

Industry Overview

Extending the super cycle

June 2018



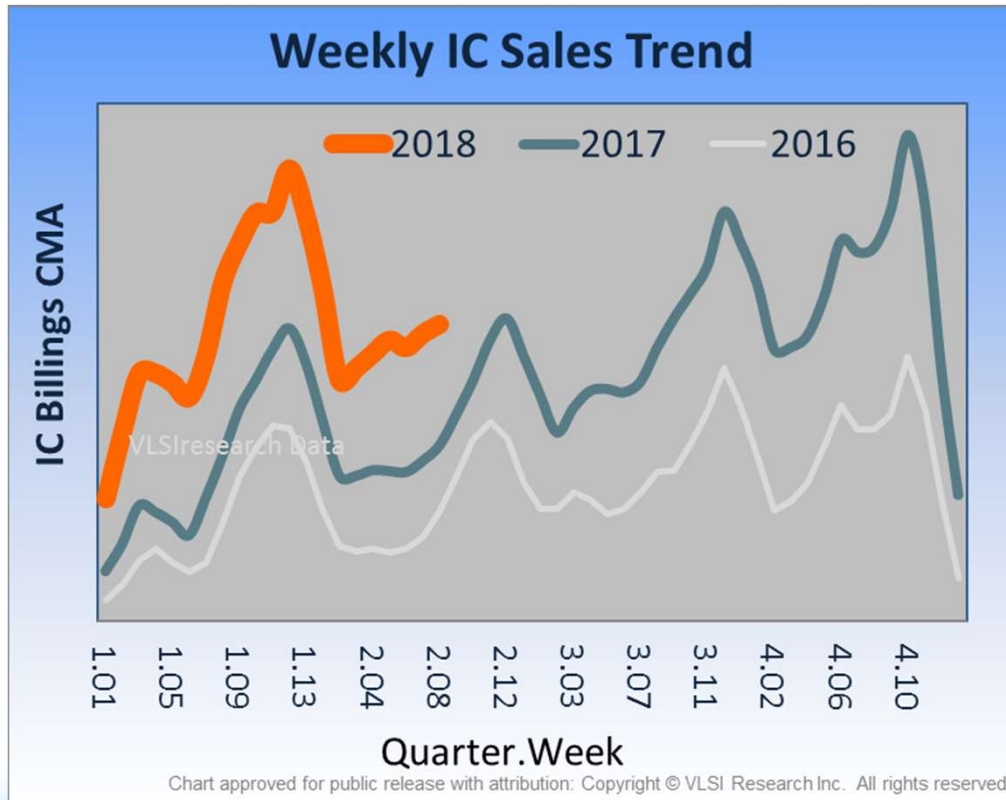
Andrea Lati

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Weekly IC Sales



Last week's IC Sales:

- W/W Crawled + 2 %
- W/Q Slipped - 4%
- W/Y Rocketed + 24%

This Quarter's Nowcast:

Holds at + 23% Q/Q_{t-4}

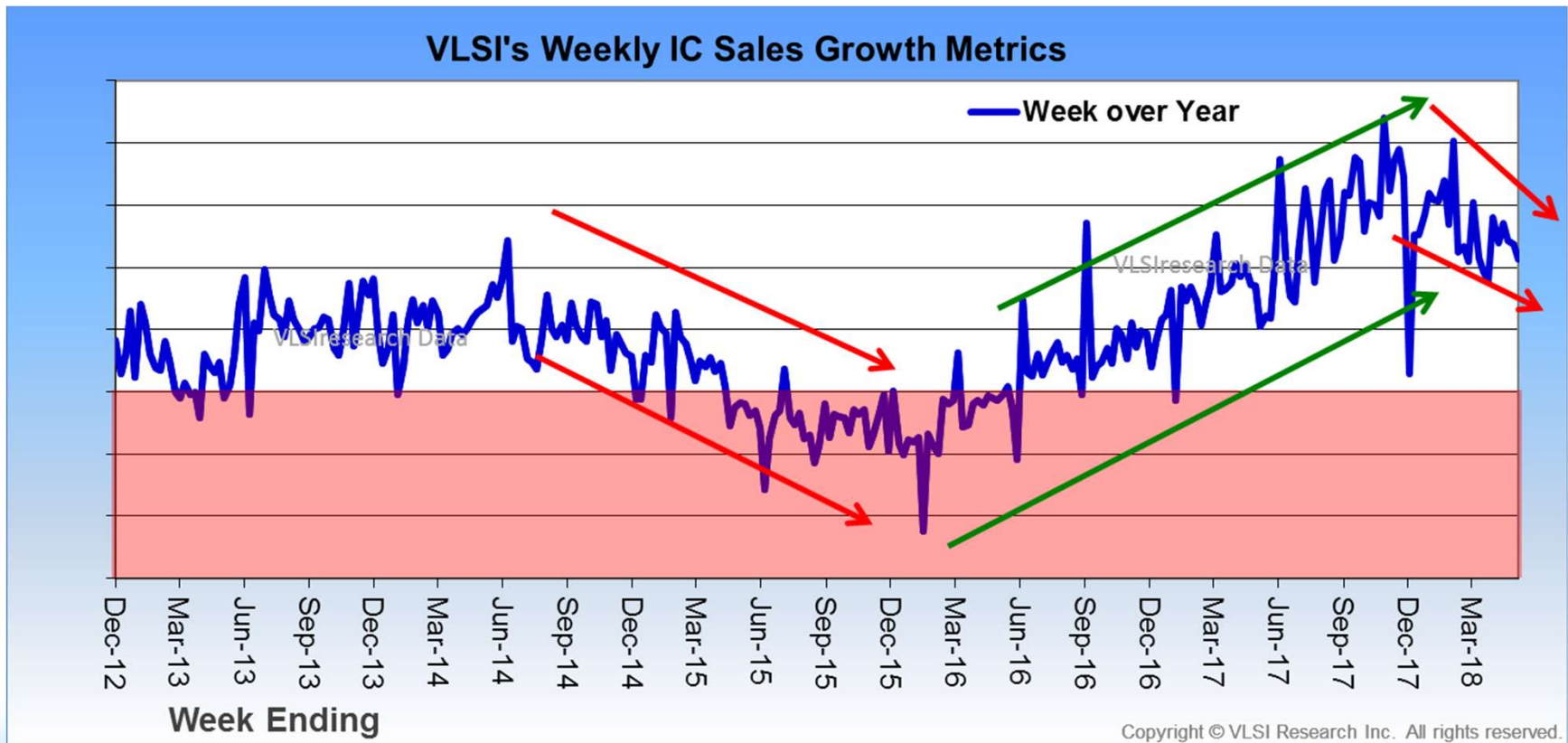
IC Weather Report:

Heats up to Warm

- Memory: Sunny, Warmer
- Foundry: Warm, Warmer
- IDM: Warm, Warmer
- SoC: Warms to Sunny
- Mobile: Sunny, Warmer
- IoT: Warm, Warmer
- Analog & Power: Warm, Warmer

Raw: data has not been 'cooked' with a moving average or some other statistical manipulation

