



Global Standards for the Microelectronics Industry

Memory Industry Updates

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Worldwide Semiconductor Business Update

- The worldwide semiconductor market was up 1.1% in 2016 to **US\$338.9** Billion
- The year 2017 is forecasted to be strong with 6.5% growth to **US\$361** billion
- The memory is forecasted to be 12.8% growth to **US\$86.6** billion in 2017
- 2018 is forecasted to be up another 2.3% to **US\$369** billion
- In 2017, the largest growth is expected across sensors, analog, and memory
- All regions are forecasted to return to growth in 2017 as well



Autumn 2016 - Q4 update	Amounts in US\$M				Year on Year Growth in %			
	2015	2016	2017	2018	2015	2016	2017	2018
Americas	68,738	65,537	72,173	74,102	-0.8	-4.7	10.1	2.7
Europe	34,258	32,707	33,892	34,636	-8.5	-4.5	3.6	2.2
Japan	31,102	32,292	33,608	34,200	-10.7	3.8	4.1	1.8
Asia Pacific	201,070	208,395	221,230	226,113	3.5	3.6	6.2	2.2
Total World - \$M	335,168	338,931	360,903	369,050	-0.2	1.1	6.5	2.3
Discrete Semiconductors	18,612	19,418	20,023	20,674	-7.7	4.3	3.1	3.2
Optoelectronics	33,256	31,994	32,679	32,241	11.3	-3.8	2.1	-1.3
Sensors	8,816	10,821	11,797	12,394	3.7	22.7	9.0	5.1
Integrated Circuits	274,484	276,698	296,404	303,741	-1.0	0.8	7.1	2.5
Analog	45,228	47,848	51,570	53,315	1.9	5.8	7.8	3.4
Micro	61,298	60,585	61,106	62,281	-1.2	-1.2	0.9	1.9
Logic	90,753	91,498	97,154	98,975	-1.0	0.8	6.2	1.9
Memory	77,205	76,767	86,574	89,170	-2.6	-0.6	12.8	3.0
Total Products - \$M	335,168	338,931	360,903	369,050	-0.2	1.1	6.5	2.3

2017F Major Capital Spenders

2017F Rank	Company	2015 (\$M)	2016 (\$M)	16/15 % Change	2017F (\$M)	17/16 % Change
1	Samsung	13,010	11,300	-13%	12,500	11%
2	Intel	7,326	9,625	31%	12,000	25%
2	TSMC*	8,089	10,249	27%	10,000	-2%
4	SK Hynix	6,011	5,188	-14%	6,000	16%
5	Micron**	4,500	5,760	28%	5,000	-13%
6	SMIC*	1,401	2,626	87%	2,300	-12%
7	UMC*	1,899	2,842	50%	2,000	-30%
7	GlobalFoundries*	3,985	1,500	-62%	2,000	33%
9	Toshiba	1,745	1,840	5%	1,900	3%
10	SanDisk/WD	1,460	1,750	20%	1,800	3%
11	ST	467	607	30%	1,050	73%
—	Top 11 Total	49,893	53,287	7%	56,550	6%
—	Others	15,339	14,695	-4%	15,755	7%
—	Total Cap Spending	65,232	67,982	4%	72,305	6%

