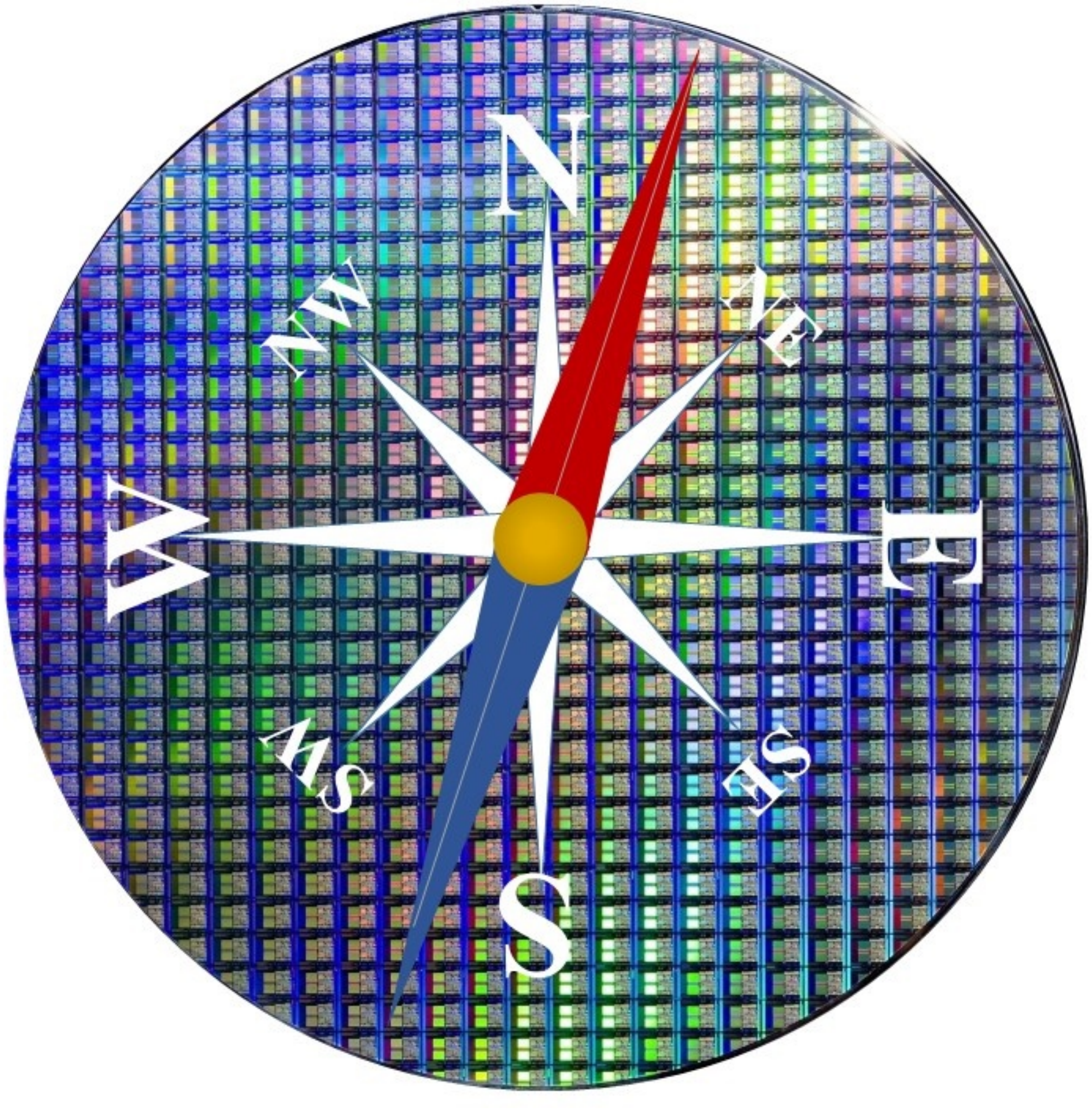
EMERGING MEMORIES FIND THEIR DIRECTION



COUGHLIN ASSOCIATES
San Jose, California
June 2020

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EMERGING MEMORIES FIND THEIR DIRECTION

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and

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SAN JOSE, CALIFORNIA

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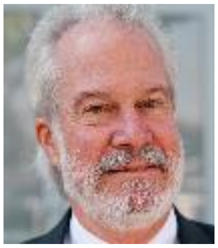
He was the founder and organizer of the Storage Visions Conferences as well as the Creative Storage Conferences. He was general Chairman of the annual Flash Memory Summit for 10 years. Coughlin Associates provides market and technology analysis as well as data storage technical and market consulting. For more information go to www.tomcoughlin.com



Jim Handy, Objective Analysis:

Jim Handy, a widely recognized semiconductor analyst, comes to Objective Analysis with over 30 years in the electronics industry including over 20 years as an industry analyst for Dataquest (now Gartner), Semico Research, and Objective Analysis. His background includes marketing and design positions at market-leading suppliers including Intel, National Semiconductor, and Infineon.

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EXECUTIVE SUMMARY

Current memory technologies including flash memory (NAND and NOR), DRAM and SRAM are facing potential technology limits to their continued improvement. As a result, there are intense efforts to develop new memory technologies. Most of these new technologies are nonvolatile memories and can be used for long-term storage or to provide a memory that does not lose information when power is not applied. This offers advantages for battery and ambient powered devices and also for energy savings in data centers.

