STATUS OF THE MEMORY INDUSTRY 2021
Market & Technology Report - June 2021

NAND consolidation, China’s bet on two key players, the rise of the CXL interface: as the memory business narrows, the market keeps growing and is poised to exceed $200B in 2026.

WHAT’S NEW
- Analysis of wafer production, bit shipments, CAPEX, and memory demand in the post-pandemic era
- Description and analysis of storage drives and memory modules with their key protocols and interfaces (e.g., DDR5, HBM2e, CXL)
- Updated market forecast (2020 - 2026) for NAND and DRAM, considering the impact of trade wars and the rise of new players from China
- Update on the NOR Flash memory business: supply-demand dynamics, players, growth drivers, applications, market shares, revenue, and more
- Updated financial analysis of leading IDM companies – including Samsung, SK hynix, Kioxia, Western Digital, Micron, and Intel
- Updated list of Chinese memory players and detail of their activities in the DRAM, NAND, NOR, and emerging NVM businesses

KEY FEATURES
- Summary of the stand-alone memory market and related technologies, including NAND, DRAM, persistent memory, computational storage, NOR, (NV) SRAM, emerging NVM, and more
- Description of technical trends and manufacturing challenges, scaling roadmaps, and players
- Overview of the storage drive and memory-module businesses
- Breakdown of the memory market from a system point of view, detailing present and future memory needs for servers, smartphones, personal computers, enterprise/client SSDs, and vehicles
- Profile of the most important end-markets for stand-alone memory, i.e., data centers, mobile, automotive, PC, and consumer electronics
- Overview of embedded memory technology and progress towards in-memory computing applications
- Mapping of the stand-alone memory supply chain, analysis of recent M&A and joint ventures, and list of noteworthy news

AMID THE PANDEMIC, TRADE-WAR TENSIONS, AND CHIP SHORTAGES, THE MEMORY MARKET OUTLOOK REMAINS BRIGHT. REVENUES WILL PEAK IN 2022 AT MORE THAN $180B

In modern data-centric societies, semiconductor memory is a ubiquitous technology and represents an impressive market (>-$120B in 2020) with solid growth potential driven by important megatrends, including mobility, cloud computing, Artificial Intelligence (AI), and the Internet of Things (IoT). NAND and DRAM are the workhorse memory technologies and are used, respectively, as storage and working memory for a broad spectrum of applications and systems, including smartphones, tablets, SSDs, PCs, servers, and vehicles. Both markets are cyclical in nature, as they are characterized by periods of shortages and oversupply that give rise to strong price variations and revenue volatility. After substantial oversupply in 2019 – with Average Selling Prices (ASPs) down 49% year-over-year for both NAND and DRAM – overall market conditions improved in 2020 despite trade-war tensions and the outbreak of Covid-19. The pandemic had a mixed impact on the memory industry: data center and laptop demand grew, automotive and smartphones faced a slowdown. The net outcome has been a relatively balanced memory demand, while NAND/DRAM production started slowing down as memory suppliers significantly underinvested in new wafer capacity. As a result, combined DRAM and NAND revenue rose 15% from 2019, reaching ~$122B in 2020.

In the present semiconductor shortage era, the storage-drive industry is facing a scarcity of SSD controllers and other NAND sub-components, which causes supply chain uncertainty and puts pressure on ASPs. The recent shutdown of Samsung’s manufacturing facility in Austin, which manufactures NAND controllers for its SSDs, further amplifies this situation and will likely accelerate the NAND pricing recovery, particularly in the PC SSD and mobile markets where impacts from controller shortages are most pronounced.

Thanks to a combination of CAPEX cuts from suppliers in recent years and flourishing demand, the future is looking bright, particularly for DRAM. Revenues will peak again in 2022, reaching record-high values of $120B (DRAM) and $68B (NAND).

In the long term, DRAM and NAND revenues are expected to grow to $81B (NAND) and $124B (DRAM) with CAGR_{20-26} of ~11% and ~6%, respectively. In the same period, the ASP is expected to decrease by ~7% (DRAM) and ~16% (NAND), driven by cost-per-bit reductions enabled by technology scaling.

2020-2026 evolution of the average DRAM and NAND content for key end-systems

(Yole Développement, June 2021)
THE MEMORY-PROCESSOR INTERFACE IS KEY FOR OVERCOMING THE “MEMORY WALL”. CXL AND DDR5 WILL ENABLE THE NEW WAVE OF DATA-INTENSIVE APPLICATIONS

The processor-memory interface is rapidly evolving to meet growing performance needs from data-intensive applications, which are being hampered by the so-called “memory wall”, a bandwidth limitation associated with data transfer between the memory and the processing unit. DDR5 DRAM is the latest updated to the Double Data Rate (DDR) standard and will significantly boost performance compared to DDR4. The new specification brings lower voltage and moves Power Management ICs (PMICs) onto the memory module. It doubles the maximum data rate and increases the die density by a factor of 4 (up to 64Gb). The production of DDR5 memory is now gaining momentum, with all leading DRAM manufacturers having already finalized their mainstream DDR5 designs. SK hynix announced that they are ready to start shipping DDR5 memory to module manufacturers, and Micron to delete announced sampling of DDR5 memory based on the 1znm technology, targeting RDIMMs for servers.

