MRAM promises life beyond eFlash: the embedded MRAM market is taking off and is expected to reach $1.2B by 2024.

**EMBEDDED MRAM IS PICKING UP STEAM THANKS TO THE STRONG INVOLVEMENT OF TOP FOUNDRY/IDM PLAYERS AND EQUIPMENT SUPPLIERS**

Nowadays, there is broad consensus in the computer memory industry that the 28nm/22nm silicon lithography nodes will be the last technology nodes for embedded Flash (eFlash). This is not because of fundamental scalability limitations, but because of economic barriers. Therefore a new embedded non-volatile memory (NVM) for code/data storage is needed. At the same time, scaling of volatile static random access memory (SRAM) is slowing down due to cell footprint degradation occurring at advanced nodes. A denser working embedded memory would therefore be highly desirable.

Among various emerging NVM technologies, spin transfer torque magnetoresistive RAM (STT-MRAM) is gaining significant momentum. It is poised to become the next embedded memory solution for a variety of integrated circuit (IC) products manufactured at the 28nm node and below. That includes low-power wearables and Internet-of-Things (IoT) devices, microcontroller units (MCUs), automotive, imaging and display ICs, edge artificial intelligence (AI) accelerators, and other application specific ICs (ASICs) and application specific standard parts (ASSPs).

In 2018, the embedded STT-MRAM market was still limited, with no volume shipments. 2019 is expected to be the year this market takes off. Samsung has recently started mass production of embedded STT-MRAM, and we expect other major foundry/integrated device manufacturers (IDMs) to enter the race soon. At the same time, multiple equipment suppliers like Applied Materials, Tokyo Electron Limited (TEL), Canon, and Lam Research, and logic companies like Qualcomm, ARM and Synopsis are increasing their research spending on MRAM. This is further propelling the development of the embedded STT-MRAM business. Thanks to the support of a large number of leading companies, Yole Développement analysts believe the embedded memory market has the potential to reach $1.2B by 2024, growing with a compound annual growth rate over this period (CAGR 2018-2024) of 295%.

On the other hand, the stand-alone memory market is expected to grow less vigorously, with a CAGR 2018-2024 of 54%, and will remain below $600M in 2024. So far, the growth has been driven by low-density (STT-)MRAM devices at 16Mb and below manufactured by a few key players, such as Everspin and Avalanche/Sony. In coming years, the stand-alone market will be mainly driven by enterprise storage applications. These include solid state drive (SSD) caching and storage/network accelerators, which are served by high-density STT-MRAM chips at 256Mb and above. The latter are typically sold to IDMs and system makers in the enterprise storage business. These companies require 12-18 months to develop new systems, so the ramp-up of STT-MRAM sales has taken a relatively long time. Notably, 1Gb 28nm devices from Everspin have recently moved into the pilot-production phase at GlobalFoundries. Their forthcoming availability in the market could trigger further growth of enterprise storage applications.
EQUIPMENT SUPPLIERS ARE TACKLING THE CHALLENGES OF HIGH-VOLUME MANUFACTURING OF STT-MRAM

STT-MRAM combines the best attributes of conventional memory types in a single technology. It features the speed of SRAM and the non-volatility of eFlash with unlimited endurance. It can be added to process flows for logic chips without significant cost increase, offering a remarkable density gain over SRAM, together with low power consumption. However, a number of difficult technical challenges need to be tackled to fully exploit the potential of STT-MRAM and enable its high-volume production. Fortunately, equipment suppliers are working hard to solve such issues and are offering new solutions enabling continuous progress.

Critical (STT-)MRAM manufacturing challenges and key equipment players* involvement towards high volume production

Deposition of MTJ stack
Goal: real-time property monitoring

Etching MTJ pillars
Goal: high-density, narrow pitch patterning

Testing and Metrology
Goal: high-speed measurement of electrical and magnetic properties

(2019 Yole Développement, August 2019)

*Non-exhaustive list of companies

EVERSPIN IS THE CLEAR LEADER IN THE STAND-ALONE MARKET. THE COMPETITION IS GETTING FIERIER IN THE EMBEDDED MRAM BUSINESS

Everspin is the clear leader of the stand-alone (STT-) MRAM market. It is the only supplier of toggle MRAM at 16Mb and below for applications requiring high reliability, such as industrial, transportation, defence and medical markets, which have for long been served by non-volatile SRAM (NVSRAM). It is also the only player supplying high-density STT-MRAM for the enterprise storage market. Avalanche has started shipping stand-alone STT-MRAM parts from 1-32Mb, manufactured at Sony using 40nm lithographic processes. It is targeting the NVSRAM market, partially challenging Everspin’s Toggle MRAM.

In the embedded business, foundry/IDM activities are advancing at a fast pace. Samsung is now in mass production on 28nm Fully Depleted Silicon On Insulator (FD-SOI). Intel, after working silently on MRAM for several years, recently confirmed that its embedded MRAM, which uses a 22nm FinFET architecture, is ready for production. At the same time, TSMC is sampling on 22nm planar bulk silicon. Also, Gyrfalcon’s MRAM-based AI chips, manufactured at TSMC, should enter volume production by mid-2020. GlobalFoundries will enter the market with embedded MRAM for replacing eFlash on 22nm FDSOI, and is working on an SRAM-like version for the subsequent 12nm FDSOI node. Seemingly, Intel is targeting eFlash replacement. Samsung and TSMC seem to be focusing primarily on embedded MRAM for replacing SRAM in applications where performance is not a priority. They are expected to enter the market with a “slow SRAM” implementation.
The overall MRAM ecosystem appears well developed and multiple companies, like NXP and Sony, are ready to adopt embedded MRAM in their IC products. We expect that 2019 will be the year of the MRAM market take off. The new “MRAM Technology and Business” report by Yole Développement provides an overview of embedded and stand-alone memory technologies. It details the market evolution for each application, the competitive landscape, the players’ dynamics, the challenges and the strategies in moving towards mass adoption of (STT-)MRAM.

**REPORT OBJECTIVES**

- Present an overview of the semiconductor memory industry with market insights and trends for different stand-alone and embedded technologies.
- Analyze embedded and stand-alone MRAM applications including: total addressable markets, roadmaps, market drivers, challenges and players’ objectives.
- Describe established and newly emerging magnetic memory technologies including: working principles, manufacturing methods, advantages and limitations, average selling price and time-to-market.
- Outline the latest activities for each key market player, as well as the current product development status.
- Provide roadmaps with technological nodes, chip density and price evolution.
- Analyze the MRAM ecosystems and its competitive landscape:
  - Mapping of the entire supply chain
  - Recent acquisitions, partnerships and funding
  - Latest company news

**COMPANIES MONITORED IN THE PRODUCT**

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Emilie Jolivet is Director of the Semiconductor & Software 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 focuses 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).
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