



IHS Markit™

Handset Demand Poised to Drive Second Half Surge in Semiconductors

Memory and foundry suppliers anticipate record revenue

July, 2017

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Agenda

- IHS Markit economic forecast
- Applications driving component demand
- Revenue forecasts
- Manufacturing impacts
- Chinese manufacturing expansions

Global economy growth accelerates to 3.0% for 2017

United States — Real GDP increased at a 1.2% annual rate in the first quarter. Real GDP growth is expected to pick up to an annual rate of 3.0% in the second quarter. Consumer spending will lead the acceleration, advancing at a 3.3% pace. Household spending is supported by sustained job growth

Eurozone — Labor markets are generally improving. Eurozone growth could be hampered by consumers becoming more cautious as their purchasing power and real incomes are squeezed by higher inflation, and limited wage growth in most countries. Real retail sales increased 0.1% m/m and 2.5% y/y in April

Japan — Japan's real GDP increased 0.5% q/q in the first quarter of 2017, its fastest pace in five quarters. Consumer spending strengthened in April, helped by a rise in disposable income. The release of new auto models and replacement demand for household appliances could support near-term expenditures, but overall consumer spending growth will remain modest until productivity and wage gains strengthen.

Brazil — Brazil has undergone extreme political turmoil. President Michel Temer has built political alliances that should help his administration serve its full Term. Recovery is likely to be gradual with some turmoil.

China — Industrial output growth slowed sharply to 6.5% y/y in April from 7.6% in March. Construction remained a key growth driver, but activity decelerated in April. Overall construction starts rose 11.1% y/y in the first four months of 2017, while housing starts increased 17.5% y/y. Office building starts, on the other hand, decreased 8.3% y/y in the January-April

2.3%

0.1%

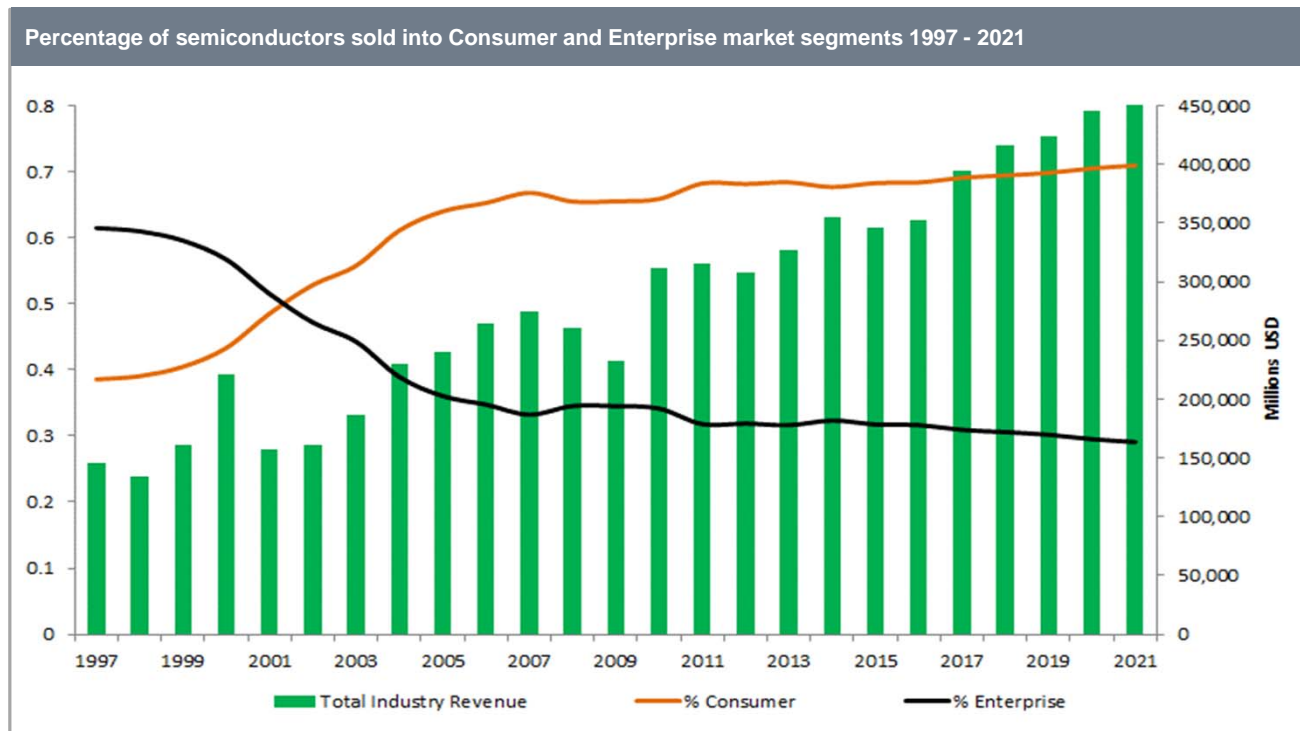
1.9%

1.3%

6.6%

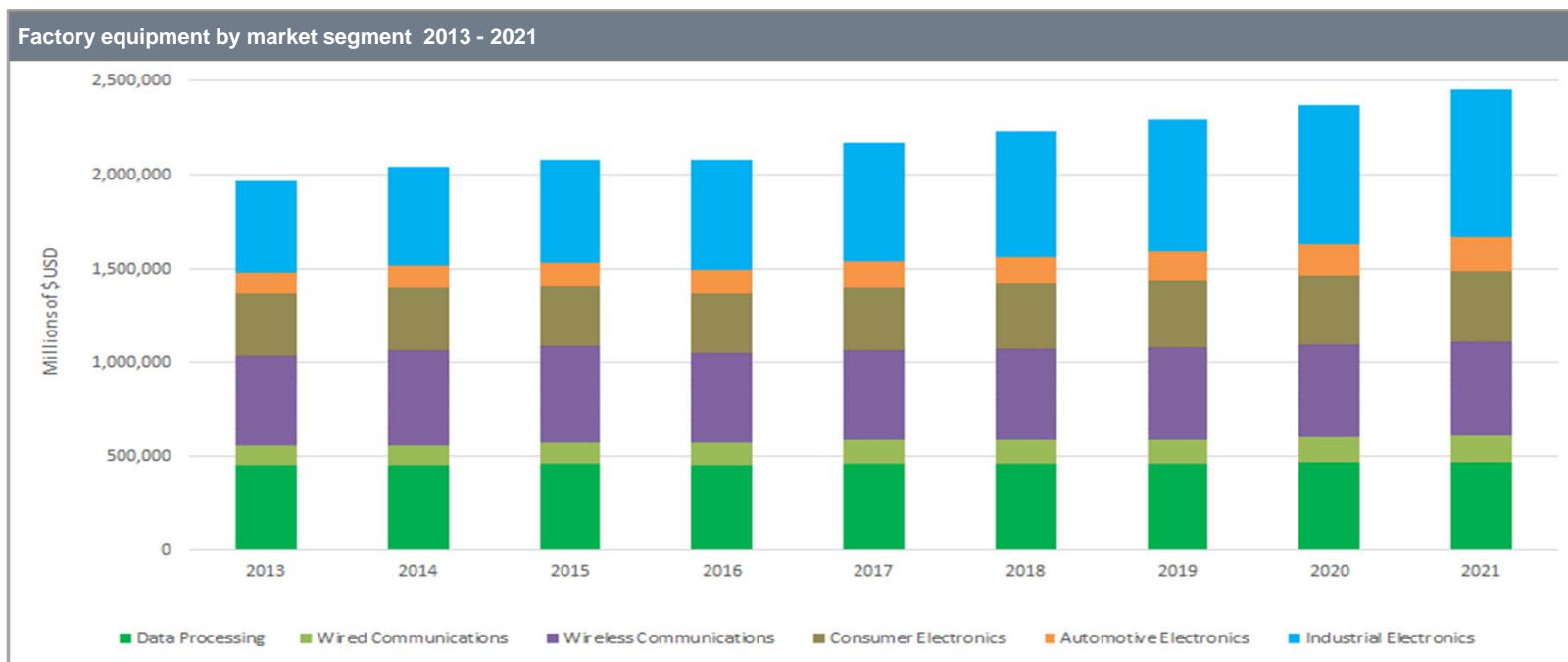
Consumers drive semiconductor demand

- Prior to 2000 the semiconductor industry relied on providing enterprise solutions. Today electronics has penetrated virtually every aspect of our lives



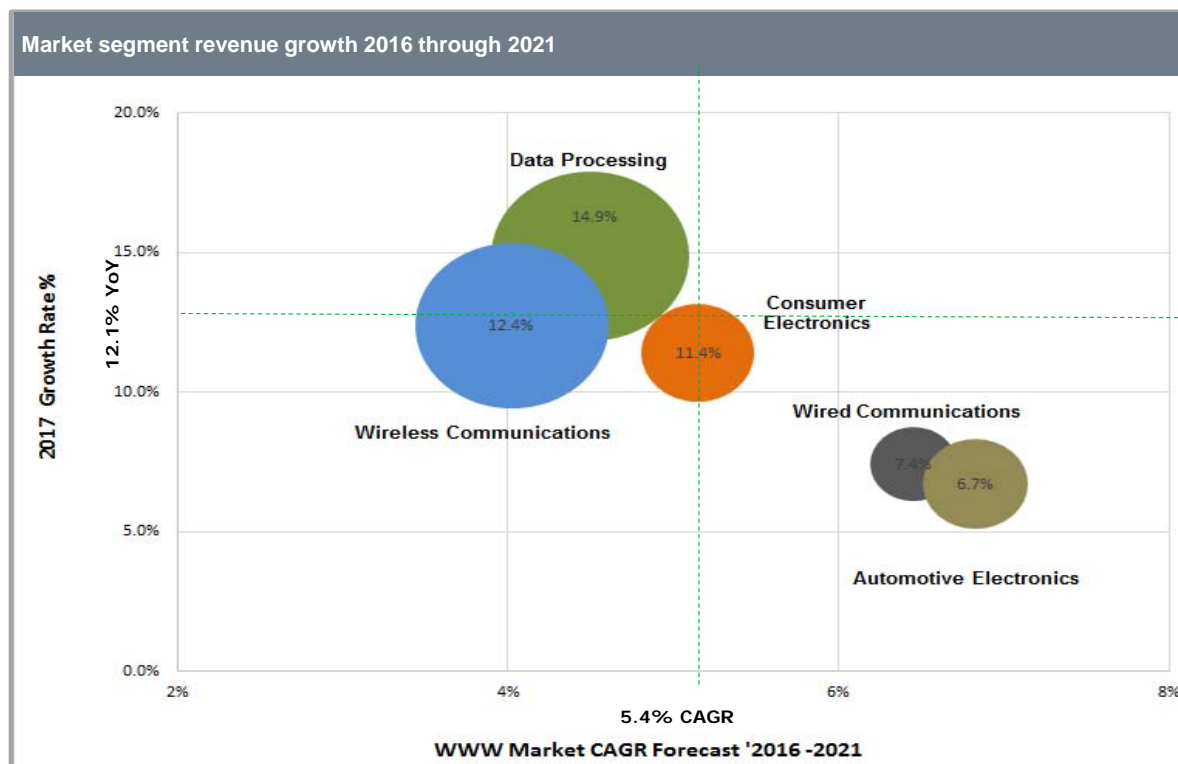
IHS Equipment revenue forecast 2013 - 2021

