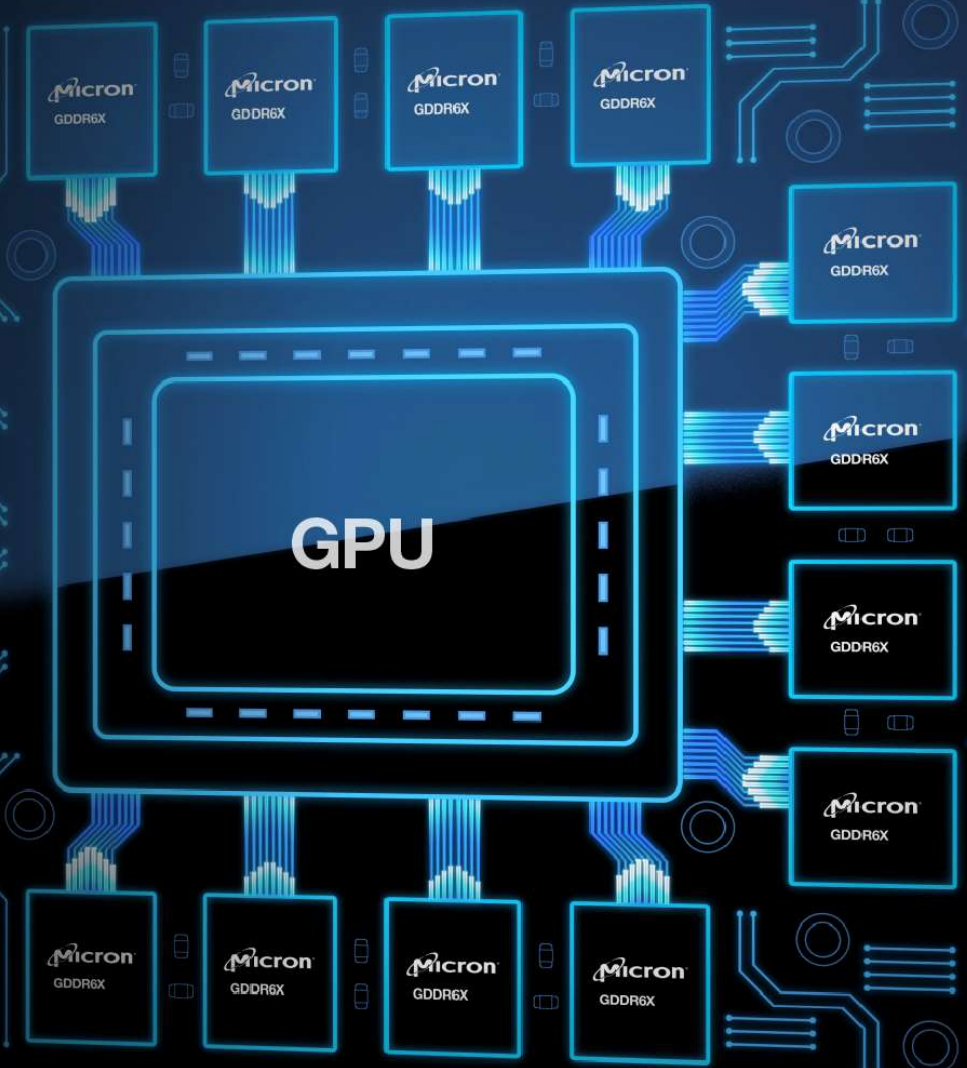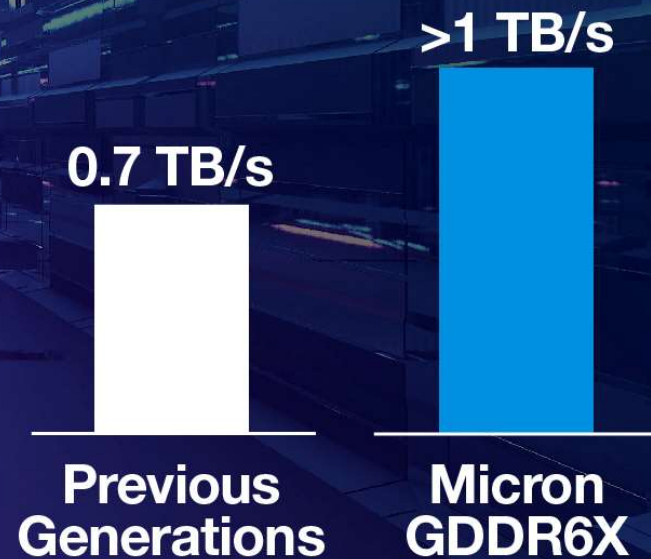# GDDR6X

