High Bandwidth Memory

Market and Technology Trends

Presenter:

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HIGH BANDWIDTH MEMORY – MARKET & TECHNOLOGY TRENDS

Presentation Outline

- **Memory Market Dynamics**

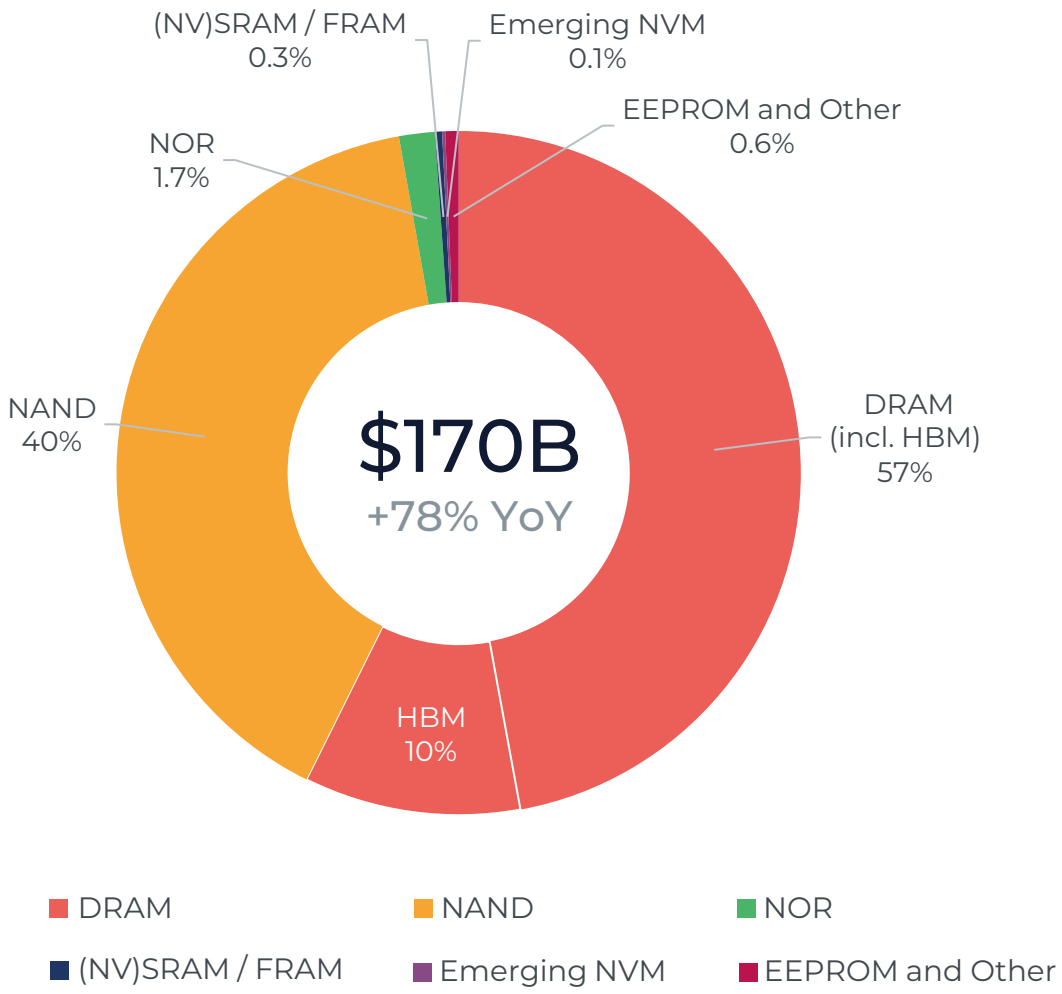
