The entrance of Chinese players and the rise of new technical solutions are poised to trigger profound changes in the memory business.

**IN 2020 NAND AND DRAM WILL DRIVE NEW GROWTH IN THE STAND-ALONE MEMORY MARKET, DESPITE THE COVID-19 PANDEMIC**

Driven by important megatrends such as mobility, cloud computing, artificial intelligence (AI), and the Internet of Things (IoT), the stand-alone memory market has experienced extraordinary growth over the past decade. However, this exciting growth period ended in Q4-2018 when both the NAND and DRAM markets started experiencing oversupply caused by weak demand. This included lower-than-expected smartphone sales and a slowdown in datacenter demand. Inventory levels increased for memory suppliers and their OEM customers, with average selling prices ($/Gb) declining by more than 40% in 2019. Meanwhile, combined DRAM and NAND revenue reached ~$106B, down 34% from 2018. In 2019, significant DRAM and NAND capex cuts initiated a market recovery that began in late-2019, and which has continued in 2020. Despite the COVID-19 outbreak – which negatively impacted the smartphone and automotive markets, but spurred demand for server and PC memory for stay-at-home activities – 2020 is expected to be a year of recovery and the beginning of a new era of prosperity for the memory industry.

NAND and DRAM are ubiquitous technologies, together accounting for 96% of the overall stand-alone memory market. Thus, they have considerable influence over the memory industry’s overall status and dynamics. However, besides NAND and DRAM, there exists a broad spectrum of technologies that fit the requirements of different end-systems and markets. NOR flash is the third-largest market (~$2.3B in 2019), fueled by numerous applications including industry and security (e.g., surveillance cameras), consumer and automotive electronics, as well as telecom infrastructure (e.g., 5G base stations). Despite some seasonality and cyclicity, NOR revenue is expected to grow at a CAGR 2019-2025 of 4%.

Other technologies, such as volatile and non-volatile (NV) SRAM, ferroelectric RAM (FRAM), and EEPROM represent “niche” markets that are rather static and collectively account for just ~1.5% of the stand-alone memory market.

On the other hand, emerging non-volatile memory (NVM) technologies – e.g., MRAM, PCM, and RRAM – are taking off in the storage-class memory (SCM) market. Their combined revenue is expected to reach around ~$4B by 2025, with a CAGR 2019-2025 of over 40%. In this area, PCM (3D XPoint) will maintain its leadership until 2025 thanks to the involvement of Intel, which leads the persistent memory business with its Optane™ non-volatile memory modules.

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**2019 – 2025 stand-alone memory market revenue forecast with breakdown by technologies**

2019

- **NAND**: $2.3B (20%)
- **NOR**: $44B (40%)
- **(N)SRAM/RRAM**: $1B (20%)
- **DRAM**: $63B (28%)
- **EPIROM, ROM, etc.**: $0.7B (0.5%)
- **PCT, MRAM, RRAM**: $0.5B (0.3%)

Total: **$111B**

CAGR 2019-2025: -9%

2025

- **NAND**: $2.9B (11%)
- **NOR**: $82B (42%)
- **(N)SRAM/RRAM**: $1B (5%)
- **DRAM**: $95B (45%)
- **EPIROM, ROM, etc.**: $0.6B (0.3%)
- **PCT, MRAM, RRAM**: $4B (2%)

Total: **$185B**

CAGR 2019-2025: +9%
THE ENTRANCE OF NEW PLAYERS FROM CHINA IS POISED TO CHANGE THE MEMORY MARKET LANDSCAPE

Market concentration has accelerated dramatically in the last decade and is now remarkably high. Three dominant NAND and DRAM players – namely Samsung, Micron, and SK hynix – and two pure NAND players, Kioxia and Western Digital, together hold ~90% of the stand-alone memory market. In 2019, all major NAND manufacturers were developing the new 1xxL generation and ramping-up production of 92/96L 3D NAND. However, to mitigate the oversupply situation, most manufacturers chose to slow their ramping of 92/96L, and many products launched in 2019 were still based on 64L 3D NAND. In the DRAM business, market equilibrium was sought via significant capital expenditure cuts in 2019 (25% - 30%) – and as late as Q3-19, plans existed at suppliers to reduce capital expenditure by as much again in 2020. Both Micron and Samsung are expected to introduce products based on 1z technology by 2020; SK hynix will follow.

