

# 3D-NAND: the ever-increasing manufacturing complexity <sup>1</sup>

***The 3D-NAND manufacturing equipment market will keep growing.***

## **OUTLINE:**

- NAND market forecasts:  
The NAND market is expected to grow to US\$81 billion in 2026 with a 6% CAGR<sup>2</sup> between 2020 and 2026.  
The 3D-NAND equipment market including etching, deposition and lithography, will grow to US\$17.5 billion by 2025, with a CAGR<sub>19-25</sub> of 9%.
- NAND Q4 2020 overview:  
NAND market revenue grew 28% in 2020.  
NAND's competitive landscape remains incredibly dynamic.  
As the NAND market evolves, the industry faces many important questions...
- Technology trends:  
3D-NAND memory manufacturers will adopt different strategies to increase the number of layers and the overall bit density per die.
- Supply chain:  
In the 3D NAND business, Samsung is the market leader with fierce competition from WD-Kioxia, followed by SK hynix and Micron-Intel.  
In China, YMTC looms on the horizon as a new NAND supplier and threatens to disrupt the status-quo.

*“Four companies – ASML, Applied Materials, Tokyo Electron and Lam Research – hold more than 70% of the overall equipment market.” asserts **Simone Bertolazzi, Market & Technology Analyst, Memory at Yole Développement (Yole)**. He adds: “ASML is the undisputed leader in the field of photolithography, whereas Applied Material, TEL and Lam Research compete for supremacy in different areas, such as deposition (CVD, ALD, PVD, etc.), etching, and*

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<sup>1</sup> Extracted from:

- [Equipment and Materials for 3D NAND Manufacturing 2020](#) report, Yole Développement, 2020
- [NAND Quarterly Market Monitor](#), Yole Développement, Q1 2021
- [YMTC's 3D-NAND Flash Memory](#) report, System Plus Consulting, 2020

<sup>2</sup> CAGR: Compound Annual Growth Rate

more. These three players will benefit most from expansion of the 3D-NAND business, but it will be also very sensitive to tail- and headwinds in the memory industry”.

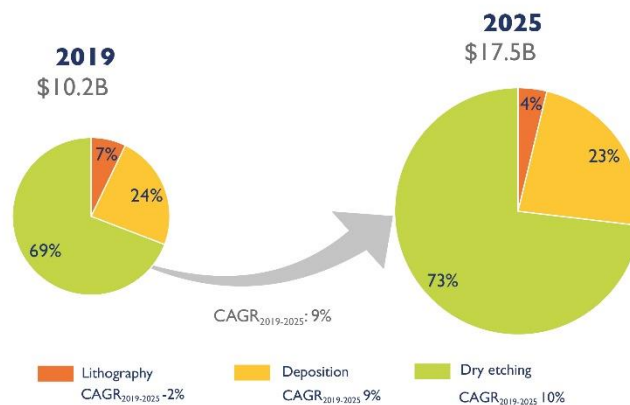
In this context, Yole and System Plus Consulting, both part of Yole Group of Companies, investigate disruptive memory technologies and related equipment and materials markets in depth. Their aim is to point out the latest innovations and underline the business opportunities. Both partners announce three NAND dedicated analyses:

- NAND Quarterly Market Monitor, Q1 2021 update that is following the NAND industry with key market figures and trends, quarter by quarter.
- Equipment and Materials for 3D-NAND Manufacturing 2020 report proposes an extensive knowledge of the NAND business and related manufacturing equipment/processes.
- In addition, System Plus Consulting delivers a special focus on the rising memory company YMTC, that is leading the Chinese market today, with a dedicated report, YMTC’s 3D-NAND Flash Memory.

With those three analyses, System Plus Consulting and Yole present a unique understanding of the NAND and 3D-NAND industry.