Week-over-Year IC Sales Growth Trends

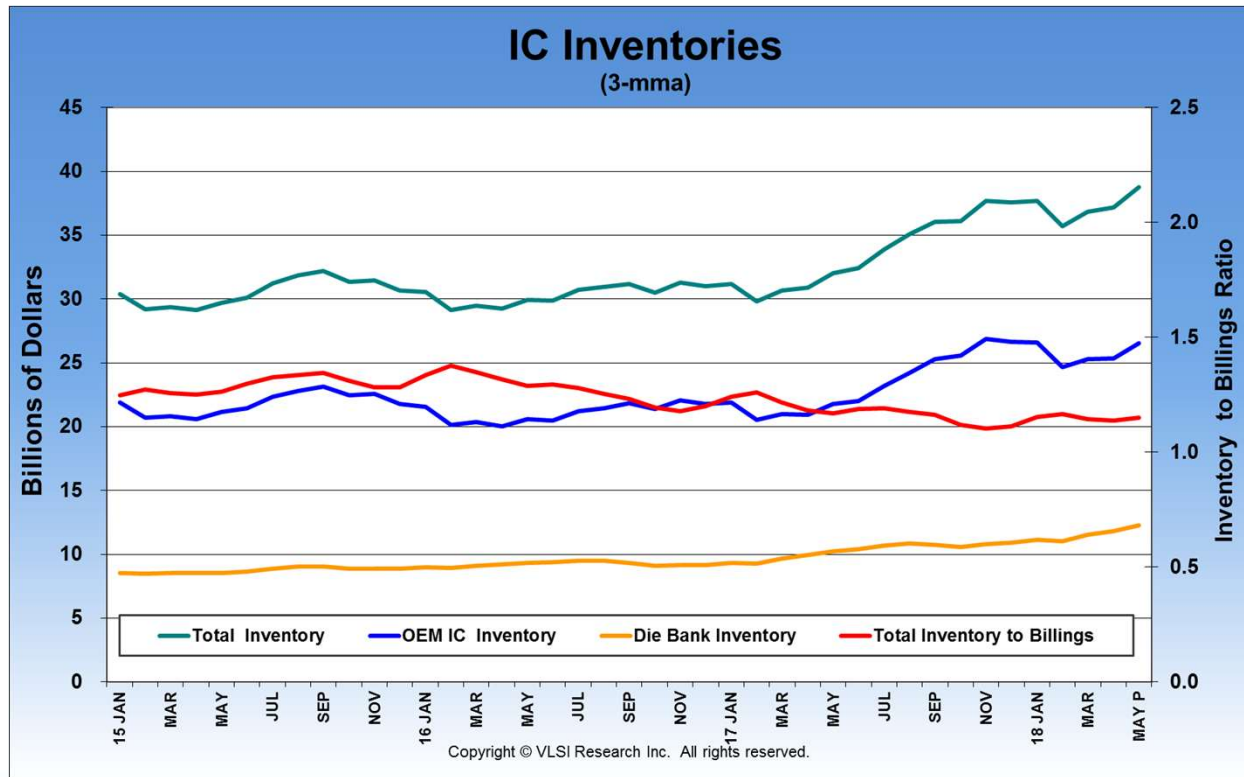


IC Demand-Supply Balance

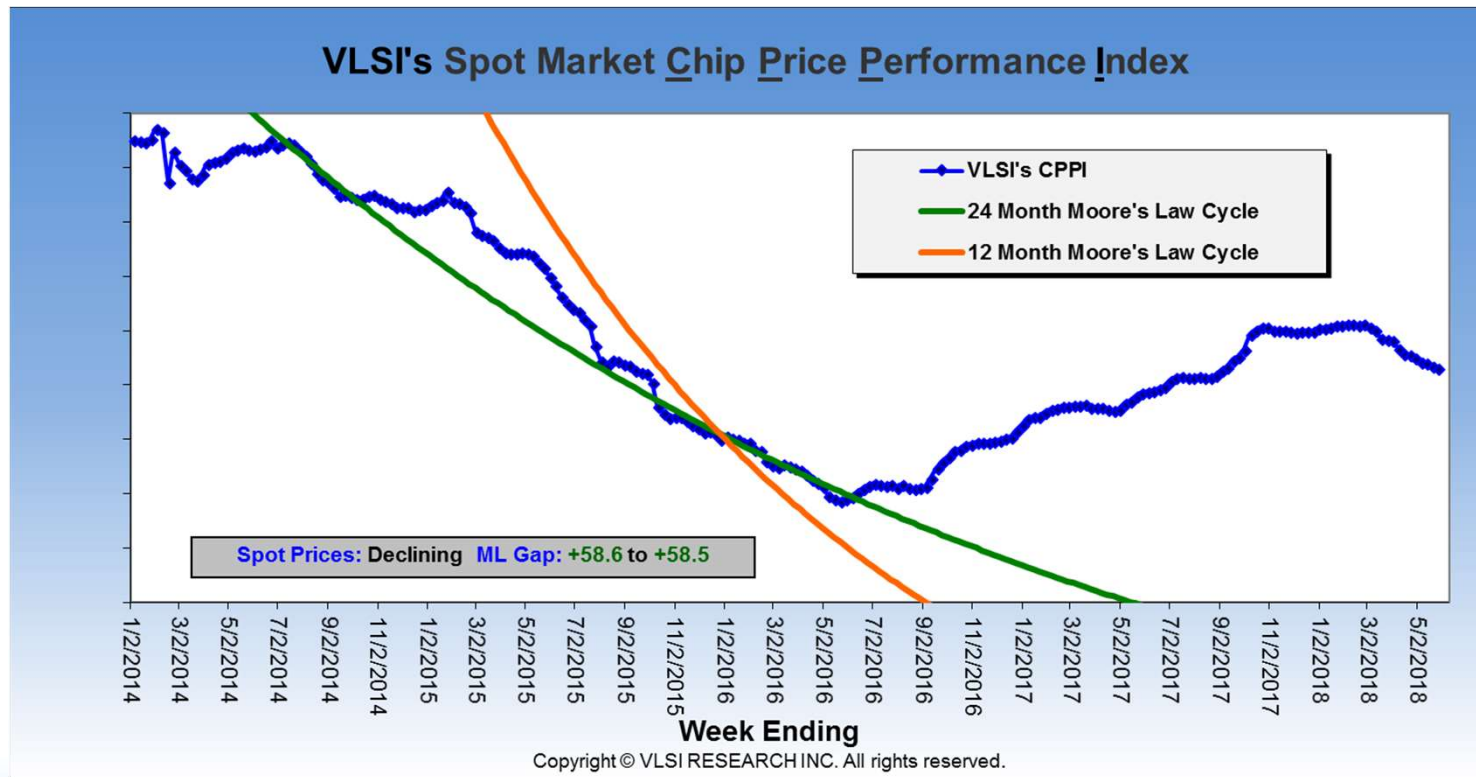
Pivot Points → Week ↓	Overall	DRAM	NAND/NVM	IDM	Foundry & Fabless	Analog & Power
	Capex Moving Capacity Up	<i>Pulling Up:</i> Data Center & ADAS - <i>Down:</i> Shrinks & Yield	<i>Pulling Up:</i> Storage & HDR - <i>Down:</i> Capacity & Yields	AI, Auto, Cloud, IoT strong	<i>Pulling Up:</i> BC*, IoT, ADAS - <i>Down:</i> Inventory rising, China Blowout	<i>Pulling Up:</i> Auto, Industrial IoT, & Complex SoC** - <i>Down:</i> Consumer
23-Mar-18	Tight	Balanced	Shortage	Tight	Tight	Tight
30-Mar-18	Balanced	Balanced	Tight	Tight	Tight	Tight
6-Apr-18	Tight	Tight	Tight	Tight	Shortage	Tight
13-Apr-18	Balanced	Loose	Balanced	Balanced	Tight	Balanced
20-Apr-18	Balanced	Saturated	Balanced	Balanced	Balanced	Balanced
27-Apr-18	Balanced	Saturated	Balanced	Balanced	Balanced	Balanced
4-May-18	Balanced	Loose	Balanced	Balanced	Loose	Tight
11-May-18	Balanced	Saturated	Balanced	Tight	Saturated	Tight
18-May-18	Balanced	Saturated	Tight	Shortage	Loose	Tight
25-May-18	Tight	Loose	Shortage	Shortage	Balanced	Shortage
1-Jun-18	Tight	Balanced	Shortage	Shortage	Tight	Shortage
4Q 2016	Shortage	Shortage	Shortage	Shortage	Shortage	Shortage
1Q 2017	Shortage	Shortage	Shortage	Shortage	Shortage	Shortage
2Q 2017	Shortage	Balanced	Shortage	Shortage	Tight	Shortage
3Q 2017	Shortage	Shortage	Shortage	Shortage	Balanced	Shortage
4Q 2017	Shortage	Shortage	Shortage	Shortage	Balanced	Tight
1Q 2018	Tight	Shortage	Tight	Tight	Tight	Balanced
2Q 2018 NowCast	Balanced	Loose	Balanced	Tight	Balanced	Tight

Range: Shortage-Tight-Balanced-Loose-Saturated-Glut *Block Chain incl crypto-currency **SoC with RF/mmW & Sensors Copyright © VLSI Research Inc. All rights reserved.