Memory Reimagined

Micron's GDDR6X memory uses innovative signaling technology to double the data rate, delivering unprecedented graphics memory performance to feed the most data-hungry workloads.

Faster. Smoother.

To achieve this breakthrough, Micron has applied innovative signal transmission technology (PAM4) to completely reimagine how memory moves data.

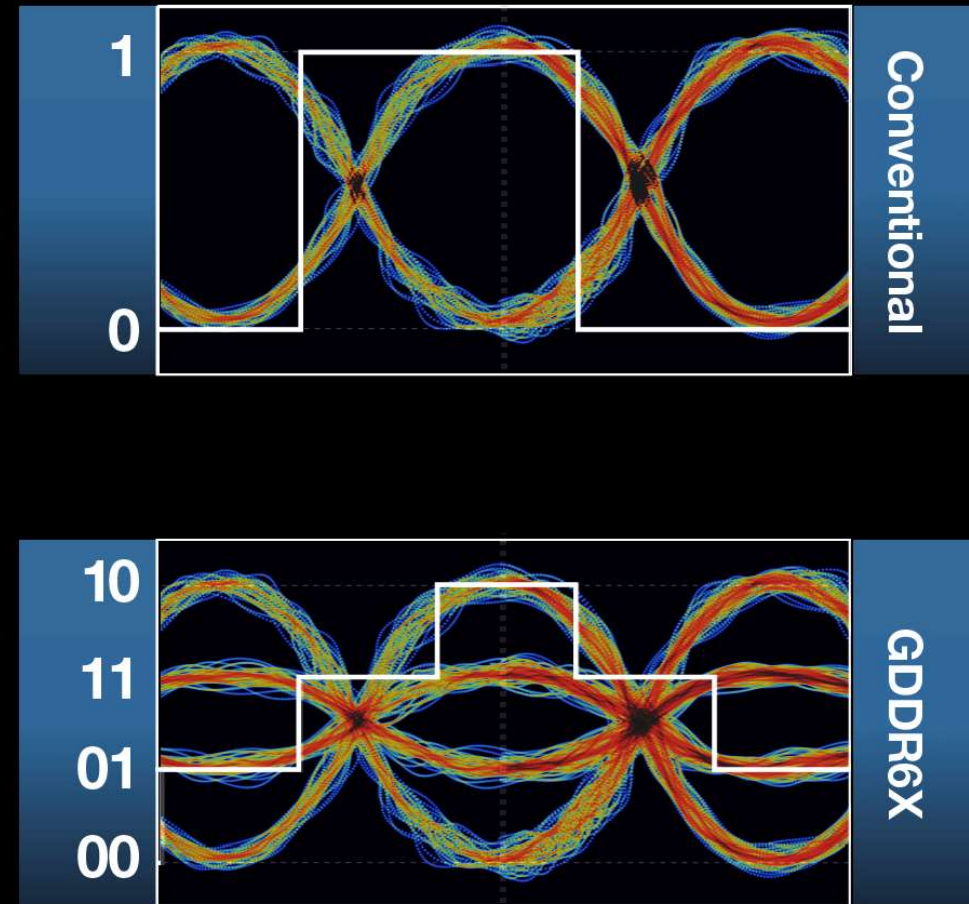System Bandwidth

>1 TB/s
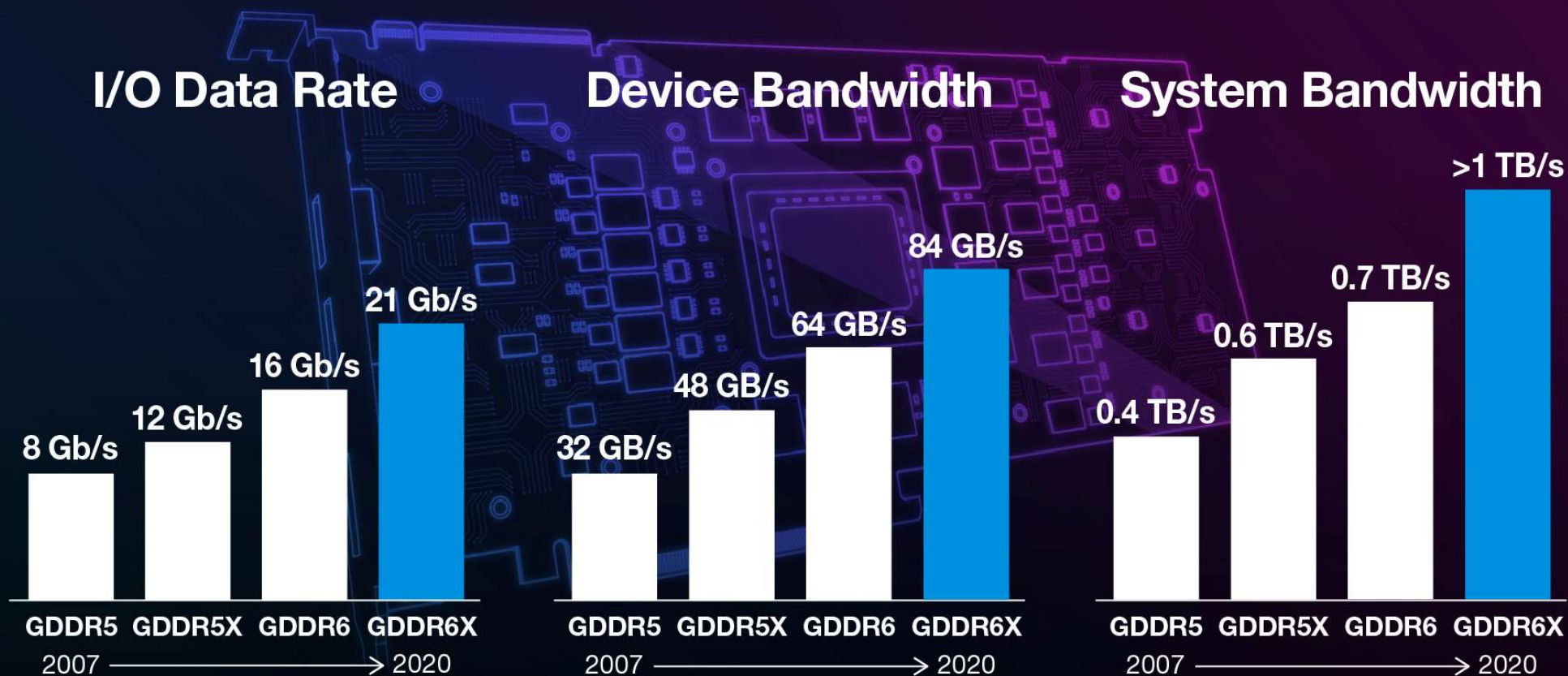
0.7 TB/s

Previous Generations

Micron GDDR6X

Doubling Data Down Every Wire

By using PAM4 multilevel signaling, Micron GDDR6X transfers more data and at a much faster rate, moving two bits of information at a time to double the I/O data rate.
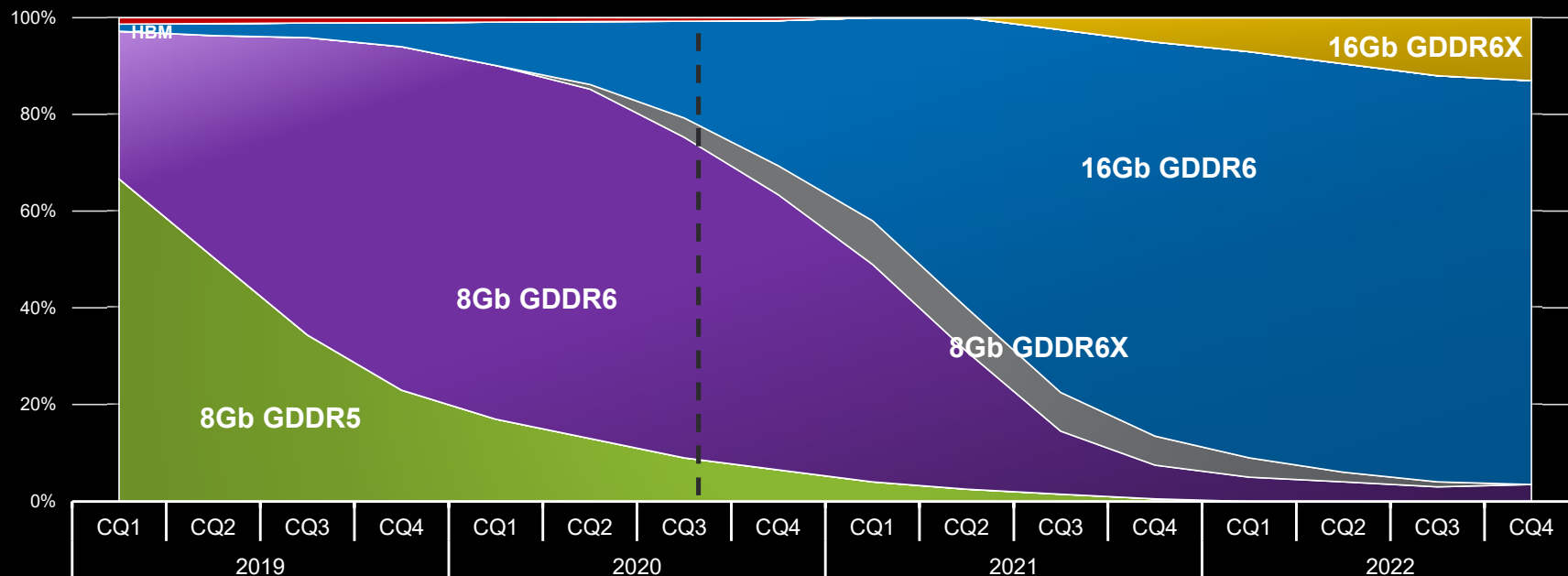
Delivering Ultra-Bandwidth

High Performance DRAM Comparison