### 3D-NAND manufacturing equipment market forecast with breakdown by process

(Source: Equipment and Materials for 3D-NAND Manufacturing 2020 report, Yole Développement, 2020)

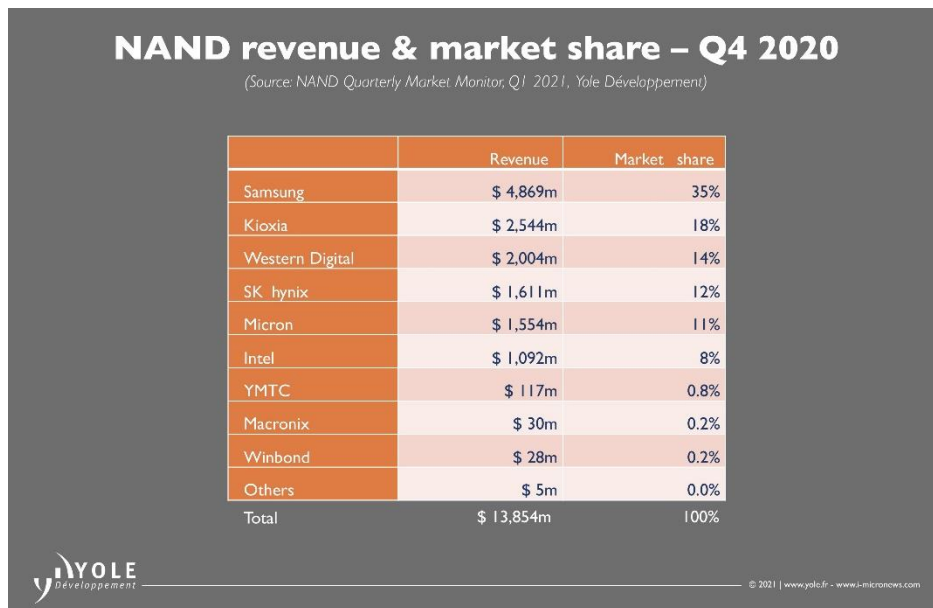


As analyzed by Yole’s team in the Equipment and Materials for 3D NAND Manufacturing 2020 report, despite some seasonality and cyclicity, which are typical of the stand-alone memory business, the NAND market is expected to grow from US\$44 billion in 2019 to US\$81 billion in 2025 with a CAGR<sub>19-25</sub> for this period of 11%. This will be driven by robust long-term bit demand fueled by rising data-centric applications in the fields of AI<sup>3</sup> and the IoT<sup>4</sup>, intelligent factories, virtual/augmented reality, and autonomous vehicles.

<sup>3</sup> AI: Artificial Intelligence

<sup>4</sup> IoT: Internet of Things

In addition, **Simone Bertolazzi** from Yole had the opportunity to discuss with **Mark Puttock**, advanced technology engagements, in the **CTO office at Entegris**, about the company’s material solutions for 3D NAND, strategy, and market status and applications. Discover the details of their discussion [here](#).



As said in the [NAND Quarterly Market Monitor, Q1 2021](#), the long-term outlook for the NAND market is positive, despite the continued presence of seasonality and cyclicity. Imbalances in supply and demand can cause market volatility in the short term, but emerging megatrends driving massive data generation and the ongoing replacement of HDD<sup>5</sup>s with NAND-based SSDs<sup>6</sup> are expected to push NAND to new heights.

According to **Walt Coon, VP of NAND and Memory Research at Yole**: *“Shortages of controllers and other NAND sub-components are causing supply chain uncertainty, putting upwards pressure on ASP<sup>7</sup>s. The recent shutdown of Samsung’s manufacturing facility in Austin, Texas, USA, 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 the controller shortages are most pronounced”*.

NAND’s competitive landscape remains incredibly dynamic. Samsung is utilizing its massive Pyeongtaek site and expanding its facilities in Xi’an, China; KIOXIA Corporation and its partner Western Digital continue to expand their footprint in Japan; SK Hynix is in the process of acquiring Intel’s NAND/SSD business; and Micron continues to be a 3D technology leader even as it transitions from floating - to replacement-gate technology. Meanwhile, a new entrant looms on the horizon: China’s Yangtze Memory Technologies Co. (YMTC), which threatens to disrupt the status-quo.

