

Embedded and stand-alone NVM: two different futures?¹

OUTLINE:

- **Embedded NVM market:**

Market forecasts: Yole Développement (Yole) forecasts a ~US\$1.7 billion embedded MRAM² market in 2026, which corresponds to ~76% of the overall embedded emerging NVM³ market.

Technology trends: embedded emerging NVM is ready for takeoff, driven by MCUs⁴, IoTs⁵, as well as memory buffers for ASIC⁶ products.

Supply chain: the embedded MRAM market is expected to grow rapidly thanks to the involvement of top foundries – TSMC, Samsung GlobalFoundries, UMC – and the first leading MRAM adopters (e.g., Sony).

- **Stand-alone NVM market:**

Market forecasts: the market will grow from ~US\$595 million in 2020 to ~US\$3.3 billion in 2026.

The stand-alone PCM⁷ market is expected to grow to ~US\$2.6 billion in 2026. It will represent about 78% of the overall stand-alone memory market at this time.

Technology trends: PCM will be the leading technology thanks to the sales of 3D XPoint products – particularly persistent memory DIMMs⁸ – that are sold by Intel in a bundle with its server CPUs⁹.

Supply chain: the stand-alone emerging NVM market will be driven by two major segments, namely persistent memory and low-latency storage.

*“The overall emerging NVM market will grow at a CAGR₂₀₋₂₆ ~44%¹⁰”, asserts **Simone Bertolazzi, Market & Technology Analyst, Memory at Yole Développement (Yole)**. “After several years in development, embedded emerging NVM technologies have gained significant maturity and are now ready for market take off.”*

¹ Extracted from:

[Emerging Non-Volatile Memory 2021](#), Yole Développement, 2021
[Intel Optane 128GB DIMM](#), System Plus Consulting, 2020

² MRAM: Magnetoresistive Random-Access Memory

³ NVM: Non-Volatile Memory

⁴ MCU: Microcontroller Unit

⁵ IoT: Internet of Things

⁶ ASIC: Application-Specific Integrated Circuit

⁷ PCM: Phase-Change Memory

⁸ NVDIMM: Non-Volatile Dual in-line Memory Module

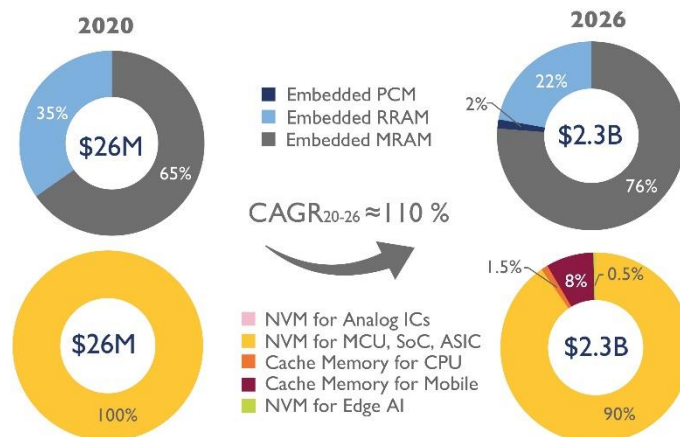
⁹ CPU: Central Processing Unit

¹⁰ CAGR: Compound Annual Growth Rate

The year 2020 has witnessed the introduction of the first commercial products based on eMRAM, namely Sony’s GPS SoCs manufactured by Samsung (28nm FDSOI) and used in Huawei’s smartwatches, as well as Ambiq’s low-power MCUs manufactured by TSMC on 22nm ultra-low leakage (ULL) process. A number of eMRAM-based devices could enter volume production in 2021, among which are GreenWave’s AI processors with GlobalFoundries’ eMRAM (22nm FDSOI) as well as edge-AI accelerators developed by Numen and Gyrfalcon (22nm ULL at TSMC). Products incorporating embedded RRAM (eRRAM) also hit the market in 2020 with Nuvoton-Panasonic introducing new IC devices with 40nm OxRAM for security applications.