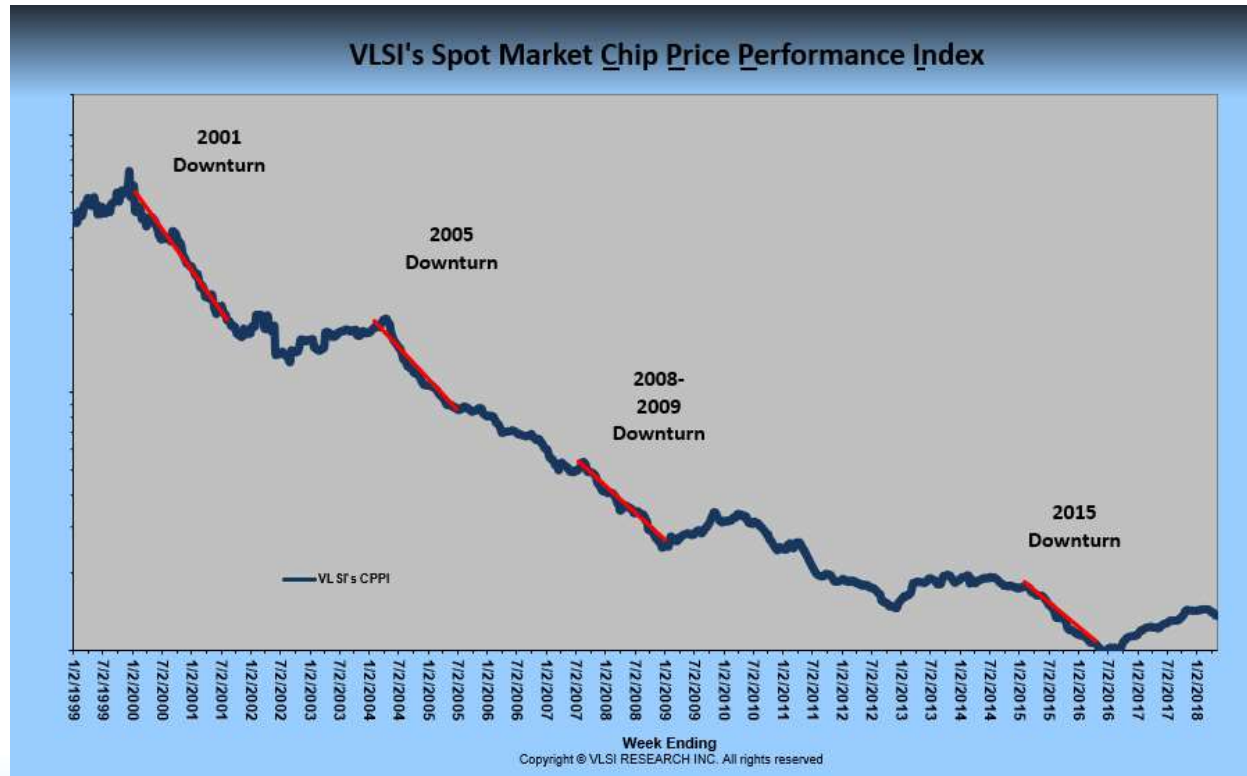
I:B ratio is healthy, but edging higher



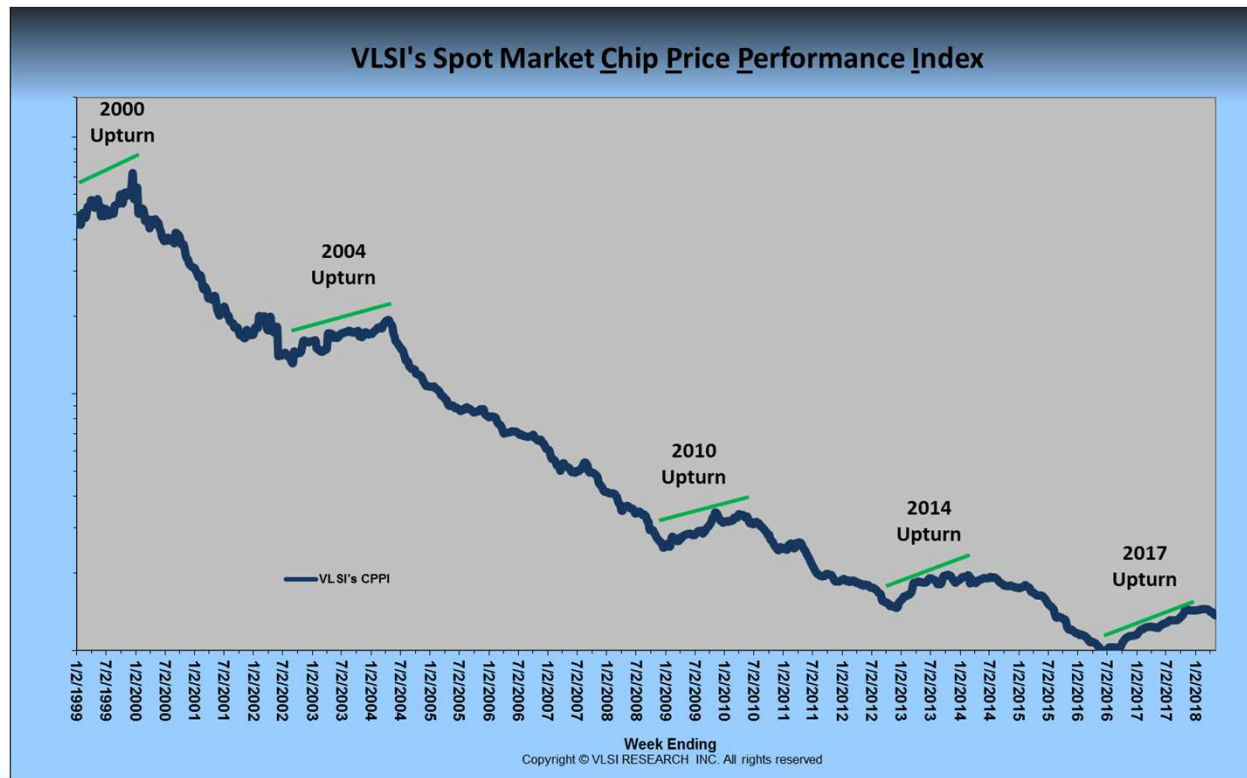
The CPPI is trending lower



Industry Downturns

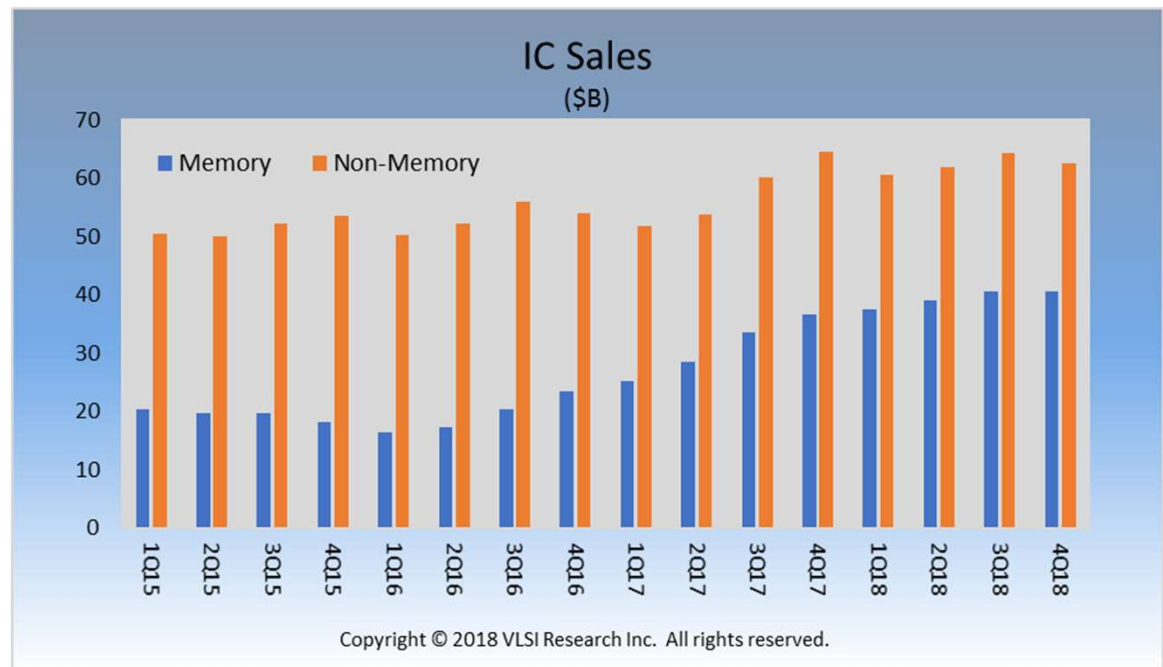


Industry Upturns

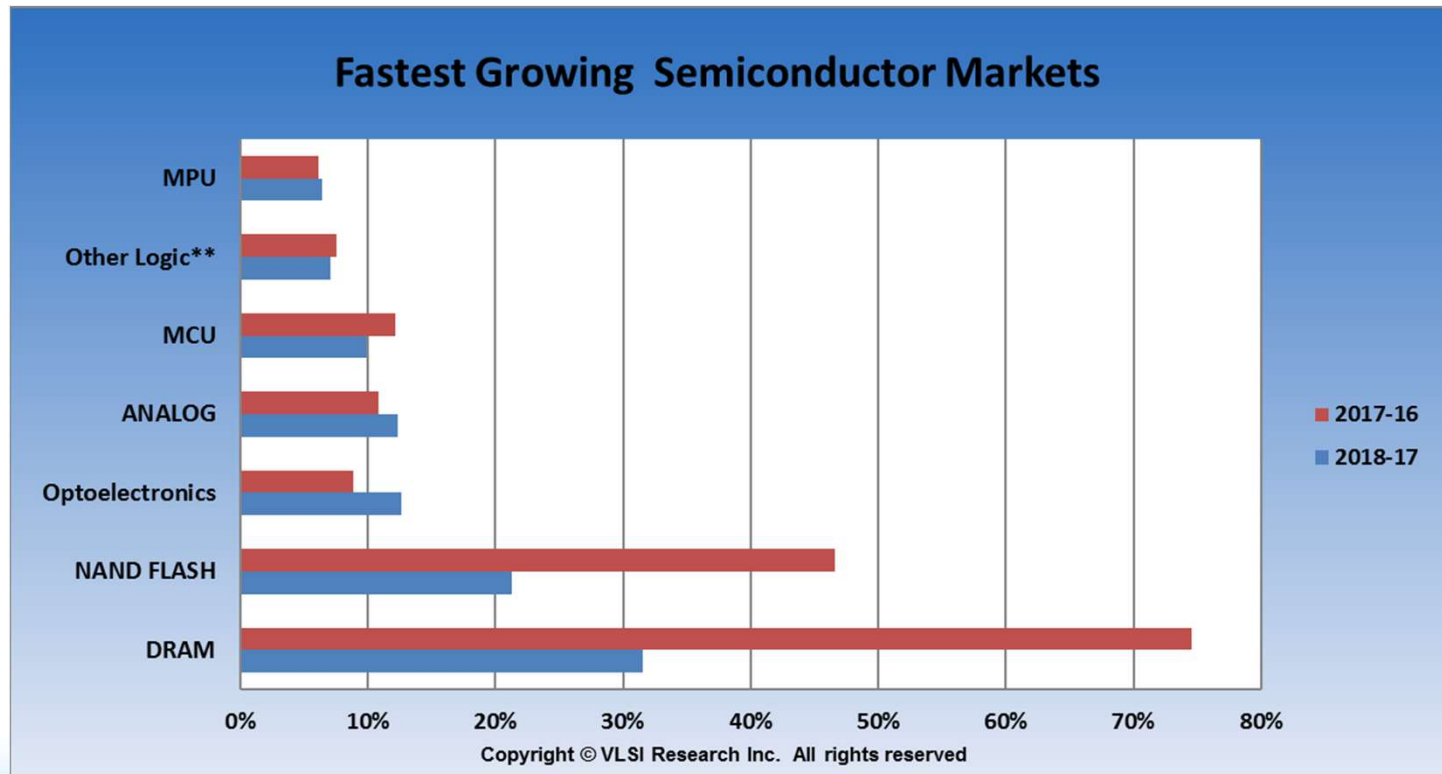


Memory ICs defied seasonality in Q1

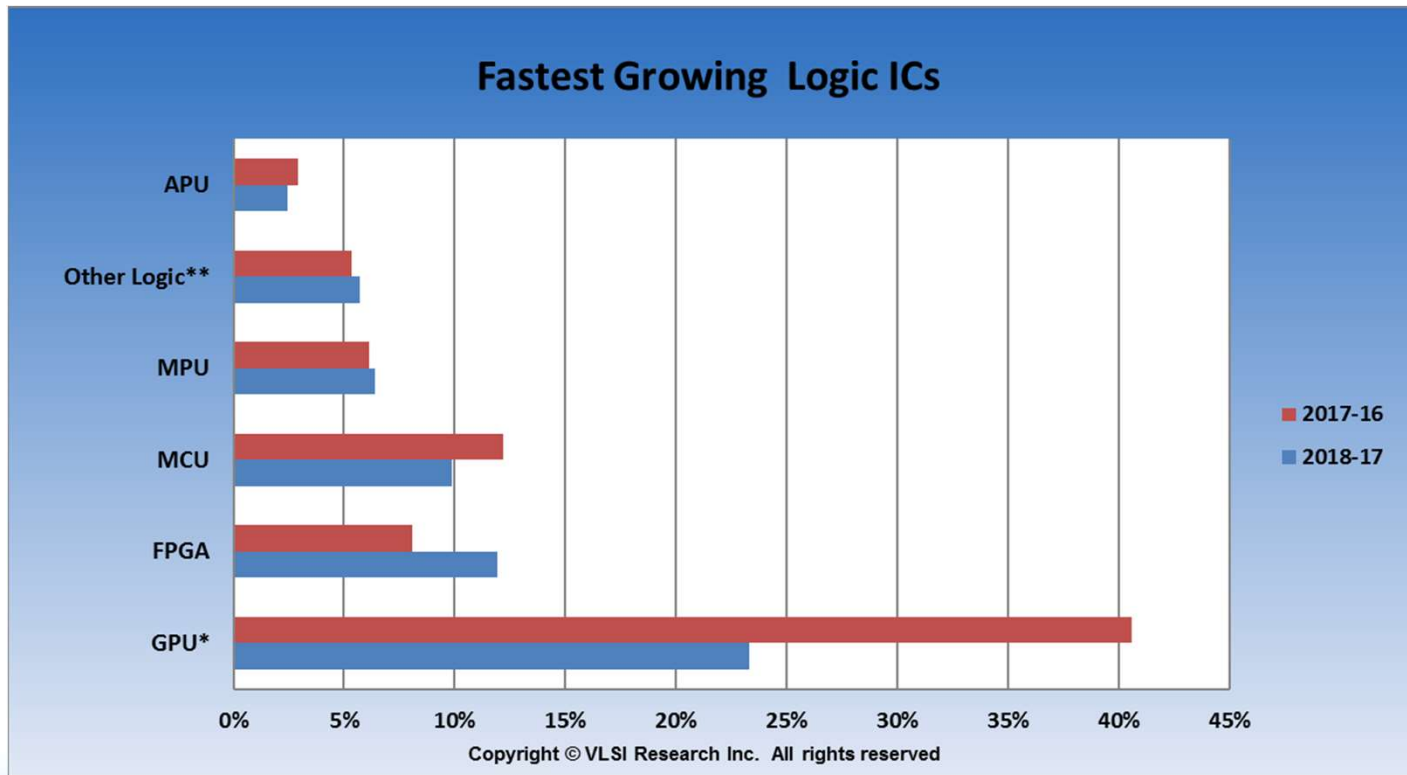
1Q18 Sales	QoQ	YoY
Memory IC	7%	47%
Non-Memory IC	-4%	16%
Total IC	-3%	27%



Memory will account for more than half of revenue gains in 2018



GPU sales soaring due to AI & Blockchain



Memory leads the way up and down

SEMICONDUCTOR SALES

(worldwide sales, \$B, calendar year)

	2015	2016	2017	2018	2019
Analog	45.2	47.9	53.1	59.6	60.5
	2%	6%	11%	12%	2%
DRAM	45.0	41.3	72.0	94.7	81.2
	-4%	-8%	75%	32%	-14%
NAND Flash	29.5	32.8	48.1	58.3	52.5
	2%	11%	47%	21%	-10%
MPU	43.9	45.6	48.5	51.6	52.7
	-4%	4%	6%	6%	2%
Other Logic	117.2	118.9	128.7	138.2	142.1
	-1%	1%	8%	7%	3%
Discrete, Opto & I	65.8	65.4	71.8	80.8	80.1
	2%	-1%	10%	13%	-1%
Total	346.6	351.8	422.1	483.2	469.2
	-0.4%	1.5%	20.0%	14.5%	-2.9%

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Capex plans: +15% in 2018

- Still very healthy capex growth
- Driven by memory
- Top six companies will account for nearly two-thirds of total spending