- Industrial equipment maintains 6% CAGR
 - > Wireless equipment is the second largest end market although revenue growth has slowed to 1% CAGR
 - > Automotive continues to show strong revenue growth with a 3.9% CAGR



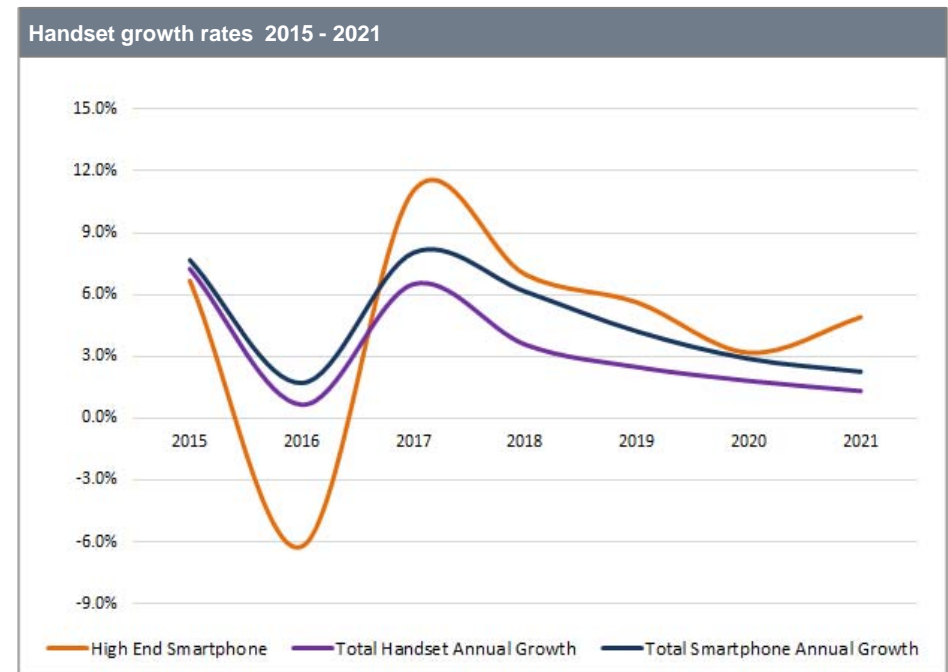
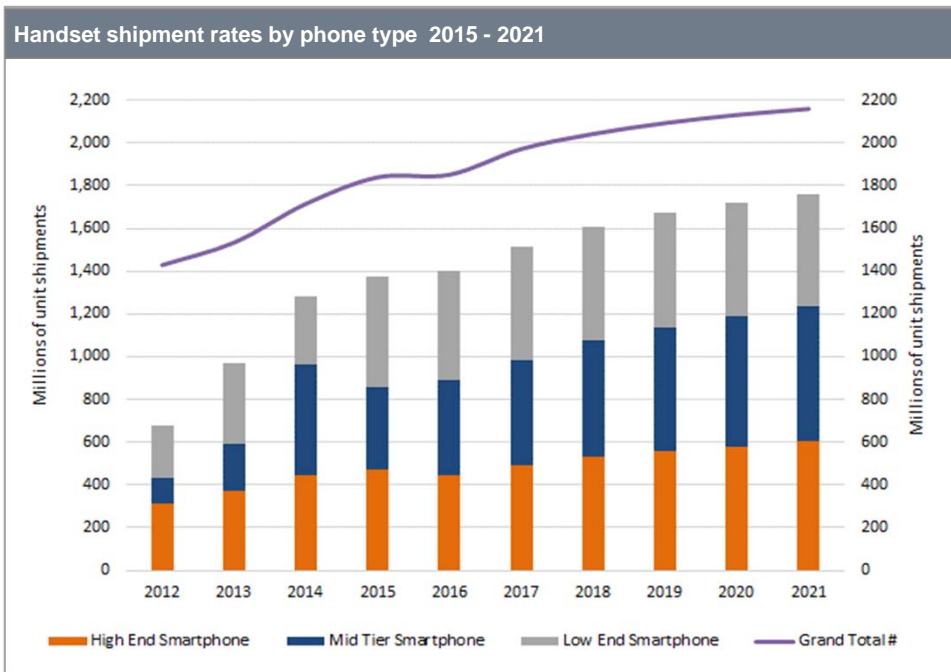
Long-term revenue forecast by major market segments

- Semiconductor industry revenue forecast for 2017 is 12.1%
 - > Manufacturing constraints for Memory components has resulted in increased ASP's impacting revenue for all applications using DRAM and NAND components

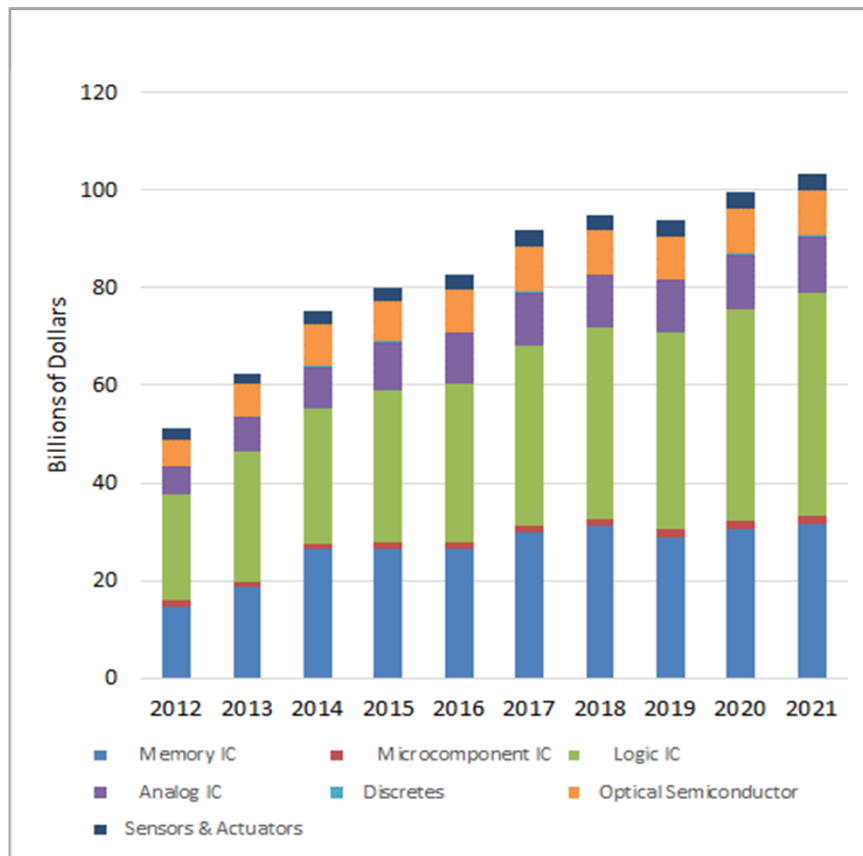


Smartphone technology drives revenue growth at leading foundry manufacturers

- Total handsets in 2017 are forecast to grow by 7%, smartphones will return to growth from anticipated introductions of revolutionary products in 2nd half of the year
- > Technology migrations will be critical for handset OEM's in 2017



Smartphone – Semiconductor Revenue



- In 2017 semiconductor revenue from handset shipments will represent approximately 23% of the total semiconductor market revenue
- Memory and Logic represent over 73% of the component revenue in handsets

> Key semiconductor components are:

IDM Manufactured

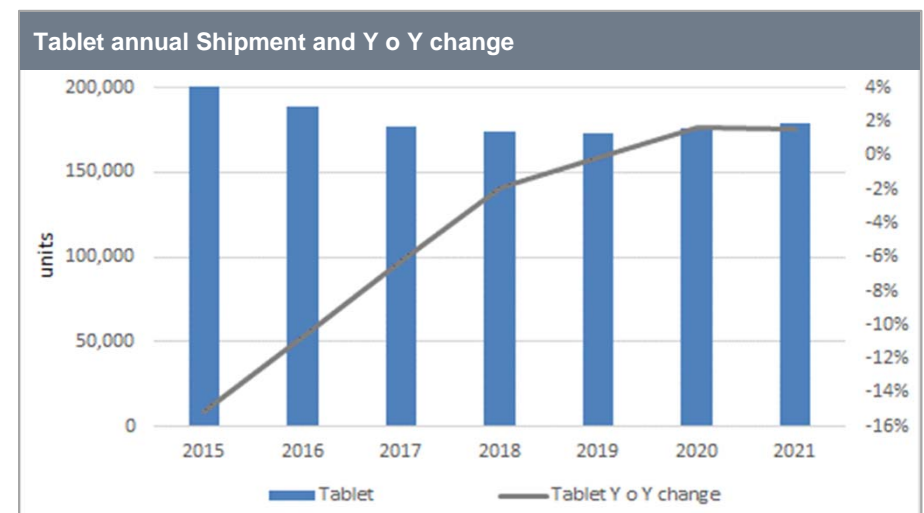
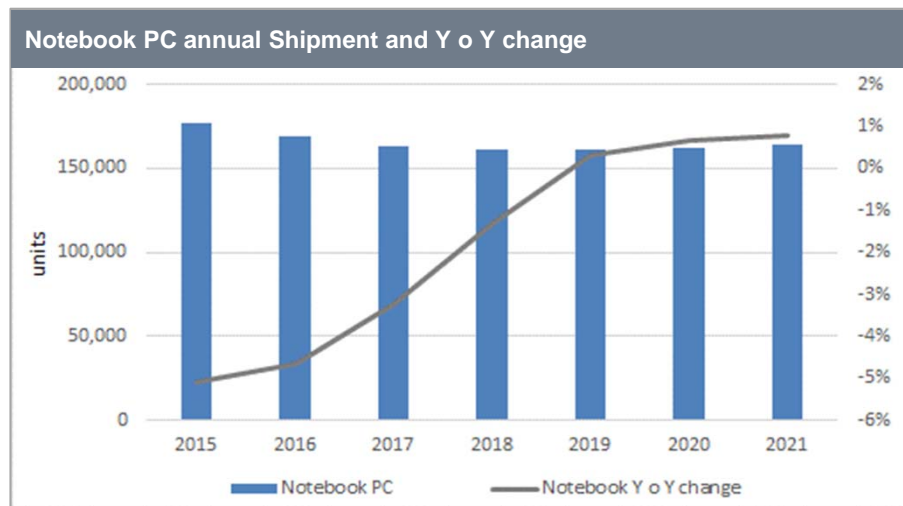
- NAND Flash
- Mobile DRAM
- CIS
- Microphone (Sensor)