The memories addressed in this report include PCM, ReRAM, FRAM, MRAM, STT MRAM and a variety of less mainstream technologies such as carbon nanotubes. Based upon the level of current development and the characteristics of these technologies, resistive RAM (ReRAM) may be a potential replacement for flash memory. However, flash memory has several generations of technologies that will be implemented before a replacement is required. Thus, this transition will not fully occur until the next decade at the earliest.

Micron and Intel’s introduction of 3D XPoint Memory, a technology that has high endurance, performance much better than NAND, although somewhat slower than DRAM, and higher density than DRAM, could impact the need for DRAM. Intel introduced NVMe SSDs with its Optane technology (using 3D XPoint) in 2017 and began to ship NVDIMM Optane products in 2019, in support of its newest generation of server processors, the Second-Generation Intel Xeon Scalable Processors. 3D XPoint uses a type of phase change technology.

Magnetic RAM (MRAM) and spin transfer torque RAM (STT MRAM) will start to replace some NOR, SRAM and possibly DRAM within the next few years and probably before ReRAM replaces flash memory. The rate of development in STT MRAM and MRAM capabilities will gradually result in lower prices, and the attractiveness of replacing volatile memory with high speed and high endurance nonvolatile memory make these technologies very competitive, assuming that their volume increases to reduce production costs (and thus purchase prices).

Ferroelectric RAM (FRAM) and some ReRAM technologies have some niche applications and with the use of HfO FRAM the number of niche markets available for FRAM could increase.

Moving to a nonvolatile solid-state main memory and cache memory will reduce power usage directly as well as enable new power saving modes, provide faster recovery from power off and enable more stable computer architectures that retain their state even when power is off. Eventually spintronic technology, that uses spin rather than current for logic processes, could be used to make future microprocessors. Spin-based logic could enable very efficient in-memory processing. Several emerging memory technologies are also being used in neuromorphic computing experiments.

The use of a nonvolatile technology as an embedded memory combined with CMOS logic has great importance in the electronics industry. NOR flash reached its scaling limit at 28nm, and soon will be replaced with one of these new technologies. As a replacement for a multi-transistor SRAM, STT MRAM could reduce the number of transistors and thus provide a low cost, higher-density solution. A number of enterprise and consumer devices use MRAM, based on field switching, to act as an embedded cache memory, and this trend will continue.

The availability of STT MRAM has accelerated this trend. Because of the compatibility of MRAM and STT-RAM processes with conventional CMOS processes, these memories can be built directly on top of CMOS logic wafers. Flash memory doesn't have the same compatibility with conventional CMOS. The power savings of nonvolatile and simpler MRAM and STT MRAM when compared with SRAM is significant. As MRAM $/GB costs approach those of SRAM, this replacement could cause significant market expansion.

We project that 3D XPoint Memory, with significant gigabyte shipments in 2020-2021, and with its important price advantage versus DRAM will grow to a baseline level of 90.0EB (exabytes) of shipping capacity by 2030. 3D XPoint baseline revenues are projected to reach $25.3B by 2030.

It is projected that total MRAM and STT MRAM baseline annual shipping capacity will rise from an estimated 18TB in 2019 to 315PB in 2030. Standalone MRAM and STT-RAM baseline revenues are expected to increase from $35M in 2019 to about $10B by 2030. Much of this revenue gain will be at the expense of SRAM, NOR flash and some DRAM, although STT-RAM is developing its own special place in the pantheon of shipping memory technologies.

The demand for MRAM and STT-MRAM will drive demand for capital equipment to manufacture these devices. While MRAM and STT-MRAM can be built on standard CMOS circuits supplied by large semiconductor fabricators, MRAM and STT MRAM do require specialized fabrication equipment for the MRAM layers that is similar to or the same as that used in manufacturing the magnetic read sensors in hard disk drives.

The increasing demand for nonvolatile memory based upon MRAM and STT MRAM will cause total manufacturing equipment revenue used for making the MRAM devices to rise from an estimated $43.8M in 2019 to between $225M to $1.29B by 2030 with a baseline projected spending of $696M.

Thus, total emerging standalone memory shipments by 2030 could range from about 163.5 Exabytes to 17.2 Exabytes with a baseline value of 90.3 Exabytes. The majority of the capacity shipments are for 3D XPoint. The revenue will range between a low of about $7.6B and a high of about $64.7B in 2030 with a baseline value of about $35.6B.

OBJECTIVE ANALYSIS
Semiconductor Market Research

Coughlin Associates
Data Storage Consulting

EMERGING MEMORIES FIND THEIR DIRECTION *Available June, 2020*

This report, jointly produced by Objective Analysis and Coughlin Associates, provides an exhaustive look at emerging memory technologies and their interaction with standard memories, both as discrete devices and in embedded applications (the memories within logic chips like ASICs and MCUs). The report provides a well of technical information, market dynamics, forecasts, and competitive analyses of the leading companies. Forecasts show how the markets will grow not only for the technologies themselves, but also for the capital equipment used to produce them. Read this to understand the competitive landscape and market drivers for these new memories, and to learn how to profit from tomorrow's market.

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