Type	Standard DRAM				Ultra-Bandwidth Solutions			
	DDR4	DDR5*	LPDDR4/X	LPDDR5*	GDDR5	GDDR6	GDDR6X	HBM2E
Die Density	Up to 16Gb	Up to 64Gb	Up to 32Gb	Up to 32Gb	Up to 8Gb	Up to 32Gb	Up to 16Gb	16 Gb 4-H and 8-H
Prefetch Size	8n	16n	16n	16n/32n	8n	16n	16n	4n
Voltage (Vdd)	1.2V	1.1V	1.1V	1.05V	1.5V and 1.35V	1.35V and 1.25V	1.35V and 1.25V	1.2V
I/O Voltage (Vddq)	Same as VDD	Same as VDD	1.1/0.6V	0.5V	Same as VDD	Same as VDD	Same as VDD	Same as VDD
Max Data Rate	Up to 3.2Gbps	Up to 6.4Gbps	Up to 4.26Gbps	Up to 6.4Gbps (investigating > 6.4Gbs)	Up to 8.0 Gbps	Up to 16.0 Gbps (>16Gbps in planning)	21 Gbps (>21 Gbps in planning)	Up to 3.2Gbps
Burst Length	BC4, 8	BC8,16	16, 32	16,32	8	16	8 in PAM4 mode 16 in RDQS mode	4
Device Width (I/O)	x4, x8, x16	X4/x8/x16	2Ch x16	x8/x16	x32/x16	2ch x16/x8	2ch x16/x8	x1024