Foundry Manufactured

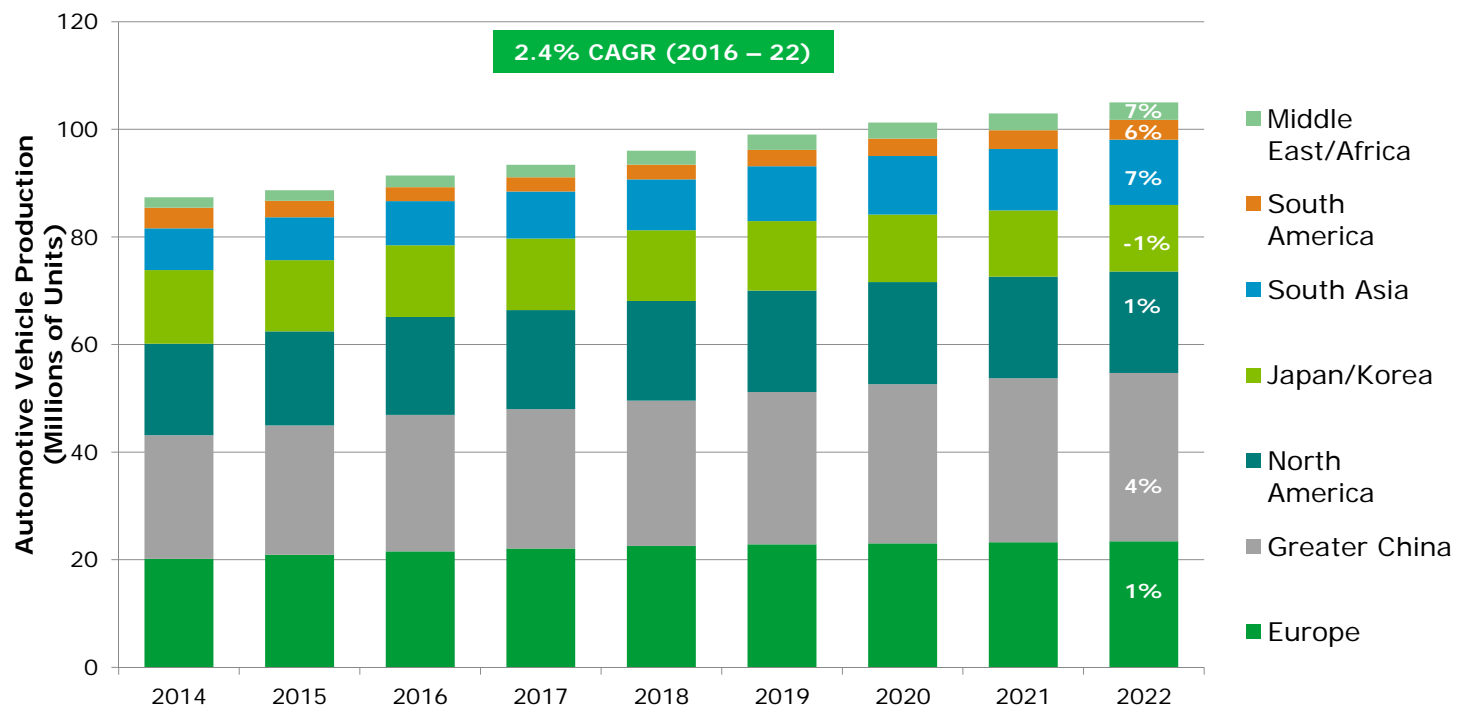
- Application Processor
- Finger Print Sensor
- PMIC
- Modem/Baseband
- ISP
- CIS

Next PC refresh cycle driven by migration to Windows 10

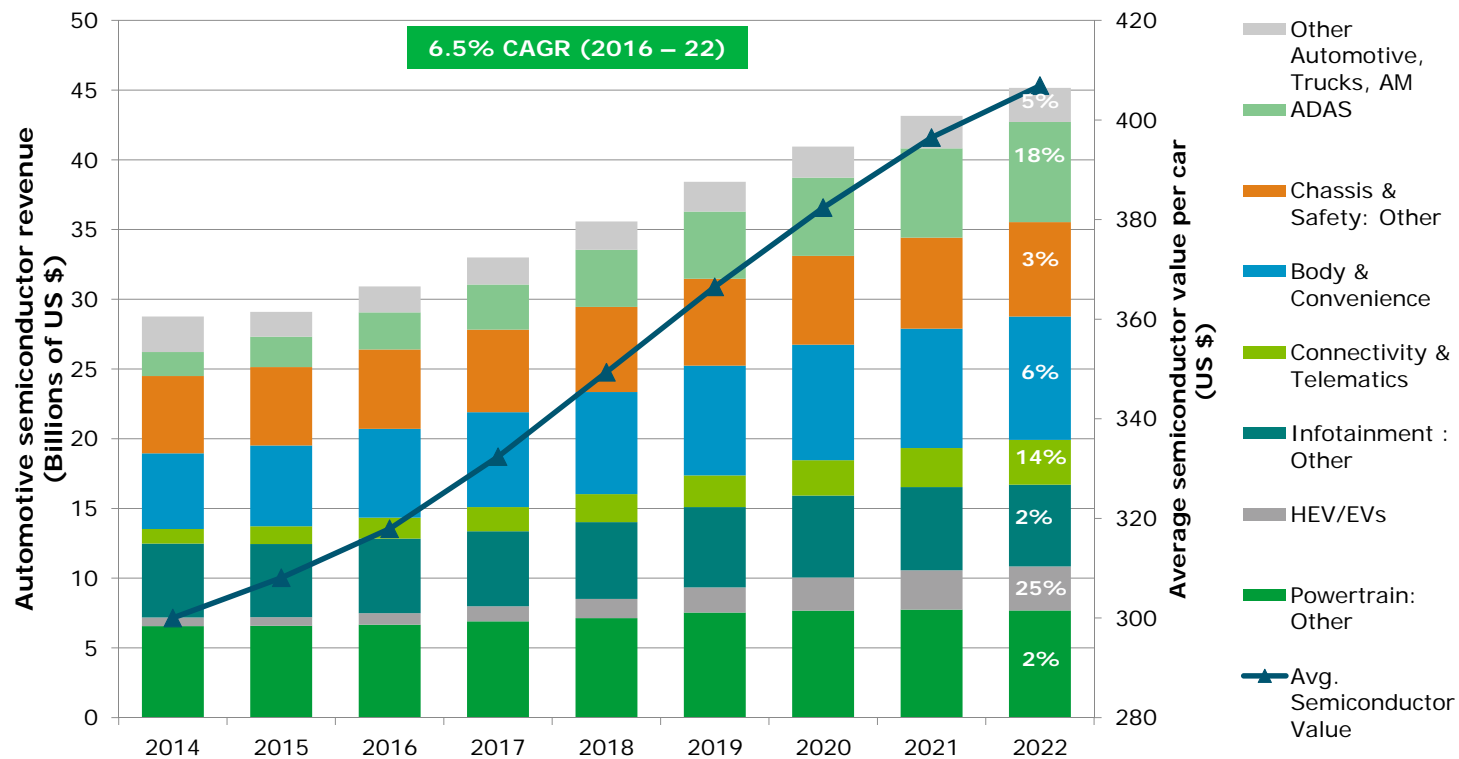
- Tablet shipments continue to outpace Mobile PC's, refresh cycle much shorter for tablets
- Notebook shipments in 2017 are forecast to decline by 3.2%, rate of decline continues to slow
- 2-in-1 design for convertibles and detachables remains in flux, the business market will eventually determine the direction suppliers will go
- Windows based systems accounted for 83.9% of Q3 notebook shipments
- North America accounts for 33% of notebooks and 24% of tablet shipments



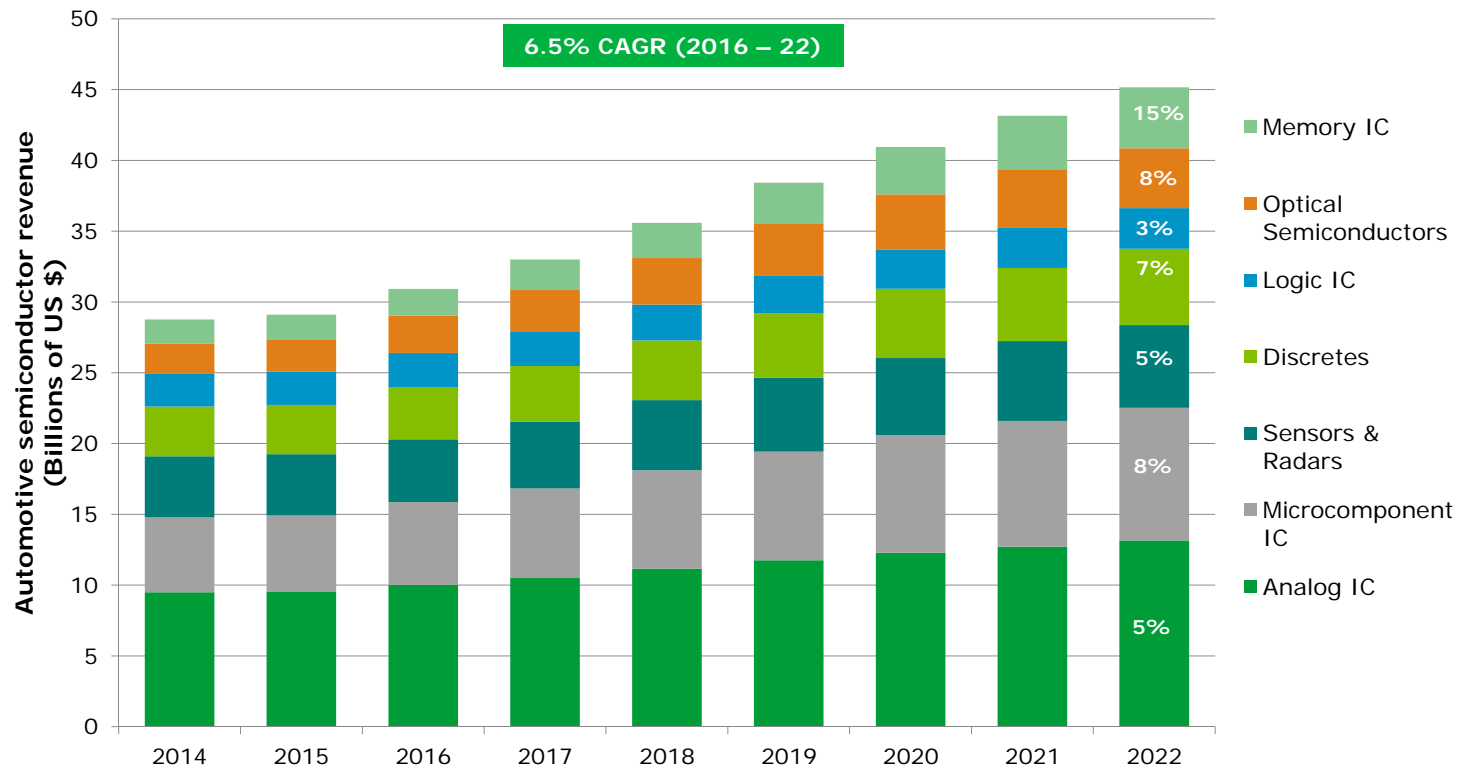
Vehicle production rises slowly and in varying degrees in emerging and developed markets



