



IHS Markit™

Global Semiconductor Market Trends

Opportunities and Challenges Facing the Semiconductor Industry

July, 2018

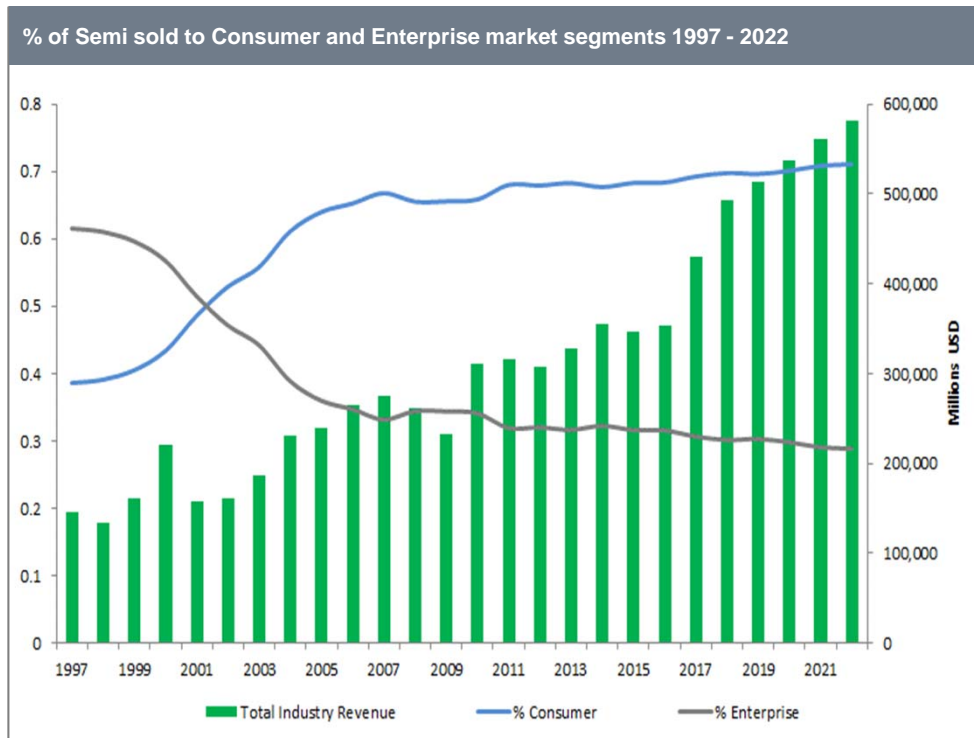
Len Jelinek, Vice President & Chief Analyst

Agenda

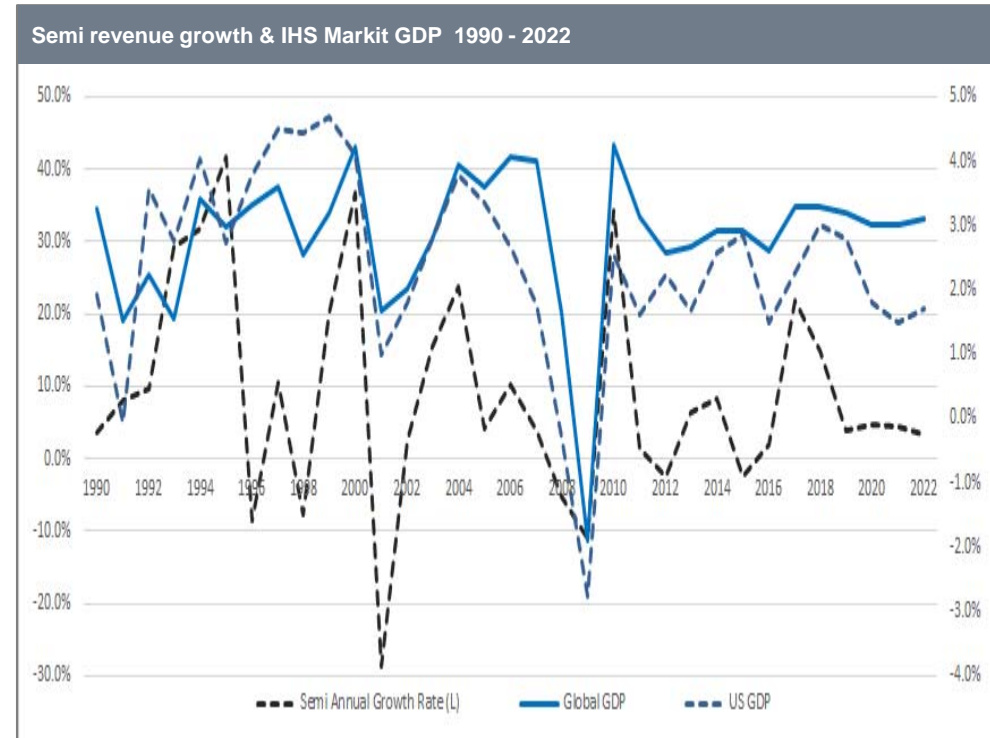
- **IHS Markit Economic Forecast and Semiconductor Cycles**
- **Competitive Landscape**
- **Applications Driving Component Demand**
- **Revenue Forecasts and Silicon Demand**
- **Manufacturing Update 2H 2018**

Global Economic Expansion Provides the Foundation for Solid Semiconductor Revenue Growth in 2018

- Approximately 70% of all semiconductor components are used in a Consumer related products
- > Good correlation exists between the global economy and revenue growth for the semiconductor industry



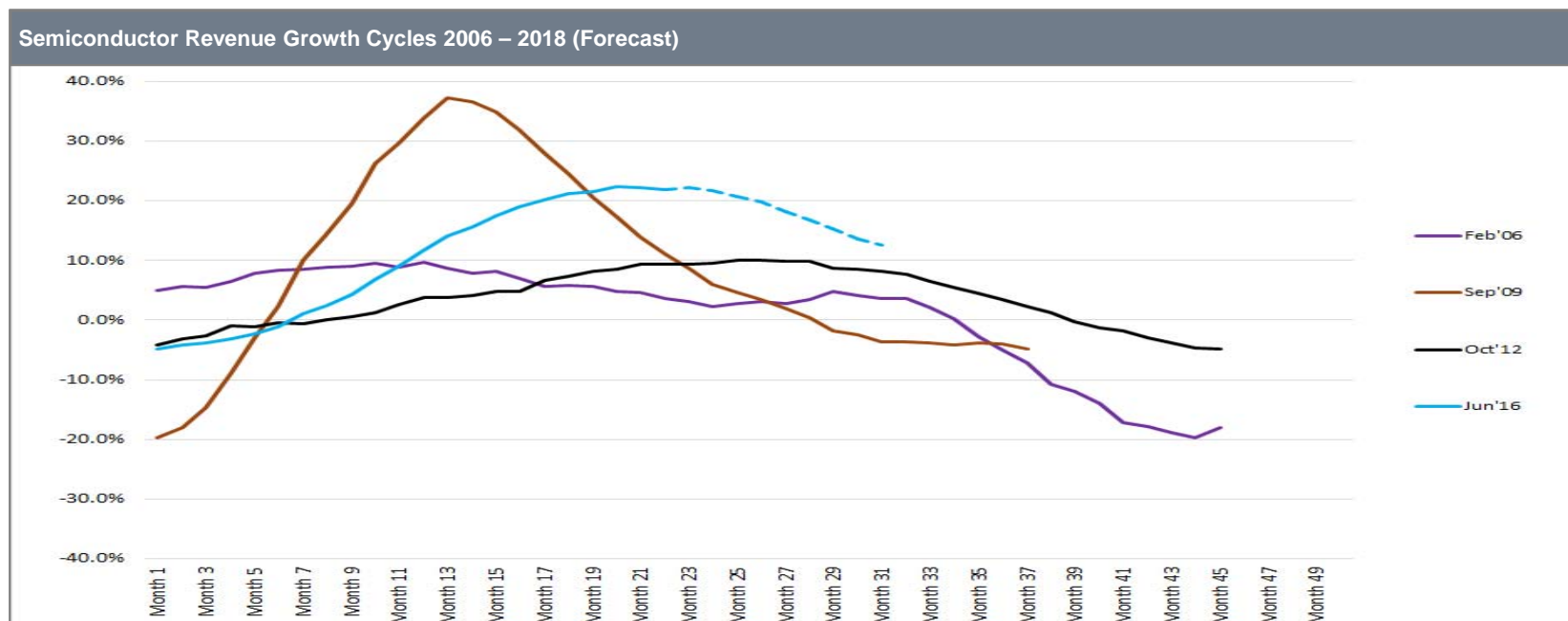
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Source – IHS Markit Competitive Landscaping Tool

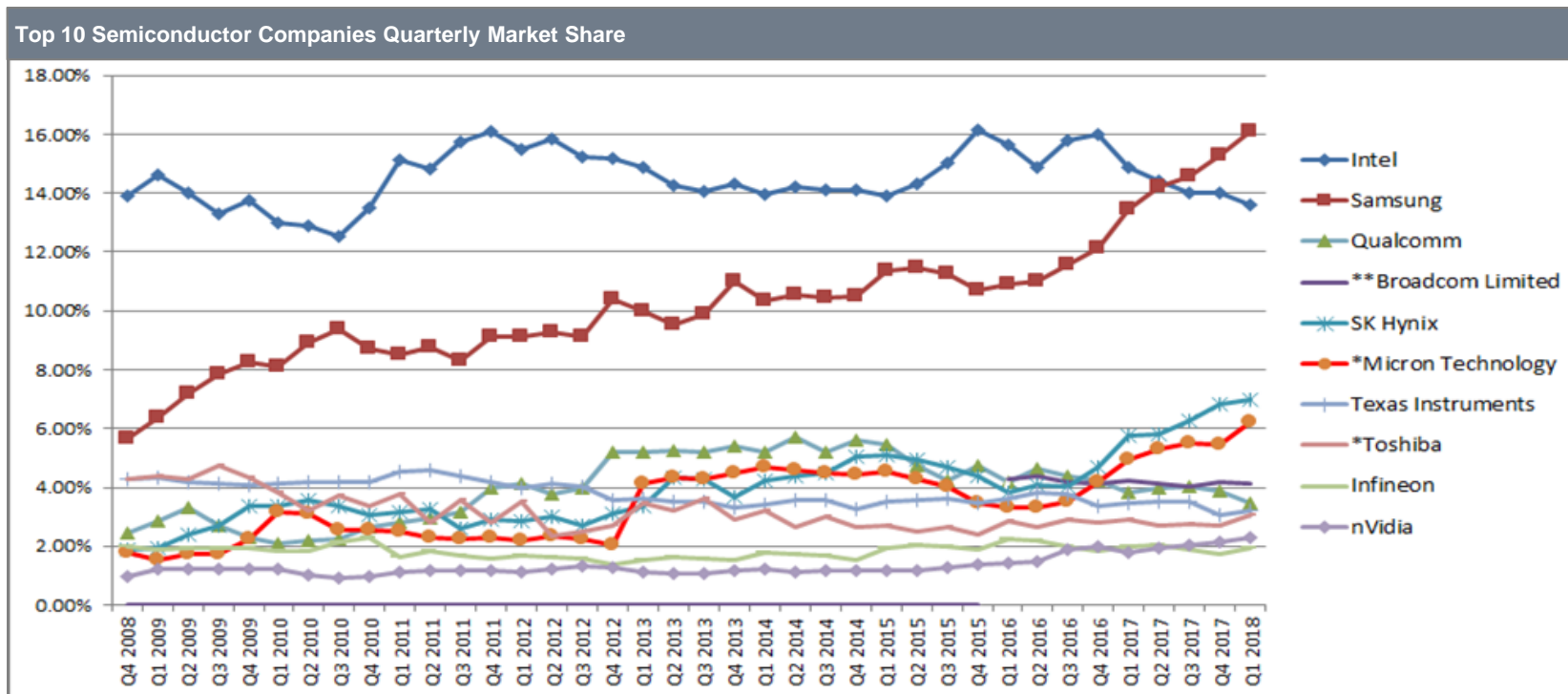
Industry Revenue Cycles Reflect Product Life Cycles

