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1Y DRAM Analysis Product Brief

June 2019

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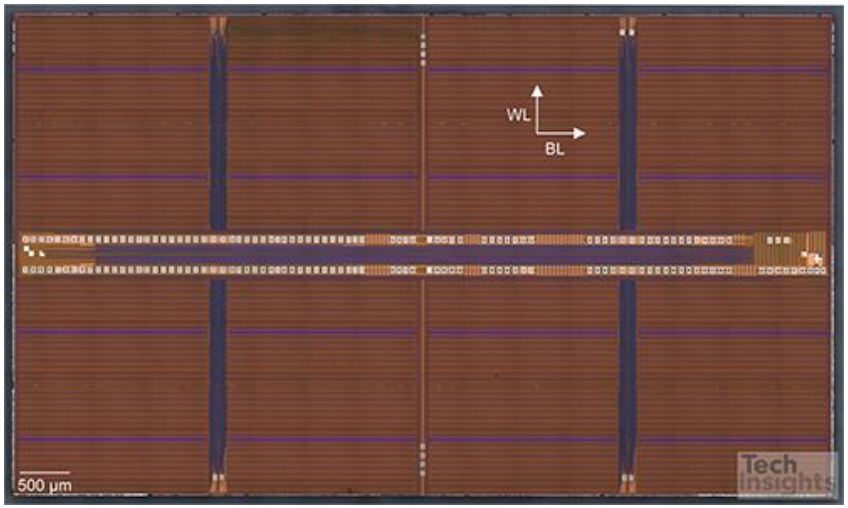
Markets	Devices	Scope
Consumer Electronics Mobile Devices Medical Devices Storage Devices Automotive Electronics Internet of Things Semiconductors Wi-Fi Clean-Tech Devices Optoelectronics	DRAM Memory NAND Flash Memory Microprocessors / Controllers Wireless R/F Analog Antennas Power Management Sensors Displays	Product Teardowns & Costing / BOM Structural / Materials Analysis Packaging Analysis Circuit Extraction and Analysis Transistor Characterization Waveform Analysis Functional Testing Software Analysis

DRAM Memory

Where PCs were once the main driving force in the Dynamic random-access memory (DRAM) industry; now, there is a much more diversified market fuelling innovation in this space. As the ever-increasing need for more powerful devices continues to build, so, too does the availability of high-capacity processors, semiconductors, and chipsets. Smartphones, tablets, data centers, automotive applications, and increasingly the IoT, as well as high-bandwidth memory requirements for AI and machine learning, are behind record industry profits.



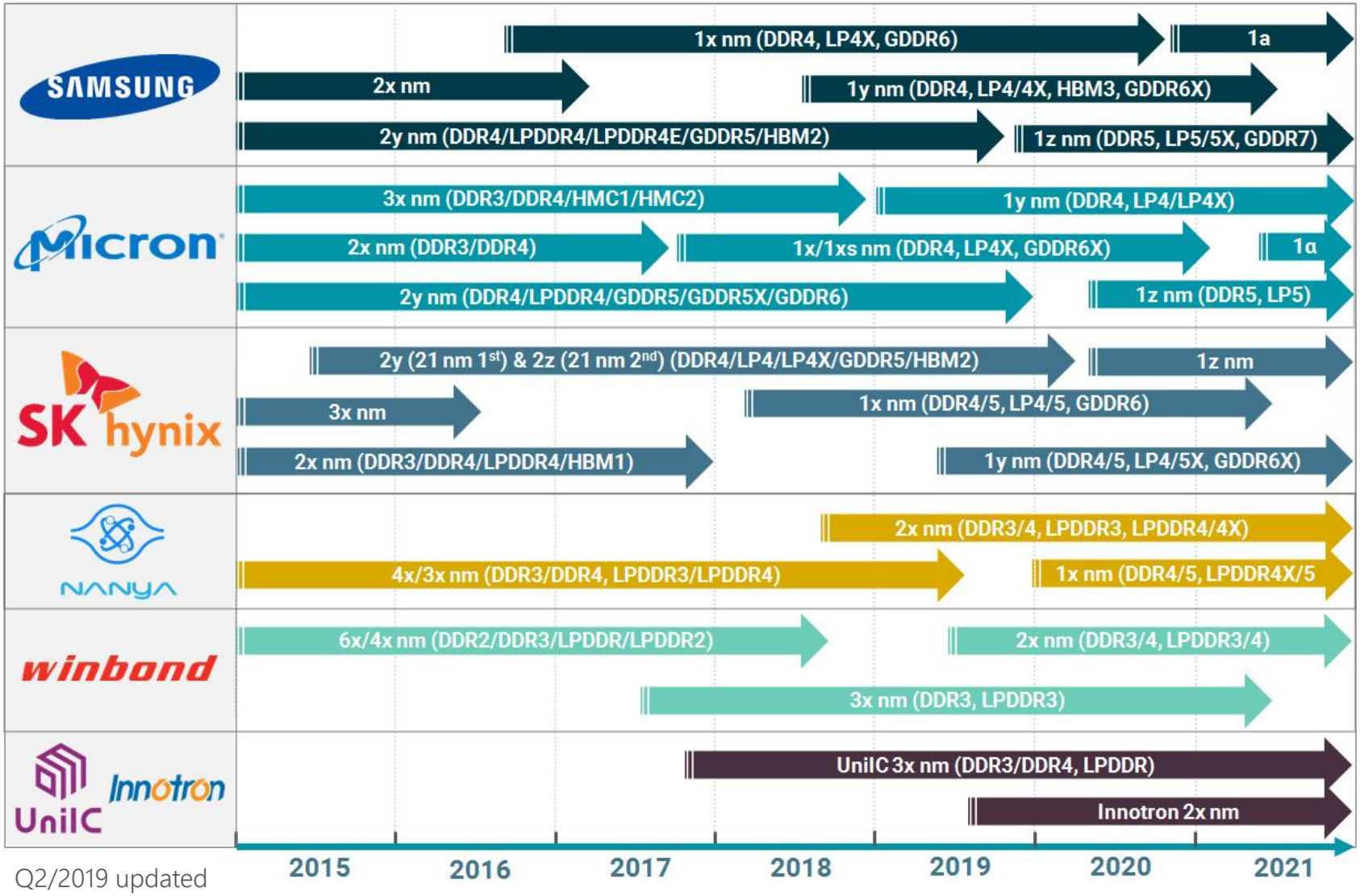
DRAM is forecast to experience a CAGR of 28.70% between 2018 and 2023. Manufacturing successes in Korea, Taiwan, Japan and China have positioned Asia as a prominent DRAM market.