2020-2026 Embedded market revenues

(Source: Emerging Non-Volatile Memory 2021 report, Yole Développement, 2021)



In this dynamic context, Yole investigates disruptive technologies and related markets in depth, to point out the latest innovations and underline the business opportunities.

Released today, the [Emerging Non-Volatile Memory 2021 report](#) presents an overview of the semiconductor memory market and provides an understanding of emerging NVM technologies and applications.

Including market forecasts, supply chain, technology trends and roadmaps, technical insights and analysis, take away messages and outlook, this study also delivers an in-depth understanding of the ecosystem and main players’ strategies.

This report provides a comprehensive analysis of the overall NVM industry, describing the different strategies of the leading semiconductor companies. Embedded memory and stand-alone memory, two industries with different ecosystems, competitive landscapes, technology status and strategies of development... Two different futures?

What are the economic and technological challenges? How does the technology evolve? Who are the key players to watch, and on which technologies are they working on? What are the impacts of the COVID-19 pandemic and how is China advancing in the NVM business?

Yole presents today its vision of the Emerging NVM industry.

As analyzed by Yole’s memory team in their new Emerging Non-Volatile Memory 2021 report, embedded MRAM is expected to be adopted more rapidly than RRAM. In an optimistic scenario of effective roadmap execution, Yole’s analysts forecast a ~US\$1.7 billion embedded MRAM market in 2026, which corresponds to ~76% of the overall embedded emerging NVM market.

However, eRRAM will remain a strong competitor. In fact, leading players have been investing in RRAM targeting eFlash replacement at 40nm and beyond:

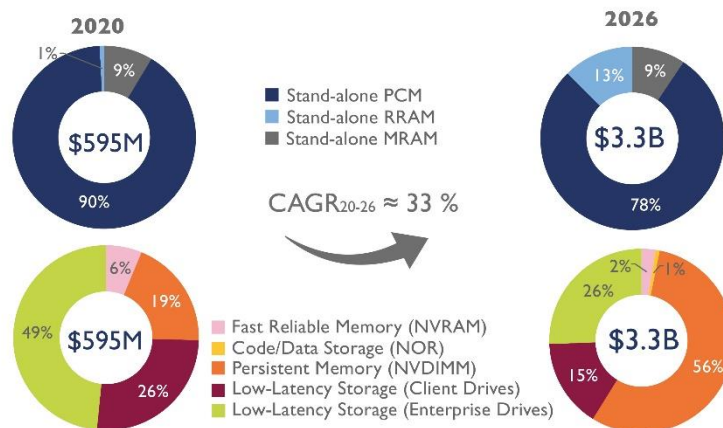
- TSMC has enriched its 40nm ULP¹¹ process with embedded OxRAM and currently offers OxRAM at 22nm.
- GlobalFoundries licensed Adesto’s CBRAMTM from Dialog Semiconductor and is now implementing it on 22nm FDSOI for low-power consumer applications.
- UMC is pursuing 28nm OxRAM development in partnership with Nuvoton-Panasonic, and they could target the smartcard market in the coming years.

And many other companies and their strategy are deeply analyzed in Yole’s Emerging NVM report...

Finally, embedded PCM is still in the race and will target eFlash replacement in automotive MCUs. STMicroelectronics is its main promoter, having selected PCM as the best emerging NVM solution for 28nm FDSOI node in the automotive market.

2020-2026 Stand-alone market revenues

(Source: Emerging Non-Volatile Memory 2021 report, Yole Développement, 2021)



According to **Emilie Jolivet, Director of the Semiconductor, Memory & Computing Division at Yole**: “The stand-alone emerging NVM market – comprising PCM, MRAM and RRAM – will grow from ~US\$595 million in 2020 to ~US\$3.3 billion in 2026. It will be

¹¹ ULP: Ultra-Low-Power

driven by two key segments, namely low-latency storage (enterprise and client SCM drives) and persistent memory (NVDIMM)”.