  Overview by Technologies

- **High-Bandwidth Memory**

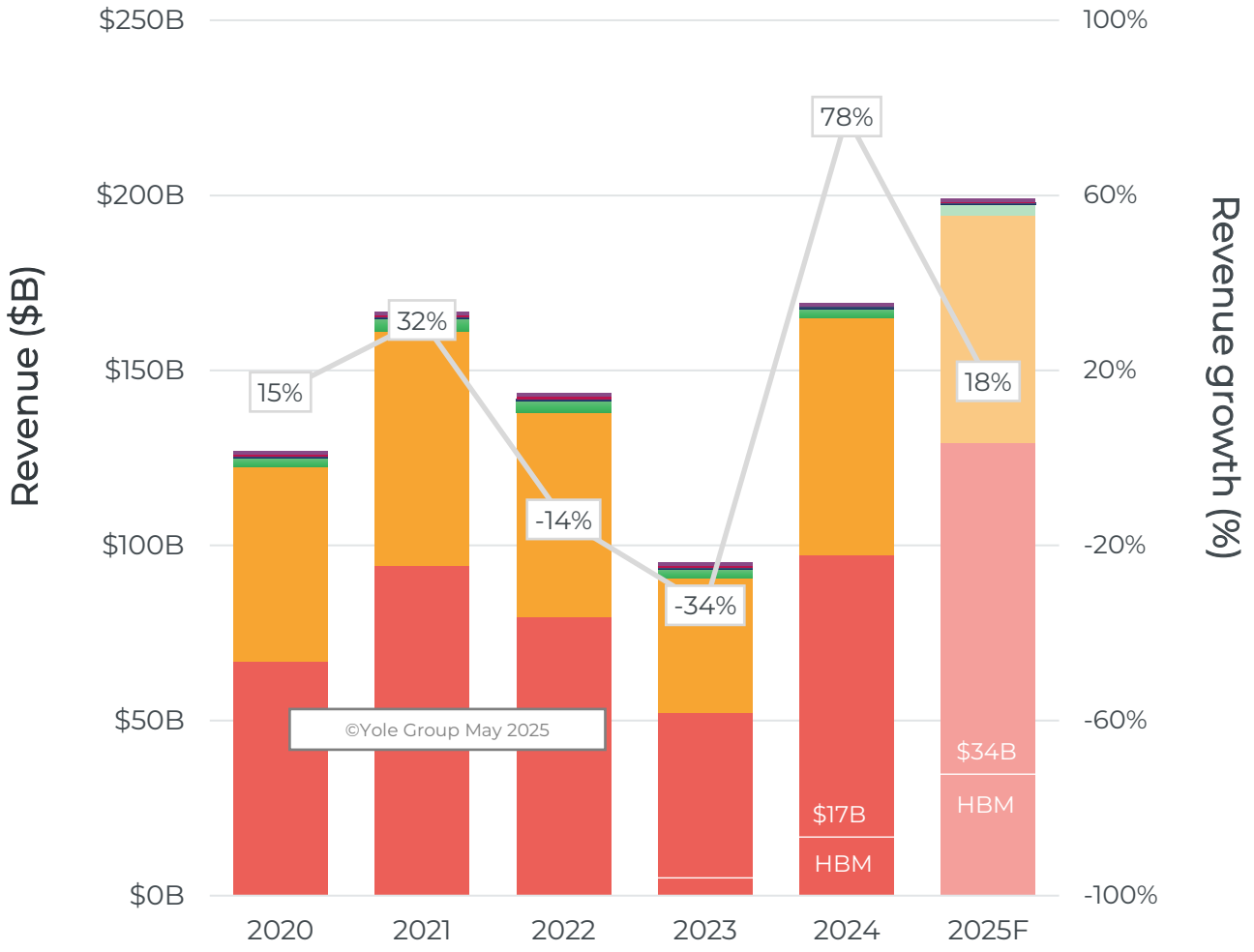
  Ecosystem and Technology Trends

MEMORY MARKET OVERVIEW

2024 Memory Market – Breakdown by Technology



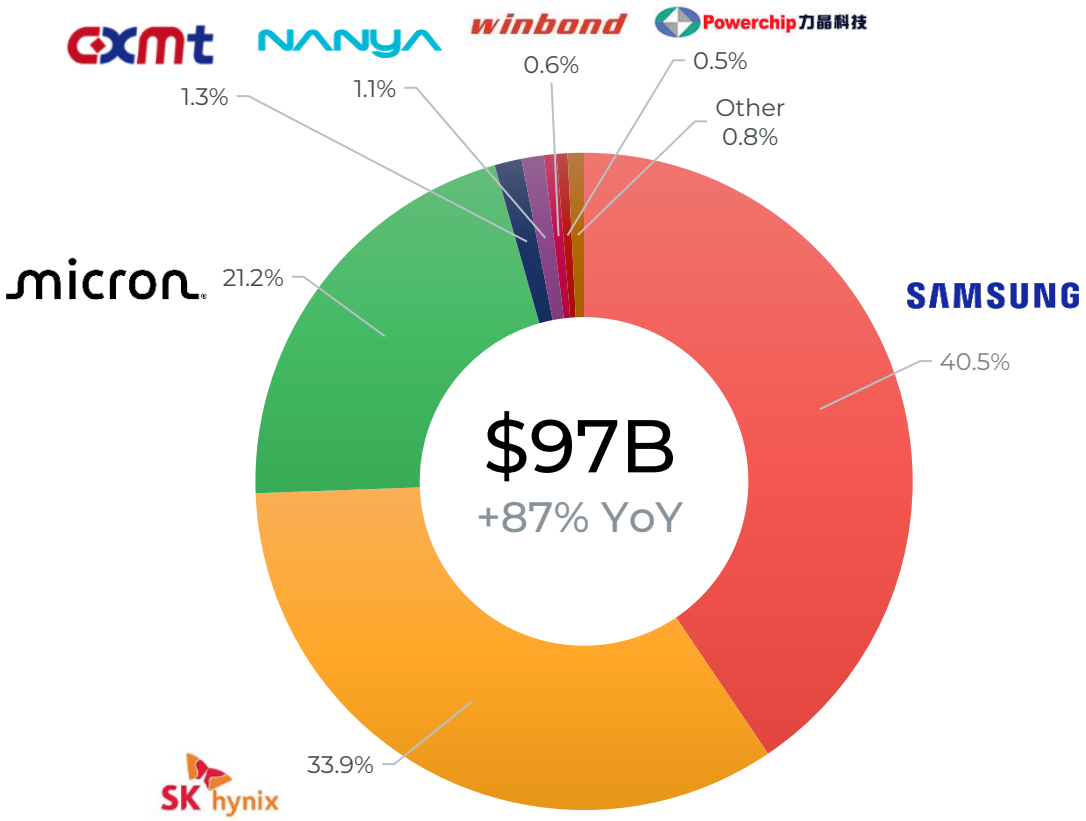
Memory Market Evolution (2020 – 2025)