With the DRAM market still booming, all the major DRAM players such as Samsung, SK Hynix, Micron and Nanya are eager to develop and release their next new successfully-scaled-down generation. The top 3 DRAM manufacturers have already jumped into the sub-20 nm technology node, by introducing offerings such as 1X nm in 2017 and 2018, like Samsung's 1X and 1Y LPDDR4X, DDR4 and GDDR6, and DRAM down-scaling will continue within a few years.

Given that DRAM cell TR engineering and capacitor structures offer limited capability to further scale down to 18 or 1a, major players may look to adopt new technology innovations such as pillar cell capacitors, higher-k capacitor dielectrics, dual work-function layers for buried wordline gates, lower-k dielectric spacers and air gaps.

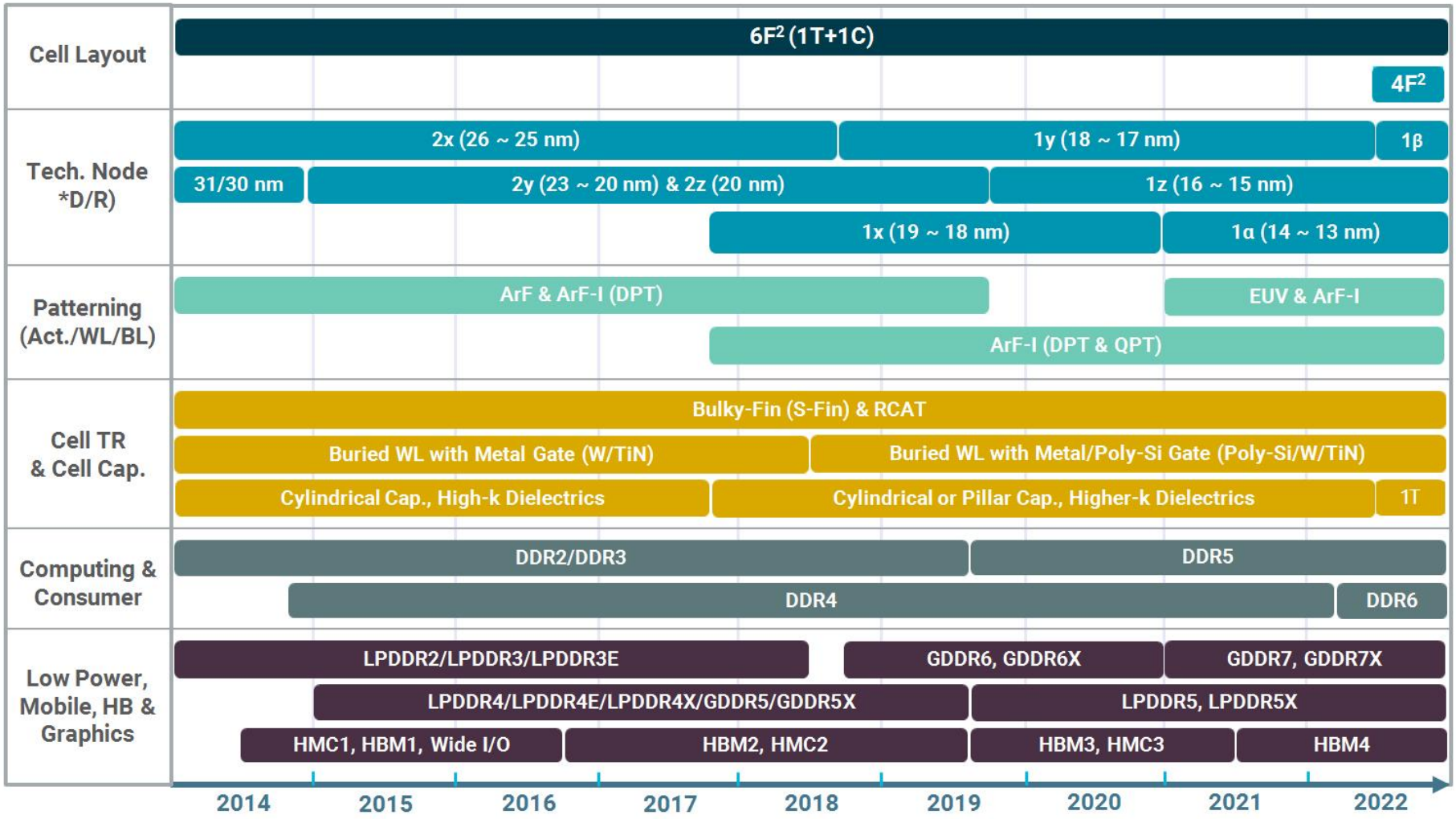
1T-DRAM or capacitorless DRAM products with 4F2 cell design may not be seen for a while, but we will see DDR5, LPDDR5 products on the commercial market by the end of this year or early next year at the latest. HBM2 (Samsung, SK Hynix) and HMC2 (Micron) are now widely used for GPU (AMD, NVIDIA). Some new Chinese DRAM companies - including UniIC and Innotron – have introduced their products to the market, and we are excited to analyze Samsung’s GDDR6.