PCM will be the leading technology thanks to the sales of 3D XPoint products – particularly PM¹² DIMMs – that are sold by Intel in a bundle with its server CPUs. New stand-alone Optane products have been launched in 2020, one of which is the long-awaited Alder Stream SSD. This is the first product that employs the 2nd generation 3D XPoint with four stacked PCM layers.

Yole’s partner [System Plus Consulting](#) has carried a comprehensive analysis of [Intel Optane 128GB DIMMs](#) in its dedicated report:

For Belinda Dube, Technology & Cost Analyst at System Plus Consulting: *“The 3D XPoint memory forms a vertical structure with multilevel memory cell array. This strategy is used to increase the density of the cells. The memory cells use a Phase Change Material. Instead of using transistors used by conventional memories, bit storage is based on a change of material resistance. The memory cells present a material with variable electrical resistance due to a change in the crystal structure”.*

In late 2020, Intel confirmed that about 200 of the Fortune 500 companies have either directly deployed Optane PM or are in the POC¹³ stages, and the POC-to-deployment conversion rate is expected to be over 85%. However, the effort to build up a software-hardware ecosystem for PM deployment has been found to be extremely challenging and time-consuming, and is currently carried out by one key player, Intel.

In comparison to PCM, the MRAM and RRAM stand-alone markets will remain significantly smaller, holding a combined ~22% share of the stand-alone emerging NVM market in 2026. The sales ramp-up time for STT-MRAM chips that are sold to IDMs and OEMs in the low-latency storage business is taking longer than expected. The use of STT-MRAM in storage modules requires significant time and resources to engineer the system architecture and develop a suitable controller technology.

Stand-alone 3D RRAM with XPoint-like structure has also been delayed compared to previously reported roadmaps: RRAM-based SSD drives will presumably be introduced using new protocols – such as CXL or Gen-Z – that are not mature yet. More time will be necessary for the new interfaces to mature to the point of triggering the adoption of novel SCM drives as alternatives to the NVMe-based drives currently available (e.g., Samsung Z-SSD, and Intel Optane SSD).

¹² PM: Persistent Memory

¹³ POC: Proof of Concept



All year long, Yole Développement and System Plus Consulting publish numerous reports and monitors. In addition, experts realize various key presentations and organize key conferences.

In this regard, Simone Bertolazzi will be part of the *Intermag 2021: 12th MRAM Global Innovation Forum*, on April 27th, 2021 from 2:00am to 3:00am. Register on [i-Micronews](#).

Make sure to be aware of the latest news coming from the industry and get an overview of our activities, including interviews with leading companies and more on [i-Micronews](#). Stay tuned!

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About our analysts

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. Previously, Simone carried out experimental research in the field of nanoscience and nanotechnology, focusing on emerging semiconducting materials and their opto-electronic device applications. He (co-) authored several papers in high-impact scientific journals and was awarded the prestigious Marie Curie Intra-European Fellowship. Simone obtained a PhD in physics in 2015 from École Polytechnique Fédérale de Lausanne (Switzerland), where he developed novel flash memory cells based on heterostructures of two-dimensional materials and high- κ dielectrics. Simone earned a double M. A. Sc. degree from Polytechnique de Montréal (Canada) and Politecnico di Milano (Italy), graduating cum laude.

Emilie Jolivet is Director of the Semiconductor, Memory & Computing Division at Yole Développement, part of Yole Group of Companies, where her specific interests cover package & assembly, semiconductor manufacturing, memory and software & computing fields. Based on her valuable experience in the semiconductor industry, Emilie manages the expansion of the technical and market expertise of the Semiconductor and Software Team. The team interacts daily with leading companies allowing semiconductor & software analysts to collect a large amount of data and integrate their understanding of the evolution of the market with technology breakthroughs. In addition, Emilie's mission focusses on the management of business relationships with semiconductor leaders and the development of market research and strategy consulting activities inside the Yole group. Emilie Jolivet holds a Master's degree in Applied Physics specializing in Microelectronics from INSA (Toulouse, France). After an internship in failure analysis at Freescale (France), she was an R&D engineer for seven years in the photovoltaic business where she co-authored several scientific articles. Enriched by this experience, she graduated with an MBA from IAE Lyon and then joined EV Group (Austria) as a business development manager in 3D & Advanced Packaging before joining Yole Développement in 2016.