- Historically cycles have lasted about 4 years and contain an initial period high demand followed by extended period of slowing growth
- The current semiconductor cycle is being driven by strong demand for Memory components (DRAM and NAND)



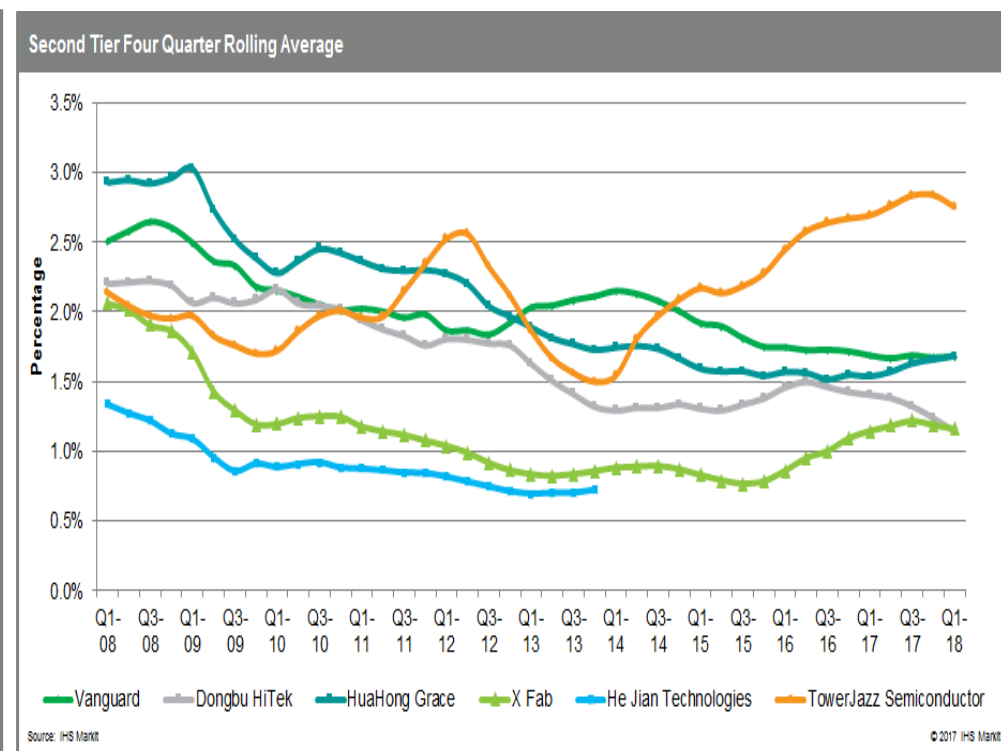
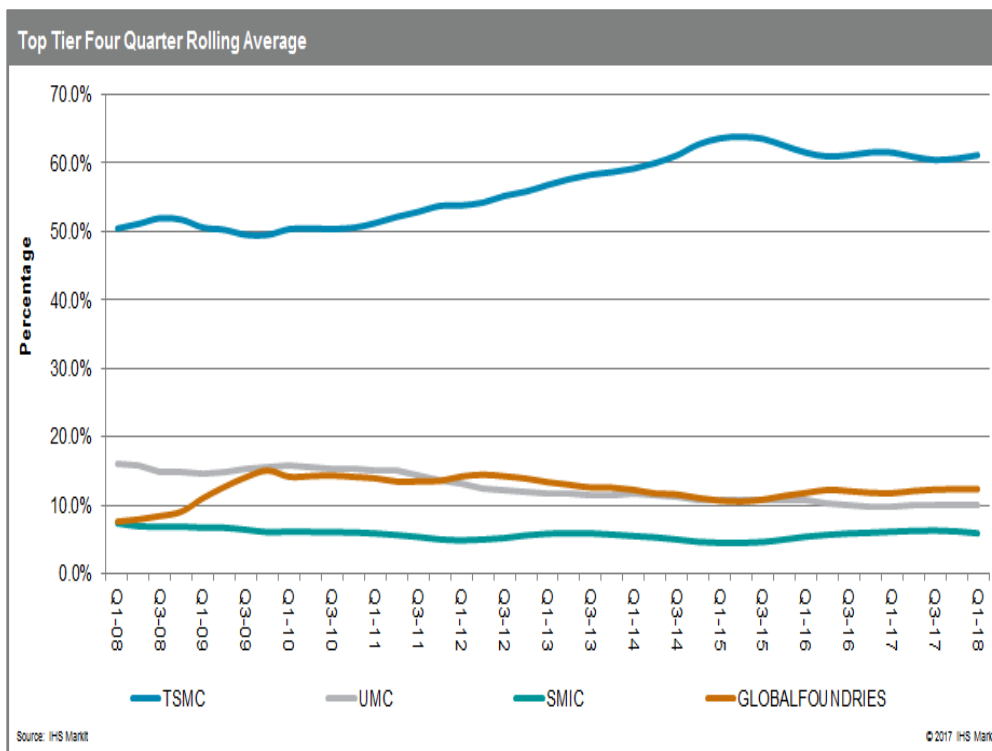
Competitive Landscape – Top 10 Semiconductor Suppliers

- Supply and demand of memory components continue to shape the semiconductor landscape in 2018
 - > Memory suppliers are forecast to generated 35% of the total industry revenue in 2018



Competitive Landscape – Pure Play Foundry Companies

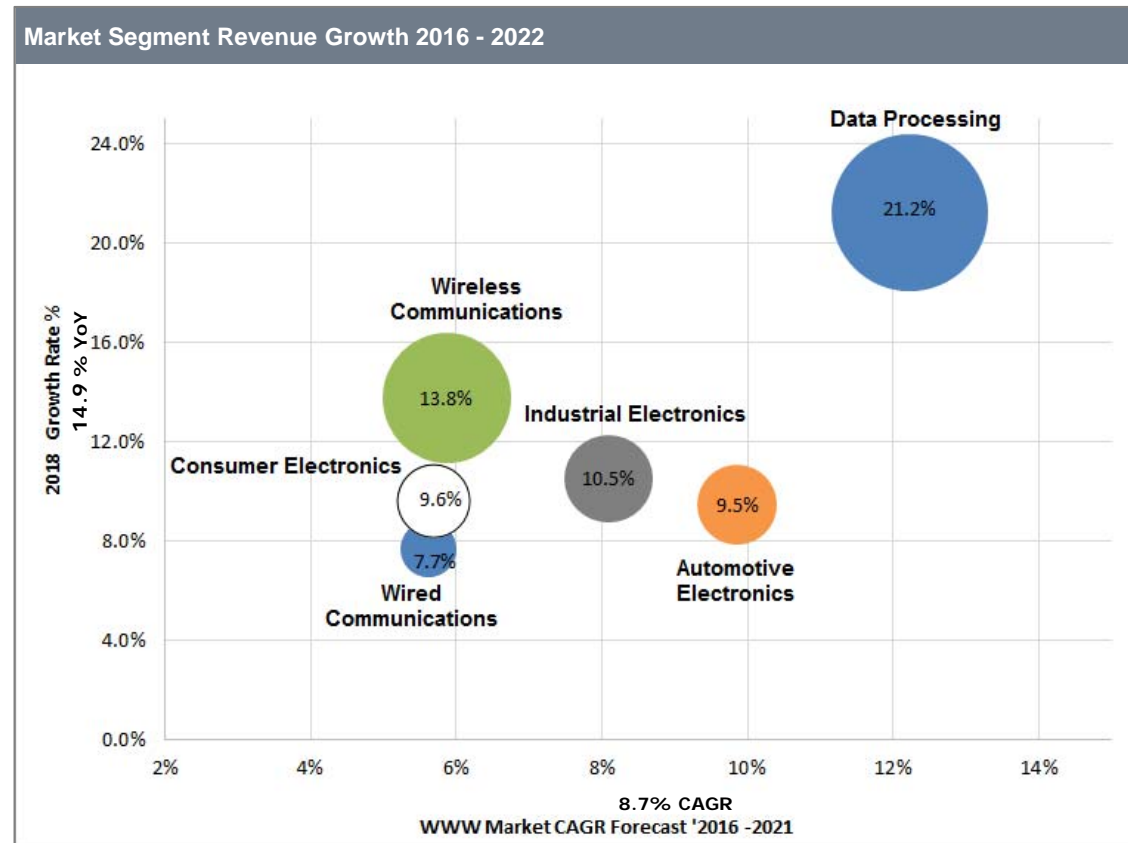
- TSMC continues to dominate the tier 1 foundry suppliers with over 60% share
- TowerJazz has emerged as the leading second tier pure play foundry supplier