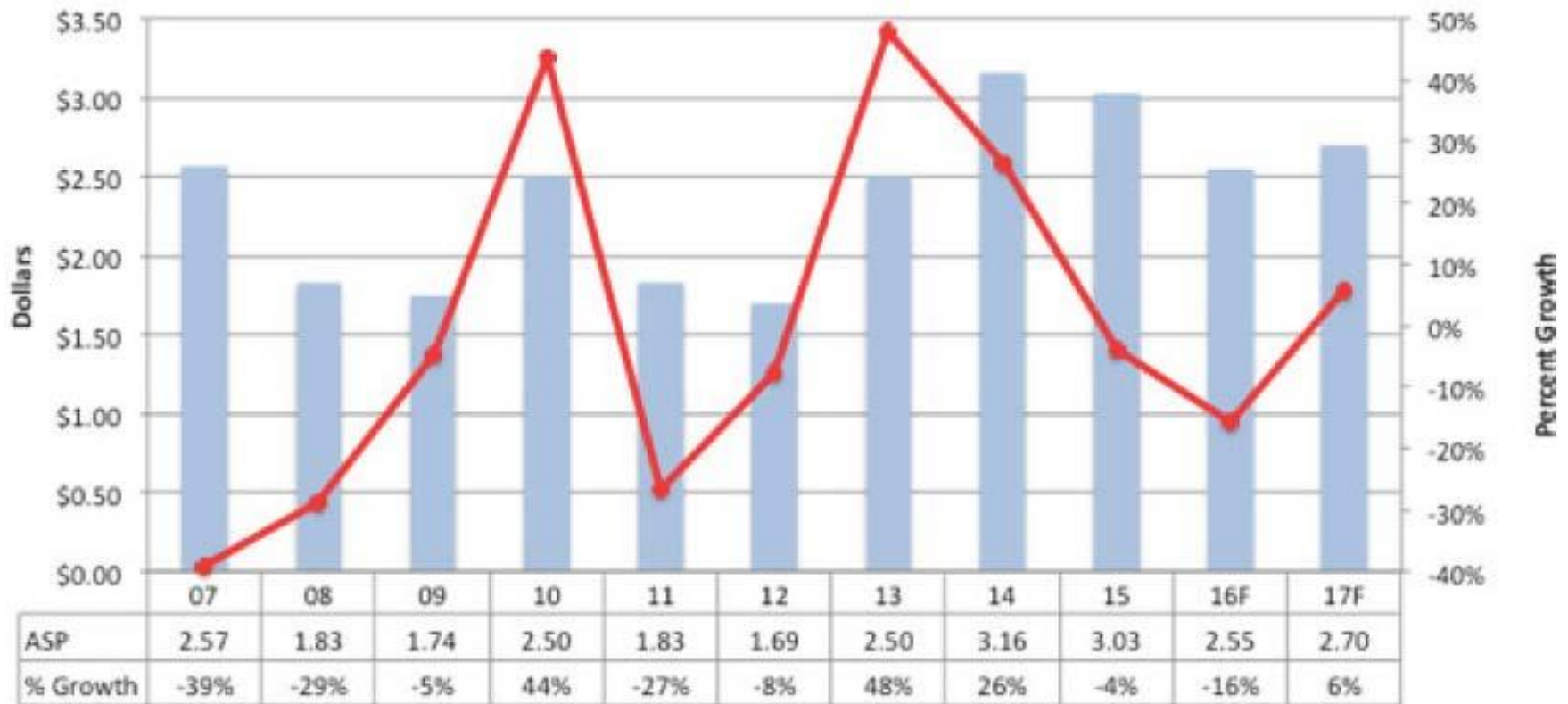
*Pure-Play Foundry

** Includes Inotera in 2017.

Source: IC Insights, Company Reports

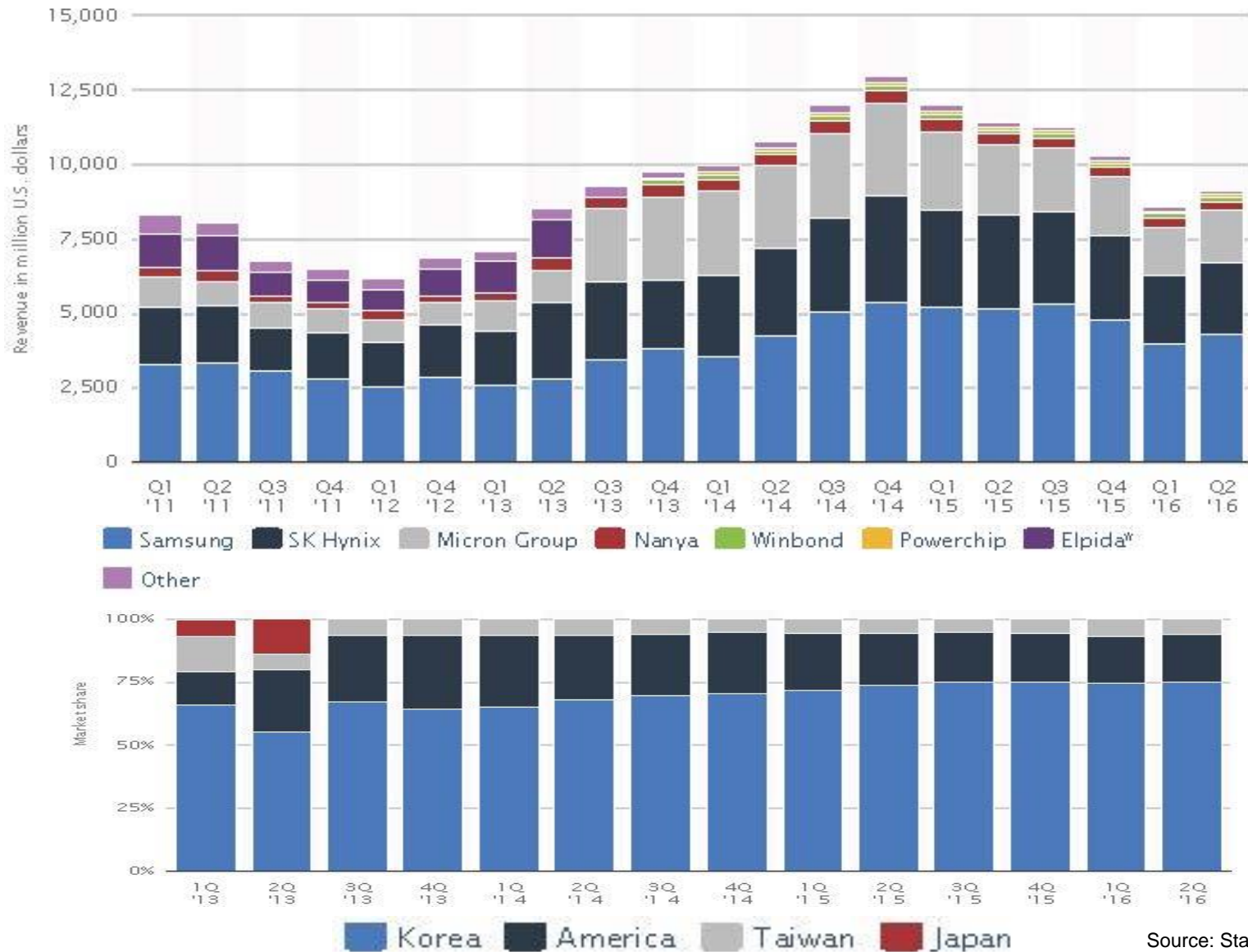
Volatile DRAM ASP Growth

- DRAM ASPs started to strengthen in the late 2nd quarter of 2016, and expected to continue increasing into 2017
- The boost to DRAM ASP is expected to come from demand for enterprise (server) systems due to the need to process “big data”
- Low-voltage DRAM continues to enjoy solid demand for use in mobile platforms



