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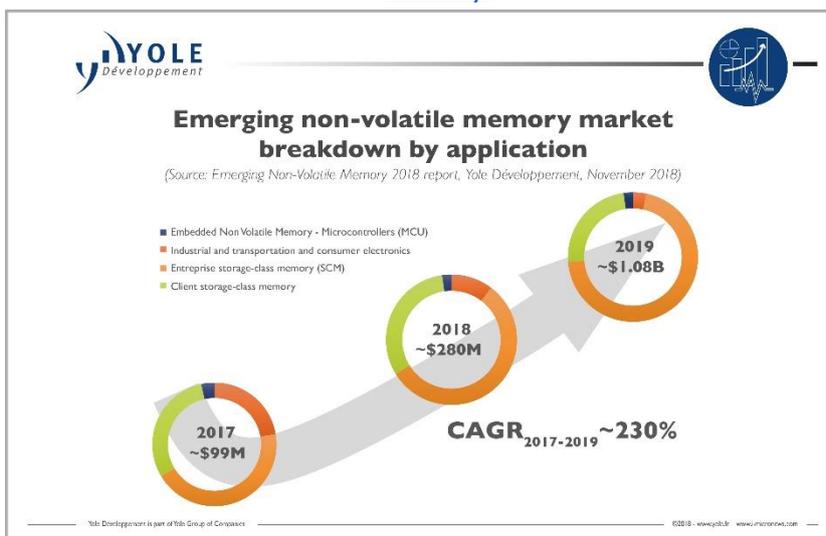
Emerging NVM¹: PCM² finally takes off in stand-alone applications

Extracted from: Emerging Non-Volatile Memory report, Yole Développement

LYON, France – December 3, 2018: Ever-growing data generation driven by mobile devices, the cloud, the IoT³, and big data, as well as novel AI⁴ applications, all part of the megatrends, requires continuous advancements in memory technologies. Emerging NVM takes benefit of this dynamic ecosystem...

After more than 15 years in development, PCM, one of the emerging NVM technologies, has finally taken off thanks to the strong involvement of two leading companies, Micron and Intel, announces [Yole Développement \(Yole\)](#). The growth mainly arises from stand-alone applications. “Although momentum is building around emerging NVM for embedded applications, stand-alone memories will be the dominant market, which will be mainly driven by SCM⁵ enterprise and client applications,” comments **Simone Bertolazzi, PhD, Technology & Market Analyst at Yole**.

The market research and strategy consulting company Yole proposes today a technology & market survey dedicated to the emerging non-volatile memory technologies and markets, [Emerging Non-Volatile Memory](#).



Yole and its partners [System Plus Consulting](#) and [Knowmade](#), deeply investigate the memory business. The Group set up this year [valuable memory services](#) and reports to deliver world class research, data and insight. The emerging NVM report is part of them.

“With our memory activities including a dedicated webcasts program covering DRAM &

NAND and emerging NVM, Yole Group of Companies provides valuable expertise and knowledge to its clients and allow them to understand the

¹ NVM : Non Volatile Memory

² PCM: Phase-Change Memory

³ IoT: internet of Things

⁴ AI : Artificial Intelligence

⁵ SCM : storage class memory

evolution of this competitive industry,” asserts **Emilie Jolivet, Director, Semiconductor & Software from Yole.**

The emerging NVM report is a comprehensive analysis of the semiconductor memory ecosystem with the following technologies (STT-) MRAM, RRAM and PCM, plus an introduction to standard memory, flash NAND, DRAM, NVDIMMs. It provides a deep understanding of the NVM applications and details the related market forecasts until 2023. NVM technologies are well described with the companies involved. In this new report, Yole’s Semiconductor & Software team highlights the competitive landscape with supply chain, market positioning and market shares analysis.

What is the status of the emerging NVM business? Yole Group of Companies invite you to enter in the memory world.

Since its latest edition, Yole’s analysts point out today market evolution and technical innovations. According to **Yann de Charentenay, Senior Technology & Market Analyst at Yole,** DRAM scaling will continue in the next five years, though at slower pace. NAND density will keep increasing thanks to continuous advancements in 3D integration approaches. And emerging NVM will not replace NAND and DRAM but they will rather complement them in “combined” memory solutions. In addition, SCM will be the main emerging NVM market and will be dominated by 3DXPoint for the next 5 years.

From a technology point of view, (STT-) MRAM is gaining momentum for embedded MCU⁶ applications since all big foundries are getting involved in this area. Stand-alone RRAM will try to catch market share to PCM on SCM applications. And emerging NVM sales will grow by more than one order of magnitude in the next three years, thanks to SCM applications.