Key Market Segments & Applications

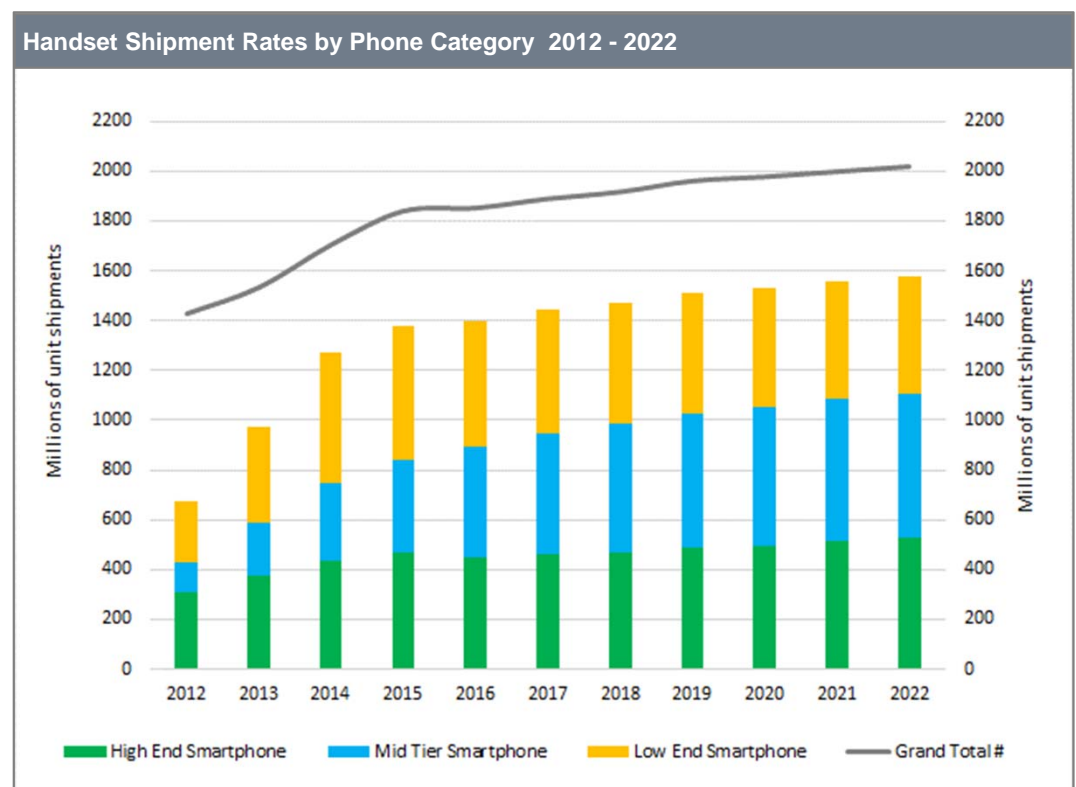
Semiconductor Revenue Forecast by Market Segments

- IHS is forecasting that the total semiconductor industry revenue in 2018 will grow by 14.9%
 - > In 2018 IHS is forecasting that Memory will grow by 30.7% and all other semiconductors will grow by 7.8%
- Wireless communication is forecasted to benefit from next generation handsets incorporating new features like biometrics, AI capability and increased battery life
- Automotive electronics continues to grow by focusing on advanced safety features
- Consumer electronics benefits from the move toward internet connected devices
- Increased servers supporting cloud computing is major driver in Data Processing segment
 - > DRAM pricing significantly impacts revenue in Data Processing



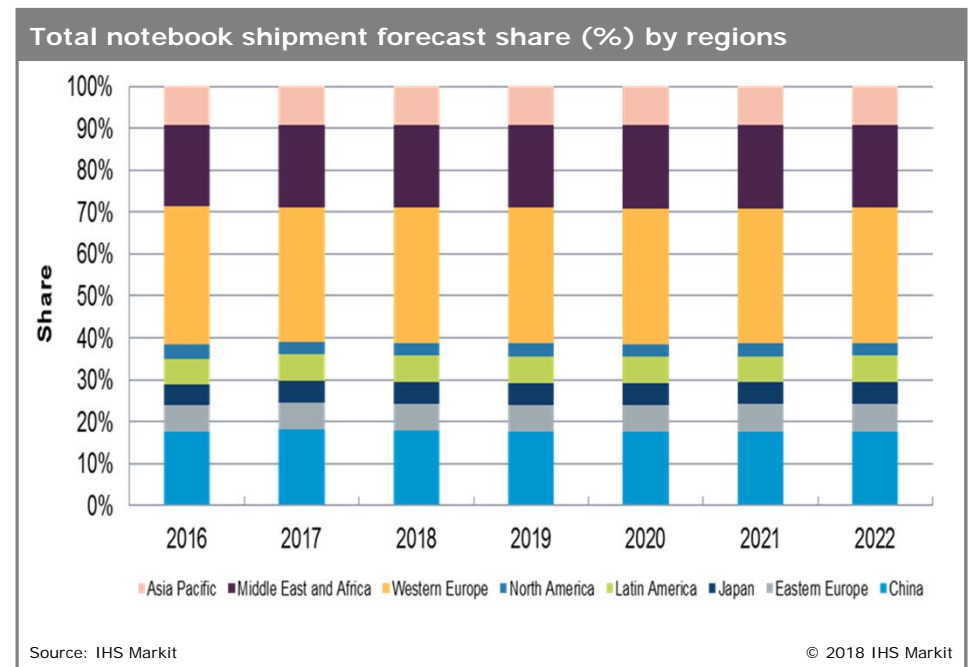
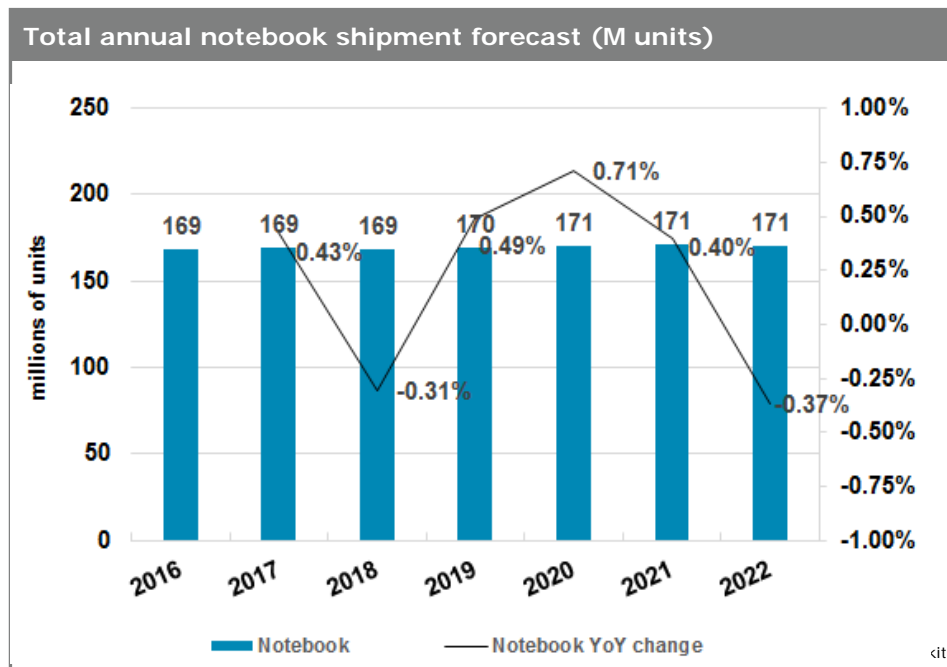
Market Saturation and Lack of Product Differentiation Impacts Total Handset Growth

- Smartphone shipments are forecast to increase in 2018 to 1.5 billion units with YoY growth rate of 2.0%
- Mid-tier smartphones are providing consumers with the most features / value for lowest price. In 2018 IHS Markit anticipates these phones will grow by 7.9%
- Smartphones sales in the second half of 2018 will be driven by:
 - > Display technology
 - > Display size
 - > Price / performance



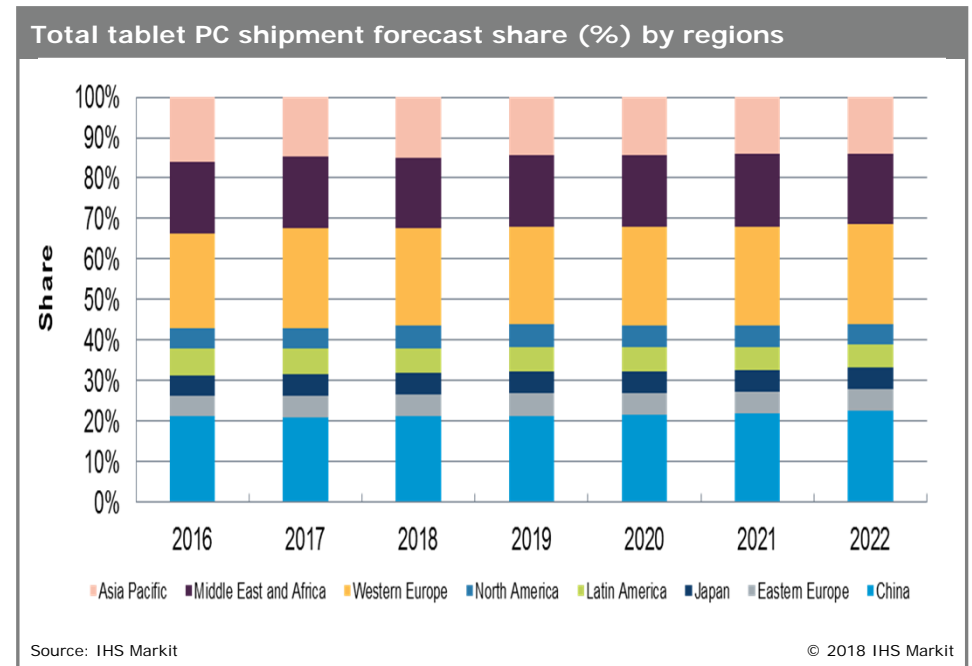
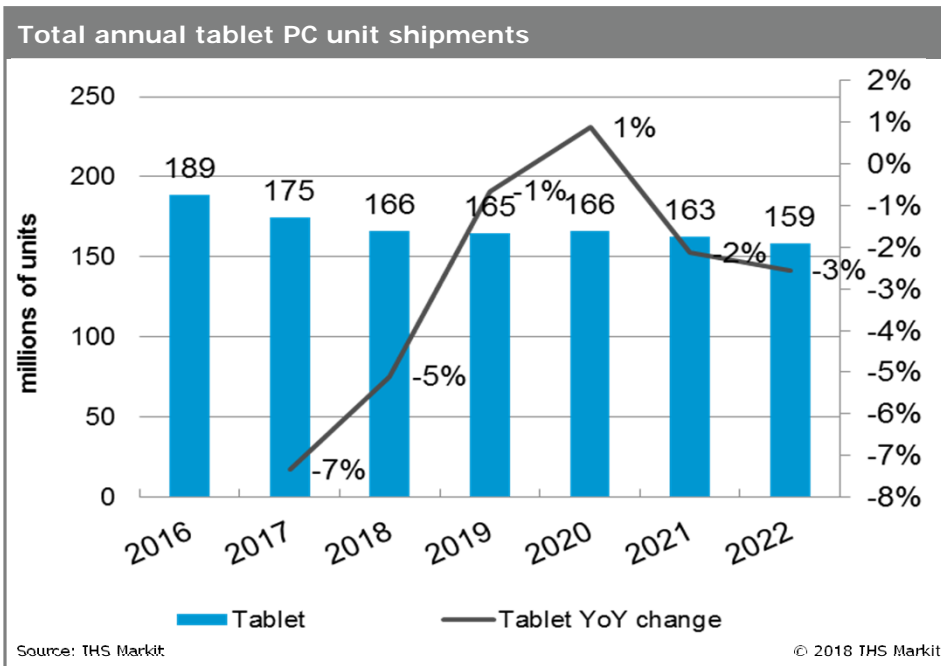
Notebook PC Annual Shipment and Shipment by Region Forecast

- Notebook PC shipments are projected to be 169M units which represents a 0.31% Y/Y declined in 2018
- Notebook shipments return to positive growth in 2019 driven by PC replacement due to the end of technical support of Windows 7 & Windows Server 2008.