Electrification, automated driving and connectivity fueling automotive semiconductor growth



Processors, high power management, memory and LEDs are the key automotive semiconductors



The Internet of Things continues to evolve

- Innovation continues to drive the three phases of IoT solutions: **Connect, Collect, Compute**

IoT solutions involve continuous development as the needs of the business and the capabilities of the technology continue to evolve –this combination is what is driving the growth and excitement around IoT.

Connect

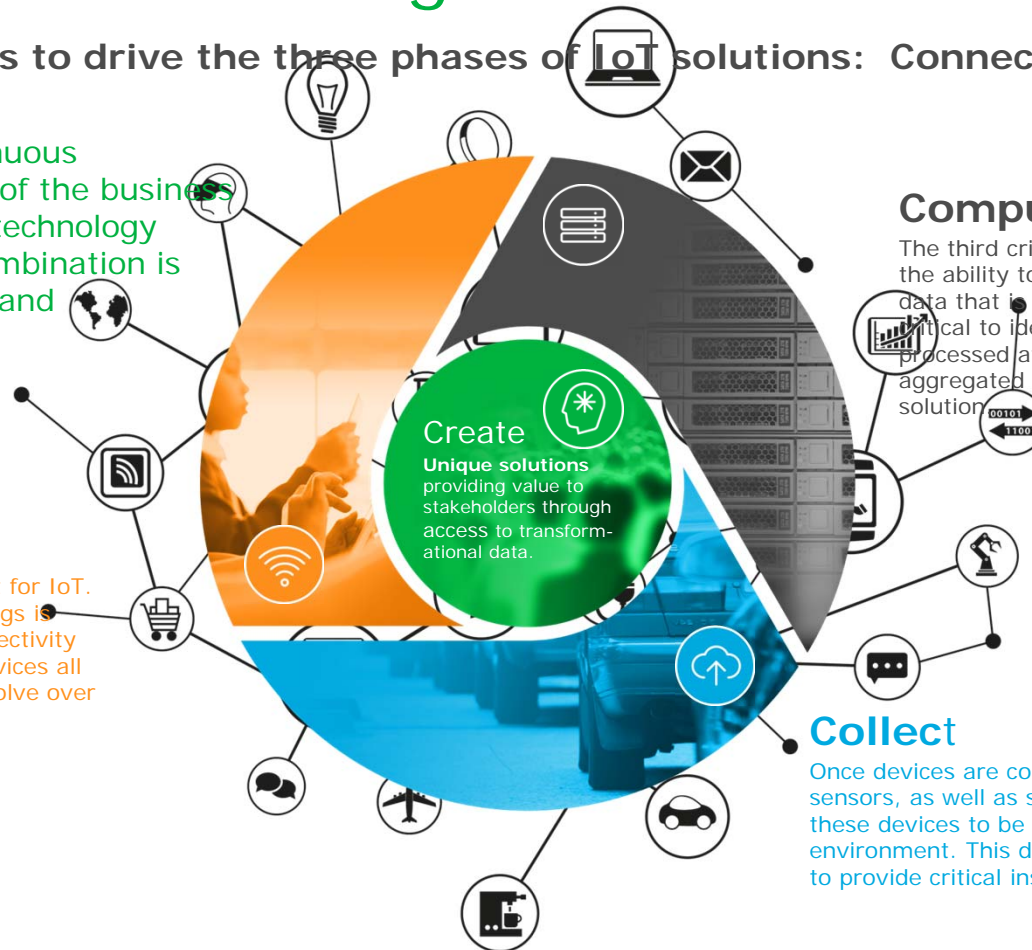
This is the foundational component for IoT. Fundamentally, the internet of things is about this idea of embedding connectivity and processing capabilities into devices all around us. This will continue to evolve over time.

Compute

The third critical element of any IoT solution is the ability to process and analyze the volume of data that is being generated by IoT devices. It is critical to identify which data should be processed at the edge, and which data should be aggregated & stored as part of a big data solution.

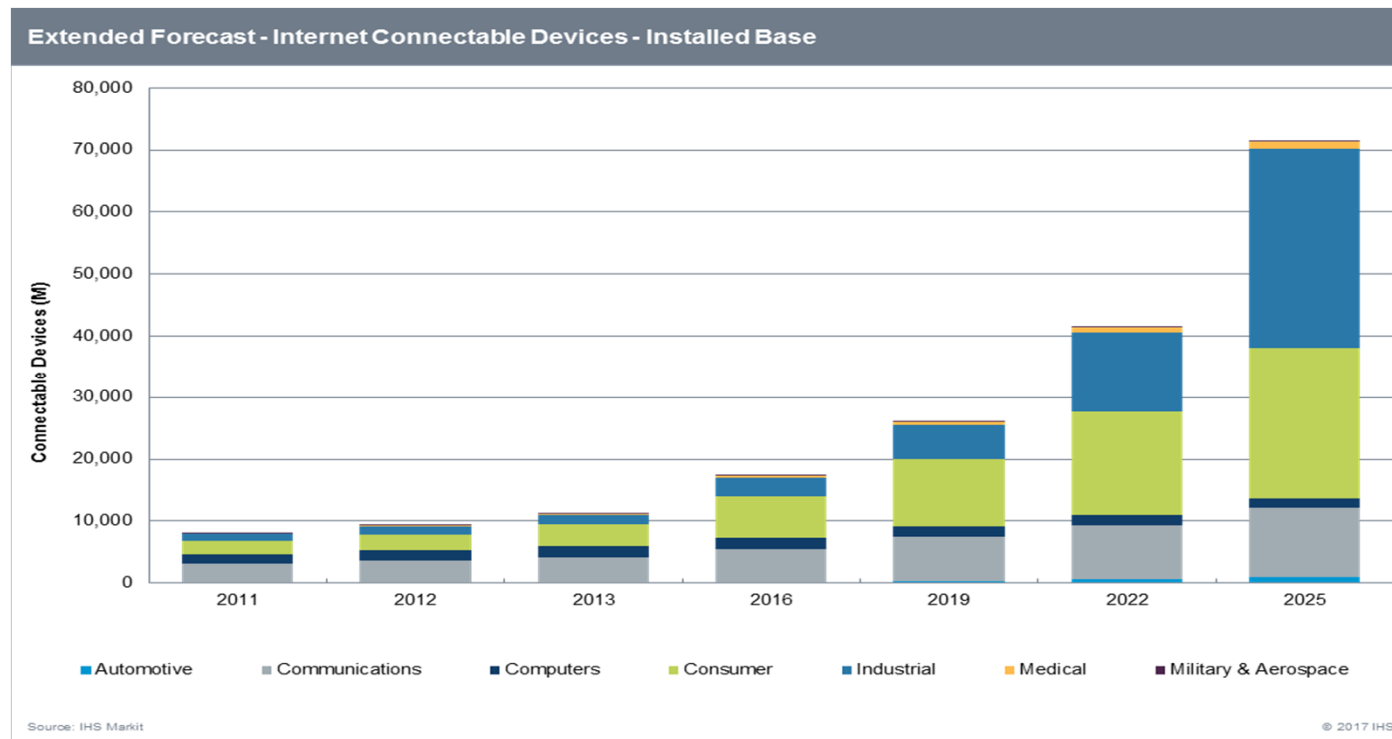
Collect

Once devices are connected, the next step is to add sensors, as well as storage, to create the ability for these devices to be aware of the surrounding environment. This data can be collected and analyzed to provide critical insights.