Meanwhile, Chinese players are starting to threaten the market’s equilibrium and could trigger profound changes in the memory business. In the NAND business, Yangtze Memory Technologies Co. (YMTC) is the leading memory maker in China. The company is currently shipping 64L NAND domestically in low volumes (including SSDs), with 128L production in development and shipments expected in 2021. YMTC’s 2020 ramp-up has been in part hampered by COVID-19, with delays in equipment deliveries/installations at its Wuhan manufacturing site.

In comparison, Chinese DRAM is still in the technology development phase. DRAM manufacturing is incredibly difficult, and it will likely take a while longer for China to achieve competitive parity with the industry at-large. Changxin Memory Technologies (CXMT), China’s most advanced DRAM maker, is expected to ramp up production on the 1xnm node in 2020. For NAND, we expect that significant output (~4%) from YMTC could reach the market in 2021, while it will take longer for DRAM. Meanwhile, stand-alone NOR flash will remain the sturdiest memory business in China thanks to a well-developed local supply-chain system and the activities of GigaDevice, a key local player.

TECHNOLOGY-NODE MIGRATION IS BECOMING INCREASINGLY DIFFICULT AND EXPENSIVE

NAND and DRAM scalability was supposed to peak in 2020, but memory manufacturers and equipment players have found new solutions to exceed this limit. New manufacturing techniques include self-aligned multiple patterning, extreme ultra-violet (EUV) lithography and metrology, as well as high aspect ratio (HAR) etching to produce contact holes in 3D NAND devices. Novel advanced packaging methods for heterogeneous integration, i.e. 3D stacking and 2.5D silicon interposer, enable high-bandwidth memory (HMB) for fast data transfer between computing units (CPU/GPU) and DRAM. All these singular technical solutions create new opportunities for the semiconductor industry to increase bit density in next-generation memory devices, improve their bandwidth, and reduce their power consumption and cost-per-bit. However, with each technology generation, bit growth is becoming significantly more expensive. For instance, multi-patterning requirements in DRAM are increasing with each node migration, resulting in additional processing steps and therefore more cleanroom space per wafer produced. As DRAM shrinks and defect probability augments, DRAM manufacturers are evaluating the idea of switching...
from self-aligned multiple patterning to EUV lithography. Noteworthy, Samsung recently announced the shipment of one million DDR4 DRAM modules that were manufactured using the EUV technology at the 1x node.

Leveraging our comprehensive expertise in memory technologies and related markets, Yole introduces the second edition of its Status of the Memory Industry report. This report seeks to provide the broadest overview of the stand-alone memory market and its competitive landscape, detailing technical challenges, opportunities, and trends in the field of stand-alone memory, including NAND, DRAM, NOR, (N)VRAM, emerging NVM, and much more.

COMPANIES CITED IN THE REPORT (non exhaustive list)


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RECENT REPORTS, MONITORS & TRACKS

- NAND and DRAM Quarterly Market Monitors
- MRAM Technology and Business 2019
- YMTC’s 3D-NAND Flash Memory – by System Plus Consulting
- LPDDR4 Memory Comparison 2019 – by System Plus Consulting
- Samsung 3D V-NAND 92-Layer Memory – by System Plus Consulting

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REPORT OBJECTIVES

Provide an understanding of stand-alone memory technologies and applications:
- Roadmaps with technology nodes, product development status, chip density, scaling challenges, and potential solutions
- Memory content evolution in key systems: servers, smartphones, personal computers, vehicles, enterprise, and client SSDs
- Main memory end-markets: datacenter, mobile, automotive, PC, and consumer electronics

Offer market forecasts for the stand-alone memory business:
- Market forecast (2019 - 2025) for NOR, (N)VRAM, and other technologies including PCM, MRAM, and RRAM
- Market forecast (2019 - 2025) for NAND and DRAM, with details on capex by players, price per bit, market share, bit demand, bit shipments, wafer production, and more.

Detail and analyze the competitive landscape:
- Financial analysis: key memory companies’ revenue, capex, R&D, operating costs, and margins
- Recent mergers and acquisitions, start-up funding, and latest company news

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ABOUT YOLE DEVELOPPEMENT

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. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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