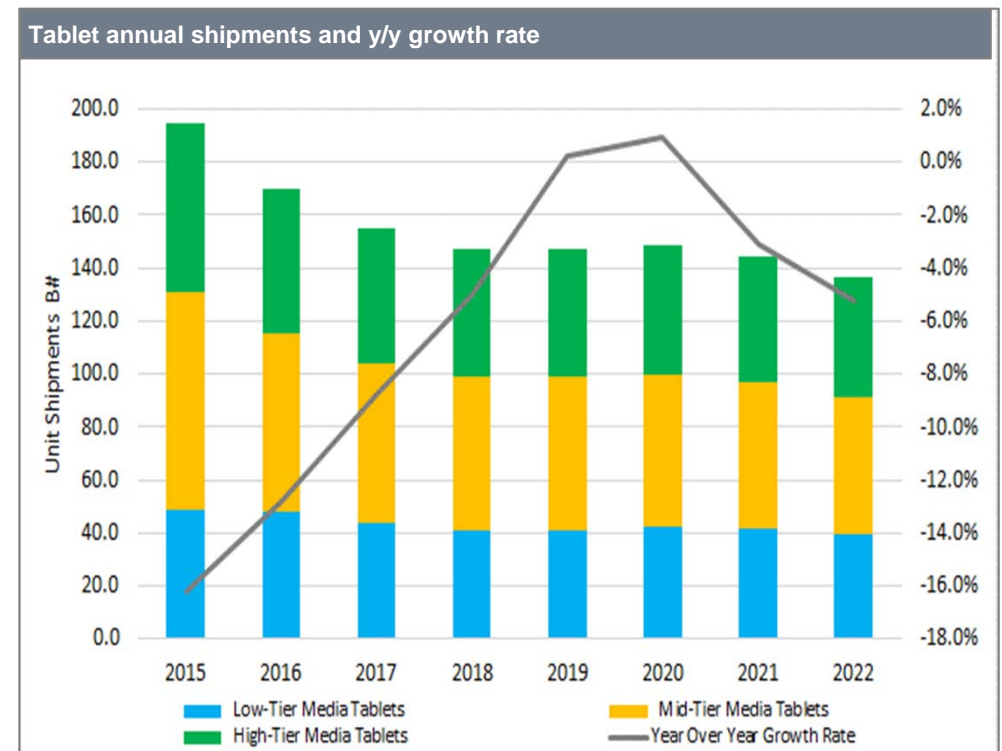
Tablet PC annual shipment and shipment by region forecast

- Tablet PC shipments are projected to be 166M units with 5.1% Y/Y declined in 2018
- New Tablet PC replacement demand from small and medium business in Western Europe comes from tablets/detachable PCs



Long-term Growth for Media Tablets Requires New Use Cases

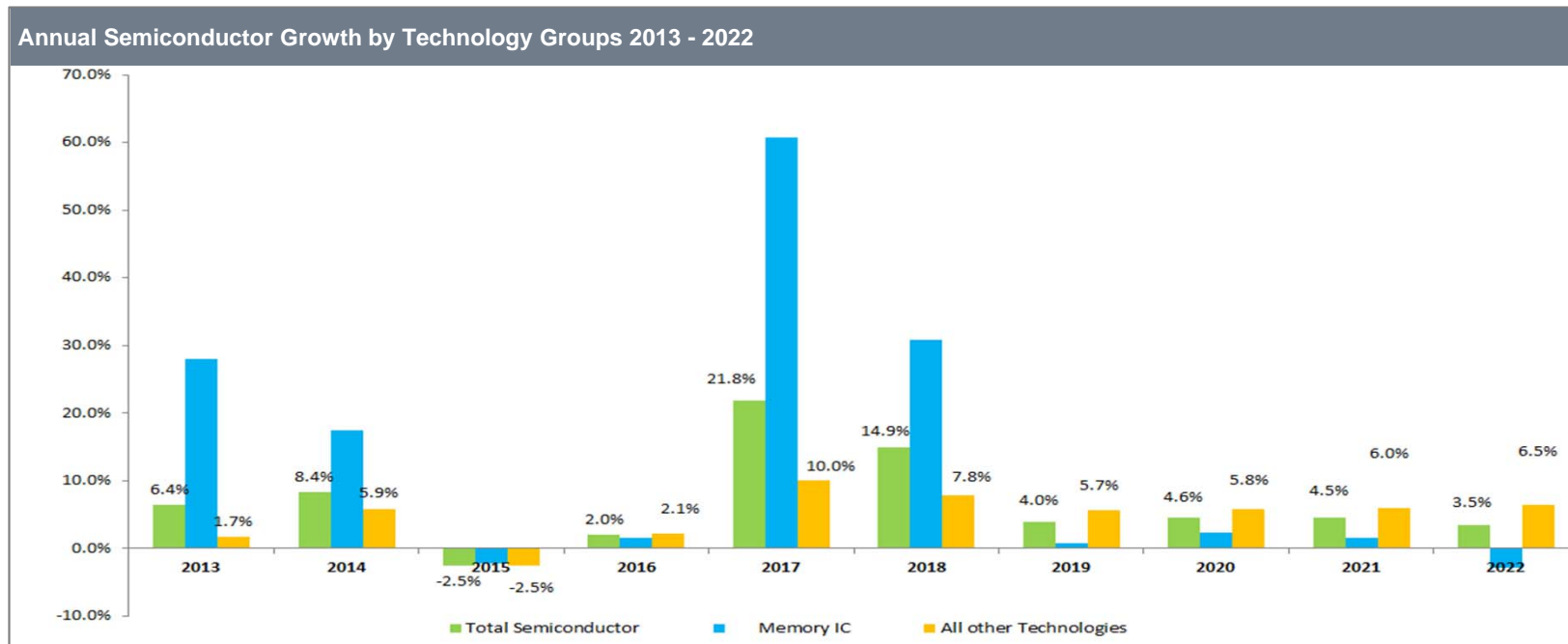
- Media tablet sales continues to decline, due to combination of slowing refresh cycles, cannibalization from smartphones and notebook PCs, and lack of radical innovation in the tablet space
- Media Tablet sales in 2018 are forecast to decline by 5.0%
- New applications continue to evolve for tablets:
 - > Apple is continuing its effort to develop applications designed for vertical business markets—education, insurance, healthcare, banking, airlines ect
 - > Japan has been in the forefront of tablet applications designed to support elderly users.
 - > Service industry is leading the way incorporating tablets for efficiency and customer satisfaction



Semiconductor forecast

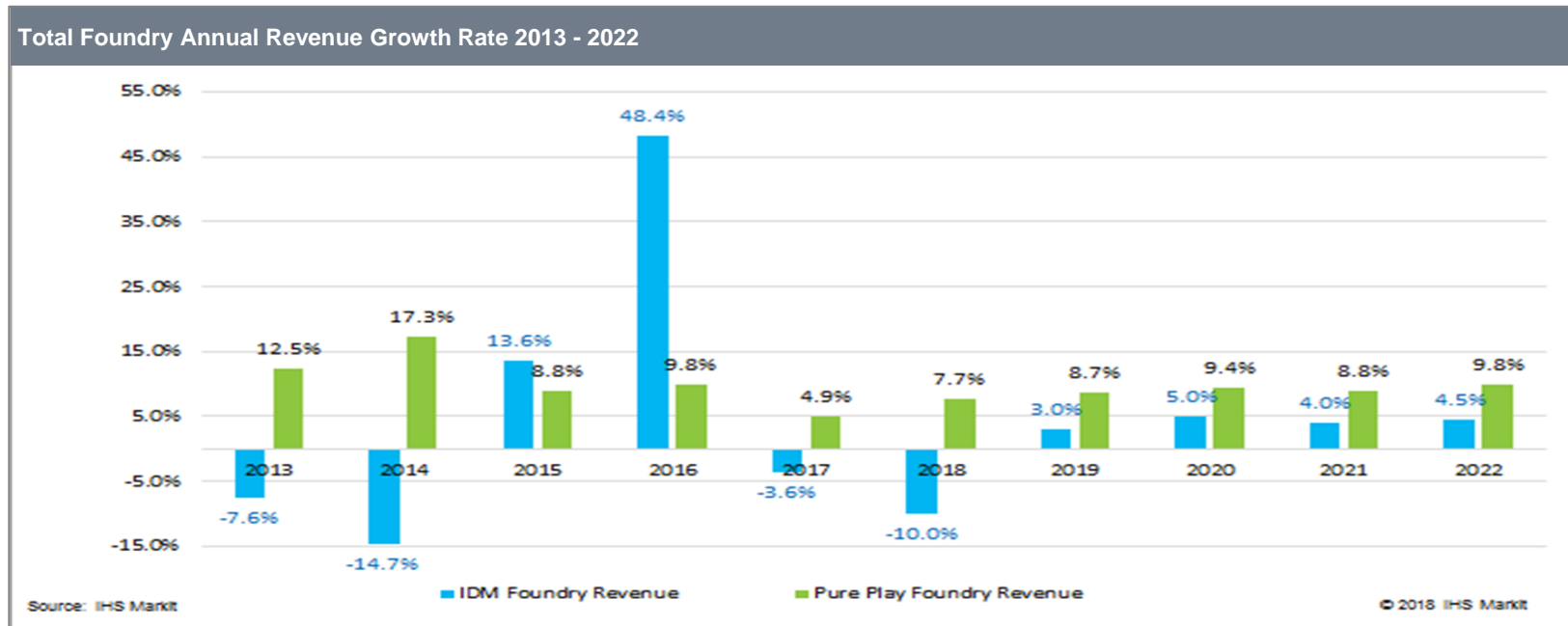
IHS Semiconductor Revenue Forecast 2013 - 2022

- Supply and demand for both DRAM and NAND continues to impact overall industry revenue growth rates
- > Growth rate for revenue from “all other” semiconductor technologies will slow in 2018 causing the industry to begin to assess further expansions