DRAM Product Roadmap



- Q2/2019 updated

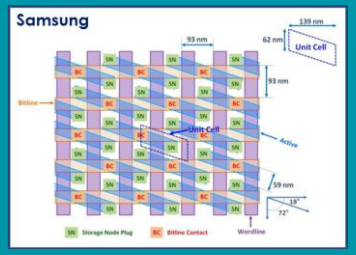
DRAM Roadmap: Technology & Application

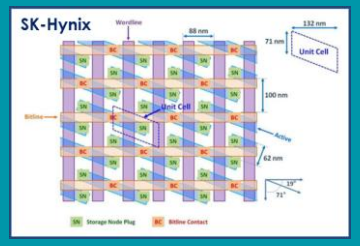


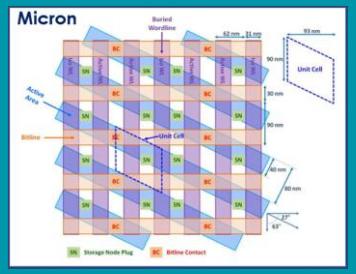
- Q2/2019 updated

DRAM Technology Innovation

30 nm – Class

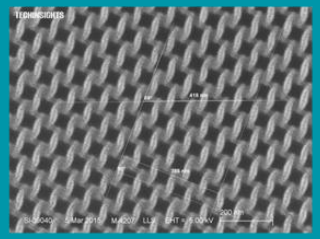


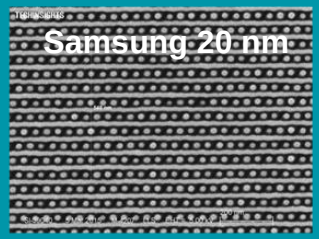




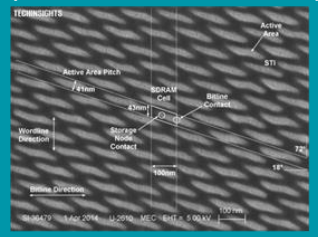
20 nm – Class

Samsung DDR4 K4A8G045WBBCPB Technology Node
(Removed from 32GB DDR4 DIMM @2015

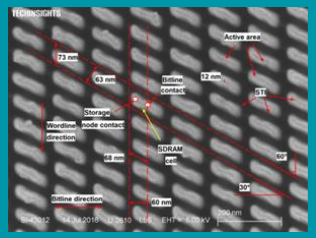


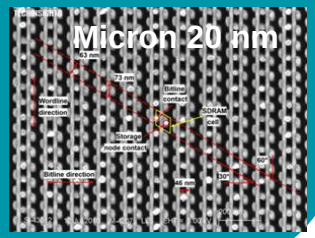


SK Hynix LPDDR3 H9TQ18ABJTMC Technology Node
(Removed from TCL idol X+ Smartphone)



Micron GDDR5X MT58K256M32JA Process Node @2016

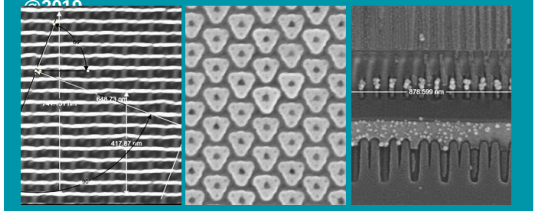




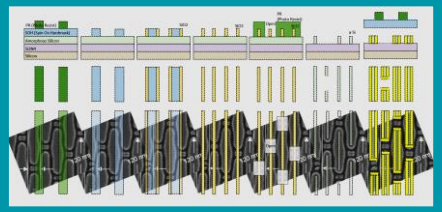
10 nm – Class

Samsung 18 nm (1x)

Samsung 1y LPDDR4X K3UHAHA0AM-AGCL S10+
@2019



- 16 nm Active HP with QPT
- 46 nm WLP, 52 nm BLP
- Honeycomb Cap.
- LP4X with 12 dies/PKG



1y, 1z, 1a (1α), etc.

More Process and Circuit Tech. Innovation needed (QPT, Pillar Cap., Higher-k, 4F2, 1T DRAM, EUV, Triple MESH, High-S/A, etc.)