Source: "Status of the Memory Industry 2025" by Yole Group

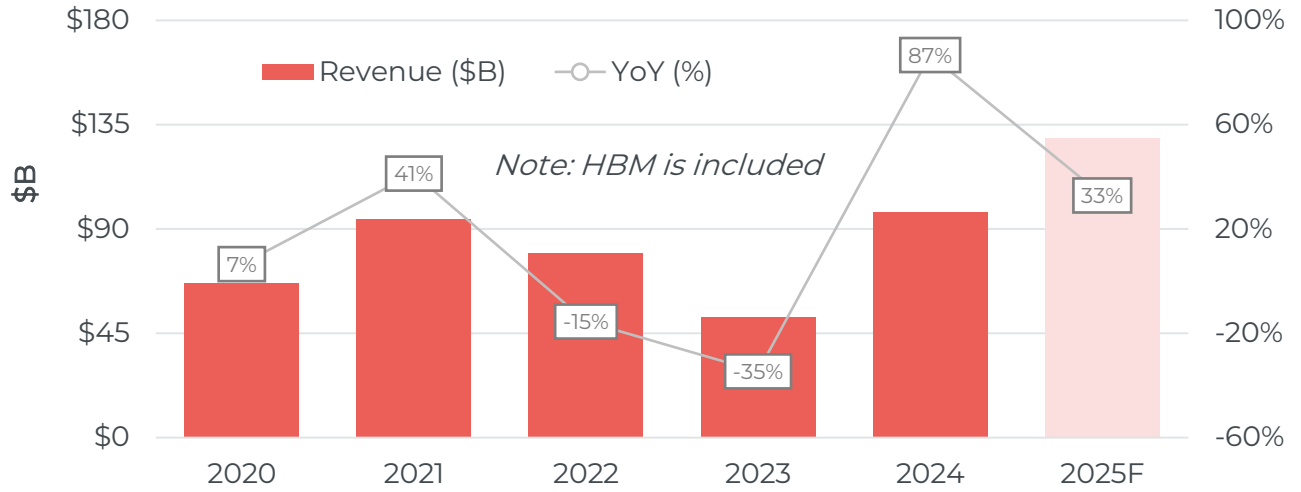
DRAM MARKET OVERVIEW

2024 DRAM Market Shares

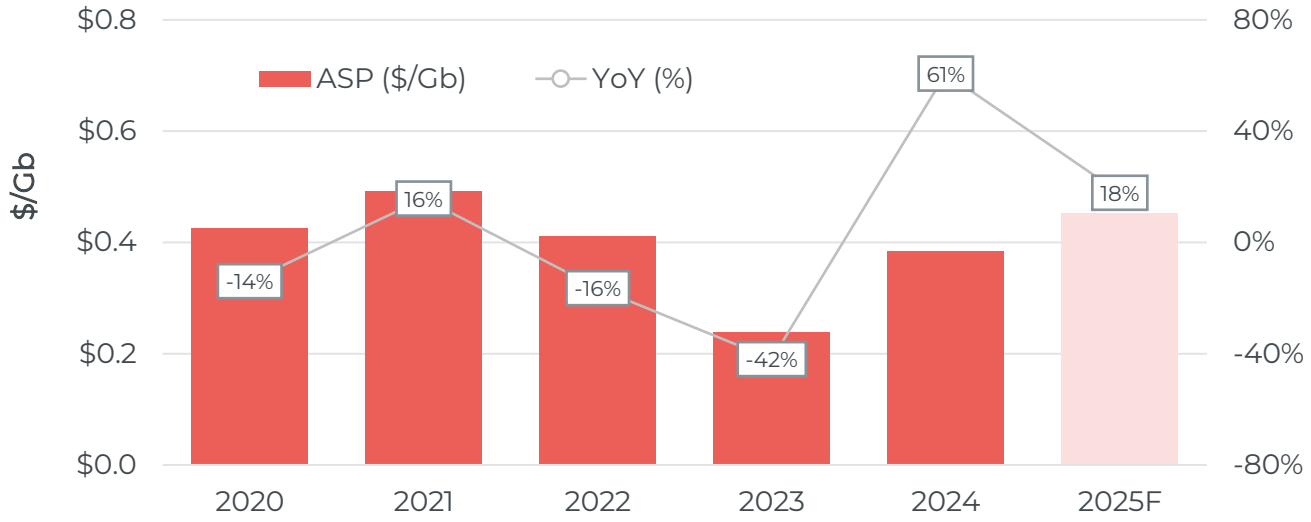


Note: revenues include chips and wafers, as well as memory modules and HBM stacks sold by IDM memory companies.

DRAM Revenue



DRAM Average Selling Price



Source: "DRAM Market Monitor Q1-2025" by Yole Group

HBM MARKET OUTLOOK – OVERVIEW

Revenue ($B)

HBM revenue ($B)

$CAGR_{24\text{-}30}$ ~33%

HBM share of DRAM market (%)

Bit shipments (B GB)

HBM bit shipments (B GB)

$CAGR_{24\text{-}30}$ ~31%

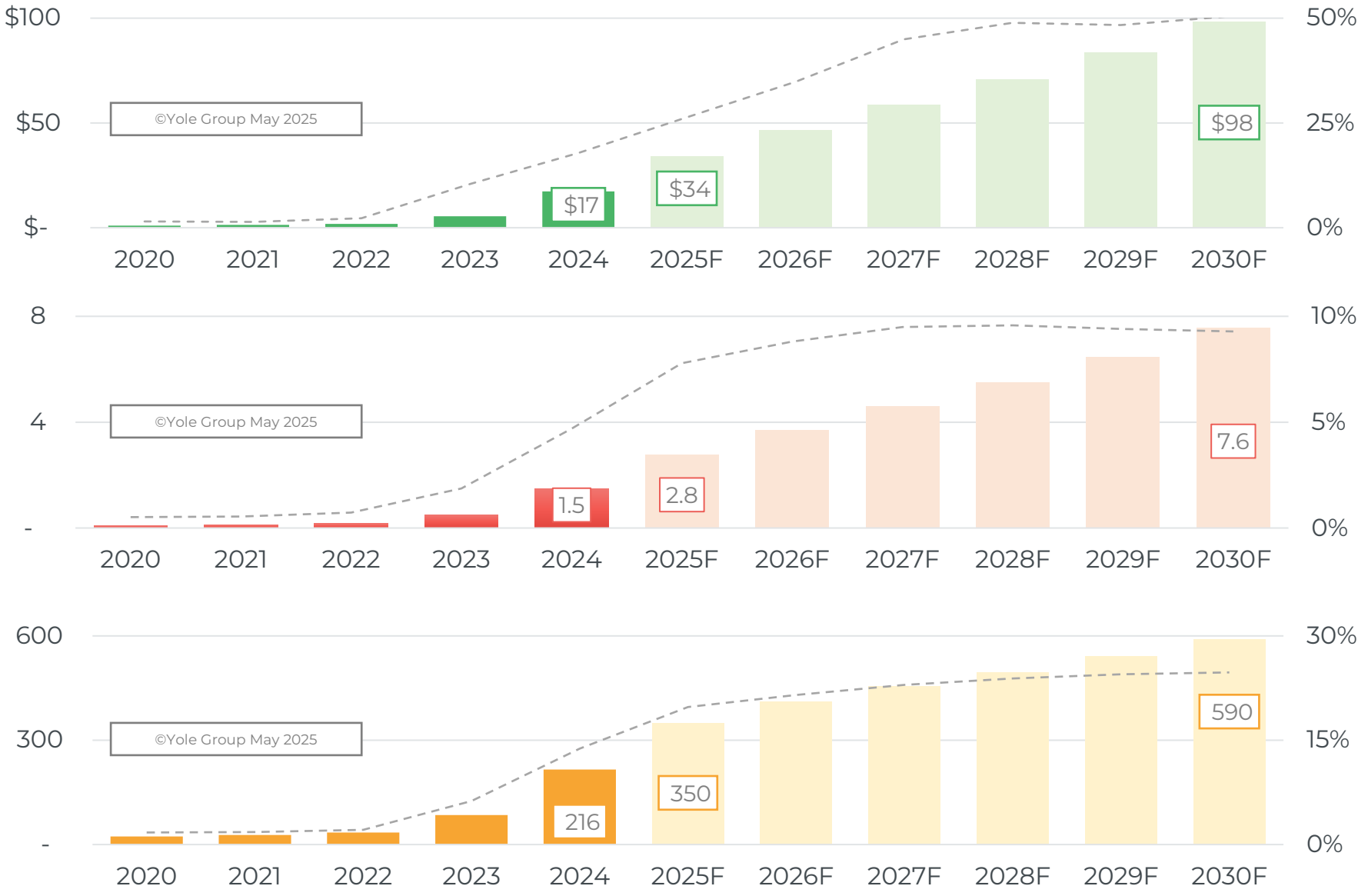
HBM share of DRAM market (%)