2018 TOP CAPEX SPENDERS

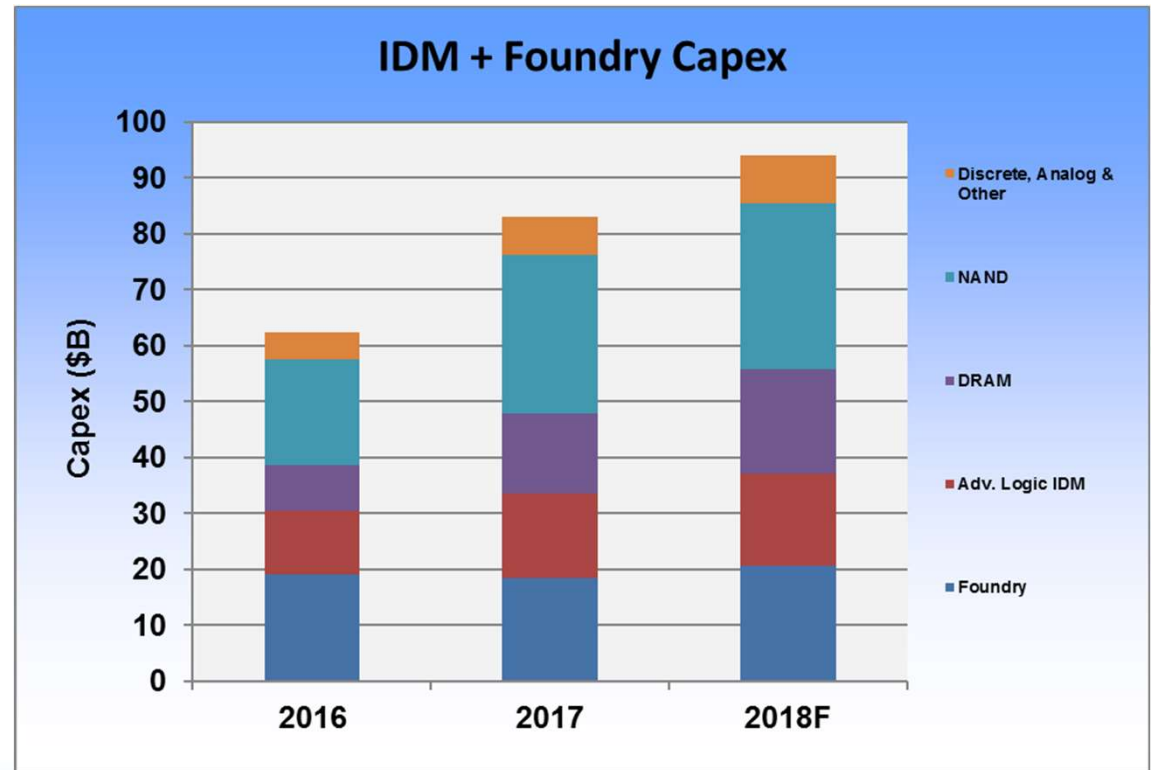
(Capital expenditures by company, \$B, ranked by 2018 Forecast)

	2015	2016	2017	2018F
Samsung	13.1	11.5	24.2	22.0
Intel	7.3	9.5	11.8	14.0
TSMC	8.1	10.2	10.9	11.8
SK hynix	6.0	5.2	8.1	11.5
Micron Technology	4.4	6.2	5.8	7.5
Toshiba/WD	3.3	4.7	6.5	7.3
GLOBALFOUNDRIES	4.1	2.5	2.8	4.5
SMIC	1.6	2.6	2.5	2.3
UMC	1.9	2.8	1.5	1.1
Sony	1.7	0.7	0.8	1.4
Others	17.7	19.1	25.1	31.6
Total	69.2	75.1	99.9	115.0
<i>y-o-y growth</i>	-1%	8%	33%	15.0%

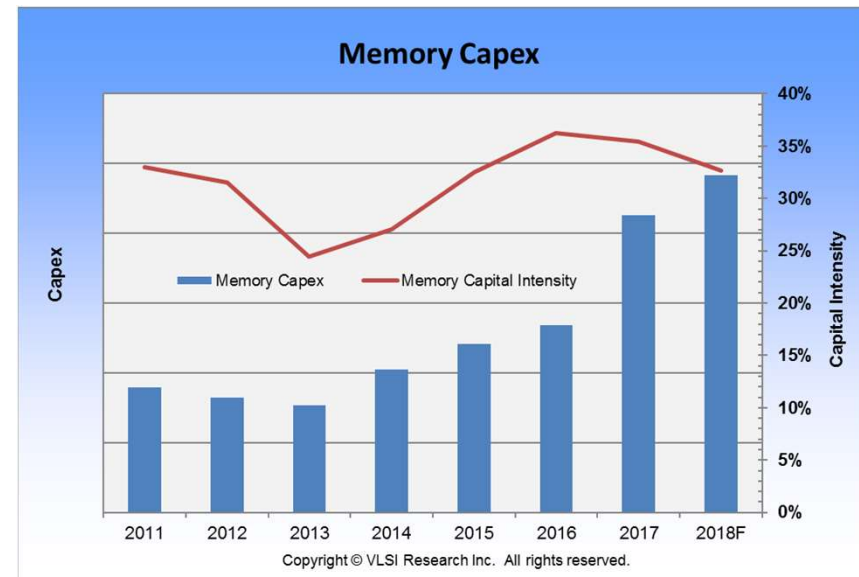
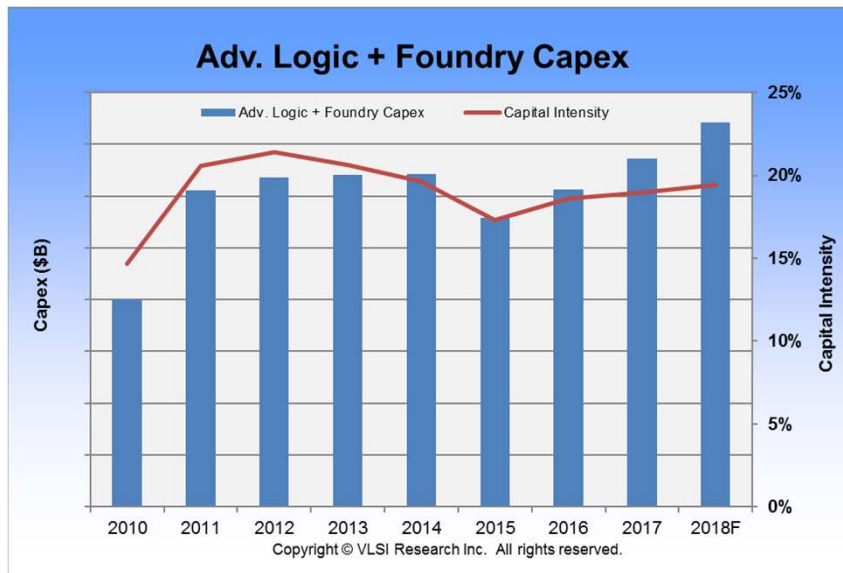
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Memory's share of spending will continue to increase in 2018

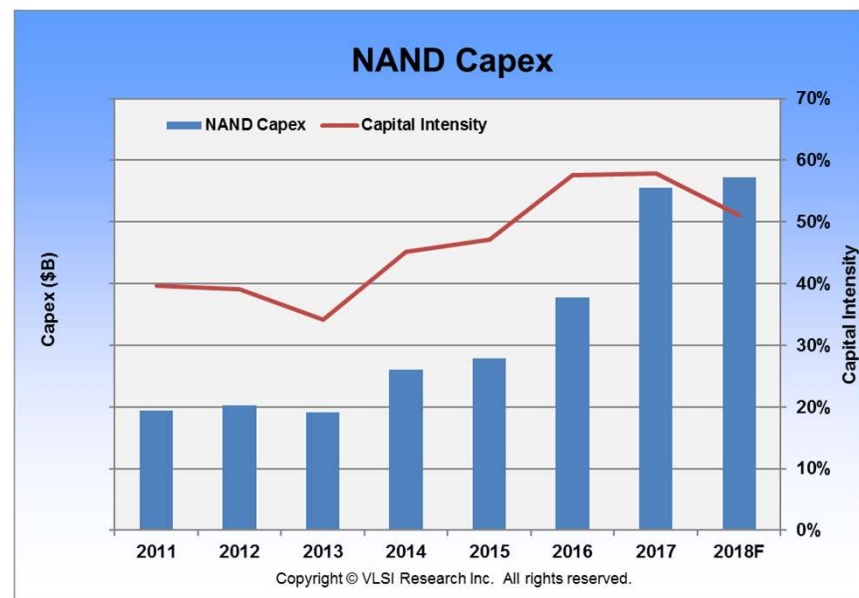
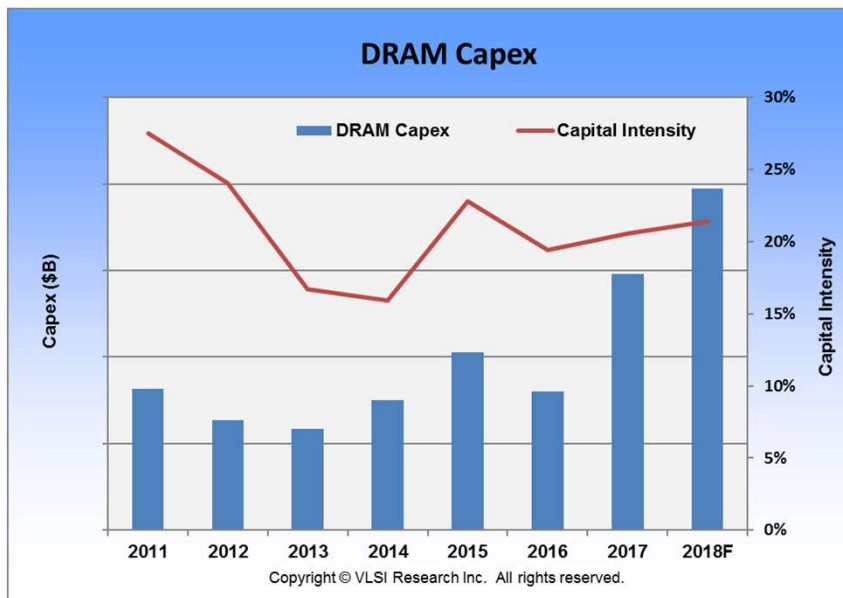
- DRAM Capex will surpass \$19B, up 33%
- DAO spending will surge 27%
- Foundry & Adv.Logic capex will increase high-single digits
- NAND Capex flat at \$28B