Source: IC Insights

Global DRAM Revenue by Manufacturers



Source: Statista

DRAM Development Trend

Memory Technologies have been and will always be the drivers of Moore's Law

Beyond 20nm, the DRAM is expected to scale:

1xnm: 16nm ~ 19nm;

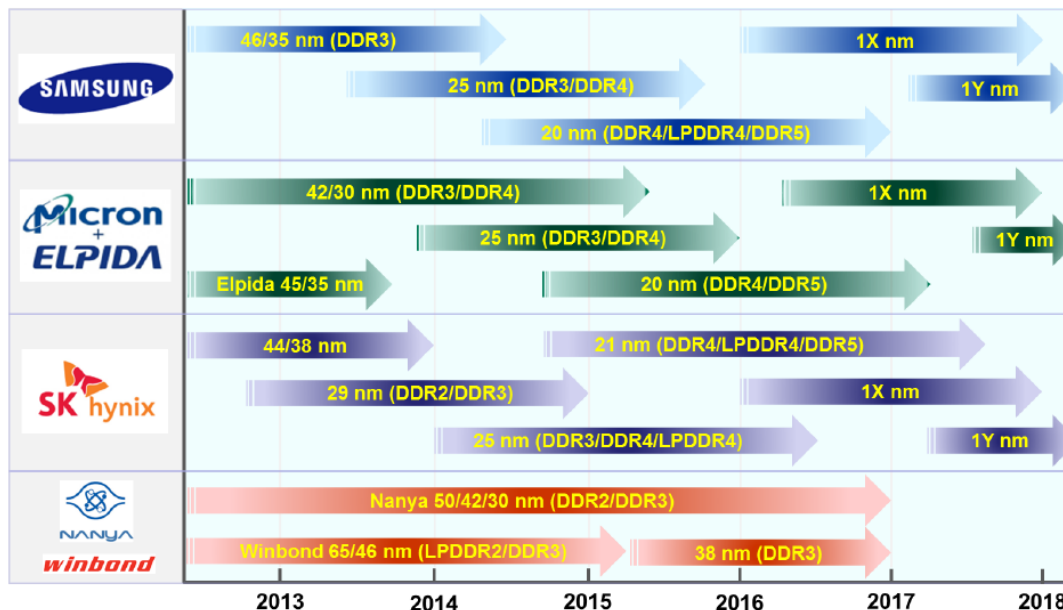
1ynm: 14nm ~ 16nm;

1znm: 12nm ~ 14nm

DRAM Technology Review

TECHINSIGHTS

■ DRAM Process Node Roadmap (Manufacturers)



DRAM Challenges

Satisfy Bandwidth requirements,

Reduce Power Consumption,

Maintain Low Cost

JEDEC is working on DDR5

- JEDEC specs for DDR5 will be released this year and sample will begin in 2018

Spec Items		DDR4	DDR5
Density / Speed		4Gb~16Gb / 1.6~3.2Gbps	8Gb~64Gb / 3.2~6.4Gbps
Interface	Voltage(VDD/VDDQ/VPP)	1.2V/1.2V/2.5V	1.1V/1.1V/1.8V
	Data IO	POD (34ohm)	POD (TBD ohm)
	CA IO	RTT	CA ODT
Core	# of banks	16Banks (4Bank Group)	16Banks(8Gb)/32Banks(16+Gb) (8Bank Group)
	# prefetch	8bits	16bits
Physical	PKG(x4,x8/x16)	78 / 96 BGA	78 / 96 BGA (TBD)
	DIMM type	R, LR, U, So	Same as DDR4
	DIMM Capacity	4GB to 256GB	8GB to 4TB
	# of DRAM / DIMM	36 (Max)	40 (Max)
	DIMM pins	288	288 (target, TBD)
	Voltage regulator	On MB	VR on DIMM
Scaling features		X	On-die ECC, tWR