Wafer Production (K WPM)

HBM wafer production (KWPM)

$CAGR_{24\text{-}30}$ ~18%

HBM share of DRAM market (%)

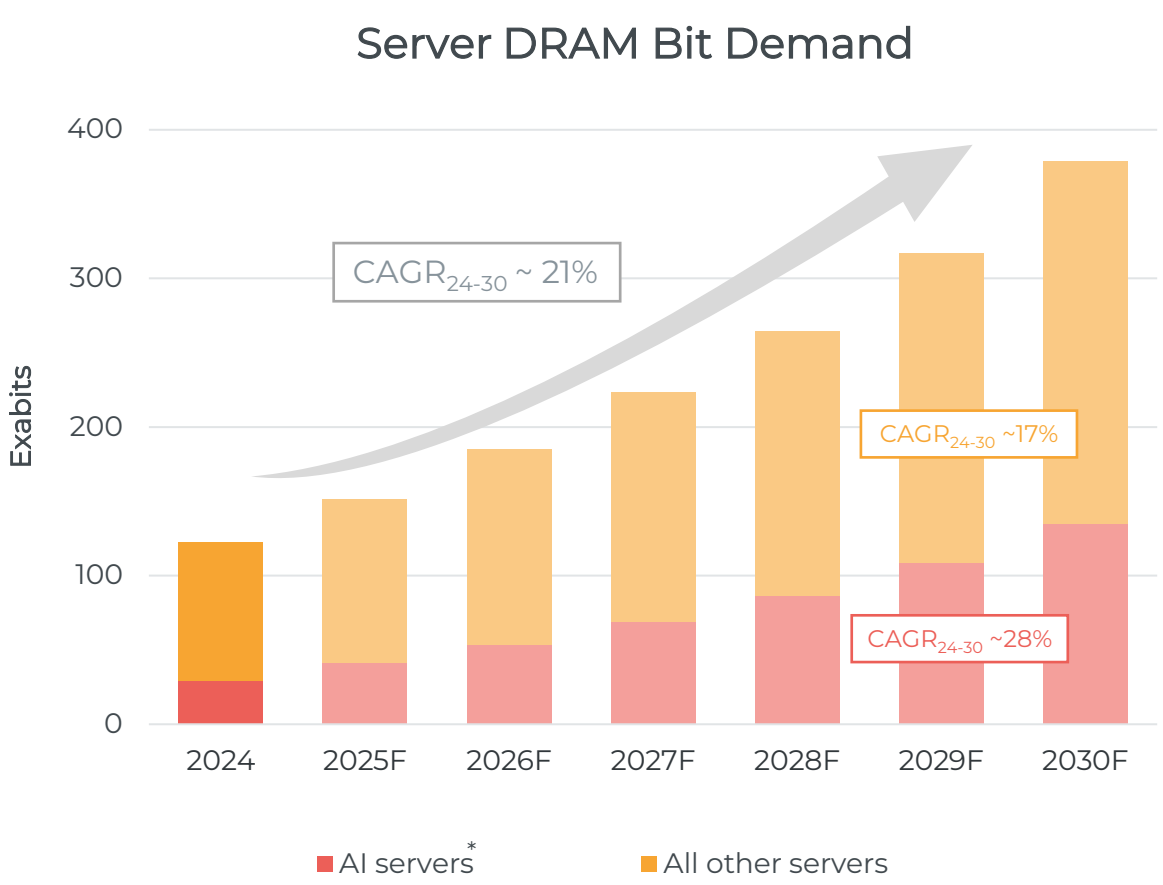


Source: "Next-Generation DRAM 2025" by Yole Group

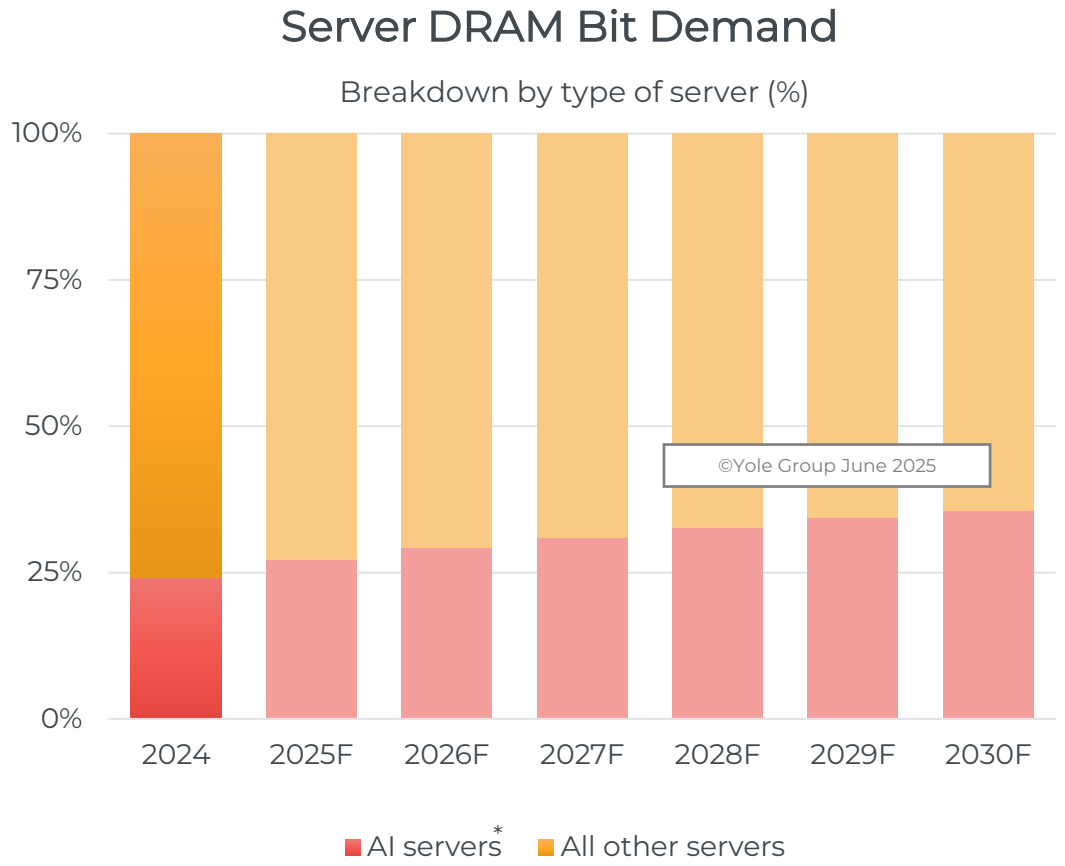
DRAM BIT DEMAND – FOCUS ON DATA CENTERS

AI applications are fueling DRAM growth in data centers

- The rise of generative AI – initiated by the release of ChatGPT in November 2022 – and the continuous expansion of data-intensive AI/HPC applications in data centers led to a significant surge in DRAM shipments in 2023. These trends will induce continuous market growth throughout the next five years.



*AI server systems dedicated to computing for AI