Higher spending levels have been supported by increasing revenues



Memory Capex



Equipment Trend for 2018 and 2019

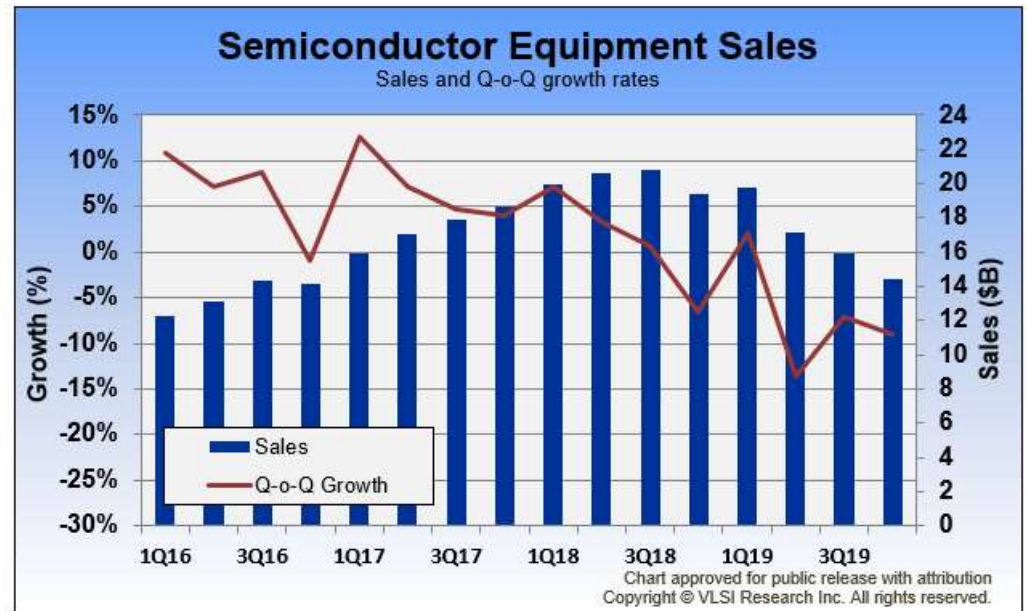
Equipment markets continue positive trend in 2018; Growth is slowing and turning negative in 2019

Semiconductor Equipment Sales

(worldwide sales, \$B, CY 2016 - 2018)

	2016	2017	2018	2019
Wafer Process Equipment	35.5	47.3	56.7	44.5
<i>y-o-y growth</i>	10%	33%	20%	-22%
Test & Related Equipment	4.0	4.7	5.2	4.8
<i>y-o-y growth</i>	8%	20%	11%	-9%
Assembly Equipment	3.6	4.4	4.9	4.6
<i>y-o-y growth</i>	13%	21%	13%	-7%
Total Systems	43.1	56.5	66.9	53.8
<i>y-o-y growth</i>	10%	31%	19%	-20%
Service	10.7	13.1	13.8	13.4
<i>y-o-y growth</i>	10%	22%	5%	-3%
Total Semiconductor	53.8	69.5	80.7	67.2
<i>y-o-y growth</i>	10.2%	29.2%	16.0%	-16.7%

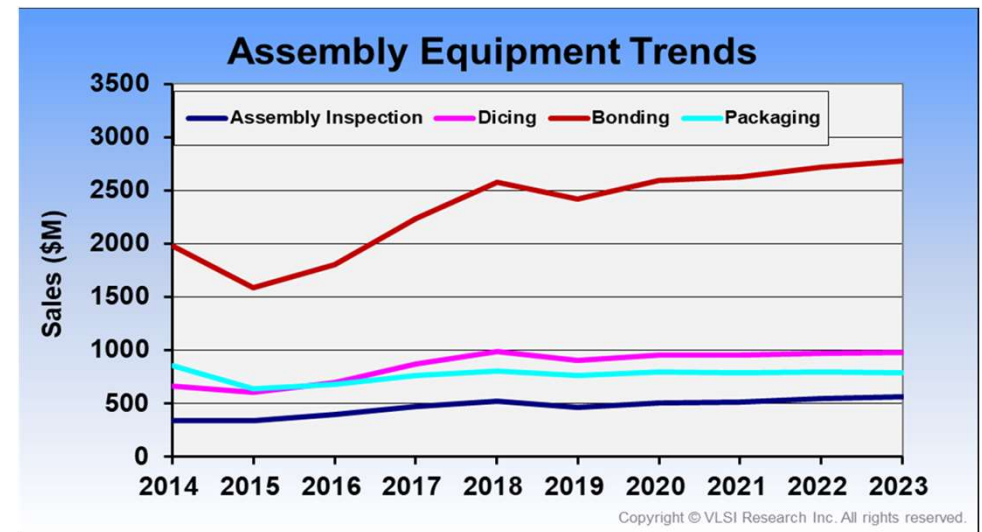
Chart approved for public release with attribution



Assembly Equipment Outlook

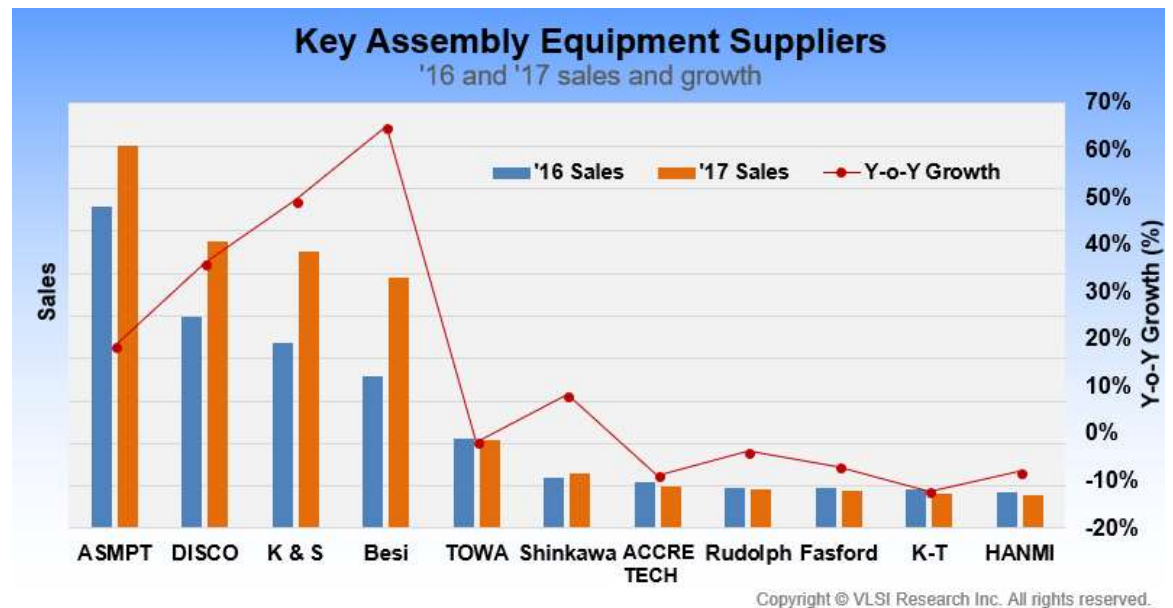
Shifting growth drivers into advanced packaging