Internal Banks	16 (x4/x8) 8 (x16)	32(x4/x8) 16(x16)	8/Ch	16	16	16	16	16 (4-H), 32 (8-H)
Bank Groups	4 (x4/x8) 2 (x16)	8(x4/x8) 4(x16)	N/A	4	N/A	4	4	4 or 8
Key Timing Parameters								
Data Rate	3.2Gbps	4.8Gbps	4.26Gbps	6.4Gbps	8.0Gbps	16.0Gbps	19 Gbps, 21 Gbps	3.2Gbps
Read Latency (tAA)	~12.5 – 15ns	~15 – 18.33ns	~17	~22ns	~15 ns	~15 ns	~15ns	~25 ns
Row Cycle Time (tRC)	45 - 47ns	47-50.3	60 - 63ns	60 to 63ns	40- 45ns	40- 45 ns	40-45ns	45ns
Bank Address Delays (tRRD/tFAW)	2.5–6.4ns/ 10-30ns	1.67-5ns/ 13.3-16.7ns	10ns/ 40ns	5ns/ 20ns	4ns/ 16ns	2.5ns/ 10ns	2ns/ 8ns	2.5ns/ 10ns
Bus Turn Delay (tWTR)	2.5 – 7.5ns	2.5 - 10ns	10ns	12ns	5ns	5ns	5ns	5.4ns
Energy per bit (est.)	10pJ/bit	6pJ/bit	5pJ/bit	4pJ/bit	9pJ/bit	8.5pJ/bit	7.25pJ/bit	6pJ/bit
Self refresh power (IDD6R)	24mW	TBD	< 1mW	< 1mW	20mW	40mW	NA	TBD