<sup>5</sup> HDD: Hard Disk Drive  
<sup>6</sup> SSD: Solid-State Drives  
<sup>7</sup> ASP: Average Selling Price

In its YMTC's 3D-NAND Flash Memory report, System Plus Consulting's analysts deeply analyzes the technical choice made by YMTC. The Chinese memory company developed its new 3D-NAND Xtacking™ architecture with two wafers for its 64-layer 3D-NAND memory, instead of a single wafer used in conventional 3D NAND memories.

**Belinda Dube, Technology & Cost Analyst at System Plus Consulting** comments:

*“CMOS periphery and NAND array wafer are manufactured separately. Wafers are connected by copper to copper hybrid bonding. This bonding technique needs a high level of accuracy and alignment precision to perfectly join the metal pads from the two wafers. YMTC's Xtacking process allows the company to significantly increase its die density compared to other players”.*

YMTC's memory enters the NAND flash market as a solution to cater for higher I/O<sup>8</sup> speed as they use advanced CMOS transistors that are manufactured on a different wafer from the NAND array. Consequently, this memory provides the combination of high speed and large density characteristics.

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



*In this context, do not miss the DRAM & NAND Memory markets show building strength – Could we be entering the next supercycle? Live Market Briefing Video. Watch it 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!*

### Press contacts

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<sup>8</sup> I/O: Input/Output

### About our analysts

**Simone Bertolazzi, PhD** is a Senior Technology & Market analyst, Memory, at Yole Développement (Yole), working with the Semiconductor, Memory & Computing division. As member of the Yole's memory team, he contributes on a day-to-day basis to the analysis of nonvolatile memory markets and 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- $\kappa$  dielectrics. Simone earned a double M. A. Sc. degree from Polytechnique de Montréal (Canada) and Politecnico di Milano (Italy), graduating cum laude.

As VP of NAND and Memory Research, **Walt Coon** is a member of the Semiconductor, Memory & Computing division, at Yole Développement (Yole). Based in the US, Walt is leading the day-to-day production of both market updates and Market Monitors, with a focus on the NAND market and semiconductor industries. In addition, he is deeply involved in the business development of these activities. Walt has significant experience within the memory & semiconductor industry. He spent 16 years at Micron Technology, managing the team responsible for competitor benchmarking, and industry supply, demand, and cost modeling. His team also supported both corporate strategy and Mergers & Acquisitions analysis. Previously, he spent time in Information Systems, developing engineering applications to support memory process and yield enhancement. Walt Coon earned a Master of Business Administration from Boise State University (Idaho, United-States) and a Bachelor of Science in Computer Science from the University of Utah (United-States).

**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

#### **Equipment and Materials for 3D NAND Manufacturing 2020**

*The 3D-NAND manufacturing equipment market will keep growing, propelled by robust long-term NAND-bit demand and ever-increasing manufacturing complexity* – Performed by Yole Développement

#### **Companies cited:**

ACM Research, Adeka, Advantest, AGC, Air Liquide, Air Products, Amec, Applied Materials, ASM International, ASML, Cabot Microelectronics, Canon, Coventor, Cypress, Dow, Dupont, Entegris, Enthone, Eugene Technology, EVG, Fujifilm, Fusion IO, GigaDevice, GlobalFoundries, Hansol Chemical, Heraeus, Hitachi Chemical, Hitachi High Technologies, Intel, JSR Corporation, Jusung Engineering, Kingston, Kioxia and more...

#### **NAND Quarterly Market Monitor Q1 2021**

*After a difficult finish to 2020, the NAND market outlook improves in early 2021. – Performed by Yole Développement, 2021*

### **YMTC's 3D-NAND Flash Memory**

*Technology and cost analysis of YMTC's 64-layer 3D NAND with hybrid bonding. – Performed by System Plus Consulting, 2020*

#### **Related reports:**

- [DRAM Quarterly Market Monitor](#)
- [Emerging Non-Volatile Memory 2021](#)
- [Status of the Memory Industry 2020 – Focus on Kioxia](#)
- [3D NAND Memory Comparison 2019](#)
- [Leading-Edge 3D NAND Memory Comparison 2018](#)

#### **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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