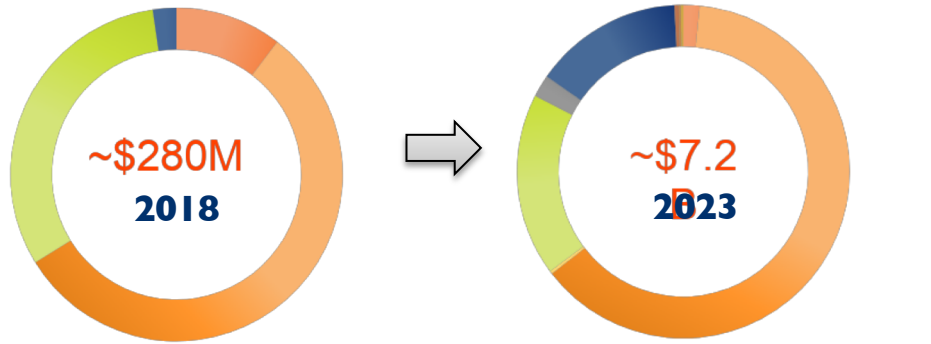
Sources: "Emerging NVM" and "Status of the Memory Industry" (May 2019) Reports by Yole





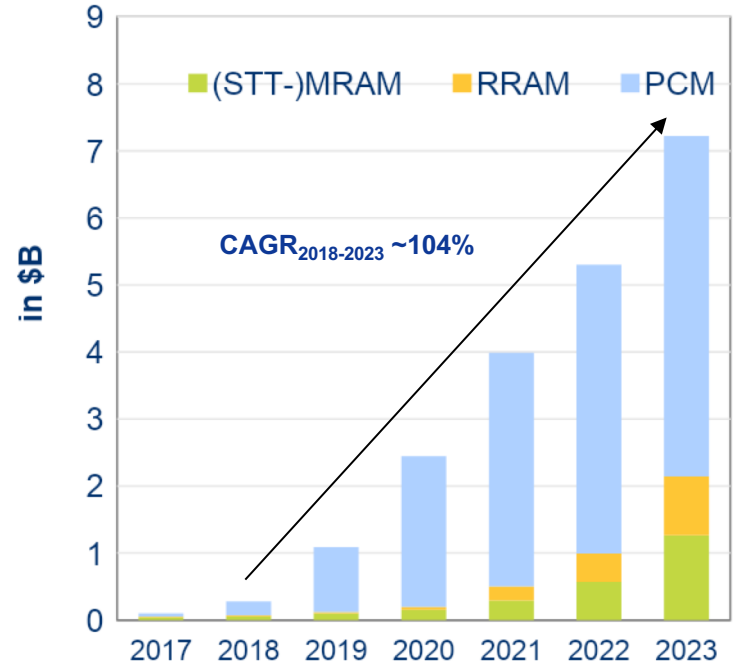
Market Projections

By applications



- Industrial & Transportation & Consumer Electronics
- Enterprise SCM
- Enterprise Storage NVDIMM-N
- Client SCM
- Mass Storage
- Embedded NVM - Microcontrollers
- Embedded Cache Memory - Mobile Devices
- Embedded Cache Memory - High-End Processors
- Embedded NVM - Artificial Intelligence

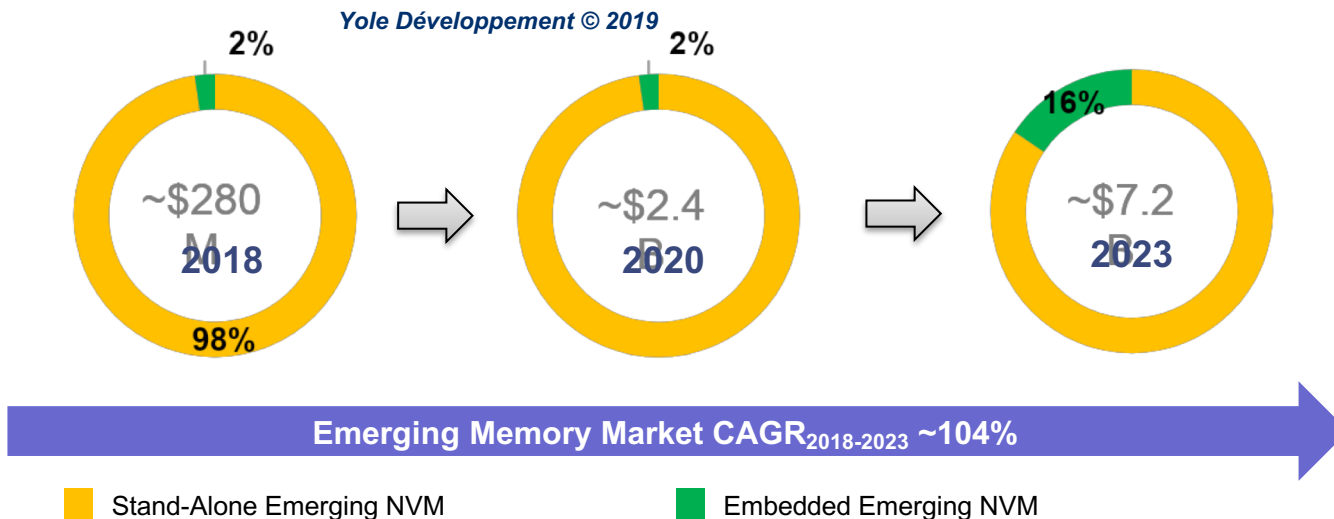
By technologies





Stand-Alone vs Embedded

- Stand-alone memory will be the dominant market and is driven primarily by Storage Class Memory (SCM) enterprise and client applications (3D XPoint).
- Embedded applications are gaining momentum and will be reaching 16% of the emerging NVM market by 2023





Embedded NVM Business

Strategic alliances are essential for mass adoption of emerging NVM

Foundry / IDM								Other / To be announced
RRAM Players	Bulk 22nm (sampling)			 Bulk 28/22nm (in development)	22nm FinFET (in development)	 40/28nm (sampling / in dev.)		 28/22nm
(STT-)MRAM Players	 22nm bulk (sampling)	 22nm FD-SOI (sampling)	 28nm FD-SOI (mass production)	 28/22nm bulk (in development)	22nm FinFET (sampling)		 28/22nm	
PCM Players							28nm FD-SOI (sampling)	



Market Adoption of Emerging NVM

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Stand-Alone Chip Provider

 **STT-MRAM**

  **3D XPoint**

Embedded NVM IP Provider

Module

 **nvNitro™ Storage Accelerator**

 **FlashCore™ Module**






Bundle  **Optane™ DIMM**

 **Xeon™ Processor**

     **Foundries**



System

     **Enterprise-Storage Players**

IoT, General Purpose and Automotive MCUs Integrators

Trojan-horse strategies are used to introduce emerging NVM technologies to the market





Summary and Outlook

- Emerging NVM will complement NAND and DRAM in hybrid memory solutions. In 2023, we expect that the emerging NVM market will remain below 3% of the overall memory market.
- The stand-alone emerging NVM market will be driven by SCM applications enabled by 3D XPoint □ PCM will remain for long the leading emerging NVM technology.
- STT-MRAM is picking up steam in the embedded business thanks to the strong involvement of top foundry/IDM players and equipment suppliers, who are providing new solutions to critical technical challenges.
- Further density improvement and bit-cost reduction are needed towards mass adoption of emerging NVM technologies □ “Trojan horse” strategies along with top-player involvement are essential.



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Thank you for your attention
Questions?

Simone Bertolazzi, Ph.D.

bertolazzi@yole.fr