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*DDR5 and LPDDR5 still in JEDEC definition. Subject to change.

Minimum associated clock cycles may also apply

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Graphic Card Market Transition (Volume 1Gb equivs)

Key Points

- 8Gb is main density from 2017-2020
- 16Gb GDDR6 intro in CY19, larger adoption from 2H2020
- GDDR6X intro in 2H'20 drives performance leadership
- 2021: 16Gb GDDR6 becomes market driver in volume
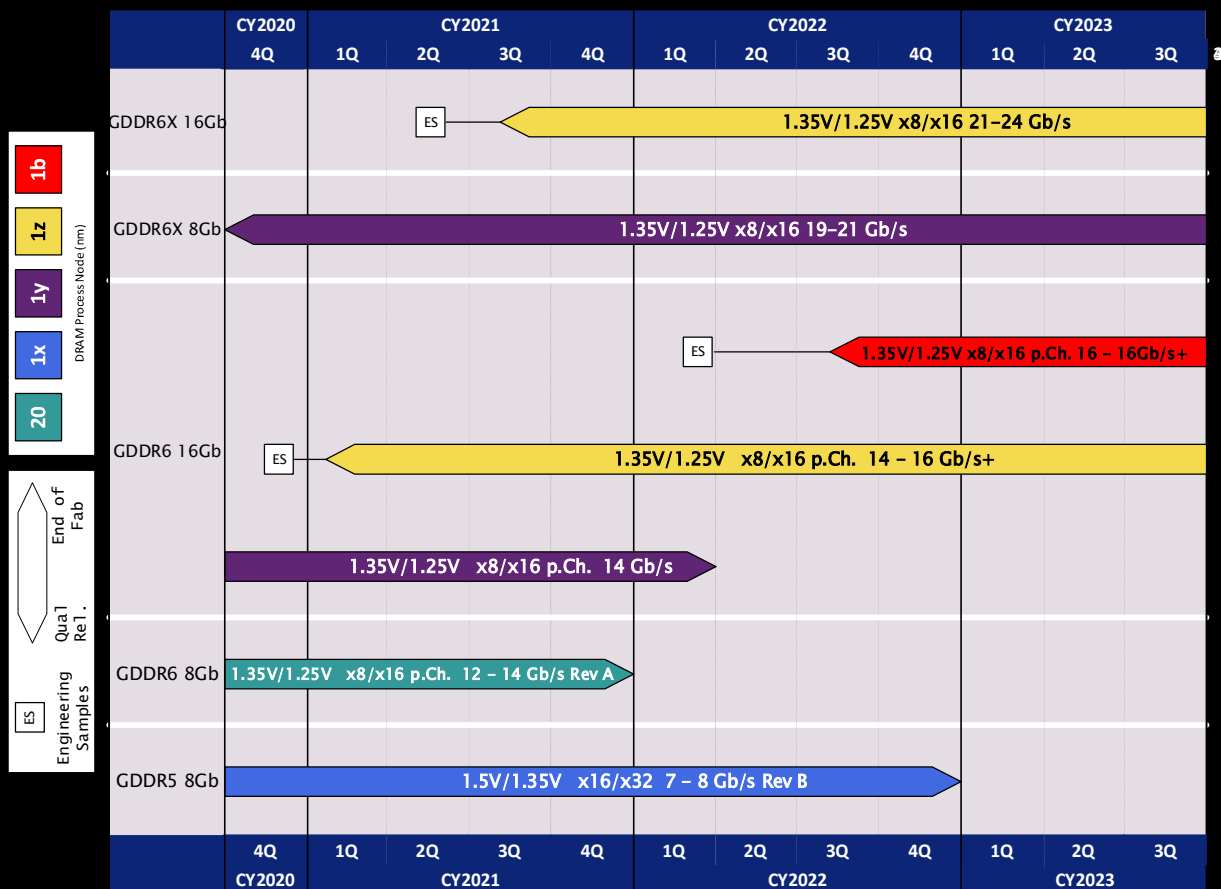- 2020: 8Gb GDDR5 remaining in some legacy platforms