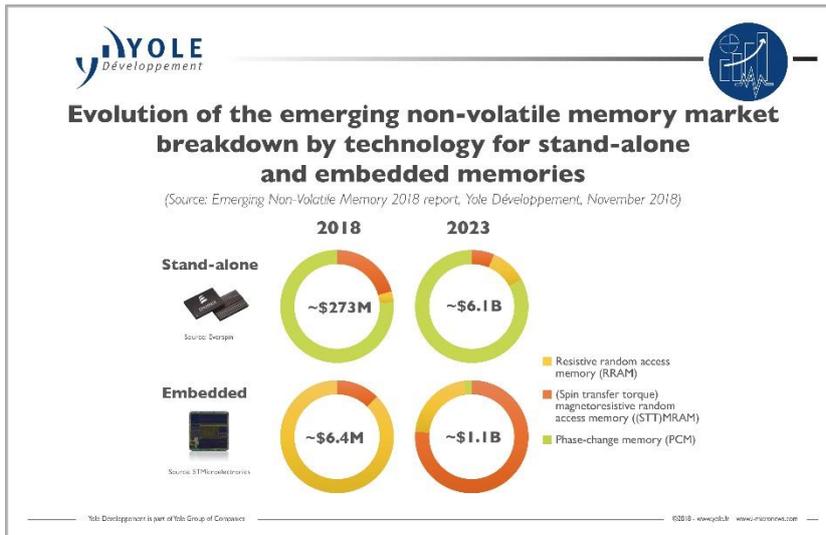
In parallel, Yole’s team identified an increased foundry involvement in (STT-) MRAM⁷ and RRAM⁸ market segment. Key players such as GlobalFoundries, TSMC, UMC, SMIC and Samsung Foundry Services develop a strong expertise with related capabilities to offer attractive services. This trend is showing a growing foundries’ interest in memory business. As an example, the leading semiconductor company, TSMC announced possible acquisition of a memory company. Moreover, analysts point out the growing number of players including Chinese companies...

In the stand-alone business, emerging NVMs will not replace DRAM and NAND but will be used in combination with them inside memory modules, e.g. SSDs, DIMMs, and NVDIMMs. In 2023, PCM will maintain its lead in the stand-alone memory market thanks to the increasing adoption of 3D XPoint as an enterprise and client SCM. It is worth noting that Samsung and Toshiba took a different strategic path by

⁶ MCU : Microcontrollers

⁷ STT-MRAM : Spin transfer torque MRAM

⁸ RRAM: Resistive RAM



developing 3D NAND-based SCM solutions such as Z-NAND (Samsung) and XL-Flash (Toshiba, showcased in August 2018). However, these technologies will be used in enterprise SSDs and will not compete with DDR4-compatible Optane DIMMs, which we expect will represent more than 50% of overall 3D XPoint sales.

RRAM was expected to be the first stand-alone

technology to compete with 3D XPoint, but it has suffered repeated delays due to technical challenges. We presume that RRAM could return in the race for SCM after 2020, and possibly start competing with NAND for mass storage applications. STT-MRAM, thanks to its high speed and high endurance, is promising for enterprise storage SCM. However, its success will be much lower compared to stand-alone PCM due to higher costs, greater fabrication complexity, and challenging scalability.

Compared to stand alone, the embedded emerging NVM market is relatively small, representing ~3% of the emerging NVM market in 2017. The market is dominated today by RRAM, since only a few RRAM based MCUs are available on the market. However, all top foundries are now getting ready with 28/22nm technology processes for STTMRAM whereas RRAM adoption has been delayed by approximately two years by SMIC and UMC.

Therefore, we expect that STT-MRAM will be the first to take-off in the coming years and will lead the embedded emerging NVM market, especially MCUs, which represent the most important embedded segment.

Emerging memory will first replace eFlash, which is facing major scaling challenges due to rising fabrication complexity/costs for technology nodes $\leq 28\text{nm}$. The adoption of STT-MRAM as an embedded cache memory (SRAM or eDRAM) in high-end processors and mobile application processors (AP) will occur later due to more strict scalability requirements ($\leq 14\text{nm}$).

AI on the edge is the most innovative application for embedded emerging NVM. Crossbar recently demonstrated various AI applications, i.e. face recognition, through the use of RRAM chips. We expect that such RRAM-based AI devices will enter the market after 2021.

Yole Group of Companies leverage decades of industry experience while partnering with its clients to make sure they are consistently

well-informed on this dynamic memory market. These years were indeed impressive, not only in terms of revenues, but also in pricing and capital expenditure. **Mike Howard, VP of DRAM & Memory Research** and **Walt Coon, VP of NAND & Memory Research at Yole** describe in a dedicated interview published last week, the memory ecosystem and its players, highlighting the latest technology advancements and the future evolutions of the market: click [Memory business: what's next?](#).