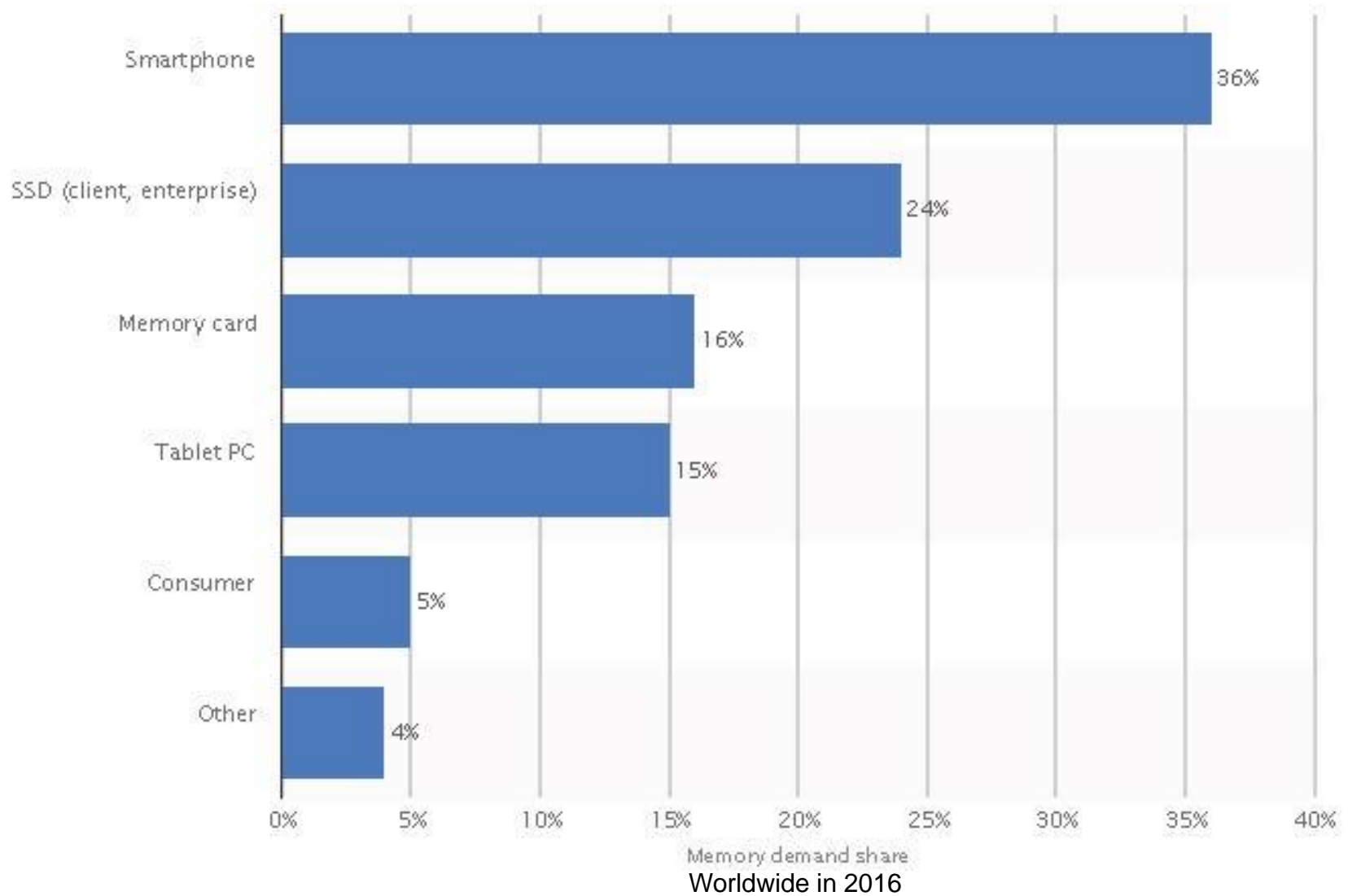
Benefits of DDR5:

- Cram more memory into PCs
- Running apps faster
- Denser than earlier DRAMs
- Consume less power

□ Servers will be the first to get DDR5, and it could reach desktops and laptops 12 to 18 months later

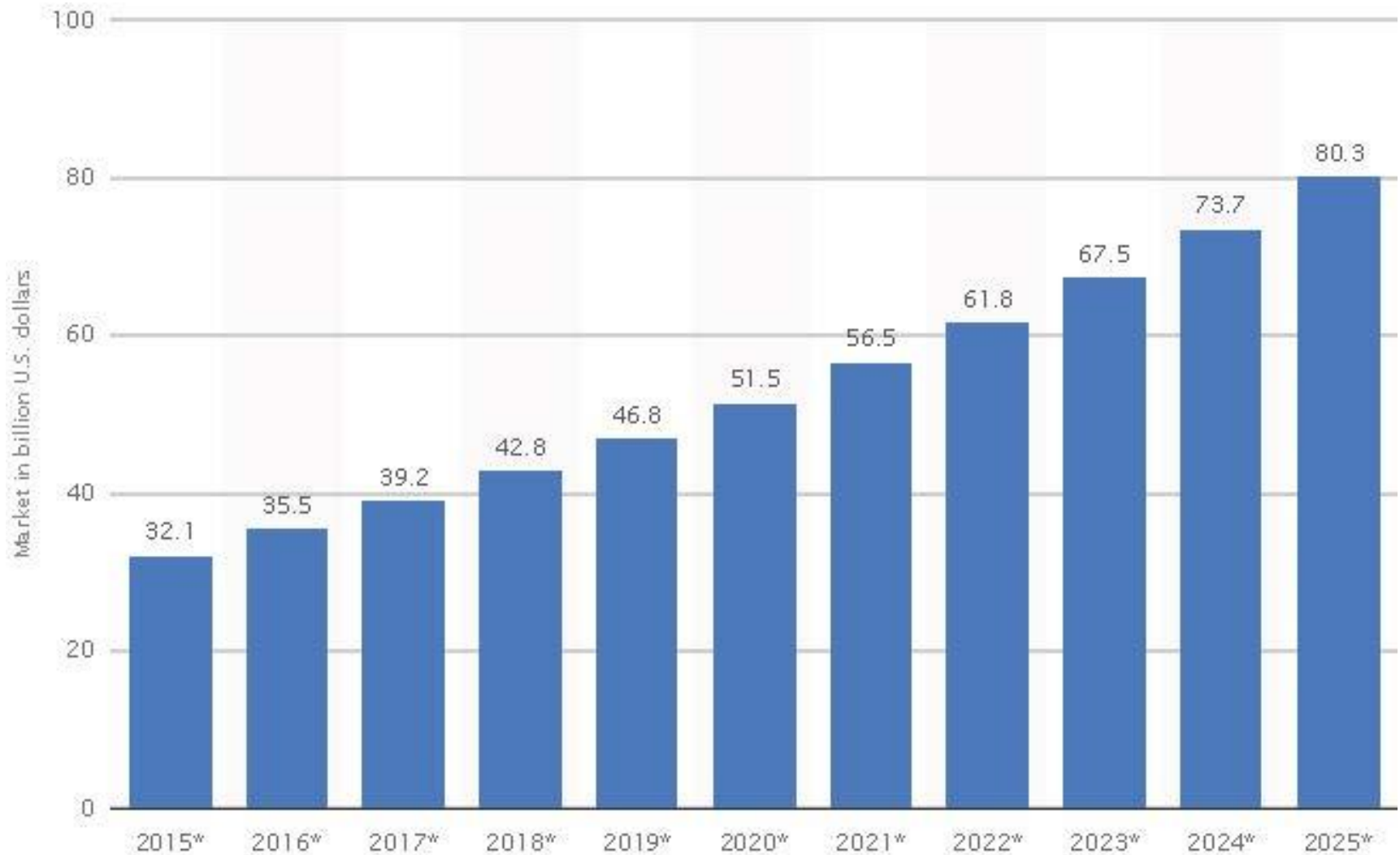
DDR SDRAM Standard	Internal rate (MHz)	Bus clock (MHz)	Prefetch	Data rate (MT/s)	Transfer rate (GB/s)	Voltage (V)
SDRAM	100-166	100-166	1n	100-166	0.8-1.3	3.3
DDR	133-200	133-200	2n	266-400	2.1-3.2	2.5/2.6
DDR2	133-200	266-400	4n	533-800	4.2-6.4	1.8
DDR3	133-200	533-800	8n	1066-1600	8.5-14.9	1.35/1.5
DDR4	133-200	1066-1600	8n	2133-3200	17-21.3	1.2