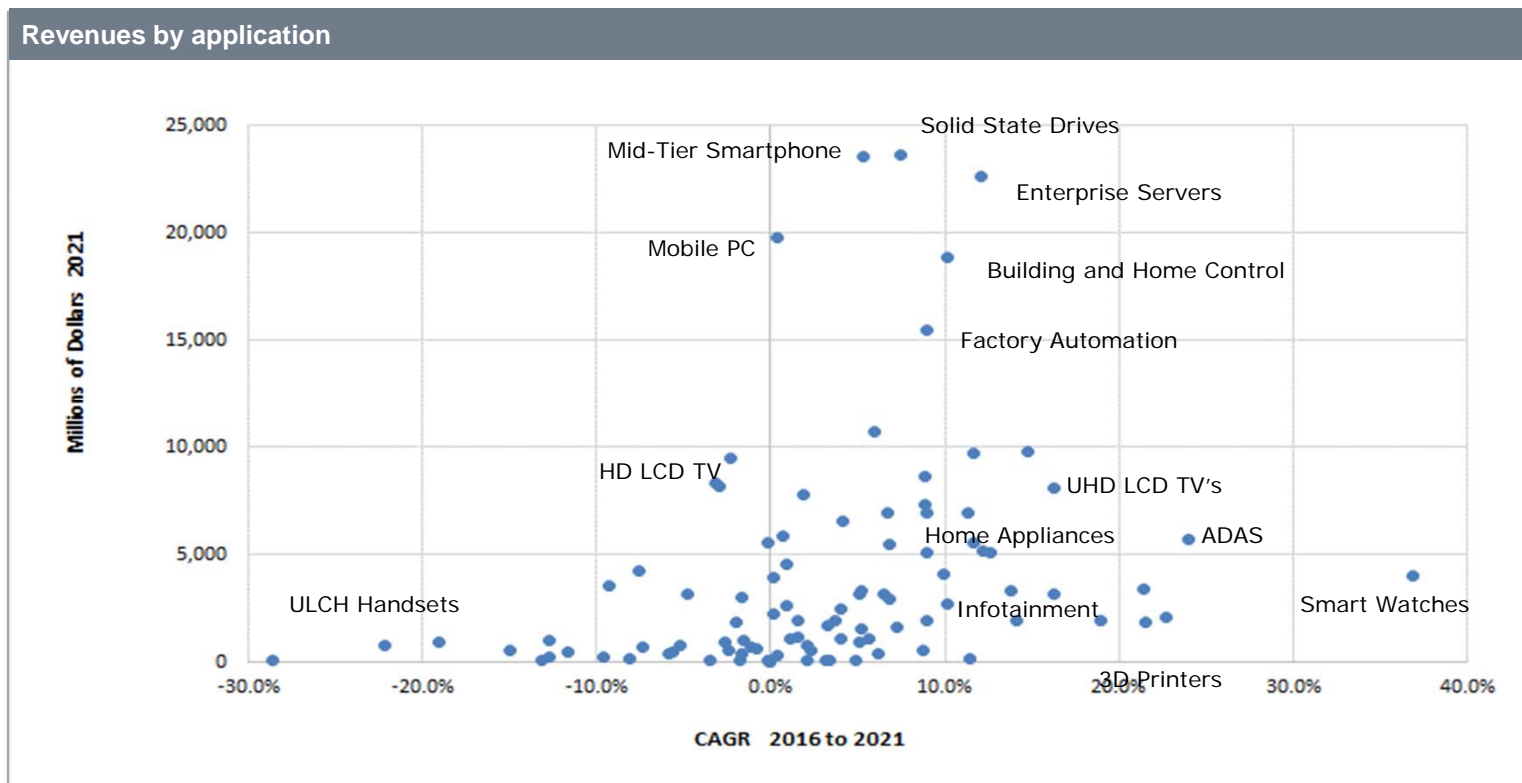
Industrial applications will drive long-term IoT opportunities

- Consumer IoT will be driven by equipment convenience or sellable “use cases” that can be tethered to existing devices such as a smartphone
- > Manufacturers must establish business cases for integrating connectivity into their devices



Blockbuster applications are difficult to identify

- Outside of High-tier smartphones the semiconductor industry provides a wide array of technology to a collection of applications servicing a very fragmented market

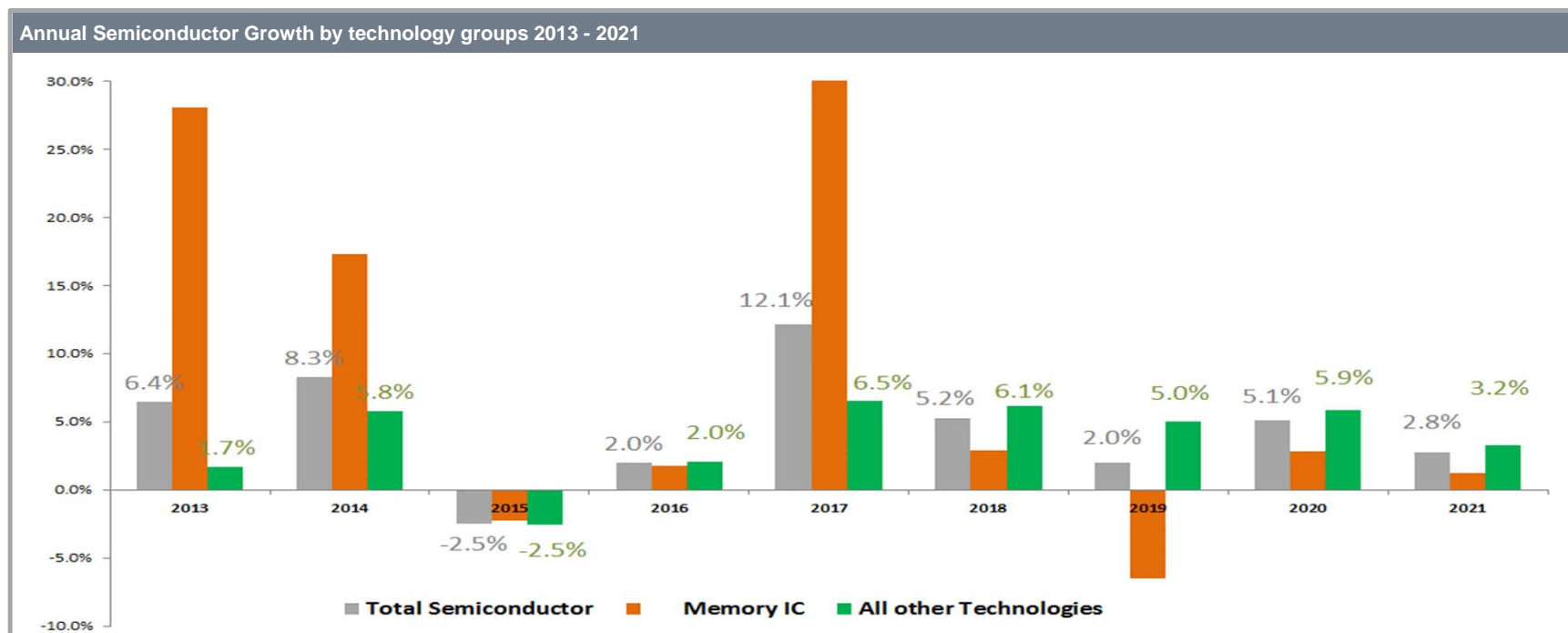


Key factors impacting semiconductor manufacturing run rates throughout 2H of 2017

- **Handsets – Introductions of new models for 2017**
 - > Components for new handset models are ramping in order to meet initial introduction demands
 - > Total handsets shipments are forecast to grow by 8.0% with high end smartphone shipments forecast to grow by 11.0% in 2017.
- **PC market – Pressure from alternative devices maintains influences overall demand**
 - > Consumers are choosing alternative devices for communication and data analytics
 - > Business segment will be critical to PC manufacturers
- **IoT applications – adoption of connectivity by consumers is critical**
 - > Low cost, high performance silicon continues to be critical driver for IoT applications
- **Inventory management throughout the supply chain**
 - > Holiday season sales will determine manufacturing run rates in Q4 and 1st half 2018

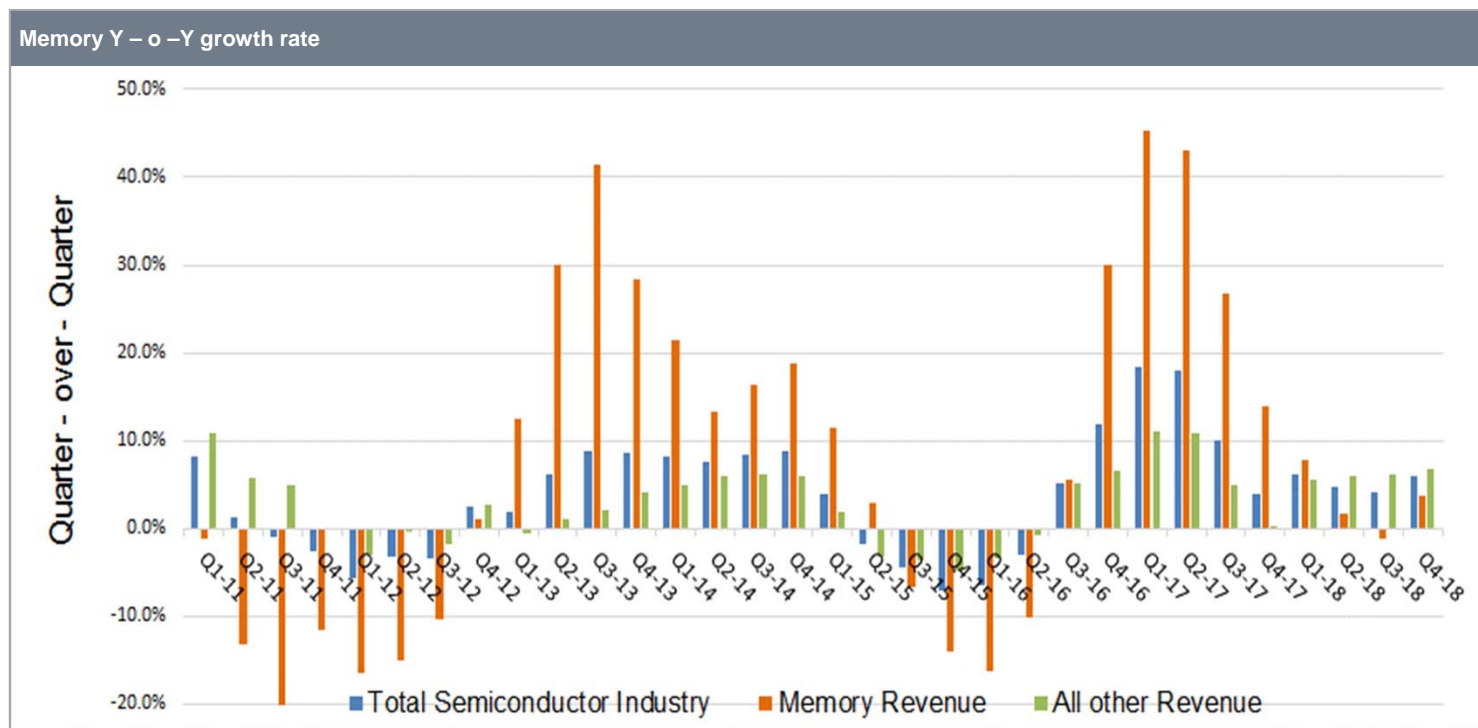
IHS Semiconductor revenue forecast 2013 - 2021

- DRAM and NAND pricing increases are driving total industry revenue growth to 12.1% in 2017.
- > DRAM and NAND manufacturing constrains have resulted in strong ASP increases over the past 4 quarters
- > Increasing demand for smartphones influences Logic and Memory demand