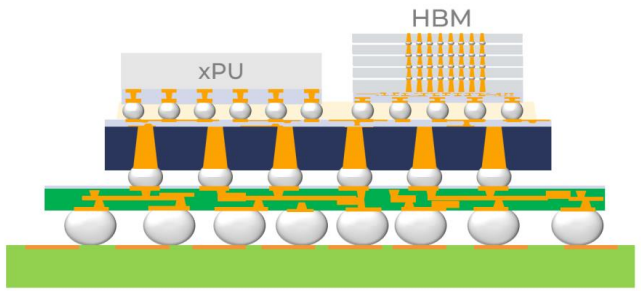
Source: "Status of the Memory Industry 2025" by Yole Group

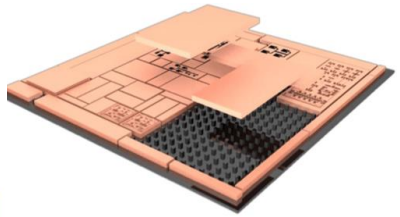
APPROACHES TO OVERCOME THE MEMORY WALL – OVERVIEW

Memory

Computing

HBM, Chiplets, Near- or In-Memory Computing





Low latency is the most important feature.
Mainly for applications requiring high bandwidth.

Memory moves towards computing

Computing moves towards memory or storage

DRAM-based processing in memory

Samsung AXDIMM solution

SAMSUNG

SK hynix

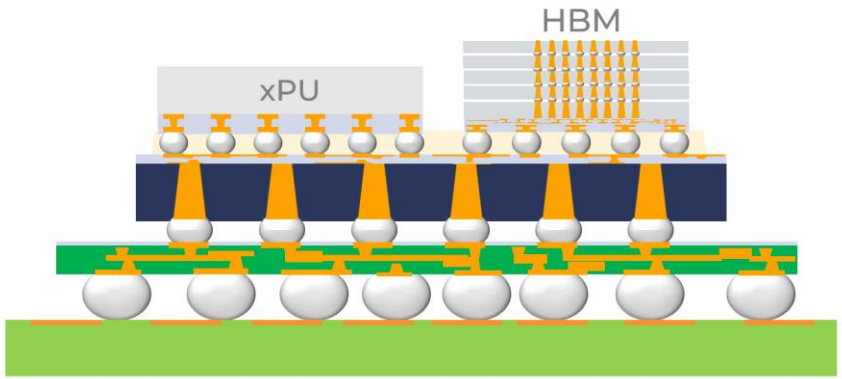
Computational storage

SAMSUNG

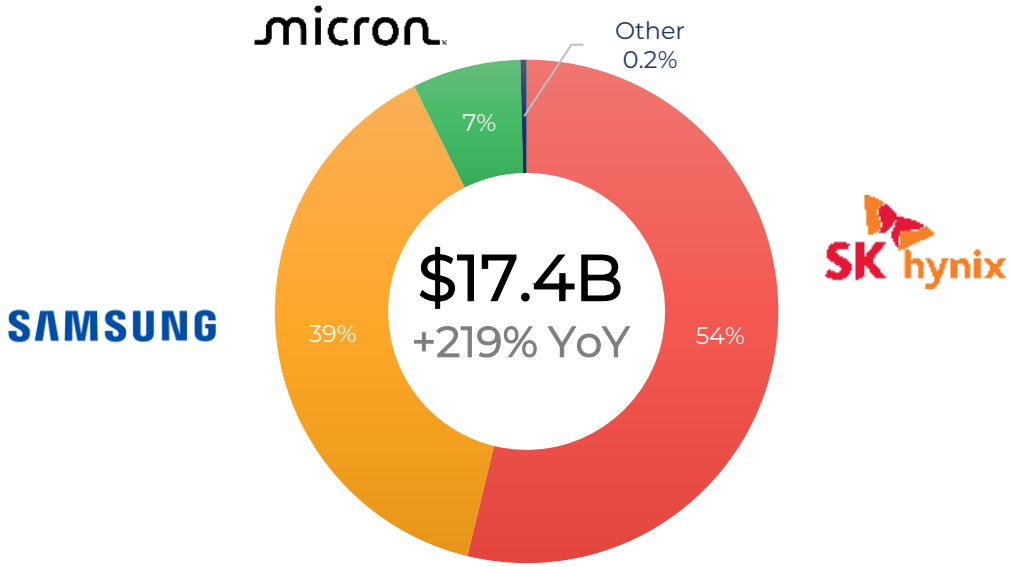
Samsung computational storage drive solution