Chart labels: HBM, 16Gb GDDR6X, 16Gb GDDR6, 8Gb GDDR6, 8Gb GDDR6X, 8Gb GDDR5

X-axis: CQ1 CQ2 CQ3 CQ4 (2019) | CQ1 CQ2 CQ3 CQ4 (2020) | CQ1 CQ2 CQ3 CQ4 (2021) | CQ1 CQ2 CQ3 CQ4 (2022)

Market Segmentation	2019	2020	2021	2022
High End/Enthusiast	8Gb GDDR6: 14-16Gb/s	8Gb GDDR6X: 19-21Gb/s 16Gb GDDR6: 16Gbps	16Gb GDDR6X: 21-24Gb/s 16Gb GDDR6: 16Gbps	16Gb GDDR6X: 21-24Gb/s
Performance	8Gb GDDR6: 12-14Gb/s 8Gb GDDR5: 8Gb/s	8Gb/16Gb GDDR6: 14Gb/s	16Gb GDDR6: 14-16Gb/s	16Gb GDDR6: 16Gb/s
Mainstream/Value	8Gb GDDR6 GDDR5	8Gb GDDR6 GDDR5	8Gb/16Gb GDDR6	16Gb GDDR6

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Graphics DRAM Roadmap – Nov'20

	CY2020	CY2021				CY2022				CY2023		
	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q

DRAM Process Node (mm): 1b, 1z, 1y, 1x, 20

- GDDR6X 16Gb: ES — 1.35V/1.25V x8/x16 21–24 Gb/s
- GDDR6X 8Gb: 1.35V/1.25V x8/x16 19–21 Gb/s
- ES — 1.35V/1.25V x8/x16 p.Ch. 16 – 16Gb/s+
- GDDR6 16Gb: ES — 1.35V/1.25V x8/x16 p.Ch. 14 – 16 Gb/s+
- 1.35V/1.25V x8/x16 p.Ch. 14 Gb/s
- GDDR6 8Gb: 1.35V/1.25V x8/x16 p.Ch. 12 – 14 Gb/s Rev A
- GDDR5 8Gb: 1.5V/1.35V x16/x32 7 – 8 Gb/s Rev B

Legend: End of Fab, Qual Rel., Engineering Samples (ES)