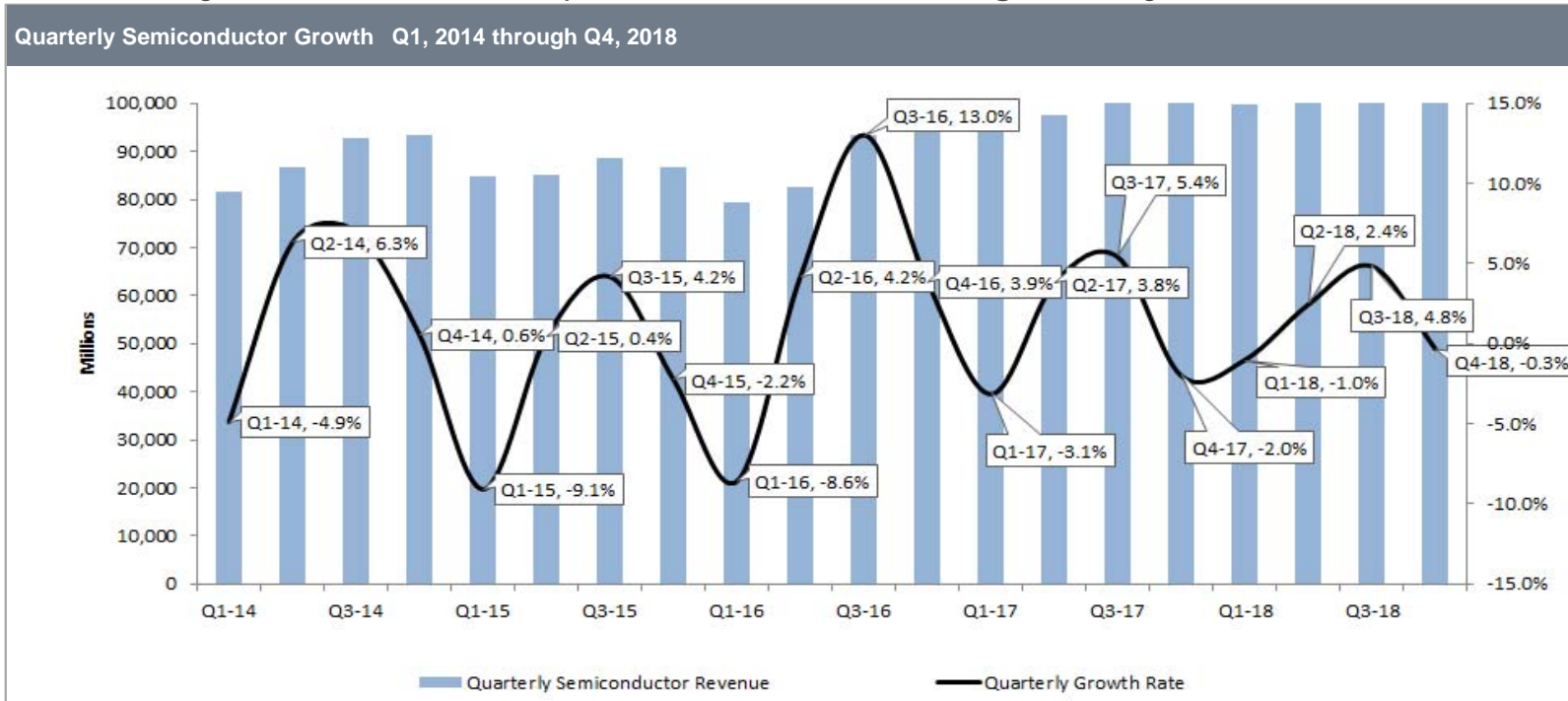
Volatility returned to the Memory market in 2017

- Strong application demand for DRAM and NAND Flash from PC's, Data centers and handsets is occurring as the industry is making technology transitions



Semiconductor industry quarterly revenue growth patterns

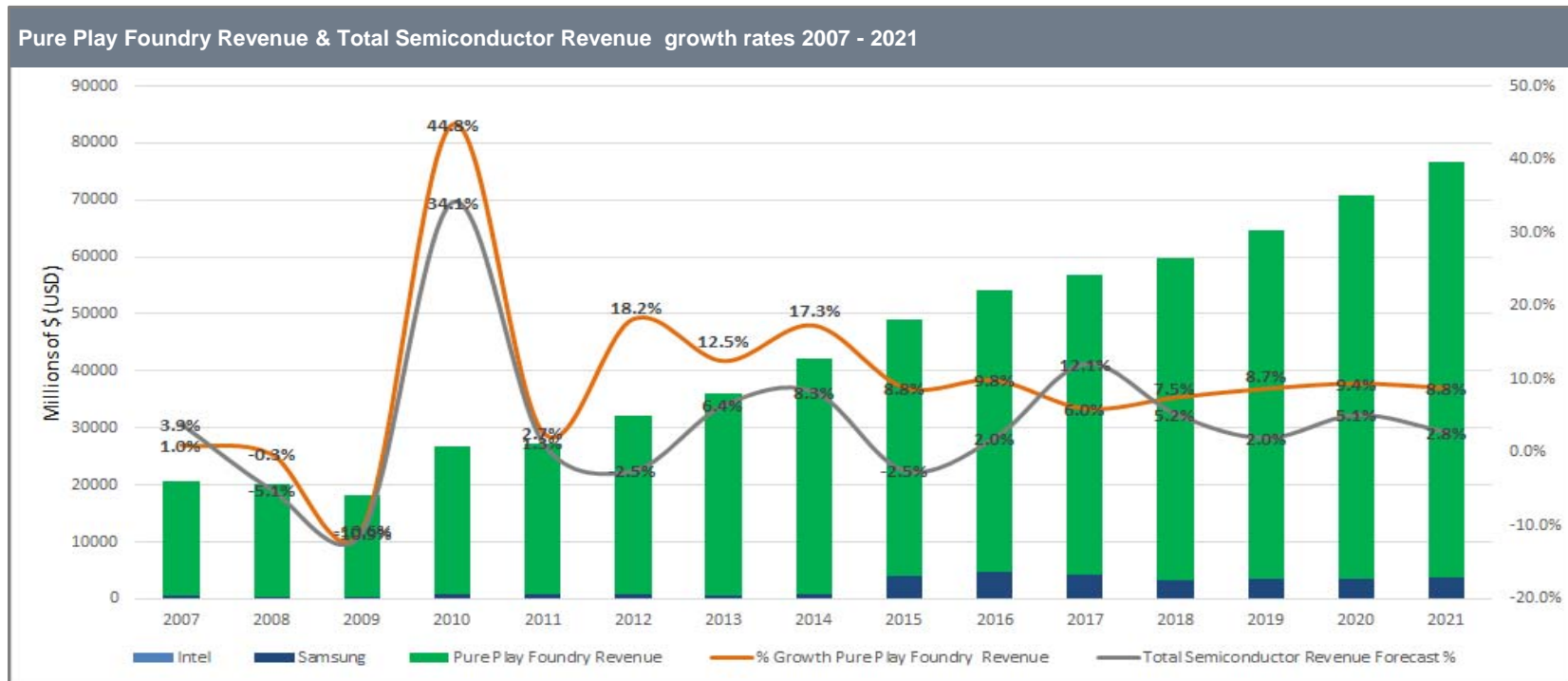
- Industry is focused on providing technology supporting consumer products
 - > Momentum starts to build in Q2 for second half of 2017 growth
 - > Memory ASP's drive the amplitude of 2017 revenue growth cycle



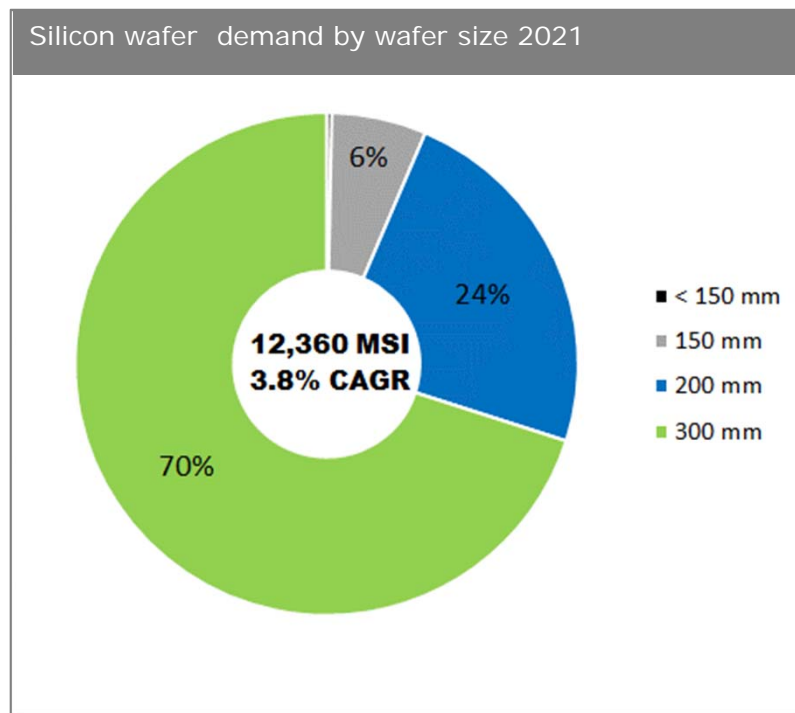
Advanced technology drives foundry revenue growth

- **Technology transitions and market consolidations will continue drive foundry revenue growth**

> Intel and Samsung influence advanced technology foundry revenue but do not drive overall foundry market