Distribution of NAND bits by device segment



Source: Statista

2D/3D NAND Flash Market Size

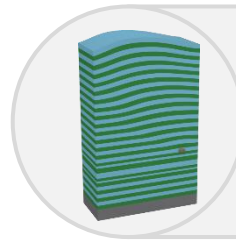
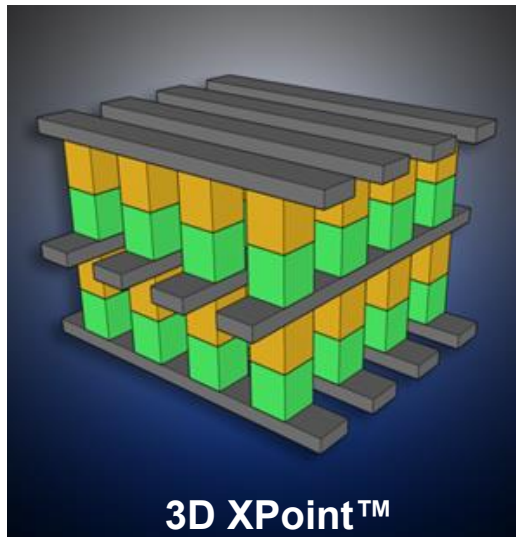
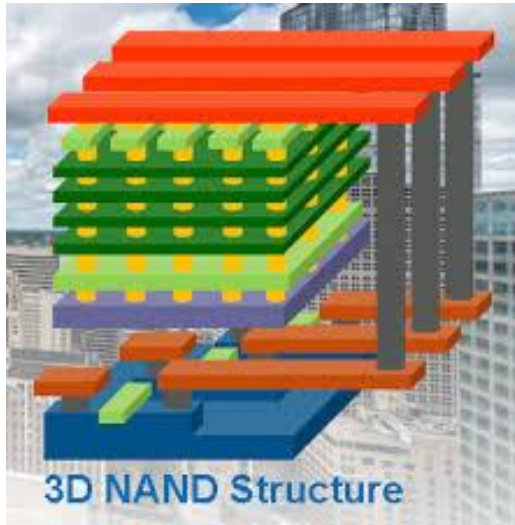


Worldwide from 2015 to 2025

Source: Statista

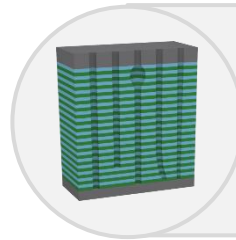
Advanced Flash Memory and Challenges

Innovative flash technologies: 3D NAND and 3D XPoint™



Stack deposition

- Wafer bow due to stress
- Layer-to-layer uniformity
- Defects



Memory Hole Etch

- Etch Selectivity to hardmask
- To-to-bottom CD uniformity
- Etch profile integrity for high aspect ratio



Wordline Fill

- Void-free fill of complex structures (vertically and horizontally)
- Stress induced wafer bow
- Defects due to fluorine attach