- Q2/2019 updated

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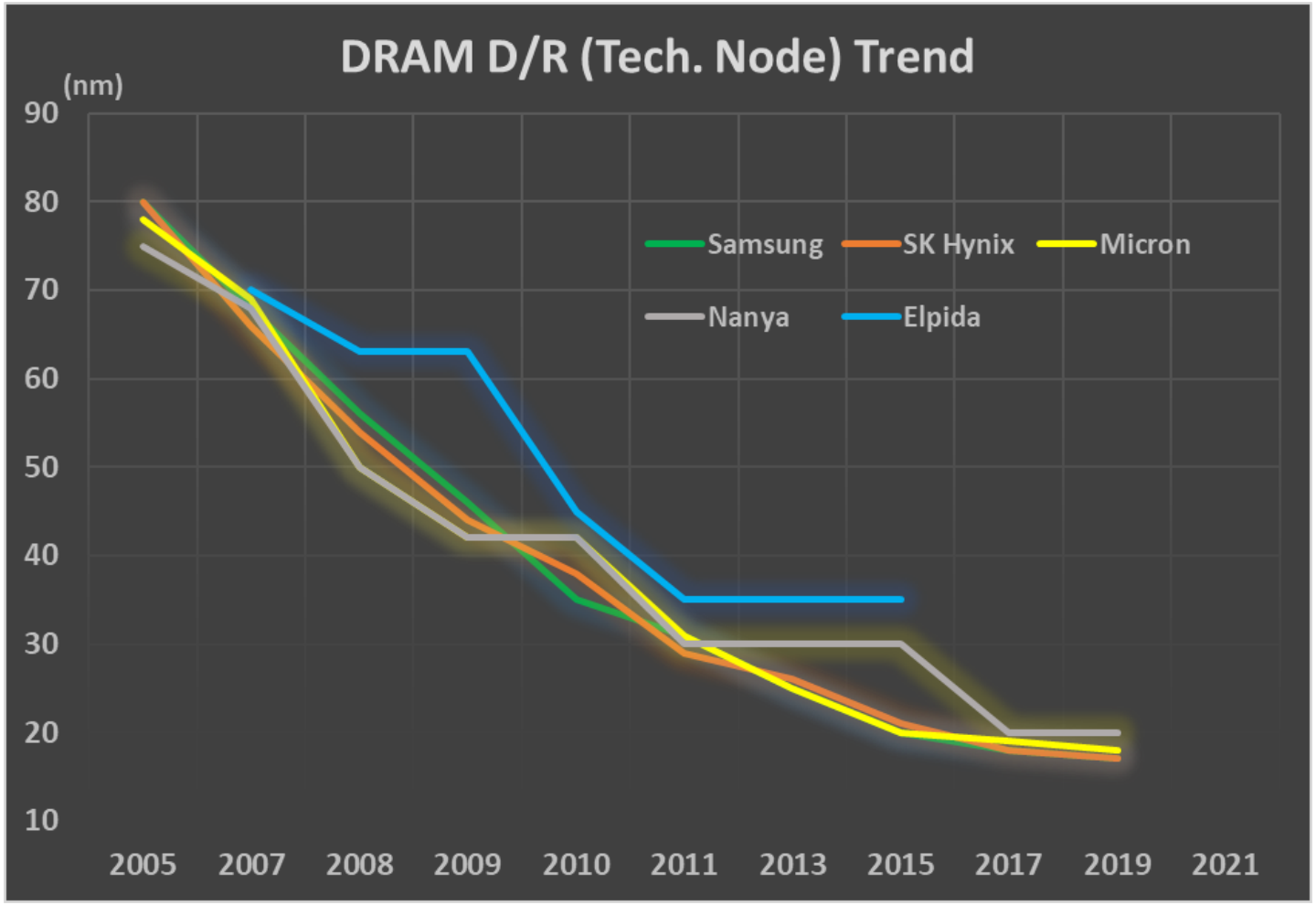
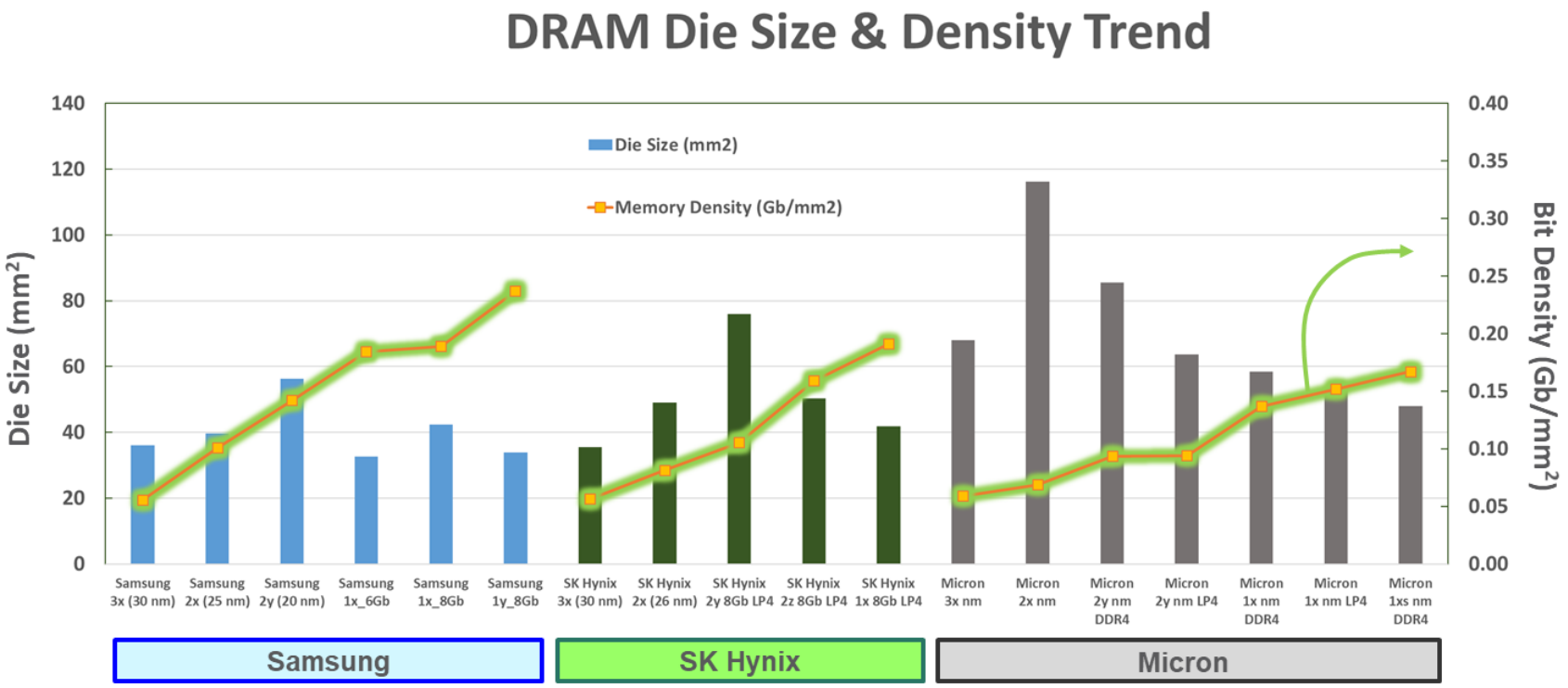
DRAM D/R (Technology Node) Trend