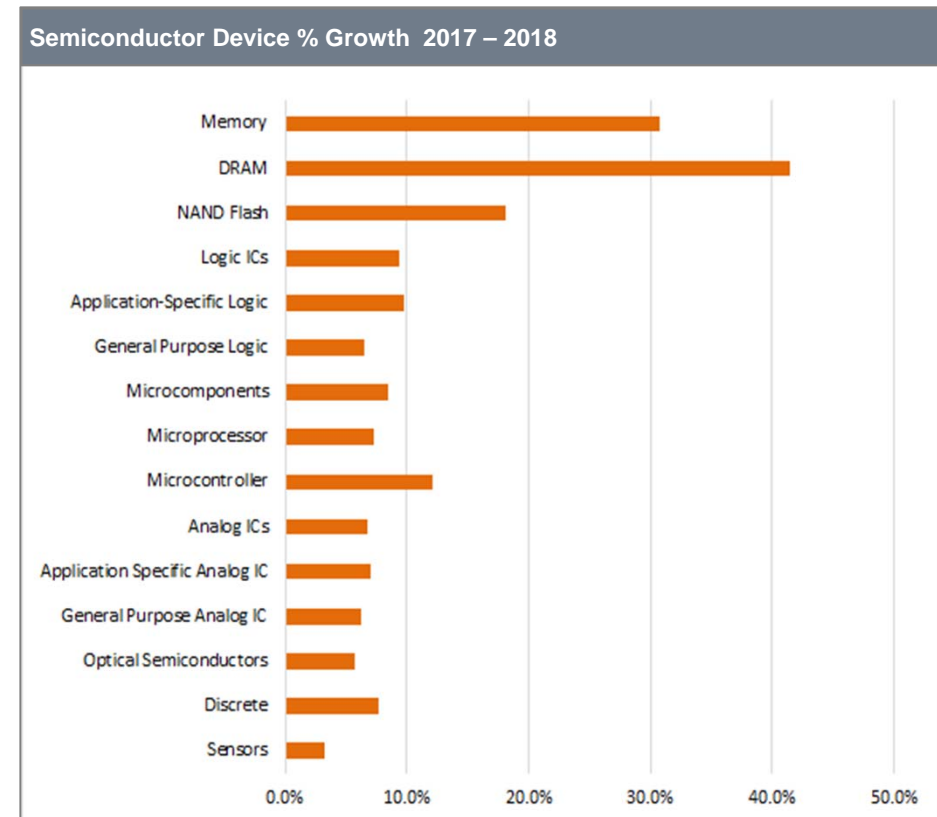
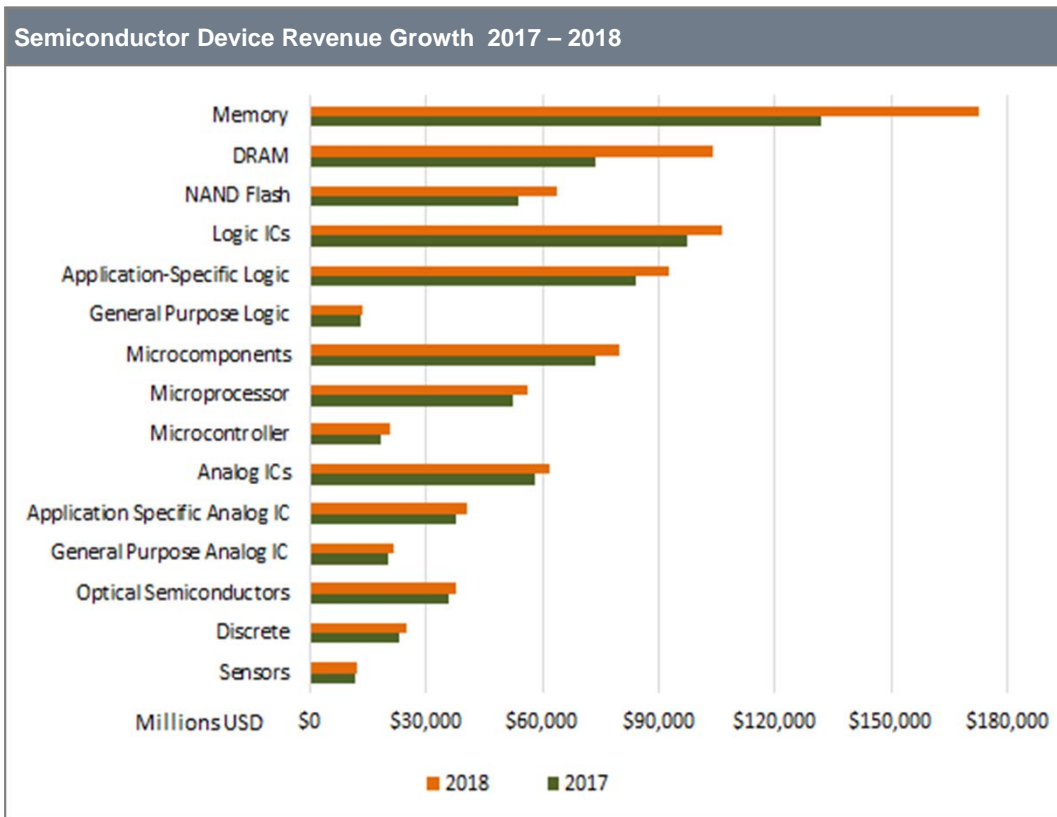
IHS Foundry Revenue Forecast 2013 - 2022

- Pure play foundry revenue growth in 2018 rebounds with the introduction of 7 nanometer technology
 - > Multiple inter-nodes designs emerging at all of the major foundries offer power, performance, area and cost trade-off opportunities for companies



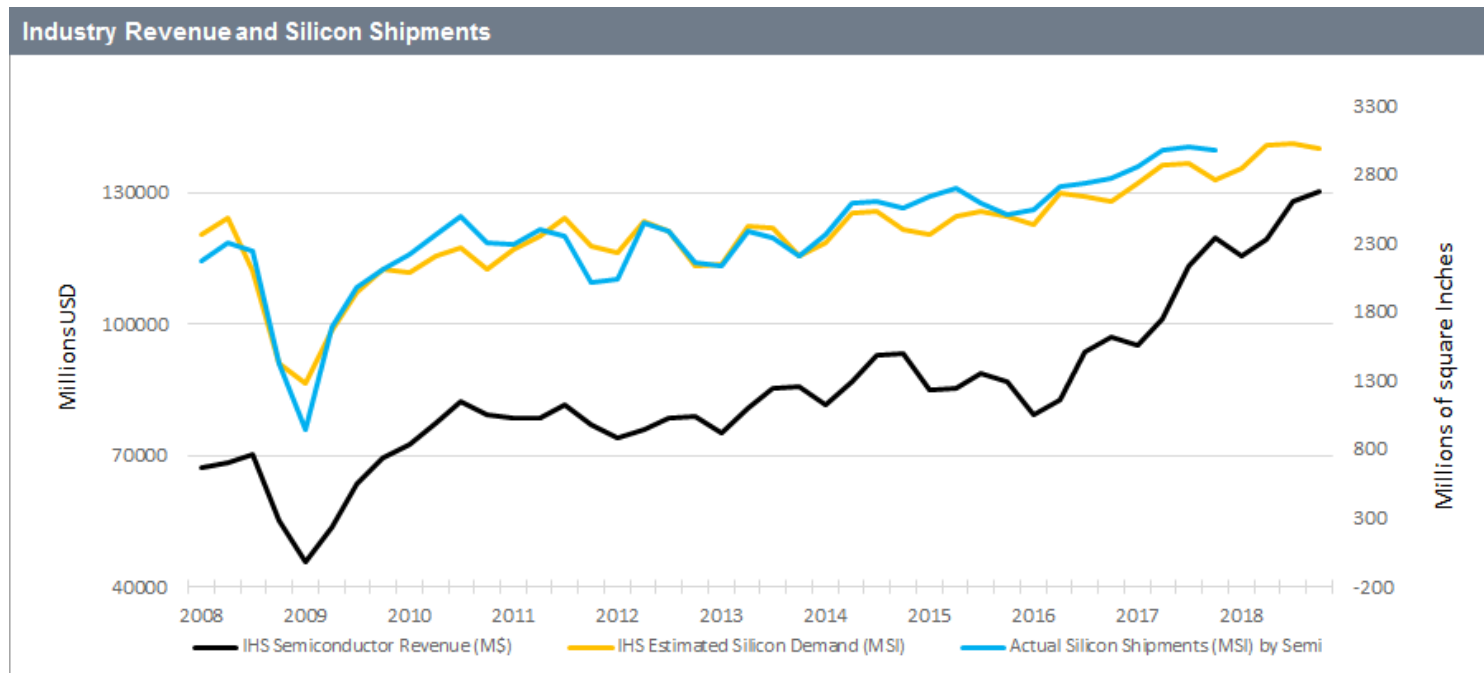
Semiconductor Device Growth Forecast 2018

- Strong DRAM demand from datacenter drives Memory revenue increase



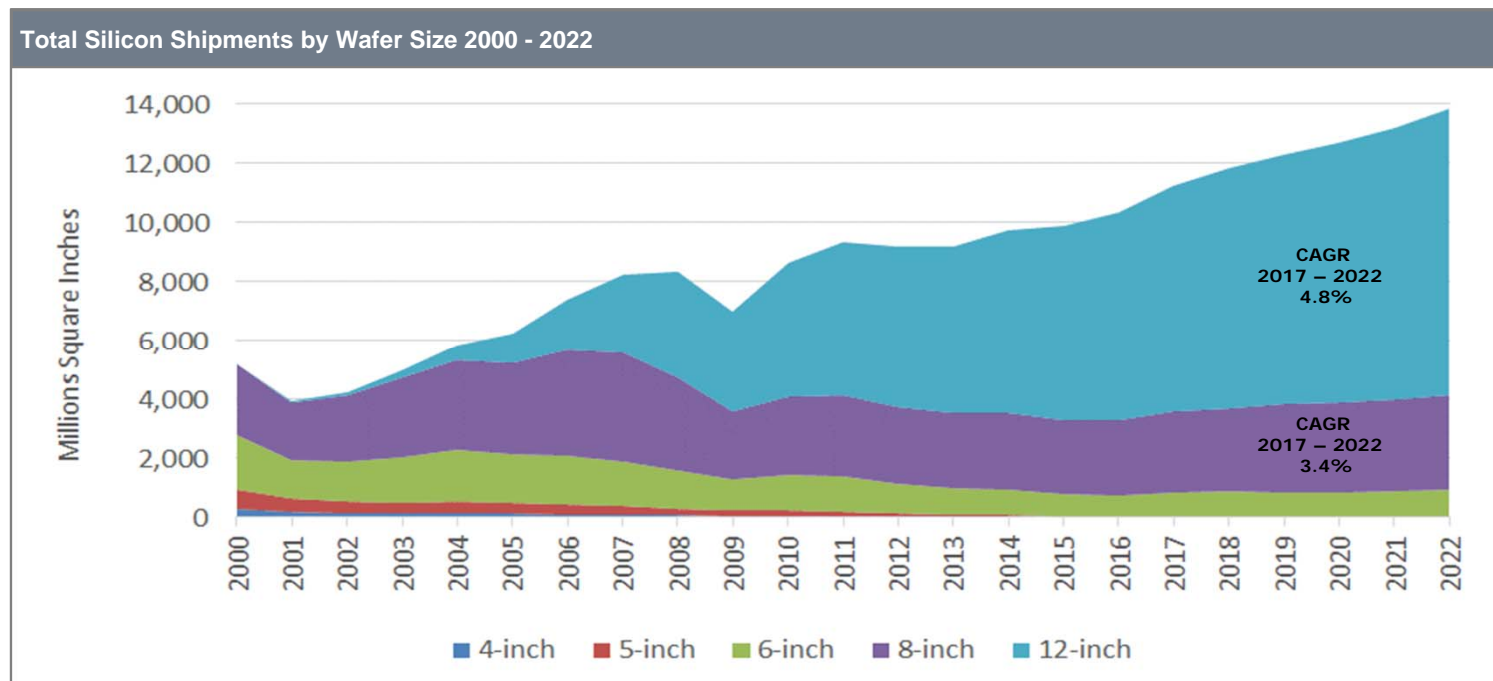
Silicon Demand by Manufactures is Forecast to grow 5.4% 2018