Data is more important for the application.
Mainly for data-intensive applications.

HIGH-BANDWIDTH MEMORY (HBM)

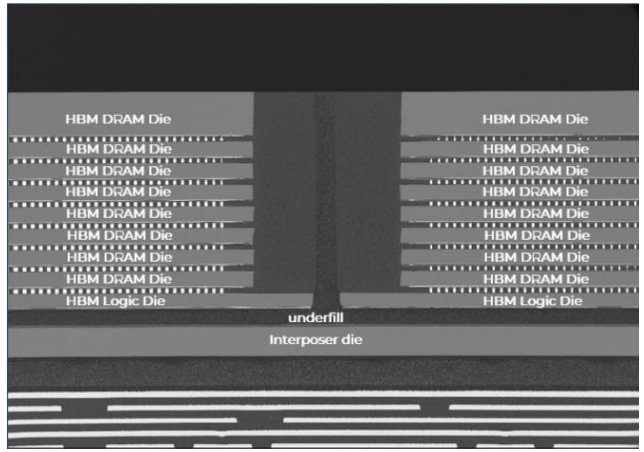


2024 HBM Revenue Market Share

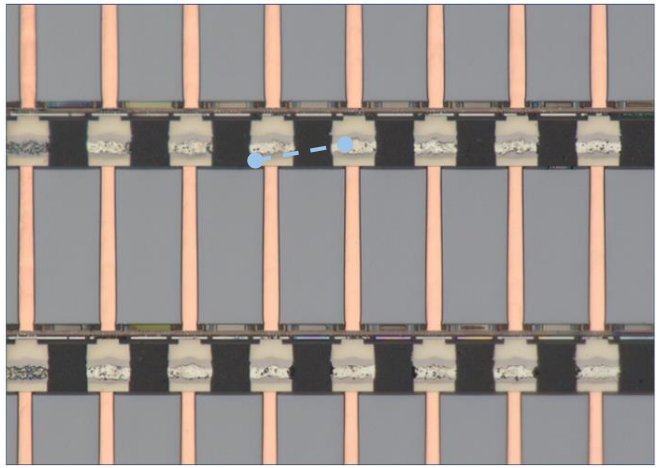


HBM Package Cross section

SK hynix



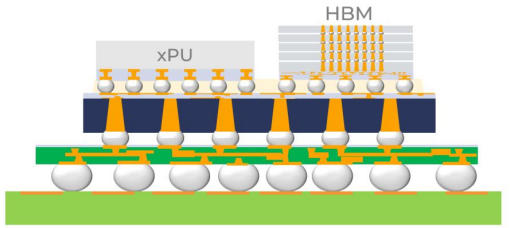
HBM Stack TSV & Microbumps



Source: "SK hynix HBM3" report by Yole Group, 2025

HIGH-BANDWIDTH MEMORY (HBM)