Key Points

GDDR6X
- FBGA 180, 0.75mm; VDD 1.35V
- 8Gb   (1ynm): 19-21 Gb/s
  - MP CQ3'20
- 16Gb   (1znm): 21-24 Gb/s
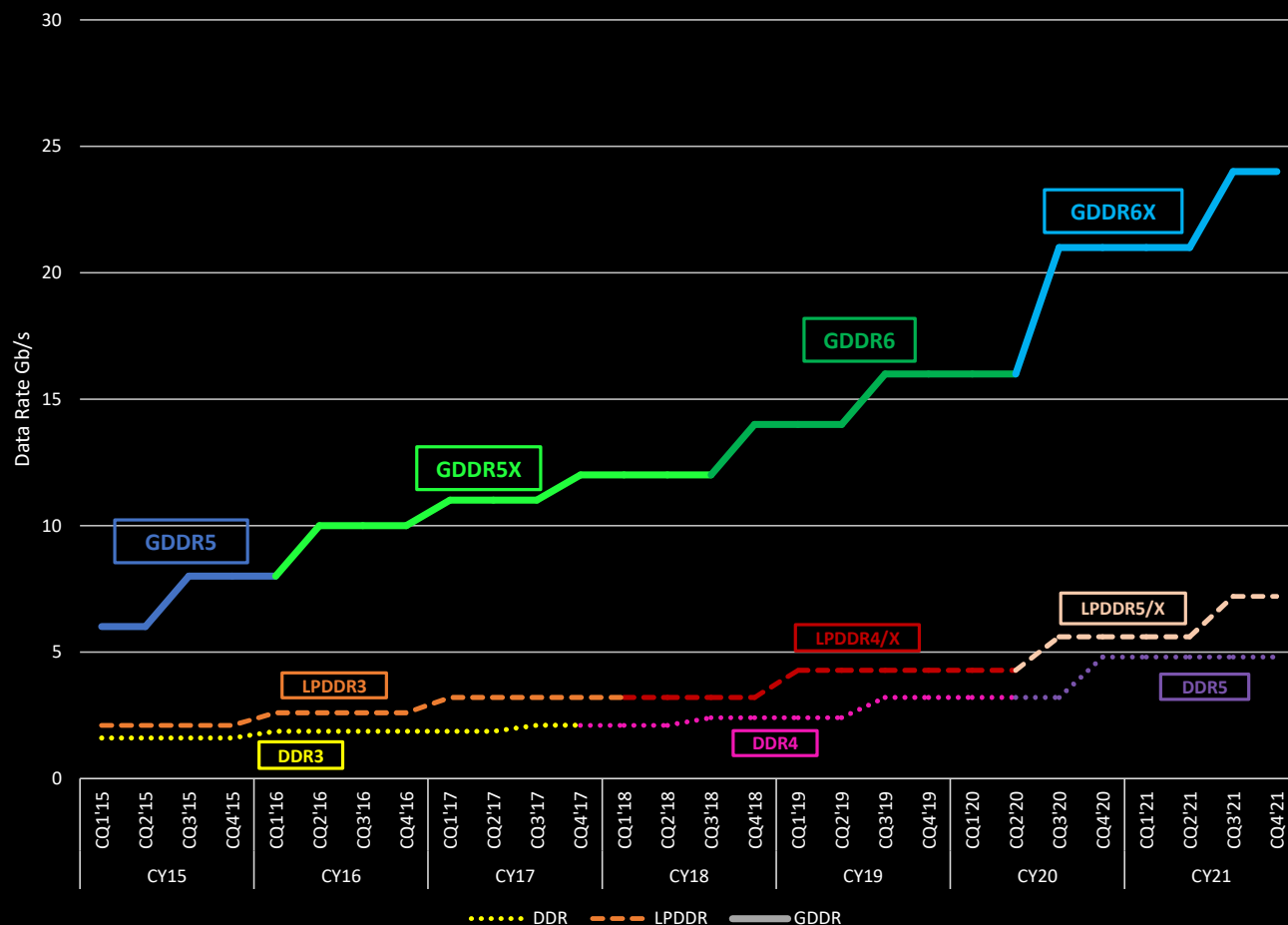 - MP CQ3'21

GDDR6
- FBGA 180, 0.75mm; VDD 1.35V / 1.25V
- 16Gb (1ynm): 14 Gb/s
  - in mass production
- 16Gb (1znm): 14-16 Gb/s+
  - ES 12/2020
  - CS 1/2021
- 16Gb (1bnm): 16-16 Gb/s+
  - Ramp in CY22
  - OD-ECC
- 8Gb   (20nm): 12-14 Gb/s
  - EOL end of CY21