- Semi estimates total silicon shipments grew by 10.0% in 2017, IHS believes actual demand required only an 8.9% growth rate for silicon shipments
- > Component manufacturers have increased the value of their raw material inventory by 27.0% since Q4, 2016



Global Silicon Demand by Wafer Size

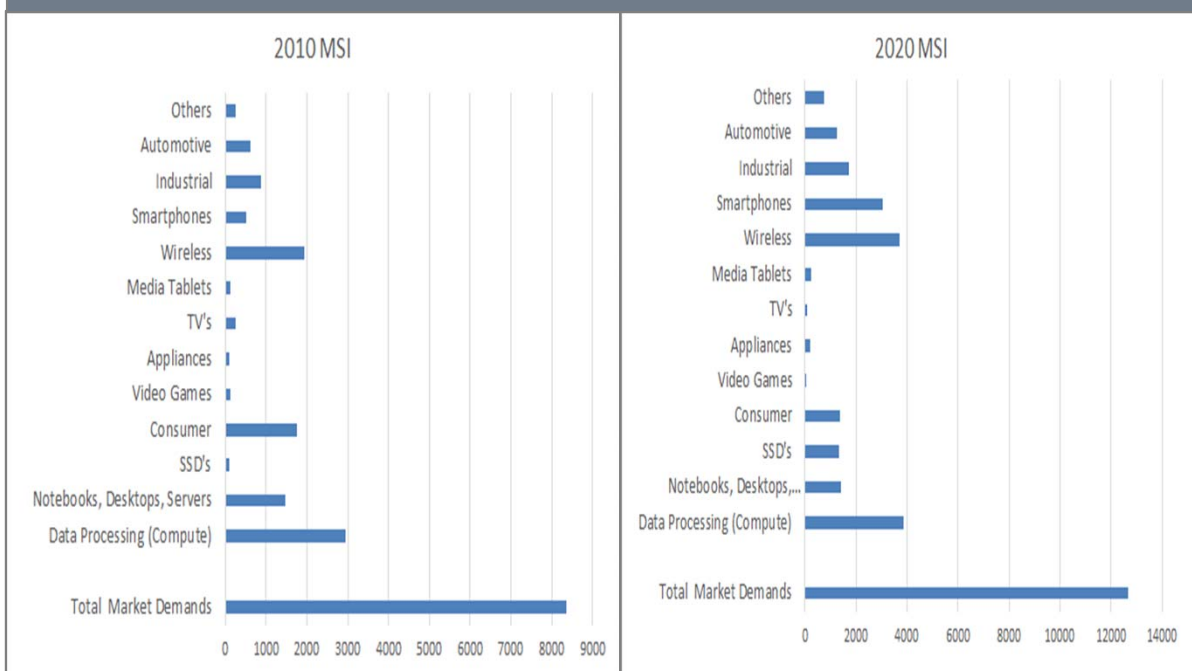
- Global silicon shipments grew by 8.9% in 2017 and are forecast to grow by 5.4% in 2018
- Silicon raw material suppliers will remain constrained until 2nd half of 2019
- > Additional capacity coming on in 2018 and 2019 should prevent industry allocations



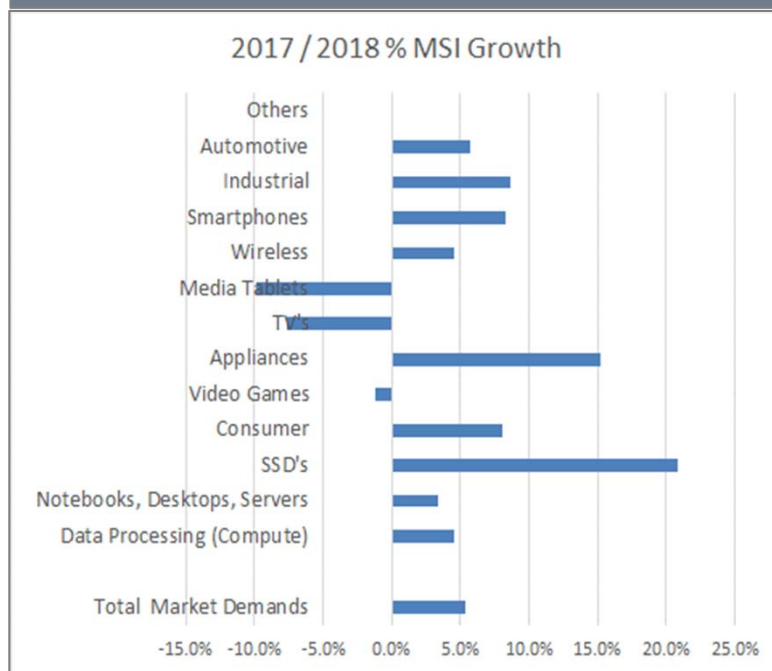
MSI Demand by End Market Application

- Global silicon shipments reflect increased demand for NAND Flash supporting strong server growth
- Smartphone saturation slows demand for silicon
- > Computational analysis (Mobile PC, Desktop and Servers) drive long-term silicon demand