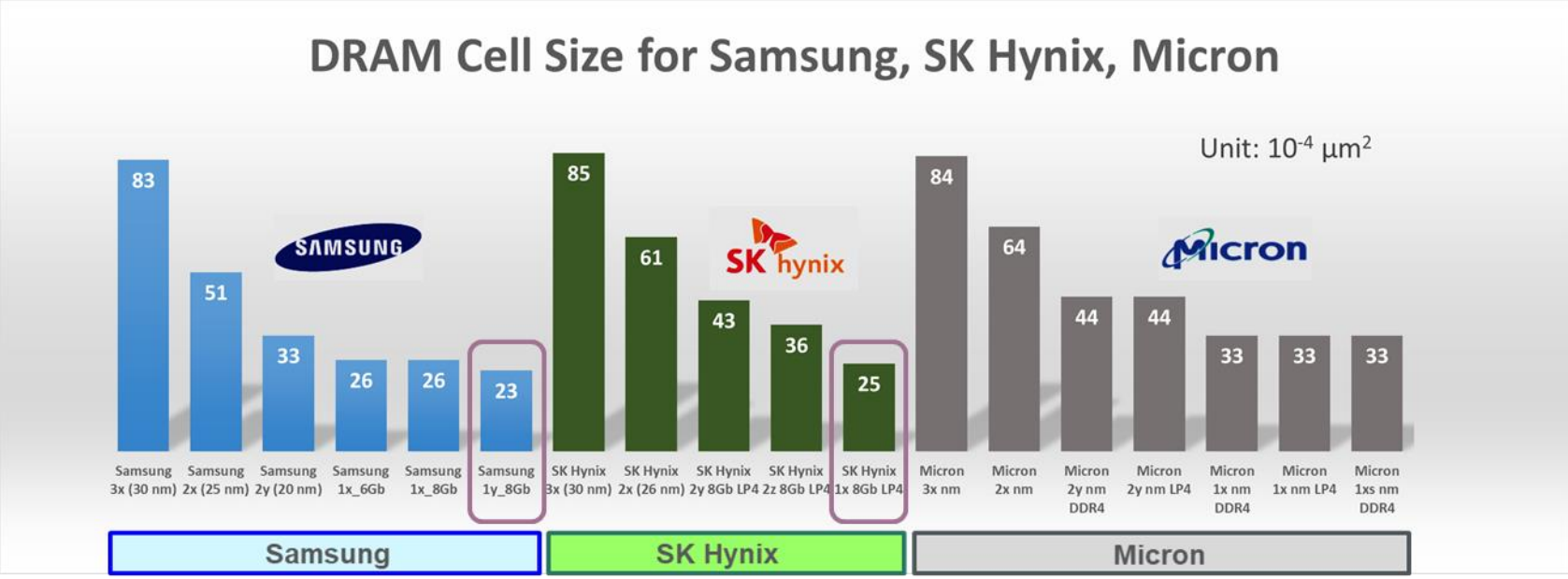


DRAM Die Size & Density Trend (updated)

- ✓ Samsung 1y ~ 0.237 Gb/mm^2, while SK Hynix 1x ~ 0.191 Gb/mm^2



DRAM Cell Size: Scaling-down Trend (updated)



Samsung 8 Gb DDR4 Die comparison: 1x *vs.* 1y

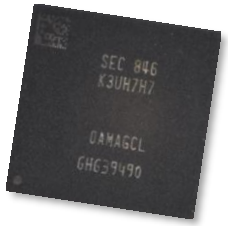
Device	1X DDR4	1Y DDR4
Parents Products	M471A2K43CB1-CRC DIMM 16GB 2Rx8 PC4-2400T-SE1-11	M471A1K43DB1-CTD 8GB DDR4 SODIMM
Components	1 GB DDR4	1 GB DDR4
PKG Markings	K4A8G085WC-BCRC	K4A8G085WD-BCTD
# die / PKG	1	1
Die Markings	K4A8G085WC	K4A8G085WD
Memory Capacity	8 Gb	8 Gb
Die Size (Seal Die: L x W)	42.35 mm^2 (8.60 mm x 4.90 mm)	33.20 mm^2 (8.02 mm x 4.14 mm)
Bit Density	0.189 Gb/mm^2	0.241 Gb/mm^2
Cell Size	0.0026 μm^2	0.0023 μm^2
Pitch (Act/WL/BL)	37nm / 48nm / 54nm	32nm / 46nm / 52nm
D/R (Likely)	18.0 nm	17.1 nm

Samsung 8 Gb LPDDR4X Die Comparison: 1x *vs.* 1y

Device	1X LPDDR4X	1Y LPDDR4X
Parents Products	Samsung Galaxy S9	Renovo Z5 phone Samsung Galaxy S10+
Components	32 Gb LPDDR4X	64 Gb LPDDR4X (Z5, S10+/DS) 96 Gb LPDDR4X(S10+ 975N)
PKG Markings	K3UH5H50MM-NGCJ	K3UH7H70AMAGCL (Z5, DS) K3UHAHA0AM-AGCL (S10+ 975N)
# die / PKG	4	8 (Z5), 12 (S10+ 975N)
Die Markings	K4F8E164HM	N/A
Memory Capacity	8 Gb / Die	8 Gb / Die
Die Size (Seal Die: L x W)	42.13 mm^2 (9.24 mm x 4.56 mm)	33.80 mm^2 (7.99 mm x 4.23 mm)
Bit Density	0.190 Gb/mm^2	0.237 Gb/mm^2
Cell Size	0.0026 μm^2	0.0023 μm^2
Pitch (Active/WL/BL)	37nm / 48nm / 54nm	32nm / 46nm / 52nm
D/R (Likely)	18.0 nm	17.1 nm

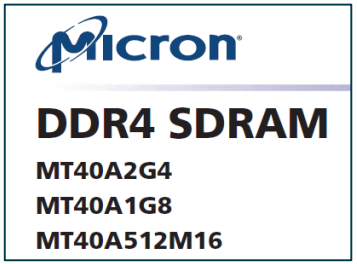
Recent 1y DDR Events

- Samsung LPDDR4X 17nm 1y
  - Found in product: Lenovo Z5 Pro GT (L78032)
  - K3UH7H70AM-AGCL 64Gb