Product Development Overview

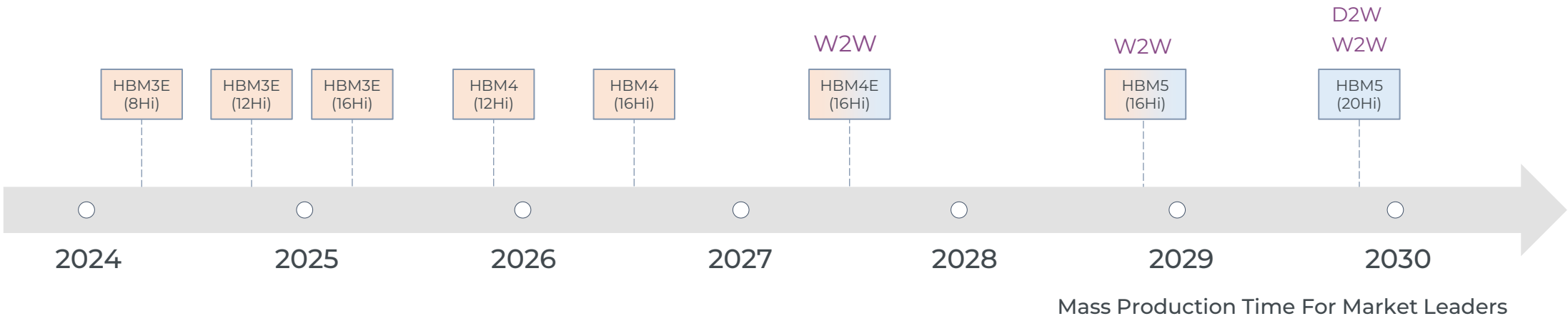


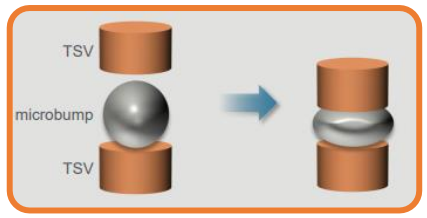
HBM generation	HBM	HBM2	HBM2E	HBM3	HBM3E	HBM4
Players with products in the market	SK hynix	SAMSUNG *Flarebolt* *Aquabolt* *Aquabolt-XL (PIM)* SK hynix	SAMSUNG *Flashbolt* SK hynix micron	SAMSUNG *Icebolt* SK hynix	SAMSUNG *Shinebolt* SK hynix micron	SAMSUNG SK hynix micron
Year of first product release	**2014**	**2018**	**2020**	**2022 - 2023**	**2024**	**2026(E)**
Typical number of dies per stack (Main packaging approach)	4Hi (TSV & microbumps)	4-8Hi (TSV & microbumps)	4-8Hi (TSV & microbumps)	8-12Hi (TSV & microbumps)	8-12Hi (16Hi)NEW (TSV & microbumps)	12-16Hi (TSV & microbumps)
Max capacity per stack	1GB	4-8GB	8-16GB	16-24GB	24-36GB (48GB)NEW	36-48GB
Die density (Typical process)	2Gb (2x)	8-16Gb (2y, 2z)	16Gb (1y, 1z)	16Gb (1z)	24Gb (1a, 1b/1β)	24Gb (32Gb)* (1b/1β, 1c/1γ)
Max data rate	1Gbps	2-2.4Gbps	3.2-3.6Gbps	5.6-6.4Gbps	8.0-9.8Gbps	≥ 6.4Gbps
Effective bus width	1,024	1,024	1,024	1,024	1,024	2,048
Max bandwidth per stack	128GB/s	205-307GB/s	460GB/s	819GB/s	1.2TB/s	≥ 2TB/s

Source: "Next-Generation DRAM 2025" by Yole Group

BONDING TECHNOLOGIES FOR HIGH-BANDWIDTH MEMORY

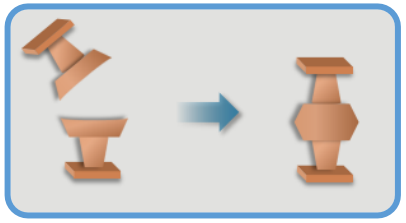
- Reportedly, wafer-to-wafer (W2W) hybrid bonding will be first used to stack the first DRAM layer and the base/logic layer. The first technologies using this approach will likely be HBM4E/HBM5 (≥16Hi), particularly in customized HBM solutions.
- Collective Die-to-Wafer (D2W) and Die-to-Die (D2D) bonding schemes will be used in subsequent generations. We currently model die-bonding approaches to start from the HBM5 generation from 20Hi.





Technologies based on MR-MUF* or NCF-TCB** with TSV and microbumps

Image credit: Applied Materials



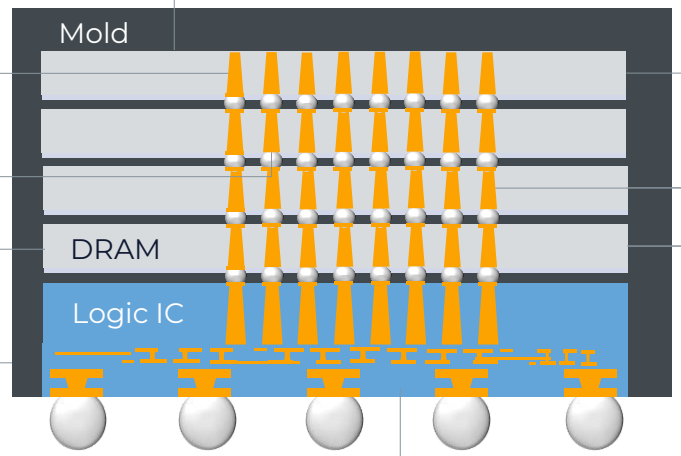
Technologies that are likely to make use of hybrid (or fusion) bonding

*MR-MUF: Mass Reflow Molded Underfill

**NCF-TCB: Non-Conductive Film Thermo-Compression Bonding

Source: "Next-Generation DRAM 2025" by Yole Group

HIGH-BANDWIDTH MEMORY – DETAILED SUPPLY CHAIN



TSV Process

APPLIED MATERIALS · TEL · Lam RESEARCH · KLA

TCB Process

Hanwha · HANMI · Shinkawa · TORAY · Kulicke & Soffa · ASMPT enabling the digital world · SEMES · SHIBAURA

Hybrid Bonding (currently in R&D)

APPLIED MATERIALS · Besi · TEL · SHIBAURA · EVG · ASMPT · set · SUSS

CMP, Grinding and Dicing

APPLIED MATERIALS · EBARA · ACCRETECH · HWATSING · DISCO · ADT

Molding Process

ASMPT · TOWA · YAMADA · Besi

DRAM

SK hynix · SAMSUNG · micron · CXMT

Logic IC

SK hynix · SAMSUNG · micron

Potential new entrants for customized HBM solutions

tsmc · Samsung Foundry · intel · SMIC

HBM IP

tsmc · NVIDIA · AMD · BROADCOM · GUC · MARVELL · SYNOPSYS · cadence · Rambus · aws · Meta · Microsoft · Google · And more...

Wafers

Shin-Etsu · SUMCO · SK siltron · GlobalWafers Co., Ltd. 環球晶圓股份有限公司 · siltronic

Plating Solution

DUPONT · BASF · ClassOne TECHNOLOGY · MacDermid Alpha ELECTRONICS SOLUTIONS · DOW · ACM RESEARCH

Gases

Linde · SK Inc. materials · MERCK · TAIYO NIPPON SANSO The Gas Professionals · Air Liquide · MESSER · SOLVAY · RESONAC

CMP Slurries and Pads

CMC MATERIALS · DUPONT · FNS TECH · MERCK · FUJIMI · TORAY · RESONAC · DOW · JSR · FUJIBO · SKC · DINGLONG

Tape (Dicing/Grinding)

Nitto · LINTEC · FURUKAWA ELECTRIC · Denka · SUMITOMO BAKELITE CO., LTD. · Mitsui Chemicals

Non-Exhaustive Lists!