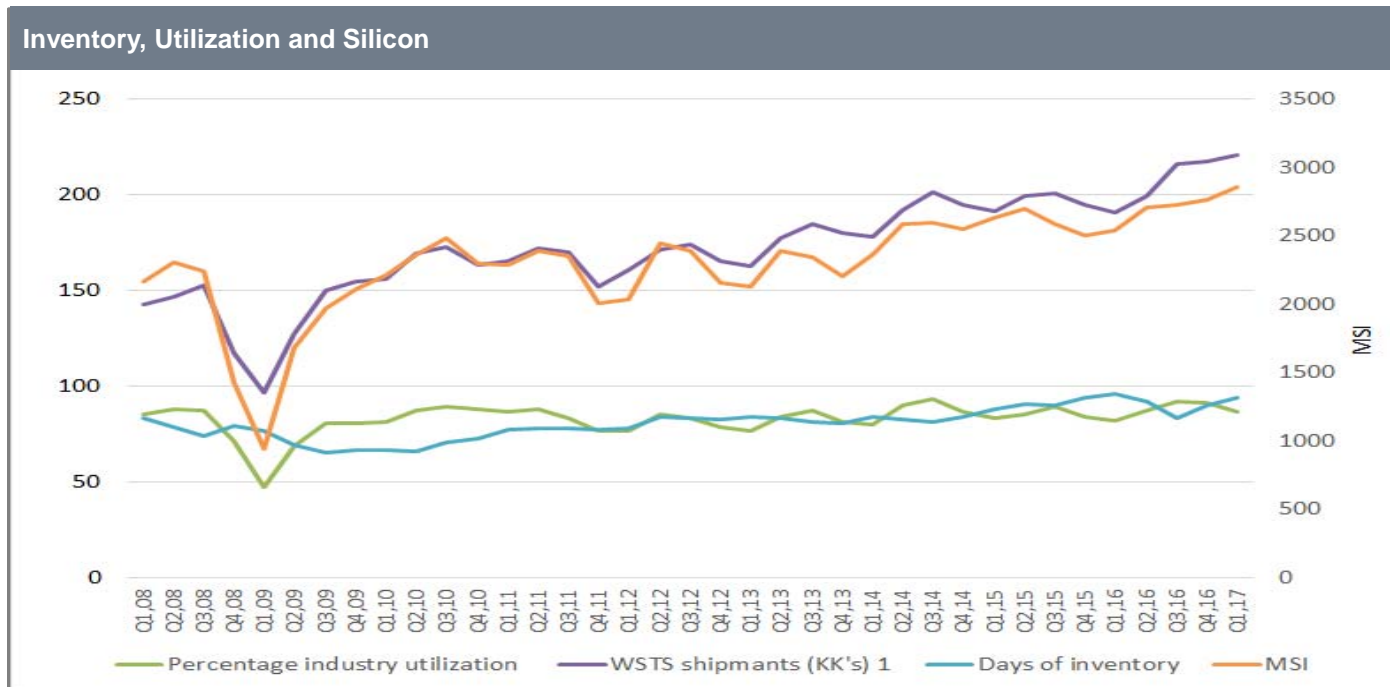
Global silicon demands will continue to grow supporting a broad array of products



- Silicon demand driven by semiconductor manufacturers is forecast to increase in 2017 to by 4.8%
- DRAM (Handsets, PC's) and NAND Flash (Handsets, SSD's) Logic (Aps Processor, PMIC, Finger Print, CIS) are primary technologies driving silicon demand
- Memory technologies account of more than 35% of industries silicon demand
- Automotive and Industrial applications only account for 20% of total semiconductor industry silicon demands.

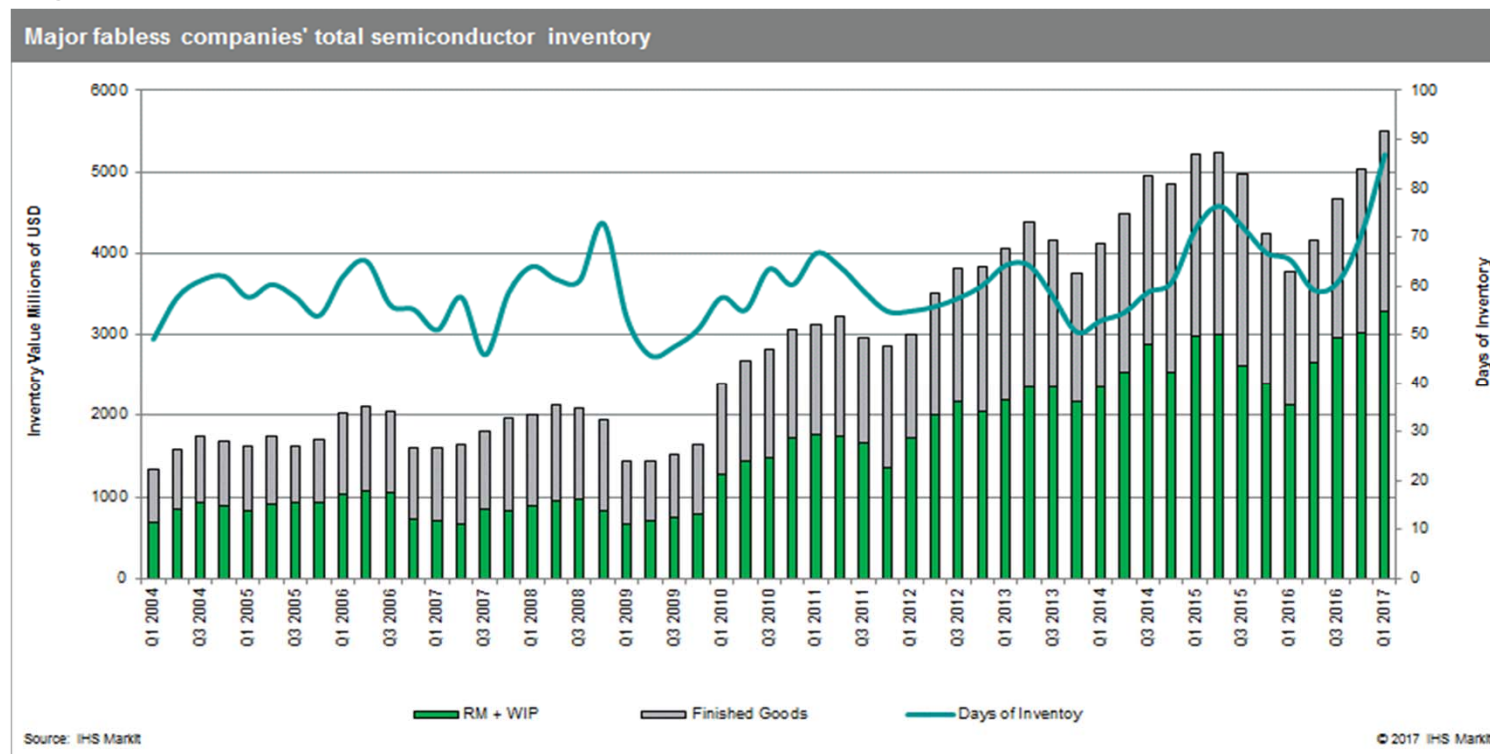
Manufacturing demands from IDM's and fabless companies have driven the industry to record levels

- Semiconductor component shipments and silicon shipments have achieved record levels
 - > DOI are above seasonally adjusted levels



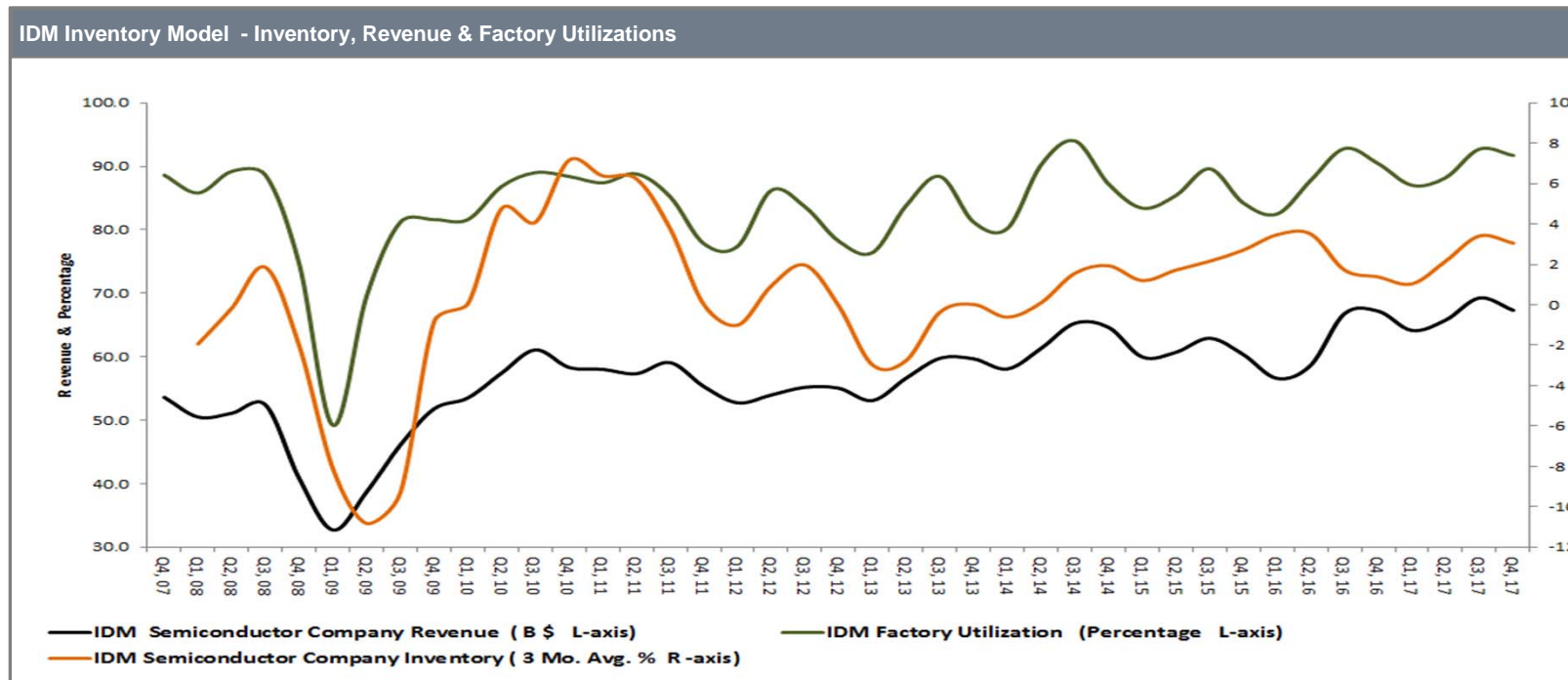
Fabless semiconductor companies are well positioned to support second half handset forecasts