Furthermore, make sure to get a deep understanding of the memory business and register today to both webcasts powered by Yole Group of Companies:



- **DRAM and NAND market: What to expect?** – Webcast on *December 6th, 2018 at 5 PM CET - 8 AM PDT*

Speakers: from Yole, Mike Howard, VP of DRAM and Memory Research and Walt Coon, VP of NAND and Memory Research - Belinda Dube, Cost Analyst at System Plus



- **“The time is now” for emerging NVM** – Webcast on *January 24, 2019 at 5 PM CET - 8 AM PDT*

Speaker: Simone Bertolazzi, PhD, Technology & Market analyst, Memory Research at Yole.

[Register today!](#)

ABOUT THE REPORT:**Emerging Non-Volatile Memory**

After more than 15 years in development, PCM has finally taken off in stand-alone applications. – Produced by Yole Développement (Yole).

Companies cited in the report:

4DS, A*STAR, Adesto, Aeroflex, Apple, Atmel, Avalanche, Buffalo, Canon, CEA Leti, Cisco, CNE, Crocus, Crossbar, Cypress, Dell, eBay, EMC, Evaderis, Everspin, Facebook, Ferroelectric Memory Company, Freescale, Fujitsu, Fusion IO, Fujian Jinhua Integrated Circuit Co., Ltd, Gemalto, Giesecke & Devrient, GigaDevice, GlobalFoundries, Google, Hefei Chang Xin, H-Grace, Hikstor, HLMC, Honeywell, HP, Huawei, IBM, Imec, Infineon Technologies, Intermolecular, Innovative Silicon, Intel, ITRI, Lenovo, Materion, Macronix, ...[Full list](#)

Authors:

- **Simone Bertolazzi**, PhD is a Technology & Market analyst at Yole Développement (Yole) working with the Semiconductor & Software division. He is member of the Yole's memory team and he contributes on a day-to-day basis to the analysis of nonvolatile memory technologies, their related materials and fabrication processes.

He (co-) authored more than ten papers in high-impact scientific journals. Simone obtained a PhD in physics in 2015 from École Polytechnique Fédérale de Lausanne (Switzerland), where he investigated novel flash memory cells based on heterostructures of 2D materials and high-k dielectrics.

- **Yann de Charentenay** works as a Technology & Market Senior Analyst for Yole Développement (Yole). Yann is strongly involved in the technology & market analysis of the applications of disruptive technologies and components: memory, MEMS and sensors... Prior his mission at Yole, Yann was engaged as a marketing engineer at the Commissariat à l'Energie Atomique (CEA, France) as well as a consultant at Algae (France). He has spoken in numerous international conferences and has authored or co-authored numerous press articles.

Yann graduated from the University of Compiègne (France) with a master degree in innovation management. He is also graduated from INP Phelma (Grenoble, France) with a master degree in materials science.

**ABOUT DRAM/NAND MEMORY SERVICES**

A full package: The DRAM/NAND Quarterly Market Monitor and the Monthly Pricing Monitor include the following deliverables:

- Excel database with all historical and forecast data.
- PDF slide deck with graphs and comments/analysis covering expected evolutions.

- Direct access to a Yole Développement analyst for one year, providing an opportunity for on-demand Q&A and discussions regarding trends, analyses, forecasts, and breaking news.

Frequency: Receive every quarter the updated Market Monitor documents and every month the updated Pricing Monitor documents.

Options:

- Pricing Monitors can be bought individually (NAND, DRAM or both).
- Memory Research are available for DRAM, NAND and both.

More Information about memory reports on i-micronews.com, [memory reports section](#).

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Specializing in patent analysis and scientific information, **Knowmade** provides technology intelligence and IP strategy consulting services. The company supports R&D organizations, industrial companies, and investors in their business development by offering them a deep understanding of their IP environment and technology trends. Knowmade operates in the following industrial sectors: Compound Semiconductors, Power Electronics, RF & Microwave Technologies, LED/OLED Lighting & Display, Photonics, Memory, MEMS & Sensors, Manufacturing &

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System Plus Consulting specializes in the cost analysis of electronics, from semiconductor devices to electronic systems. Created more than 20 years ago, System Plus Consulting has developed a complete range of services, costing tools and reports to deliver in-depth production cost studies and estimate the objective selling price of a product.

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Founded in 1998, **Yole Développement (Yole)** has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS & Sensors - Imaging - Medical Technologies - Compound Semiconductors - RF Electronics - Solid State Lighting - Displays - Photonics - Power Electronics - Batteries & Energy Management - Advanced Packaging - Semiconductor Manufacturing - Software & Computing - Memory and more...

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business. . For more information, visit www.yole.fr and follow Yole on [LinkedIn](#) and [Twitter](#).

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