Stair Etch

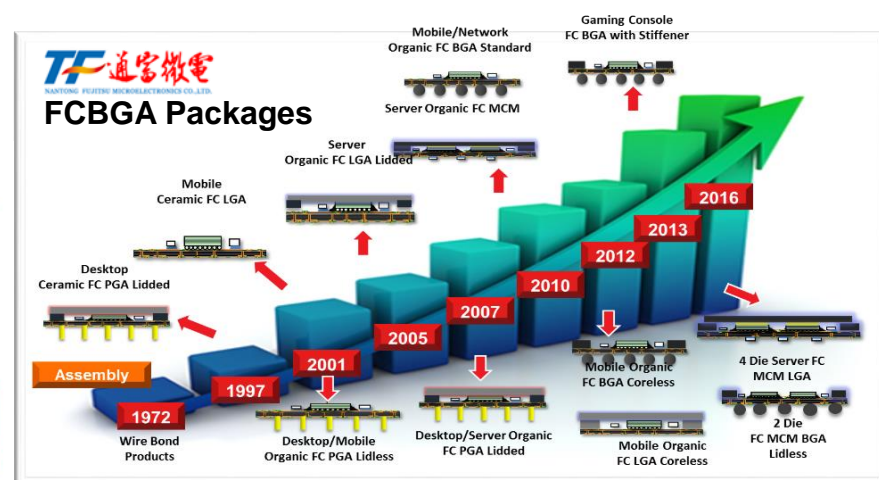
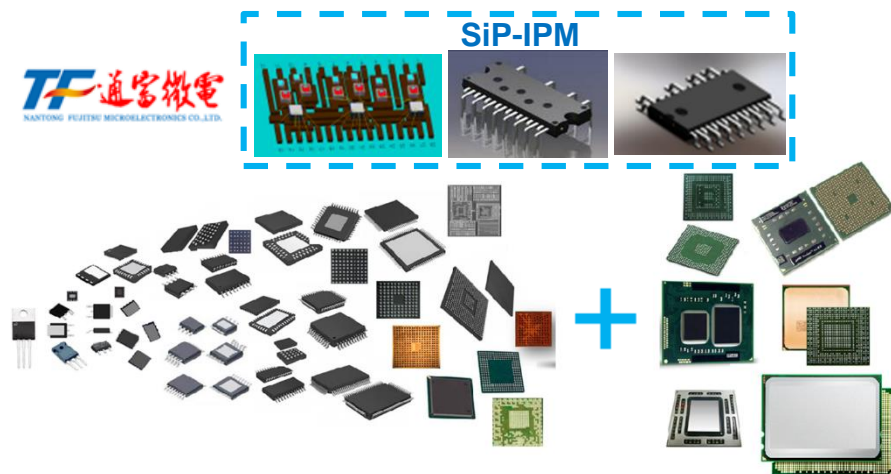
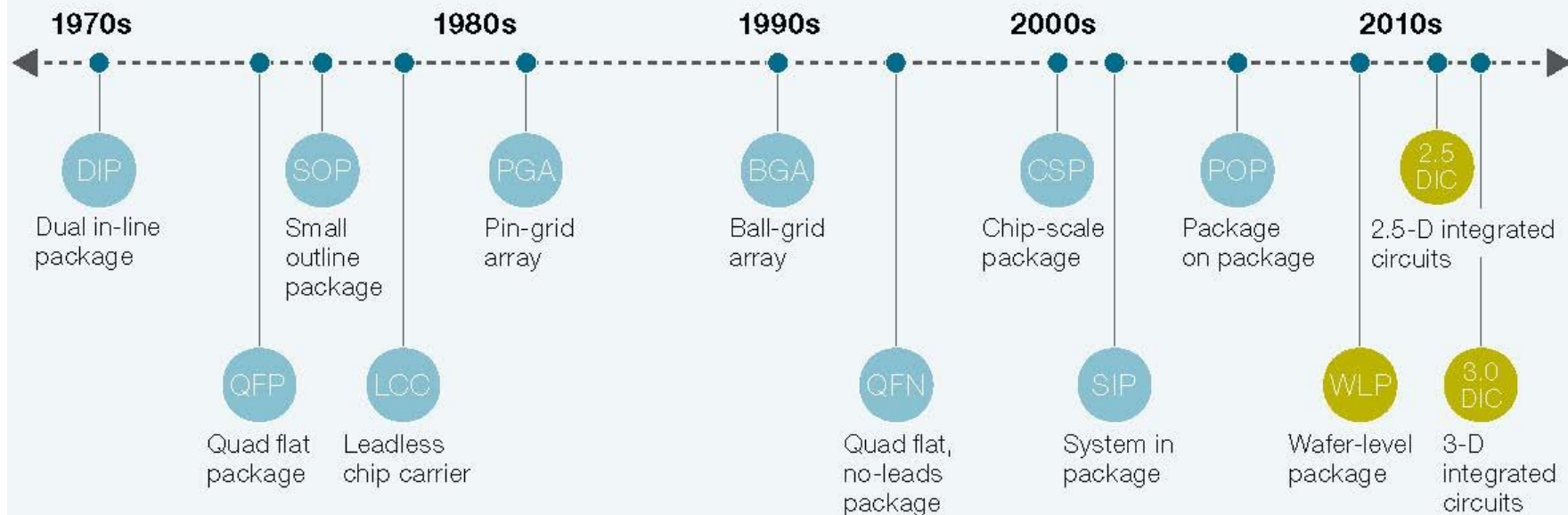
- Etch precision for repeatable stair CD
- Lateral/vertical selectivity (to photoresist)