- Broad increase in semiconductor units has driven assembly equipment demand
 - Technology transitions has driven growth higher
- Mobile devices drive Advanced Packaging
 - WLP, Flip Chip, Thin Packages, POP
 - Low-end mobile phones are using more flip chip
 - FOWLP-related equipment demand is increasing as TSMC and OSATs are investing
 - HBM2 is a new technology requiring advanced capacity
 - Analog and DRAM expanding to flip-chip



Assembly Suppliers

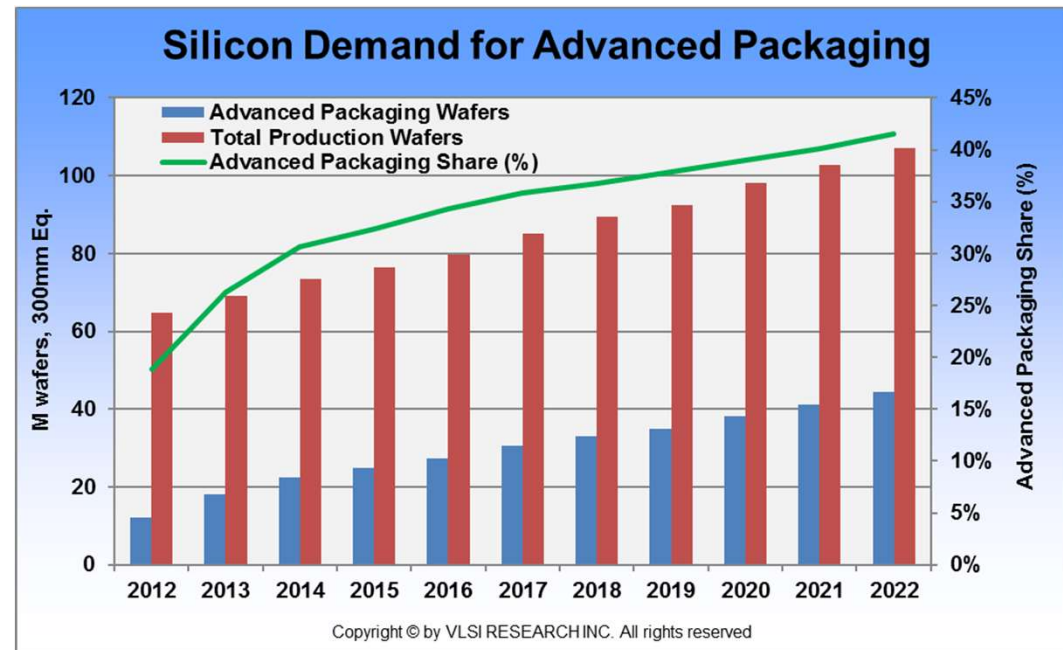
- Top 5 suppliers have gained significant share in the last five years
 - from 42% in 2013
 - to 66% in 2017



Advanced Packaging⁺ continues to gain share

Advanced Packaging is in mainstream:

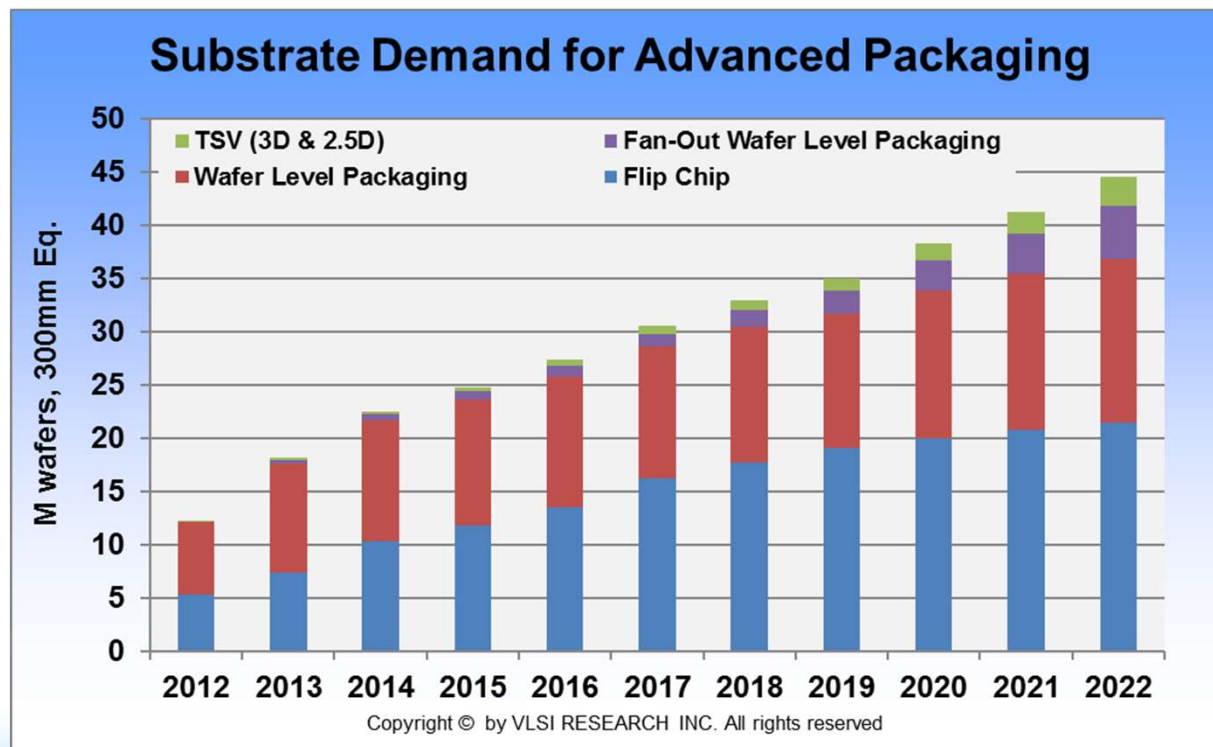
- Close to 36% of wafers use advanced packaging interconnects
- Mobile, data center, and automotive drives demand
- More low pin count devices are using AP



⁺Advanced Packaging (AP) includes area array format and thru-silicon-via interconnected packages. AP interconnects are formed in wafer format, diced and then connected to substrate. For the purpose of this analysis they are categorized as Flip Chip (F/C), Wafer Level CSP Packaging (WLP), Fan-Out Wafer Level Packaging (FO-WLP) and Through Silicon Via (TSV)

Advanced Packaging Substrate Demand

WLP and Flip Chip continues to dominate

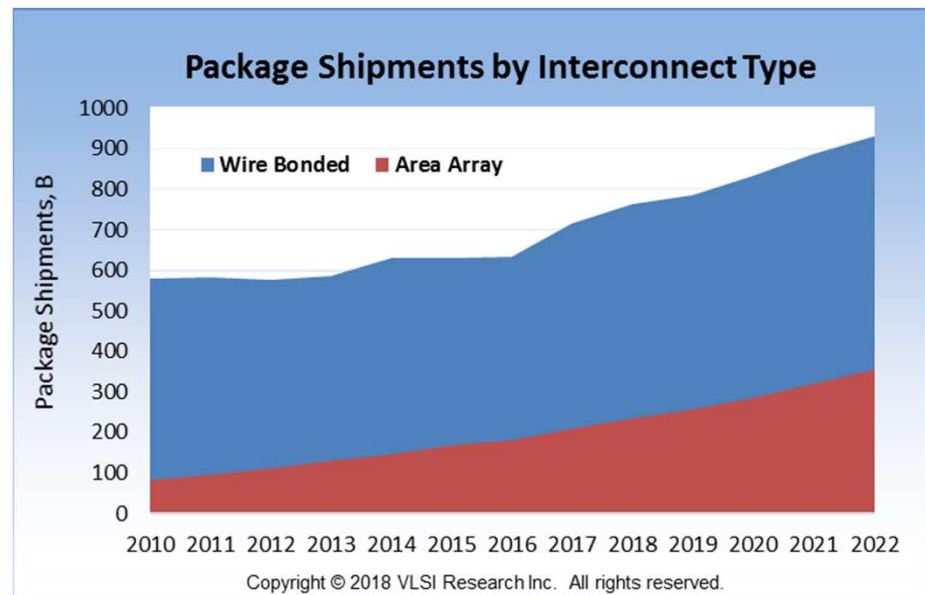


- Total advanced packaging silicon demand five-year CAGR is 9.1%
 - Compared to overall production wafers CAGR at 4.7%
- Flip Chip is the largest segment
 - WLP five year CAGR 4.4%
 - Flip Chip five year CAGR 5.7%
 - FO-WLP forecast has been scaled back.
 - Muted demand after Apple/TSMC surge
 - Cost continues to be a significant hurdle