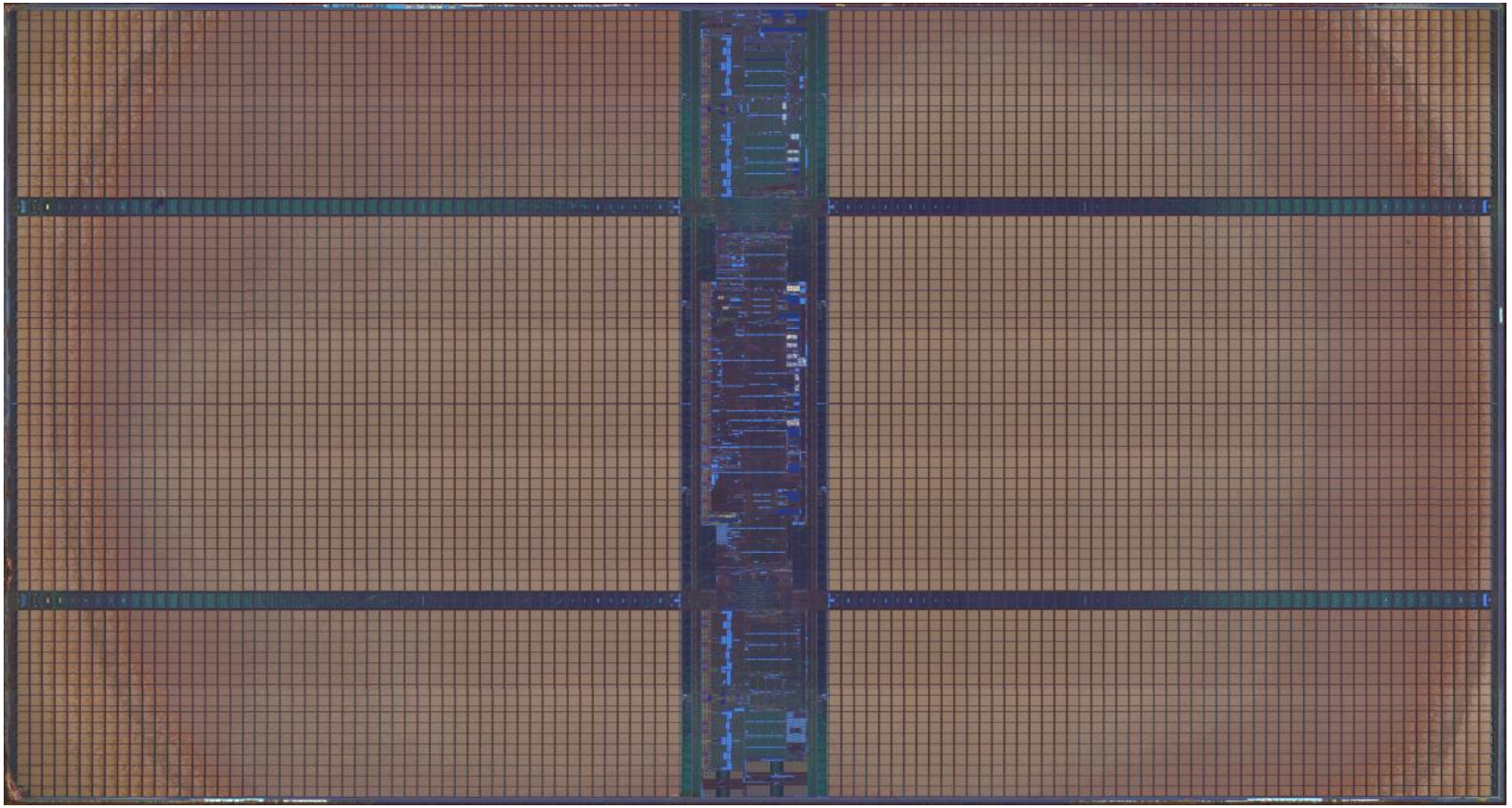
- Samsung DDR4 17nm 1y
  - Found in product: Samsung M471A1K43DB1-CTD DDR4 DIMM
  - K4A8G085WD-BCTD 8GB