GDDR5
- 8Gb (1xnm): 7.0 - 8.0 Gb/s
  - 1.35V support up to 8Gbps

Top Performance by a Memory Technology

Key Points

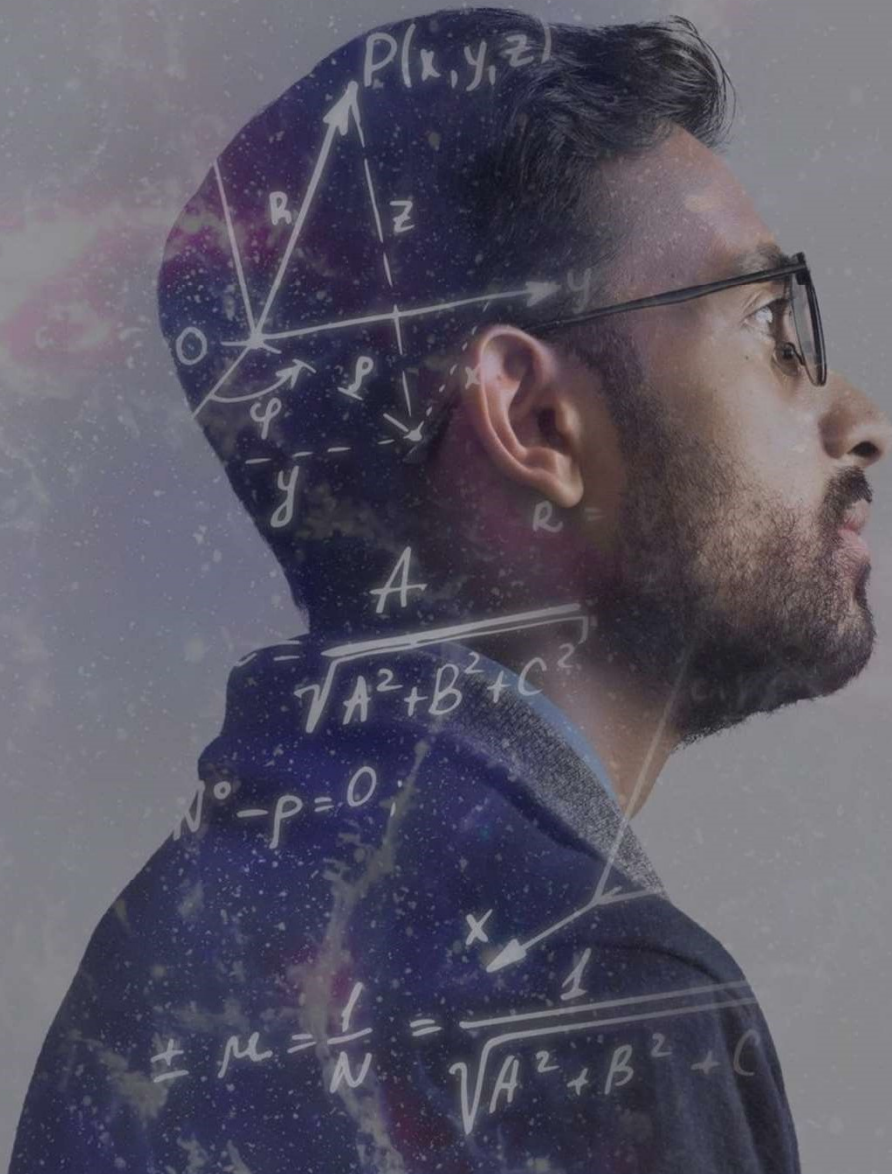**GDDR5**
- 8Gb 8Gbps MP now

GDDR5X – EOLed

GDDR6
- 8Gb 16Gbps MP now
- 16Gb 16Gbps MP now

GDDR6X
- 8Gb 19Gbps MP now
- 8Gb 21Gbps MP now
- 16Gb 21Gbps in 2H'21
- 16Gb 24Gbps in 2H'21

GDDR7
- ~CY23