Total Silicon Shipments MSI 2010 & 2020

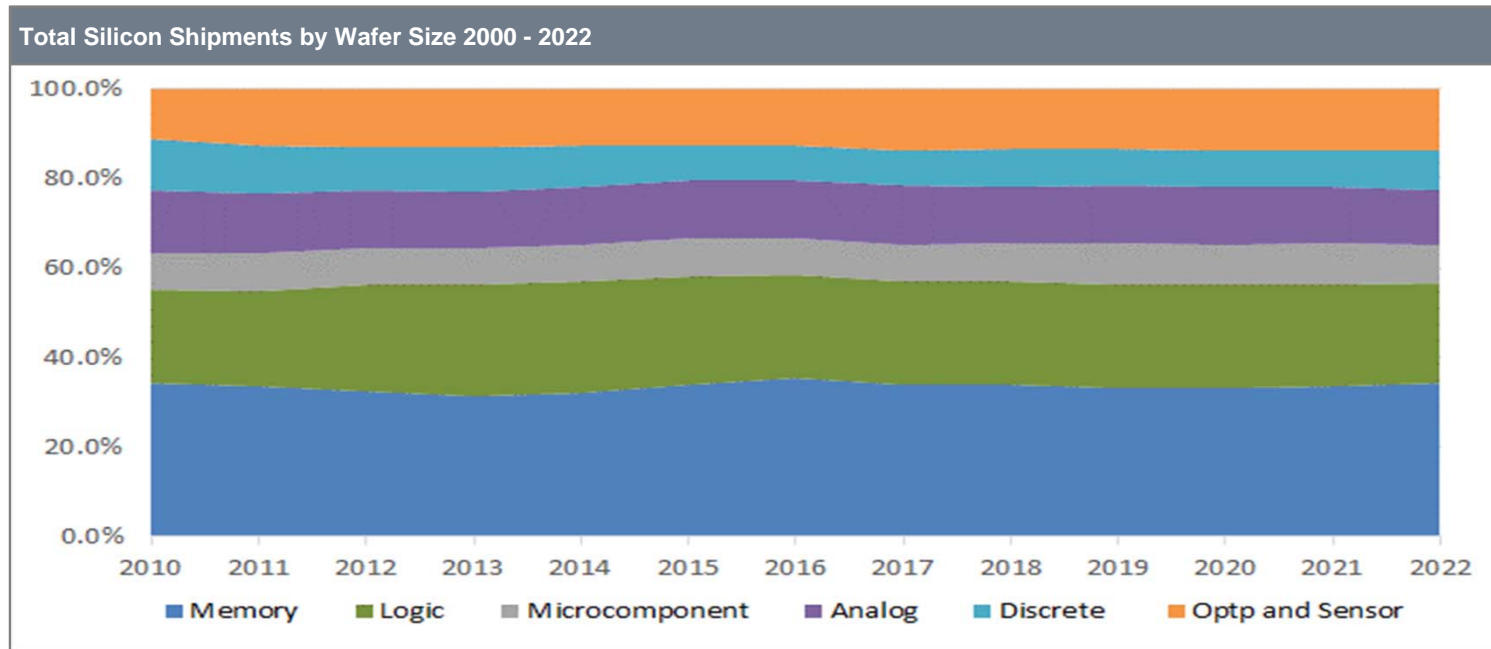


Total Silicon Shipments MSI Growth Rate



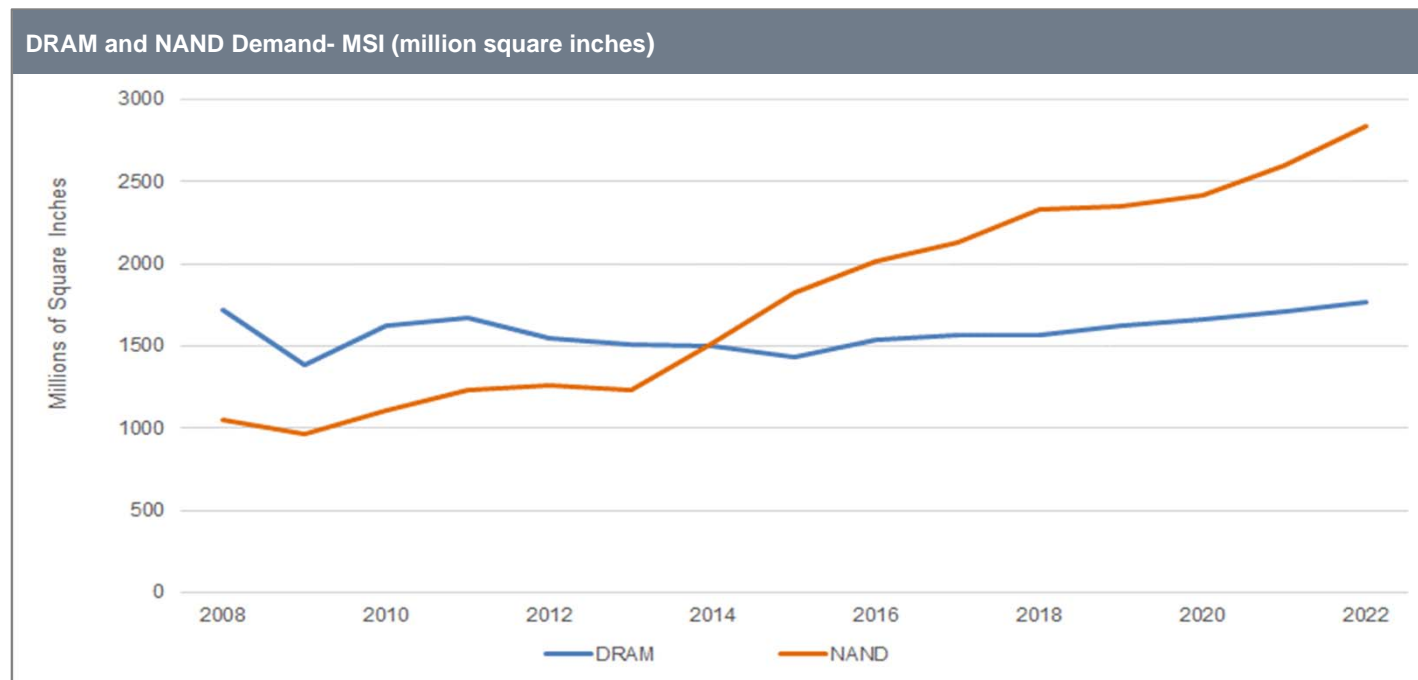
MSI Silicon Demand by Technology

- Memory and Logic will require 57% of the global silicon MSI shipped to the Semiconductor manufacturers in 2018
- > Power Management (Analog and Discrete) will require 21% of the global silicon material shipments in 2018

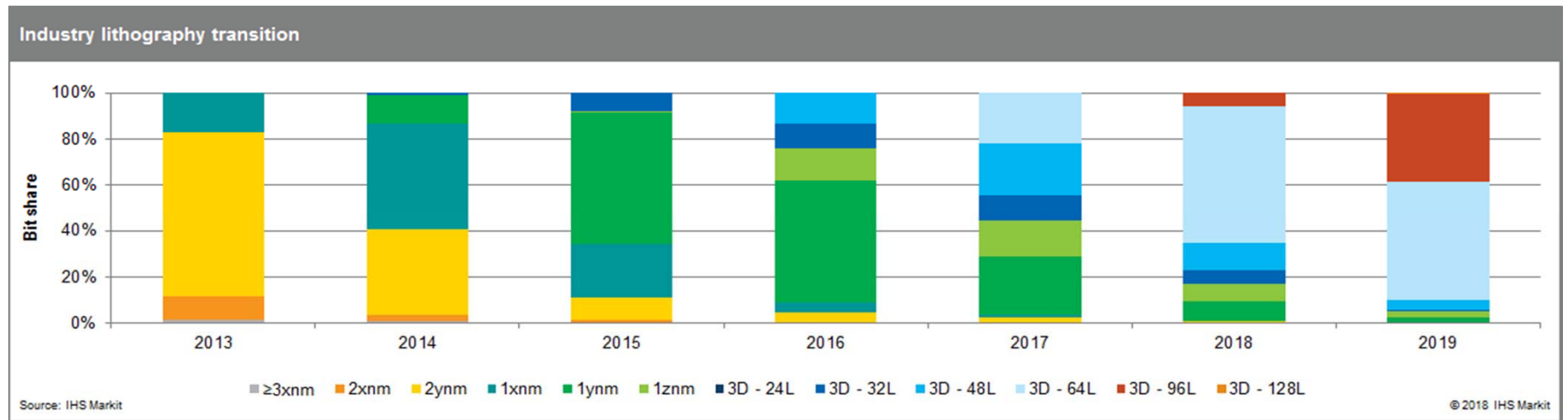


Datacenter, Handsets and SSD's Drive NAND Silicon Demands

- DRAM MSI forecast to grow by a 2.1% CAGR and NAND MSI forecast to grow by a 4.9% CAGR (2017–2022)
 - > Major expansions are underway at Samsung, Hynix and Toshiba/Western Digital
 - > Emergence of new manufacturing companies in China are focused on supporting long-term domestic demand



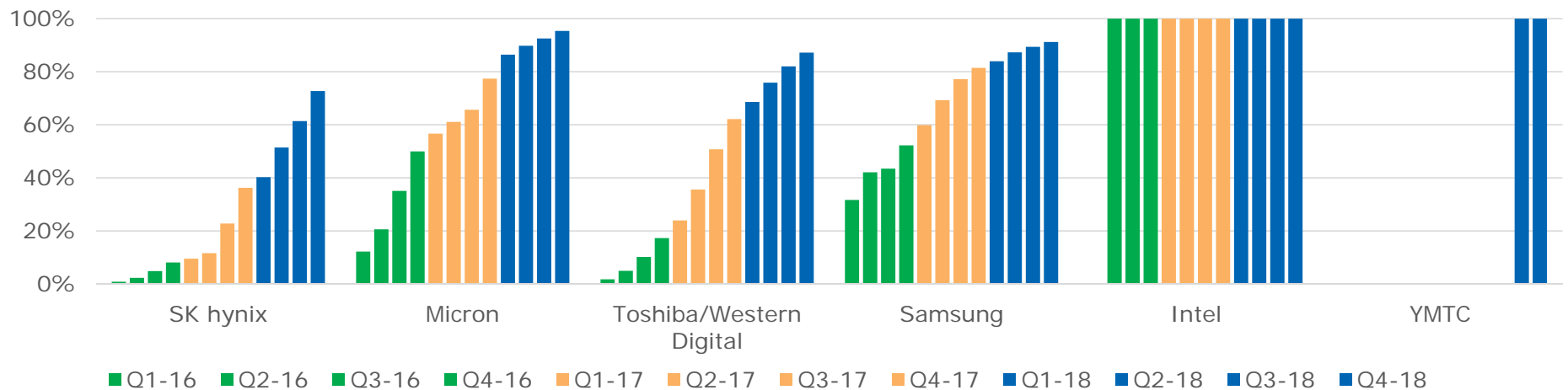
NAND Technology and Lithography Migrations



- Predominant 3D process in 2018 will be 64-layer, accounting for 59% of total bit production in 2018.
 - > 96-layer 3D NAND will begin to show up late 2018, but is expected to grow rapidly and replace 64-layer in 2019 to account for 38% of all NAND bit production.
 - > Planar NAND production will continue into the foreseeable future, driven by segments that demand lower density die not offered by 3D NAND technology. Industrial and automotive markets will likely continue demand for planar technology

3D NAND Status: 2D/3D Wafer Mix by Vendor

3D NAND % of bit output



NAND K WPM	Q1-17	Q2-17	Q3-17	Q4-17	Q1-18	Q2-18	Q3-18	Q4-18	Q1-19	Q2-19	Q3-19	Q4-19
2D	1,120	1,007	882	749	664	564	478	387	310	240	181	124
3D	422	538	660	764	813	910	1,009	1,102	1,133	1,212	1,288	1,361
Total	1,543	1,545	1,542	1,513	1,477	1,474	1,487	1,489	1,443	1,452	1,469	1,485
% 3D wafers	27%	35%	43%	51%	55%	62%	68%	74%	78%	83%	88%	92%

Manufacturing update 2018

Key Issues and Opportunities Impacting Semiconductor Manufacturing Run Rates Throughout 2018

- **Component inventory management**

- > IDM's and fabless semiconductor companies must continue to verify existing manufacturing run rates with 2nd half demands to avoid product obsolescence

- **Technology development and transitions**

- > The transition to 7 nanometer by the leading foundries will be critical for next generation handsets and high performance computing applications
- > SOI development and implementation for specific applications within the automotive and consumer markets

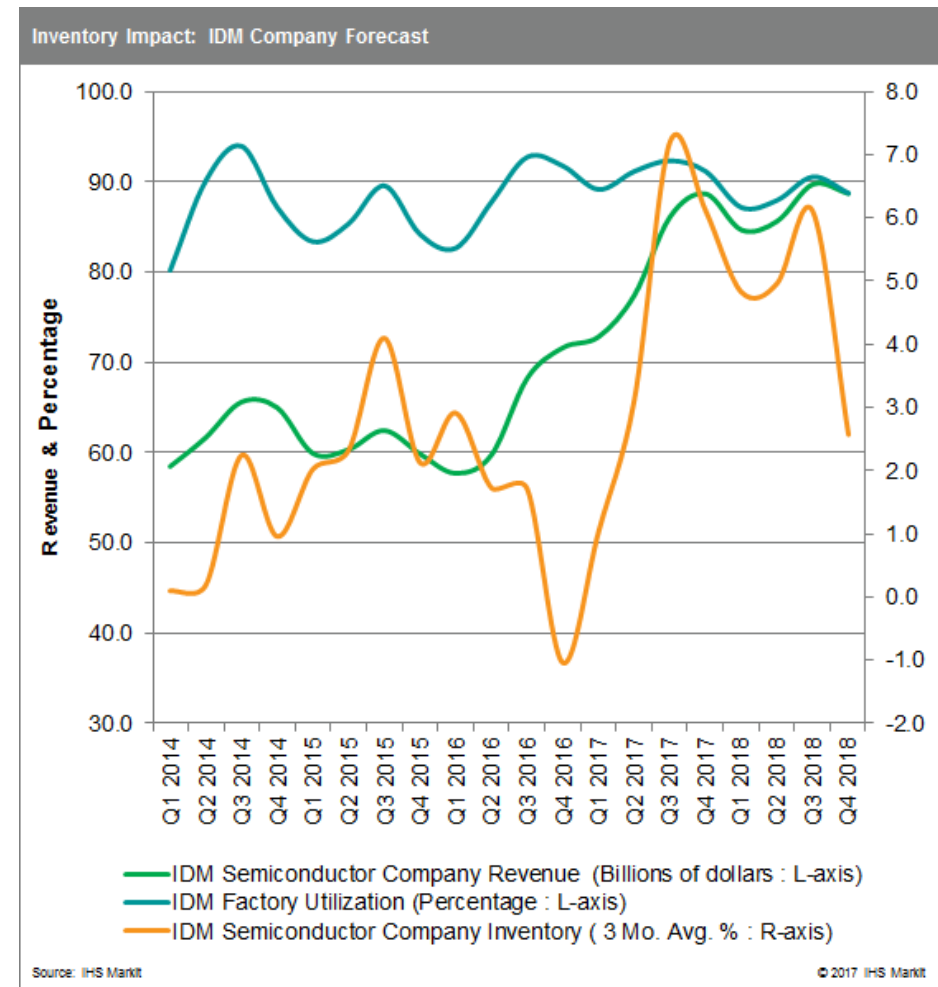
- **Seasonal application demands**

- > Demand for components supporting handsets, PC, and tablets are forecast to be weak through the first half of 2018
- > Adoption of IoT into the home and consumer holiday shopping trends will drive second half demand