Interconnect Mix is Changing

40% of IC packages are using AP interconnect

- IC AP interconnect share to increase from 40% in 2017 to 52% in 2022
- Wire bonded packages accounted to 77% of total semiconductor packages in 2017
 - 72% share in 2022
 - CAGR 5.4%



VLSI's View

- Semiconductor demand is rolling over to slower growth
- Pressure on memory prices is increasing
- 2019 downturn is likely and driven by Memory & Macroeconomy
- Advanced Packaging is mainstream technology
 - 23% of all packages and steadily growing
- Foundry and IDMs invested heavily in packaging
 - Memory, data center, and automotive are the key segments
- Fan-Out Wafer Level packaging will take more time to become major interconnect technology
 - New interconnect generations always take more time than expected
 - Cost is a major hurdle



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... and backup slides



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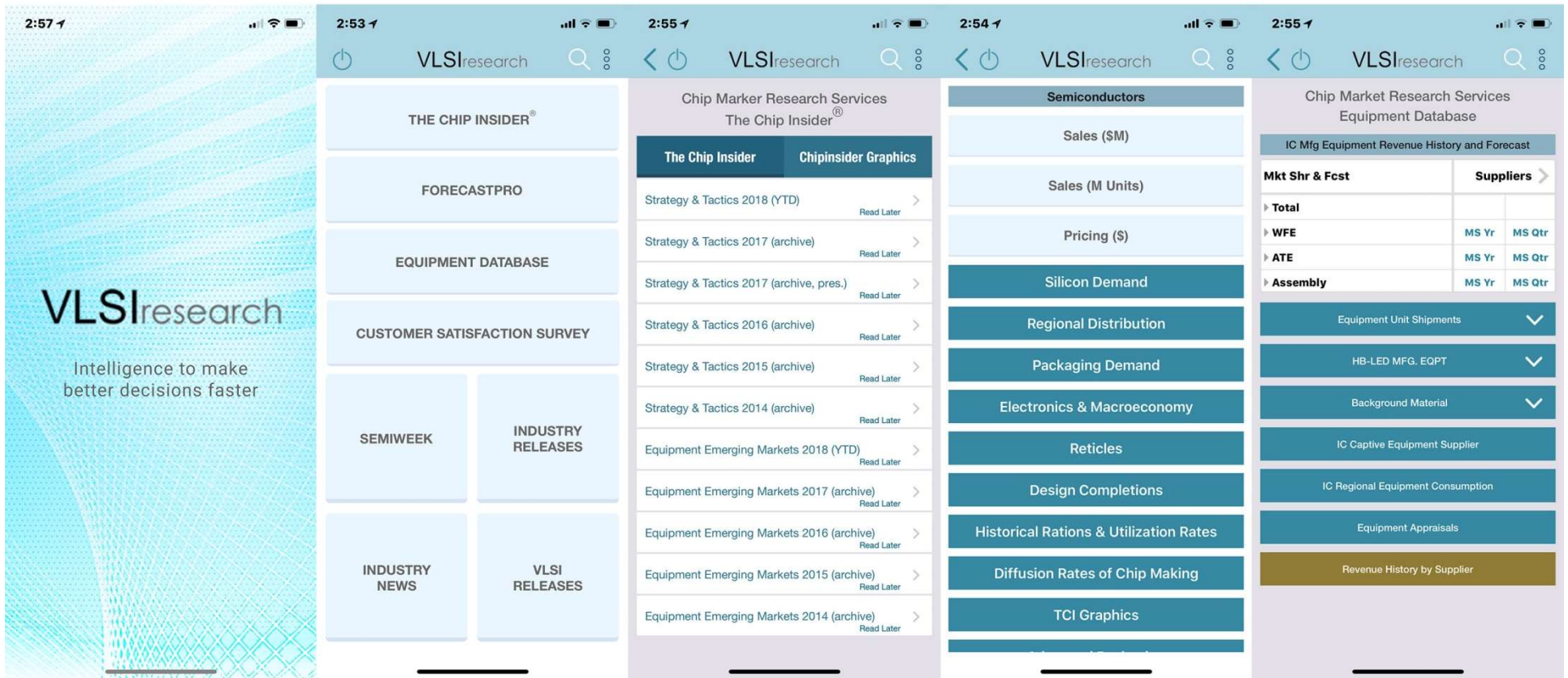
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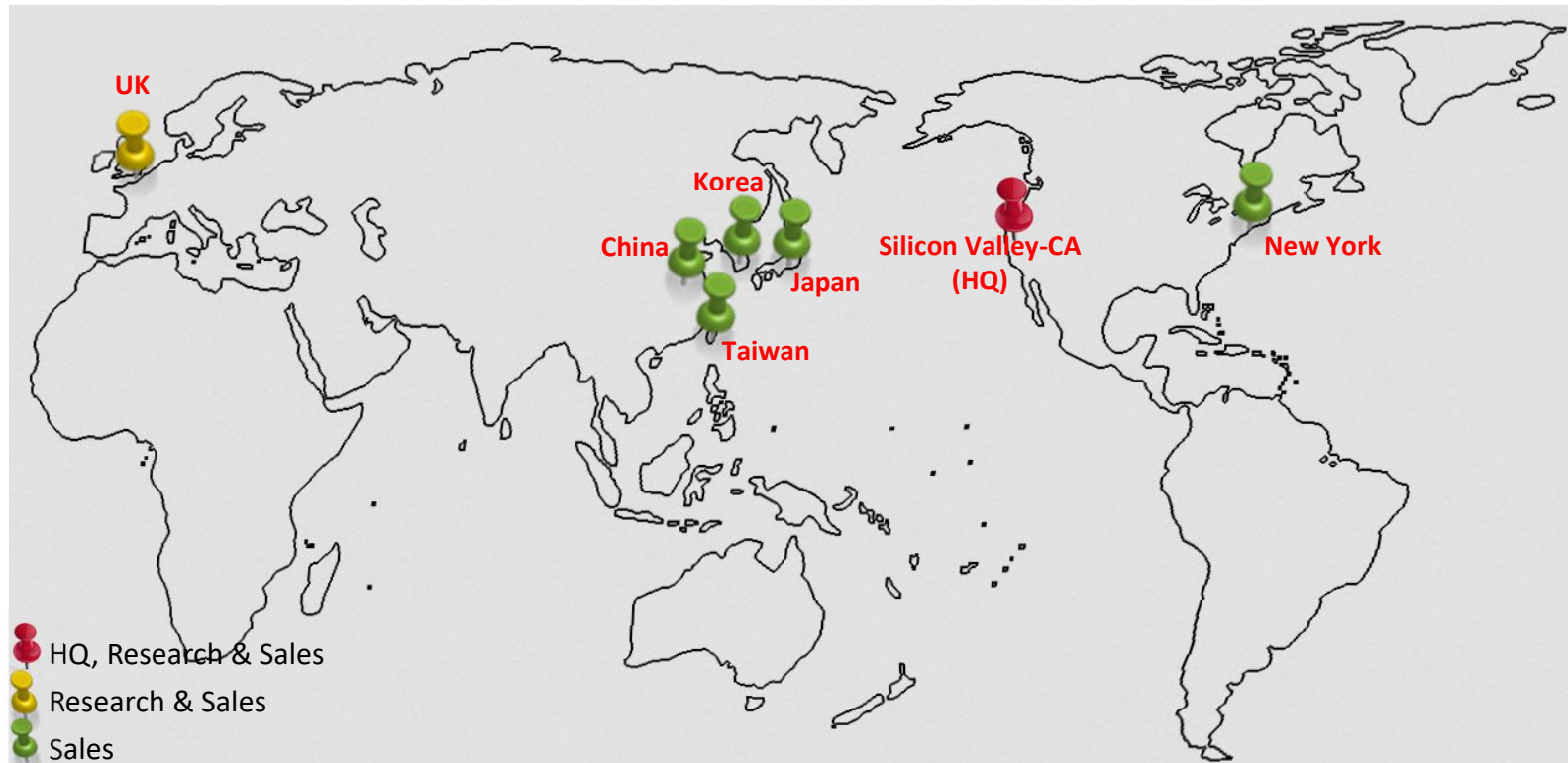
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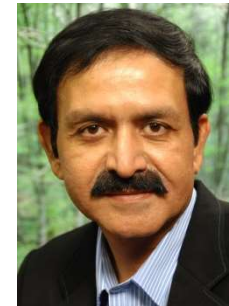
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