Belinda Dube serves as a Technology & Cost Analyst at System Plus Consulting, part of Yole Développement. Belinda's core expertise is memory technology, especially DRAM and 3D NAND flash memory. At the same time, she also investigates IC technologies as well as advanced packaging. Belinda's mission is to develop reverse engineering & costing reports. She also works on custom projects, where she works closely with the laboratory team to set up significant physical & chemical analyses of innovative memory chips. Based on the results, Belinda identifies and analyzes the overall manufacturing process and all technical choices made by the memory makers. The objectives of these analyses are to understand the structure of the device, identify all materials used, and point out the link between functionality and technology selected by the memory company. In addition, a significant portion of her mission is dedicated to a strategic technology watch, where her aim is to identify innovative memory chips and manufacturing processes. Based on her expertise, Belinda updates internal simulation tools and runs custom training sessions and demos with industrials. Belinda attends many international trade shows & conferences where she collects valuable information and meets leading memory players. She regularly has an opportunity to reveal pertinent results during key onsite presentations and webcasts. Prior to System Plus Consulting, Belinda had the opportunity to work on several R&D projects dedicated to MEMS technologies and new substrates at INSA (Lyon, France). With a core Micro & Nano Electronics expertise, Belinda graduated from INSA (Lyon, France) with a master's degree in Instrumentation & Nanotechnology Engineering.

About the reports

Emerging Non-Volatile Memory 2021

Embedded NVM readies to take off driven by low-power applications. Stand-alone NVM continues its journey toward mass adoption, despite ecosystem slowdowns. – Performed by Yole Développement

Companies cited:

4DS, Adesto, Ambiq Micro, Antaios, Apple, Applied Materials, ARM, Avalanche, Buffalo, Canon, CEA Leti, Cerfe Labs, CXMT, Cisco, Crocus Nanoelectronics, Crossbar, Cypress, Dell, Dialog Semiconductor, eVaderis, Everspin, Facebook, Ferroelectric Memory Company, Fujitsu, GigaDevice, GlobalFoundries, Google, GreenWaves, Gyrfalcon, H-Grace, Hikstor, HLMC, Honeywell, HP, Hprobe, Huawei, IBM, IMEC, Infineon, Intel, Intermolecular, Intrinsic Semiconductor, ITRI, JHICC, Jiangsu Advanced Memory Technology, Kioxia, Lam Research, Lenovo, Macronix, Materion, Mediatek, Merck, Microchip, Micron, Mythic, Nantero, Nanya, National Tsing Hua University, NEC, NetApp, Nike, Nokia, Numen, Numonyx, Nuvoton, NXP, Panasonic, Qualcomm, Rambus, Reliance, Renesas, Rohm, Samsung, SanDisk, Seagate, SK hynix, Smart Modular Technologies, SMIC, Sony, Spansion, Spin Ion Technologies, Spin Memory, Spin-Orbitronics Technologies, Spintec, STMicroelectronics, Stanford University, Syntiant, TDK, Texas Instruments, Tezzaron, Tohoku University, Tokyo Electron, Teledyne e2v, Toshiba, TowerSemi, TPSCo, Tsinghua Unigroup, TSMC, UMC, Violin Memory, Weebit, Western Digital, Winbond, XFab, XMC, YMTC, and more...

Intel Optane 128GB DIMM

Analysis of Intel's Persistent Memory DIMM that integrates Intel's 3D XPoint memory dies... The Optane DIMM introduced in 2019 has one of the highest levels of integration, presenting a full system on a module. Intel Optane products have pioneered 3D XPoint commercial devices, mainly targeting data center storage. – Performed by System Plus Consulting

Related reports:

- [MRAM Technology and Business 2019](#)
- [Status of the Memory Industry 2020](#)
- [DRAM Quarterly Market Monitor](#)
- [NAND Quarterly Market Monitor](#)

About Yole Développement

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... [More](#)

About System Plus Consulting

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... [More](#)

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