2018 Inventory Management Model

Integrated Device Manufacturers

- Market demand for consumer products in the second half of 2017 required companies to ramp manufacturing throughout the year
- Seasonality toward consumer holiday sales will dictate manufacturing cycles in 2018
 - > Global handset sales will be key for IDM's and the entire semiconductor supply chain
 - > Automotive and industrial demands are forecast to continue to grow throughout 2018 forcing Discrete and Analog companies to maintain higher than historical inventory levels

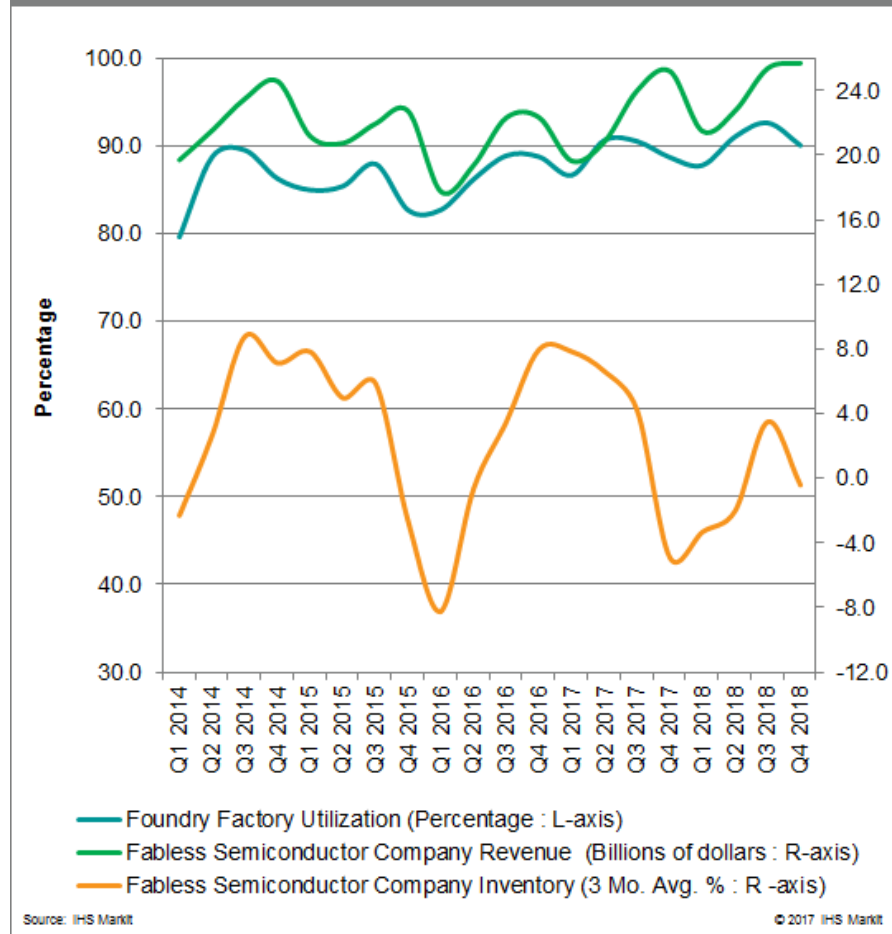


2018 Inventory Management Model

Fabless / Foundry Semiconductor Companies











- Wireless communication drives fabless / foundry manufacturing demands
 - > Foundry manufacturers anticipated stronger than historical demand throughout 2H of 2017.
 - > Demand for mobile products peaked in Q3 excess inventory was not consumed until Q1'18
- Advanced technology 7 nanometer, will drive strong demand in both Q3 and Q4 of 2018
- Seasonal sale pattern will drive inventory management by fabless / foundry companies throughout 2018

Inventory Impact; Fabless semiconductor companies



Investments in Memory and Advanced CMOS Technology will Drive Record CapEx Expenditures in 2018

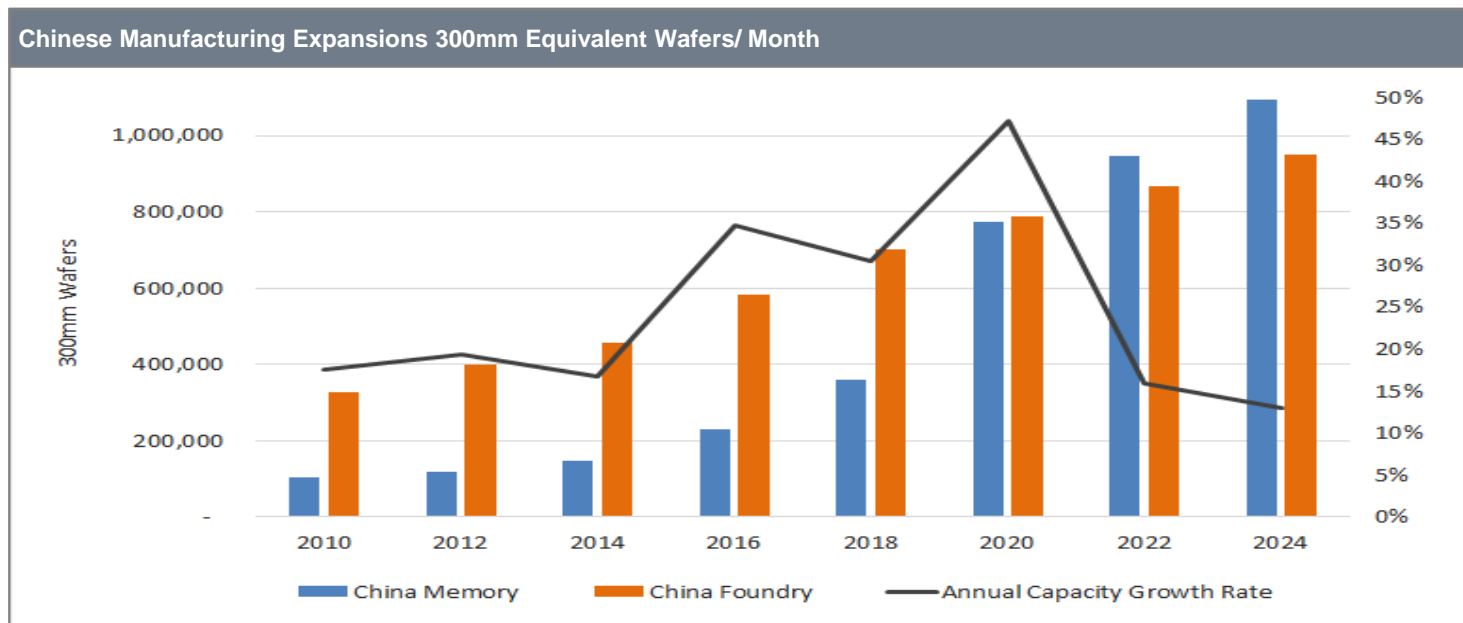
- Total capital expenditure in 2017 grew by 36.8% to \$89.8 Billion
 - > Capital Expenditures in 2018 are forecast to be \$95.6 billion (6.4% YoY growth rate)
 - > China Capital expenditures will exceed \$12 billion USD

		2016 CapEx	2017 CapEx	2018 CapEx Forecast	Notes
	Samsung	11,347	24,239	23,500	DRAM expansion and technology migration to 18 nanometer, 3D NAND expansion
	Intel	9,625	11,778	14,000	Transition to 10 nanometer technology, expansion in NAND Flash in China
	TSMC	10,098	10,500	10,350	10 nanometer expansion, 7 nanometer development, China factory build-out
	SK Hynix	5,116	8,105	6,826	Capacity expansion in M14 and 3D NAND
	Micron Technologies	6,137	5,850	7,500	Increased capacity and technology migrations both DRAM & NAND
	Toshiba	4,090	4,676	4,600	New factory expansion
	GLOBALFOUNDRIES	2,720	2,818	2,500	7 nanometer R&D, Dresden SOI R&D, China expansion
	Yangtze River Storage		2,500	3,500	New factory in China
	SMIC	2,695	2,459	1,900	Factory expansions Beijing, Shenzhen, Tainjin
	UMC	2,877	1,464	1,100	14 nanometer, expansion of 28 nanometer in Xiamen, China

China

Chinese Manufacturing Expansions “Made in China 2025”

- China currently has low market share and limited technical capability in four major areas identified in the China National IC Development Guideline: IC design, manufacturing, package/testing, and equipment/material
- Goal is to reduce importation of semiconductors while growing domestic capabilities



Summary

- An strengthening global economy should provide a positive tailwind for semiconductor industry in 2018
 - > Consumers and business anticipate positive economic growth in 2018 this should provide stable demands for semiconductor components throughout 2018
- IHS anticipates that semiconductor revenue in 2018 will grow by approximately 14.9%
 - > Impact on the semiconductor industry revenue from volatility of memory pricing continues to be impactful
 - > Non memory component revenue growth will slow in 2018 to 7.8%, down from 10.0% in 2017
- Silicon shipments will remain constrained throughout 2018 IHS Markit anticipates additional capacity coming on-line in second half of 2019 which will alleviate industry concerns
 - > Total silicon demand growth YoY forecast to be 5.4% in 2018 (11.8 B square inches)
- Inventory dollars increased by 6.5% in Q1, DOI increased by 4.4 days to 96.8.
 - > Inventory value of raw material increased by 13.7% in Q1 2018
- Capital investments will continue to grow in 2018 by 6.4%, supporting new technology development, capacity expansions for memory, and advanced CMOS
- Next generation demand drivers supporting IoT, 5G, and autonomous driving are still several years away from impacting semiconductor component manufacturing

Thank You

July, 2018

• **Len Jelinek, Vice President & Chief Analyst**