Source: LAM Research

Electronic Packaging Evolution since the 1970s

Source: IC Insights; Yole Développement; McKinsey analysis

Advanced packaging



Advanced Memory Packaging & Segments



Smart Phone



Desk Top



Tablet



Notebook



Server

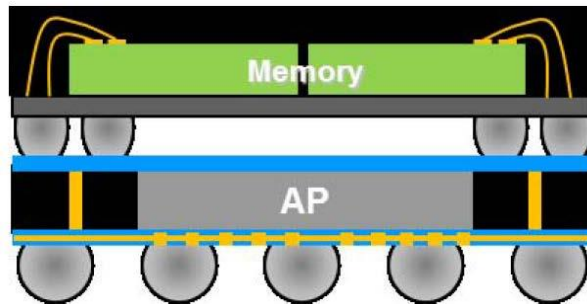


HPC

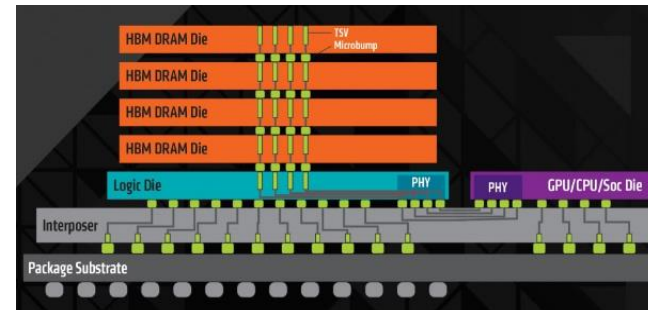


Networking

Source: JEDEC



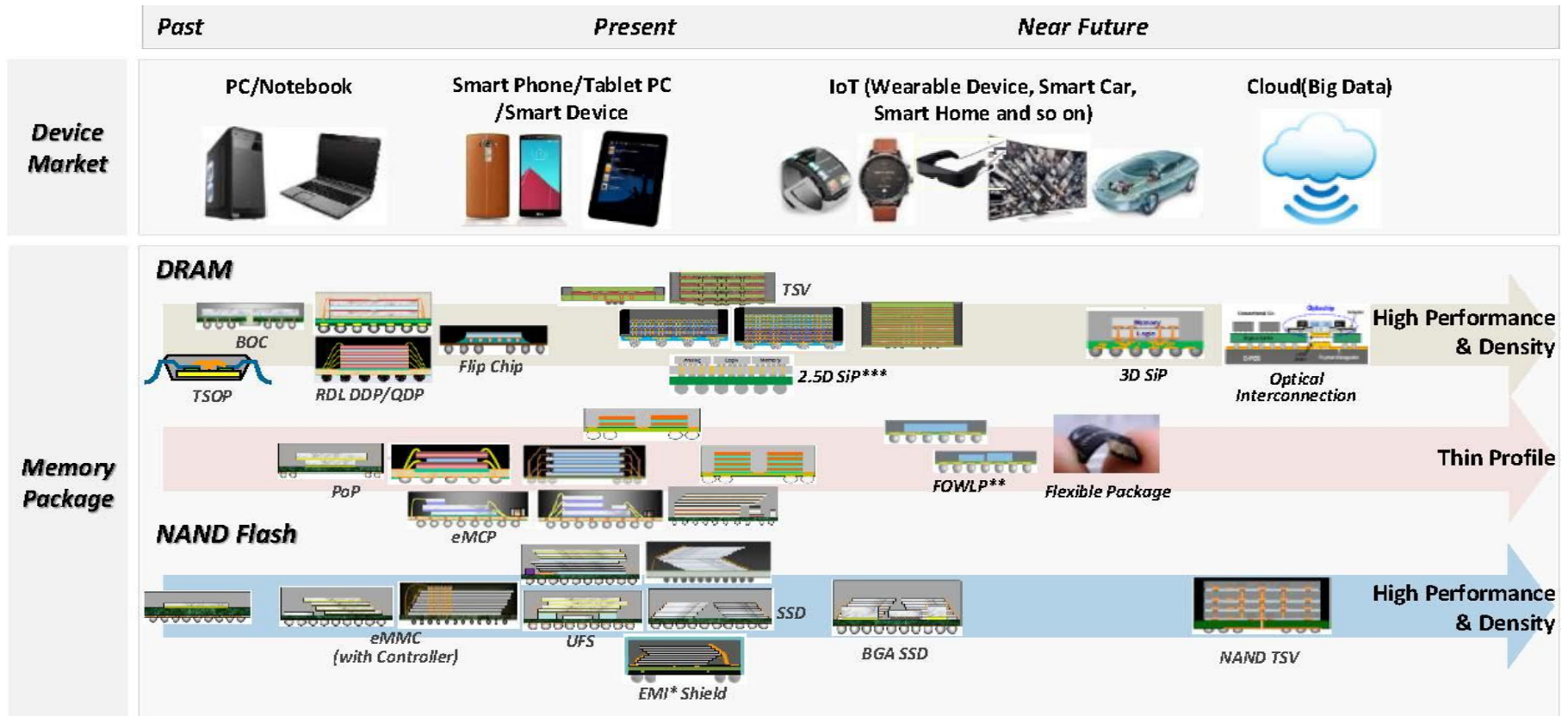
The cross-section of InFO_PoP package.



AMD HBM breaks the processing bottleneck

Memory Packaging Roadmap

FC and TSV/WLCSP should satisfy faster speed, wider bandwidth and smaller/thinner



Source: SK htnix

China Developing Memories

Yangtze River Storage Technology (YRST)