Source: "Next-Generation DRAM 2025" by Yole Group

MEMORY BUSINESS IN MAINLAND CHINA

Companies active in the HBM ecosystem

Non-Exhaustive Lists!

micron
Xi'an (Assembly & test)

SAMSUNG
Xi'an (3D NAND)

UniIC 西安紫光国芯半导体有限公司 Xi'an UniIC Semiconductors Co., Ltd.
Xi'an (DRAM)

SMIC
Beijing (Foundry)

GigaDevice
Beijing (NOR, NAND, DRAM)

SOLIDIGM
Dalian (3D NAND)

HUA TIAN
Gansu, (OSAT)

SK hynix
Wuxi (DRAM)

SJSEMI
Jiangyin (OSAT)

Longforce
Suzhou(OSAT)

TF 通富微電
Jiangsu, (OSAT)

JCET
Jiangsu, (OSAT)

Wuhan (PCM)

YMTC
Wuhan (3D NAND)

XMC
Wuhan (Foundry)

YXSC
Wuhan (DRAM, NAND)

JHICC 晋华
Fujian(DRAM)

Puya
Shanghai (NOR, EEPROM)

RM
Hefei (RRAM)

cxmt
Hefei (DRAM)

SwaySure
Shenzhen (DRAM)

HUAWEI
Shenzhen (OEM)

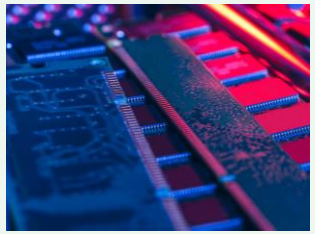
Source: "Status of the Memory Industry 2025" by Yole Group

SUMMARY & OUTLOOK

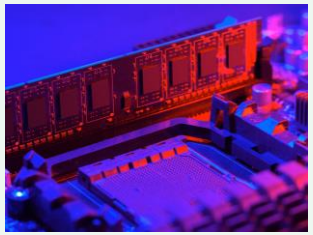
- HBM is no longer just a niche product, it's at the heart of the AI revolution, and the battle for HBM leadership is becoming a strategic race on the global stage.
- HBM is reshaping the DRAM industry, capturing a growing share of the market with a projected 33% CAGR and expected to reach ~50% of DRAM revenue by 2030.
- Revenue is set to double from approximately $17 billion in 2024 to around $34 billion in 2025.
- Advanced bonding solutions enable higher memory stacks and seamless logic integration – crucial for AI system innovation.
- China is stepping up its efforts to localize HBM production: strong domestic AI-accelerator demand, substantial government support, and an established industry network are likely to secure Chinese players a meaningful HBM foothold within the next few years.

YOLE GROUP MEMORY PRODUCTS

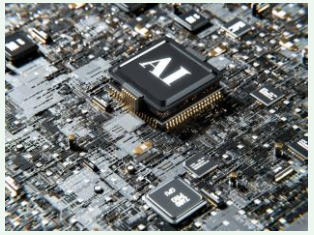
Market Monitors and Reports



NAND Market Monitor



Next-generation DRAM 2025 – Focus on HBM and 3D DRAM

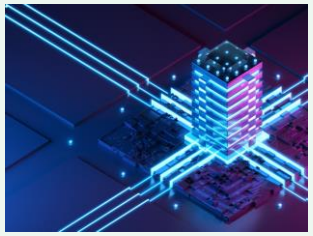


Generative AI 2025

Neuromorphic Computing, Memory and Sensing 2024

DRAM Market Monitor

Status of the Memory Industry 2025

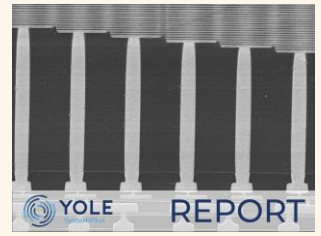


Emerging Non-Volatile Memory 2024

2025 edition coming soon

Status of the Processor Industry 2025

Technology, Process and Cost Reports



YMTC 232-layer 3D NAND

CXMT G4 DDR5 DRAM

SK hynix HBM3

MCU - Nuvoton M2L31 512 KB RRAM

FMS the Future of Memory and Storage

Non-exhaustive lists

ACKNOWLEDGEMENTS

Memory and Computing Analysts at Yole Group

John Lorenz Principal Analyst, Memory (DRAM)	Thibaut Grossi Senior Analyst, Memory (NAND)	Simone Bertolazzi, PhD Principal Analyst, Memory	Josephine Lau Senior Analyst, Memory	Daniel Niu Market Researcher	Tom Hackenberg Principal Analyst, MCU	Belinda Dube Senior Analyst, Integrated Circuits	Ying-Wu Liu Analyst, Integrated Circuit
							
› **Experience** 15+ years in memory and computing (Micron Technology) › **At Yole** DRAM, processors › **Education** Bachelor of Science in Mechanical Engineering from the University of Illinois Urbana-Champaign (USA), with a focus on MEMS devices.	› **Experience** 15+ in Electronic Procurement (Semiconductor, PC BA and software) › **At Yole** NAND › **Education** M.Sc. in Electronic and Computing science	› **Experience** 15 years in emerging semiconductor devices › **At Yole** Memory › **Education** Ph.D. in Nanoelectronics (EPFL, Switzerland) M.Sc. in Micro & Nanotechnology M.Sc. in Engineering Physics	› **Experience** 10+ years in memory and storage industry › **At Yole** Memory › **Education** Bachelor of business marketing Passed chartered financial analyst level	› **Experience** 3+ years in memory and processor industry › **At Yole** Memory, computing and AI China Market › **Education** Master's degree in chemical engineering	› **Experience** 20+ years in computing and microcontrollers › **At Yole** Computing › **Education** BSEE/BSECE from the University of Texas at Austin specializing in Processors and FPGAs.	› **Experience** 5+ years in computing, memory and advanced packaging › **At Yole SystemPlus** Memory, Computing & Advanced Packaging › **Education** M.Sc. in Nanoelectronics and Nanotechnology M.Sc. Electronics & Instrumentation	› **Experience** 8 years in the semiconductor industry › **At Yole SystemPlus** Computing › **Education** M.Sc. in theoretical physics M.Sc. in Integration, Security and Trust in Embedded systems

Thank you for your attention!

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