- Micron 17nm 1y
  - Found Component
  - MT40A2G4SA-062E:J 8GB



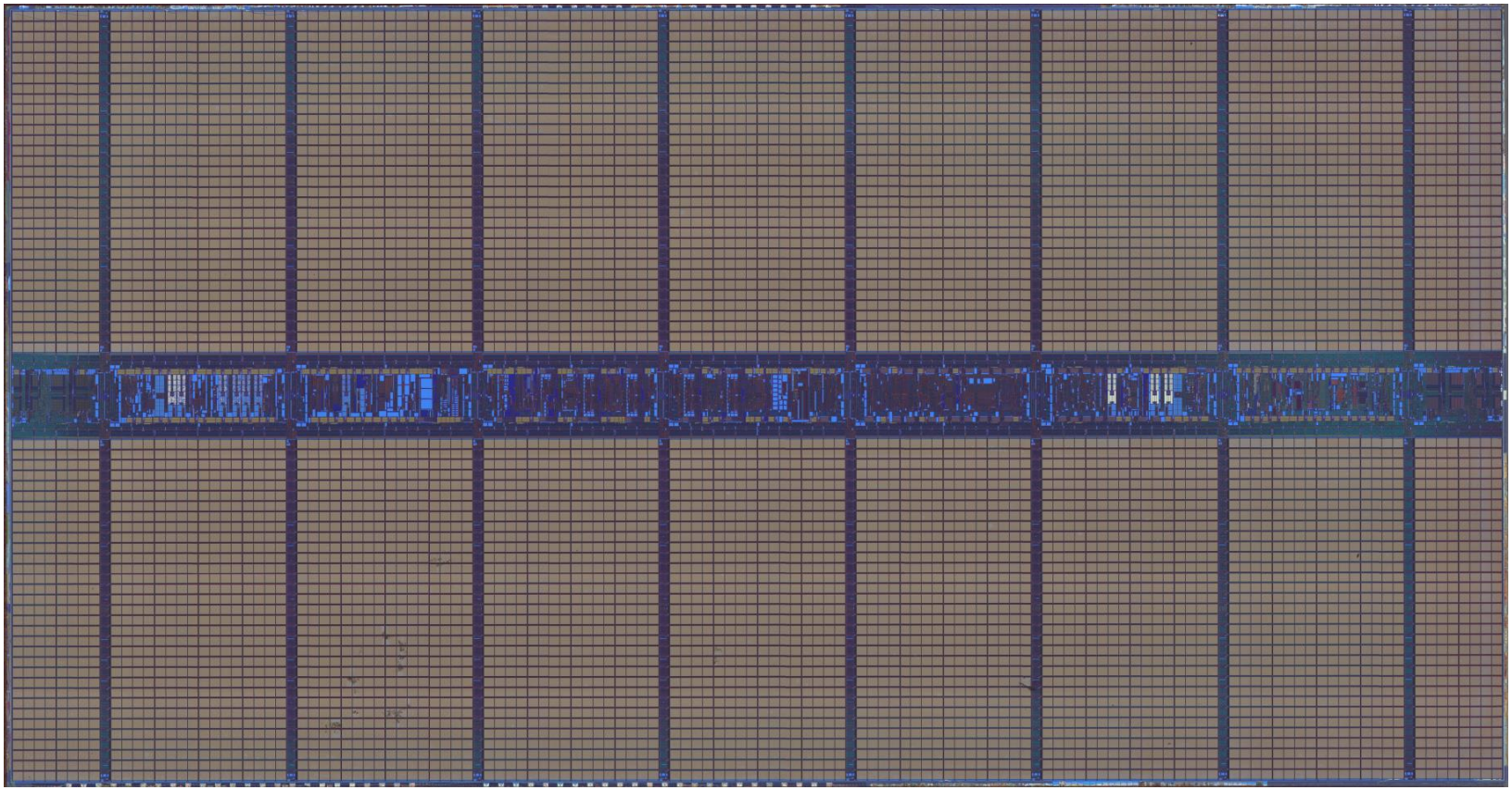
- Looking for:
  - SK Hynix 1y

Samsung LPDDR4X 17nm 1y K3UH7H70AM-AGCL



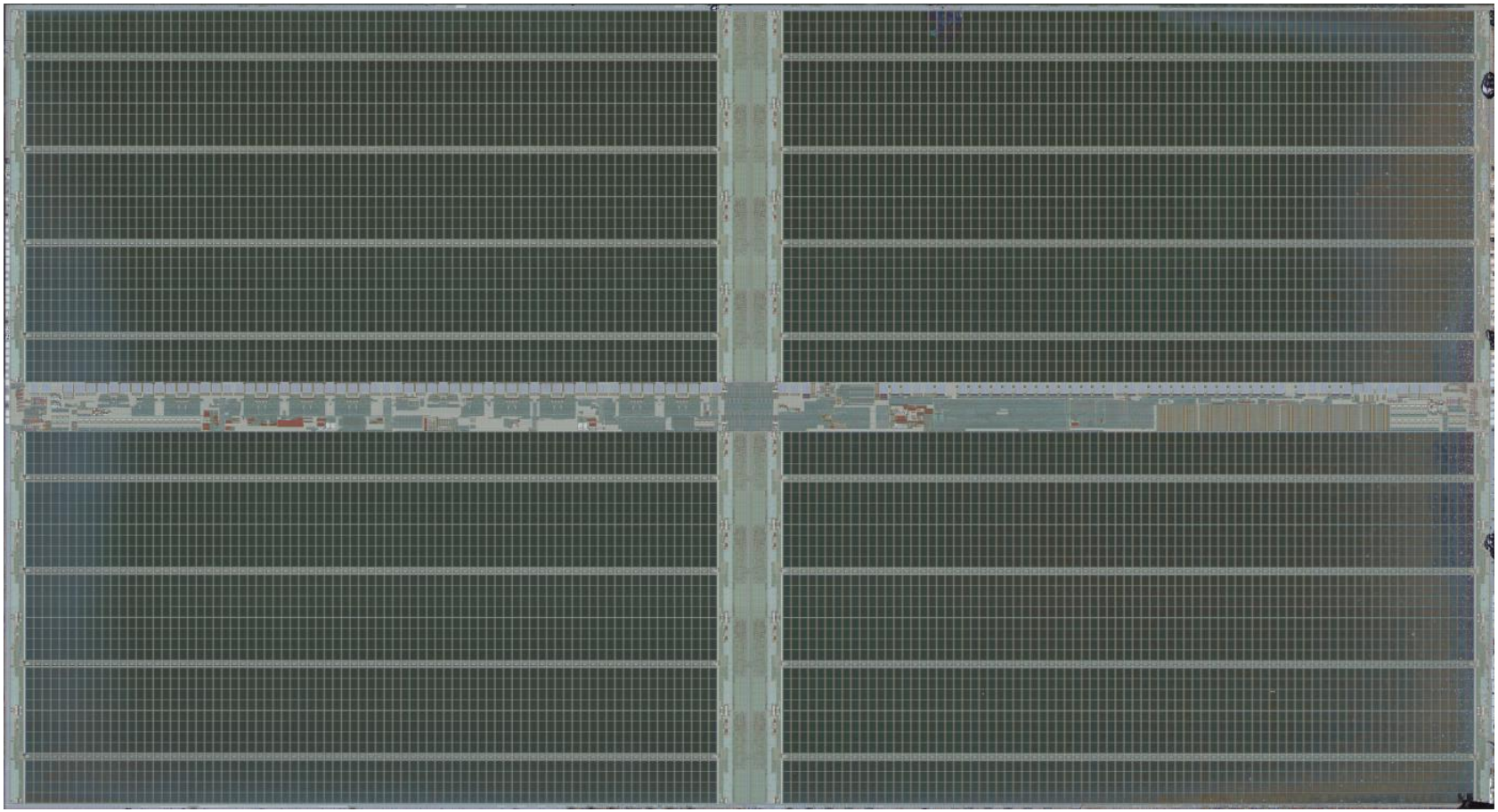
8Gb: 8.03mm x 4.28mm

Samsung DDR4 17nm 1y K4A8G085WD-BCTD



8Gb: 8.08mm x 4.19mm

Micron 17nm 1y MT40A2G4SA-062E:J



8Gb: 8.57mm x 4.64mm

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Item	Part Number	Process Reports	Circuit Reports
Samsung LPDDR4X 17nm 1Y	K3UH7H70AM-AGCL	• AME-1902-802 (May 31) • MFR-1902-801 (Complete) • TCR-1905-801 (TBD)	• Contact TechInsights for more information
Samsung DDR4 17nm 1Y	K4A8G085WD-BCTD	• MDP-1905-804 (June 3) • MFR-1902-802 (Complete)	• CAR-1904-801: Array, peripherals and Datapath • Tentative: Full Circuit Analysis
Micron 17nm 1y	MT40A2G4SA-062E:J 8Gb DDR4	• MFR-1905-802 (June 28) • AME-1905-801 (Aug. 1)	• Contact TechInsights for more information

Other Key DRAM reports:

Item	Part Number	Process Reports	Circuit Reports
SK Hynix 17nm 1y	searching for part	-	-
SK Hynix DDR5/LPDDR5*	searching for part	-	CAR-1903-801: Full Analog Circuit Analysis

AME = Advanced Memory Essentials
MFR = Memory Floorplan Analysis
MDP = Memory Peripheral Design

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Additional DRAM Analysis Reports

Report Name	Manufacturer	Item Code	Product Code	Availability
Studio Database on the Samsung DDR4 17nm 1Y (Samsung DDR4 17nm 1Y)	Samsung	SAM-K4A8G085WD-BCTD	SDB-1904-801	In Creation
CircuitVision Analysis of the Array and Periphery of the Samsung K4A8G085WD-BCTD 17nm 1Y DDR4	Samsung	SAM-K4A8G085WD-BCTD	CAR-1904-801	In Creation