The “Status of the Memory Industry 2021” report will provide an overview of DIMMs, SSDs, and interfaces, marking the beginning of Yole’s program in the field of memory modules and storage drives.

THE MEMORY BUSINESS IS NARROWING: CHINA HAS CHOSEN ITS TWO CHAMPIONS – YMTC AND CXMT – AND THE NAND MARKET KEEPS MOVING TOWARDS CONSOLIDATION

China is a key market for memory suppliers, accounting for more than 35% of the overall NAND and DRAM memory sales. In the last years, Chinese central and local governments – in partnership with private players – have been investing billions of dollars in developing a local memory industry and bridging the gap between domestic production and consumption. While Chinese funding agencies have been supporting many semiconductor projects in the last few years, nowadays, they are more cautious and concentrate investments on the most reliable/promising technologies and players. The priority is clearly given to mainstream memories that are critical for the growing data center and mobile businesses. These are being developed by two key players: YMTC (NAND) and CXMT (DRAM). YMTC is currently shipping 64L NAND in low volumes domestically (including SSDs), with 128L production under development. CXMT is currently the leading DRAM maker in China, followed by Tsinghua Unigroup; broad commercialization is planned with Gen 3 products, while initial production will be limited and available only in the local market.

On October 20th, 2020, SK hynix announced the acquisition of Intel’s NAND manufacturing capacity in Dalian, its NAND-related IP, and its SSD business. This deal is beneficial to both parties and is not likely to have a major impact on the memory markets in the near term, as the two suppliers historically served different end markets – Intel focused on enterprise/data center; SK hynix focused on mobile and consumer segments. However, the longer-
term impacts could be significant if this serves as the first step and motivator for subsequent consolidations that could alter the structure of the industry. With YMTC entering the market in the coming quarter/years, broad industry consolidation may be the best path towards a a healthier industry...

REPORT OBJECTIVES
Present an overview of the stand-alone memory market:
- NAND, DRAM, NOR, 3D XPoint, (NV)SRAM, and more
- Competitive landscape, activities, and strategies of key market players
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, PC, vehicles, and SSDs
- Main memory end-markets: data center, mobile, automotive, PC, and consumer electronics
Offer market forecasts for the stand-alone memory business:
- Market forecast (2020 - 2026) for NOR, (NV)SRAM, and other technologies, including emerging NVM
- Market forecast (2020 - 2026) for NAND and DRAM, with details on CAPEX by player, 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
- Supply chain mapping from materials/equipment manufacturers to storage drive and memory module makers

COMPANIES CITED IN THE REPORT (non exhaustive list)

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RELATED REPORTS, MONITORS & TRACKS
- DRAM Quarterly Market Monitor
- NAND Quarterly Market Monitor
- Emerging Non-Volatile Memory 2021
- Equipment and Materials for 3D-NAND Manufacturing 2020
- Micron LPDDR5 12GB Mobile Memory
- Intel Optane 128GB DIMM

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CONTACT

**Western US & Canada**
Steve Laferriere - steve.laferriere@yole.fr
+1 310 600-8267

**Eastern US & Canada**
Chris Youman – chris.youman@yole.fr
+1 919 607 9839

**Europe and RoW**
Lizzie Levenez – lizzie.levenez@yole.fr
+49 15 123 544 182

**Benelux, UK & Spain**
Marine Wybranietz - marine.wybranietz@yole.fr
+49 69 96 21 76 78

**India and RoA**
Takashi Onozawa – takashi.onozawa@yole.fr
+81-80-4371-4887

**Korea**
Peter Ok - peter.ok@yole.fr
+82 1040890233

**Japan**
Miho Ohtake – miho.ohtake@yole.fr
+81 34405-9204
Toru Hosaka – toru.hosaka@yole.fr
+81 90 1775 3866

**Japan and Singapore**
Itsuyo Oshiba – itsuyo.oshiba@yole.fr
+81-80-3577-3042

**Greater China**
Mavis Wang – mavis.wang@yole.fr
+886 979336809 +86 136 61566824

**Sales Coordination & Customers Service**
David Jourdan – david.jourdan@yole.fr
+33 472 83 01 90
Fayçal El Khamassi – faycal.khamassi@yole.fr
+33 472 83 01 95

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 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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CONTACTS
For more information about:
- Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
- Reports & Monitors: David Jourdan (david.jourdan@yole.fr) & Fayçal Khamassi (faycal.khamassi@yole.fr)
- Public Relations: Sandrine Leroy (sandrine.leroy@yole.fr)
- Marketing & Communication: Jean-Christophe Eloy (eloy@yole.fr)

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**Product**

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1. Products are sent by email to the Buyer after Seller’s confirmation:

   a. Within a few days from the Seller’s confirmation of the order for Products and any related fees if applicable;

   b. Within a reasonable time for Products ordered prior to their delivery date. The Buyer shall endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2. The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in Article 3 above.

4. The mailing is operated through electronic means either by email via the sales department or automatically online via an online order management platform. In case that the Buyer has not selected to receive notifications, the Sellers platform has the required capacities and authorisations to provide the Report(s) to the Buyer. If the Product electronically delivered to the Buyer shall in all events be made available to the Buyer. The Buyer agrees to produce sufficient evidence of such defects.

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5.2 To secure the payments due to the Seller, the Buyer shall define within its Company an identified user who will have the right to invoice all work performed at the time of termination, and to take legal action for damages.

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