- Acquired XMC
- 3D NAND, DRAM
- Beijing, Wuhan, Nanjing

Fujian Jin Hua Integrated Circuit

- Partner with UMC
- DRAM
- Quanzhou

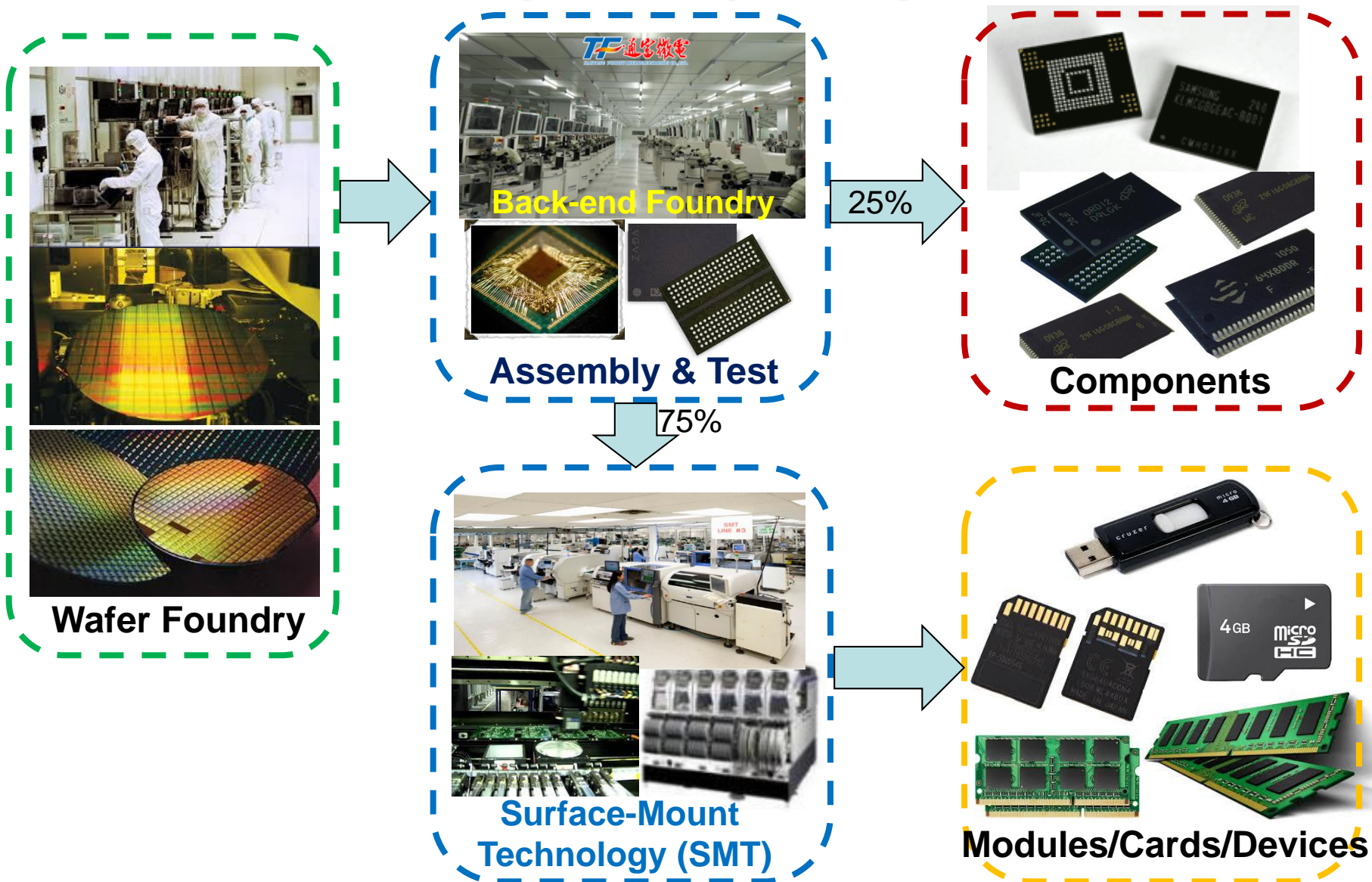
GigaDevice Semiconductor

- Publiced at Shanghai Stock Exchange - [603986](#) (SHA)
- Acquired ISSI, a USA company
- NOR, NAND, SPI flash, DRAM, MCU
- Beijing



Source: EE Time

Memory Industry Eco-system



JEDEC Encourages China Memory Makers Join Industry Leaders



March 8, 2017

To Whom It May Concern:

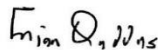
Mr. Andrew Peng is an official representative of the JEDEC Solid State Technology Association, which is the global leader in the development of standards for the microelectronics industry. JEDEC is working to help Chinese companies benefit by taking a leadership role in the development of open industry standards.

To facilitate this goal, JEDEC is developing plans for two new task groups in China:


- **JEDEC China Memory Task Group:** led by co-chairs Mr. Desi Rhoden (Chairman of the JC-42 Solid State Memories Committee) and Mr. Andrew Peng (Vice-Chairman of both the JC-63 Multiple Chip Package Committee and the JC-64.8 Solid State Drives Subcommittee).
- **JEDEC China Packaging Task Group:** led by co-chairs Mr. John Norton (Chairman of the JC-11 Mechanical Standardization Committee) and Mr. Andrew Peng (Vice-Chairman of both the JC-63 Multiple Chip Package Committee and the JC-64.8 Solid State Drives Subcommittee).

JEDEC looks forward to engaging with more Chinese companies and government entities in the global microelectronics standards development processes with the formation of JEDEC China Task Groups.

Sincerely yours,



Mian Quddus
Chairman



John J. Kelly
President

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JEDEC Solid State Technology Association, the global leader in the development of standards for the microelectronics industry, is committed to ensuring that Chinese electronic designers and manufacturers have access to timely information on the latest standards generated by JEDEC committees and have the opportunity to participate in the JEDEC standards development process.

JEDEC encourages all Chinese electronic designers and manufacturers to join the new JEDEC Task Groups, interact with JEDEC member companies and take their place with other leaders in the global microelectronics industry.

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Global Standards for the Microelectronics Industry

Memory Plays a Vital Role in Building the Connected World

The Internet of Things



Source: The Register, 5 May, 2014