Partial CircuitVision Analysis on the Nanya Elixir N2CB2G80BN-CG 50nm 2Gbit DDR3 SDRAM	Elixir	ELX-N2CB2G80BN-CG	CAR-1801-207	In Creation
Samsung K4A8G085WD-BCTD 1y 8 Gb DDR4 SDRAM Memory Floorplan Analysis	Samsung	SAM-K4A8G085WD-BCTD	MFR-1902-802	Published
SK Hynix H5AN8G8NCJR-VKC 1X DRAM DDR4 Memory Floorplan Analysis	Hynix	HYN-H5AN8G8NCJR-VKC	MFR-1901-802	Published
Samsung K3UH6H60AM-AGCJ 1x LPDDR4X SDRAM Transistor Characterization	Samsung	SAM-KMDJ6001FMA319	TCR-1901-801	Published
CircuitVision Analysis of the Micron Technology MT53D512M64D4NZ-053_WT_D LPDDR4 SDRAM	Micron Technology	MIC-MT53D512M64D4NZ-053_WT_D_die	CAR-1806-202	Published
SK Hynix H9HKNNNEBMBU-DRNEH LPDDR4X SDRAM 1x Advanced Memory Essentials	Hynix	HYN-H9HKNNNEBMBU-DRNEH	AME-1811-801	Published
SK Hynix H9HKNNNEBMBU-DRNEH LPDDR4X SDRAM Memory Floorplan Analysis	Hynix	HYN-6GALLPD4E	MFR-1811-802	Published
Micron Technology MT40A1G8SA-062E 1x nm DDR4 SDRAM Transistor Characterization of the Word Line Drivers and Sense Amplifiers	Micron Technology	MIC-MT40A1G8SA-062E	TCR-1805-801	Published
CircuitVision Analysis of DQU and Main Amp block of the Samsung K3UH5H50MM LPDDR4X DRAM	Samsung	SAM-K3UH5H50MM-NGCJ	CAR-1802-901	Published
SK Hynix H9HP52AECMMD-BRKMM NAND Flash and LPDDR4 SDRAM Module Exploratory Package Report	Hynix	HYN-H9HP52AECMMD-BRKMM	EXR-1809-802	Published

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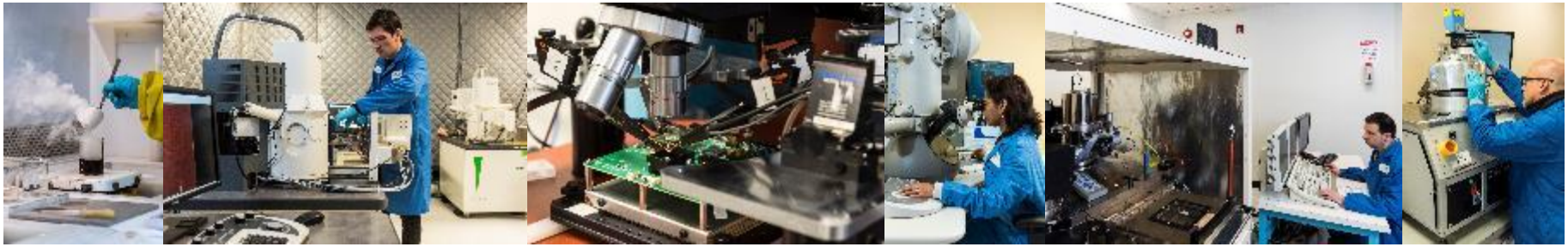

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