- Inventory levels for components are at record levels



2017 inventory management model – IDM's

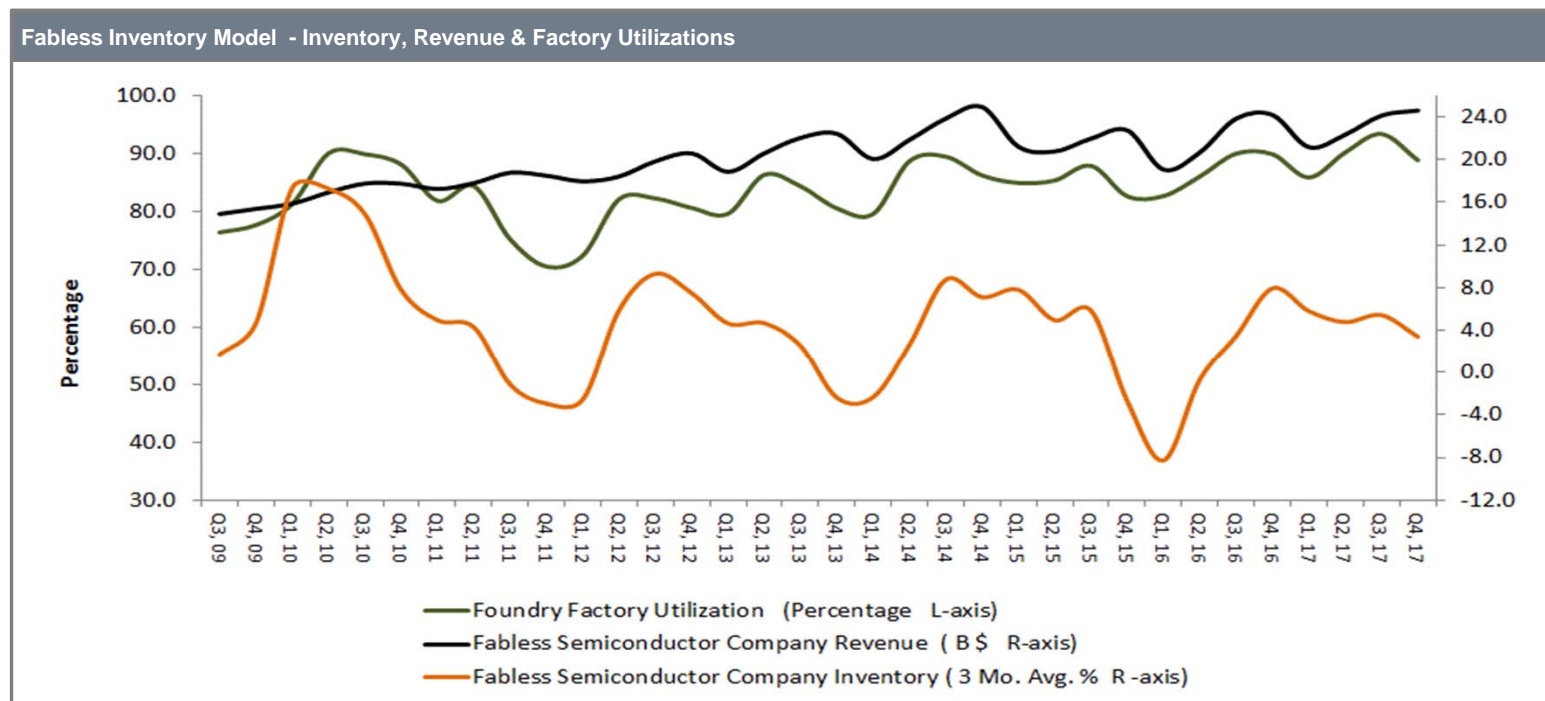
- Market demand for consumer products in the second half of 2017 requires companies to ramp manufacturing throughout the year
- Inventory is anticipated to grow throughout the first half of the year, manufacturing is forecast to slow in Q4 in order to achieve year-end financial goals



2017 inventory management model – Fabless / Foundry











- **Wireless communication drives fabless / foundry manufacturing demands**

> Foundry manufacturers are anticipating stronger than historical demand throughout 2H of 2017, next generation technology demand peaks in Q3 in support of iPhone 8 and next generation android handsets



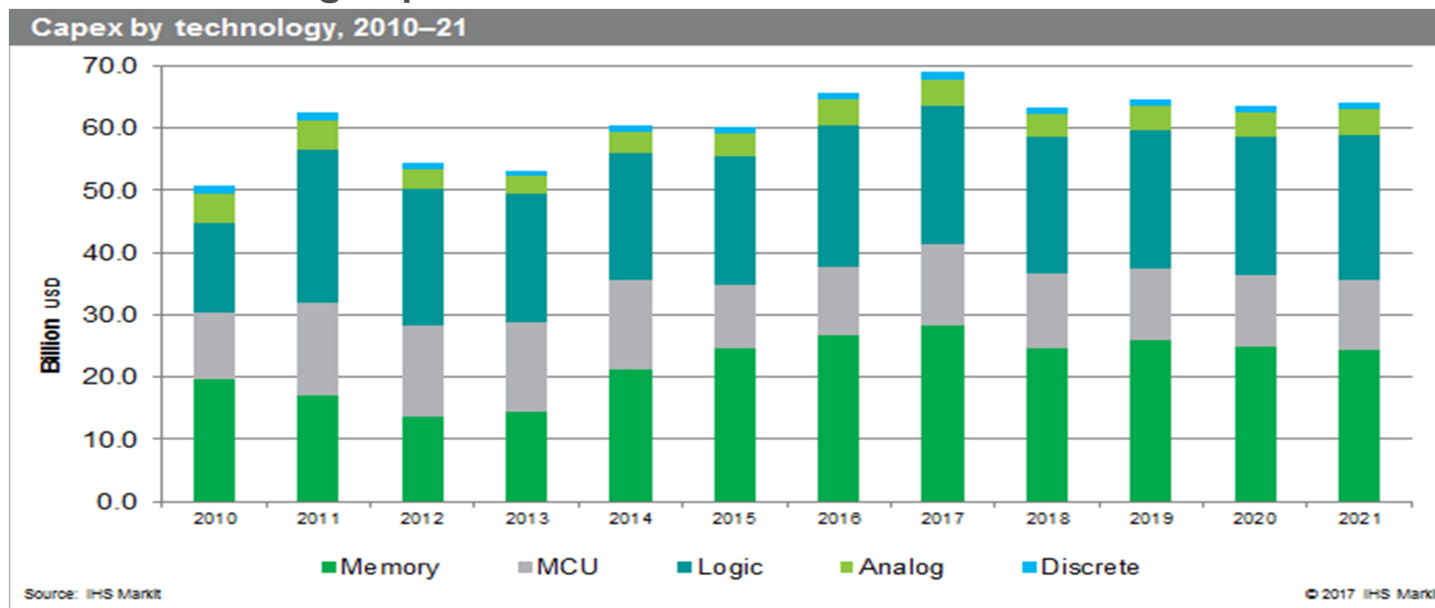
Investments in leading edge technology will result in record CapEx expenditures

- Spending is anticipated to be more uniform throughout 2017
 - > Capital Expenditures in 2016 were \$65.5 billion (9.1% YoY growth rate)
 - > Total capital expenditure in 2017 are forecast to grow by 3.2%

		2016 Expenditure	2017 CapEx Fcst.	Notes
	Samsung	11,347	12,500	DRAM expansion and technology migration to 18 nanometer, 3D NAND expansion
	TSMC	10,186	10,000	10 nanometer expansion, 7 nanometer development, China factory build-out
	Intel	9,625	12,000	Transition to 10 nanometer technology, expansion in NAND Flash
	Micron Technologies	5,873	5,000	Increased capacity and technology migrations (40% DRAM)
	SK Hynix	5,264	5,849	Capacity in M14 and 3D NAND
	GLOBALFOUNDRIES	3,053	2,800	7 nanometer R&D, Dresden SOI R&D, China expansion
	Toshiba	2,479	2,600	New factory expansion
	UMC	2,877	2,000	14 nanometer, expansion of 28 nanometer in Xiamen, China
	Sony	850	830	
	SMIC	2,695	2,300	Factory expansions Beijing, Shenzhen, Tainjin
	Other	11,648	12,110	

Investments for Memory and Logic technologies fuel long-term revenue growth

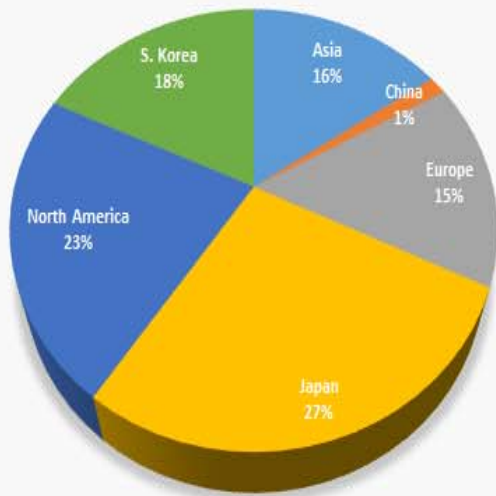
- DRAM technology migrations, NAND implementation of 3D manufacturing, and increased demand supporting SSD, data center and mobile require increased memory expenditures
- Logic technology migrations supporting mobile, computing and consumer electronics
- Chinese manufacturing expansions



Total foundry wafer capacity continues to transition to China

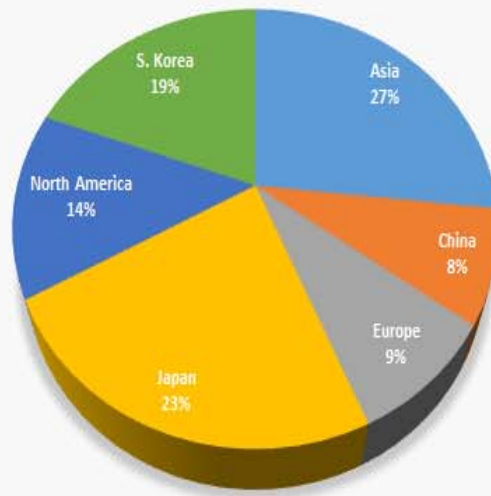
- Foundry manufacturing continues to be put in-place to support the next wave of innovative from domestic fabless companies

2000



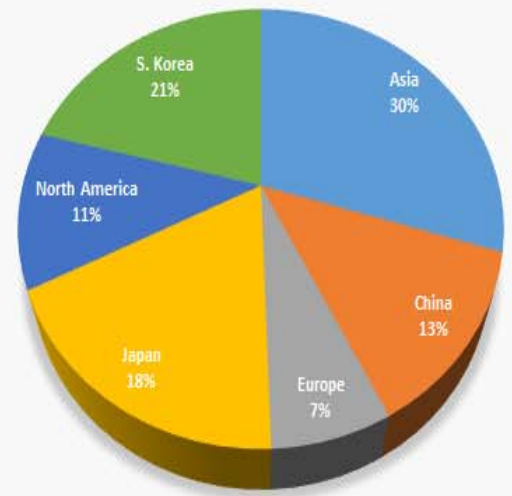
Asia China Europe Japan North America S. Korea

2010



Asia China Europe Japan North America S. Korea

2020



Asia China Europe Japan North America S. Korea

China's semiconductor manufacturing strategy

- China is strategically focusing on two key areas in order to drive domestic semiconductor expansion with the overall goal to minimize dependence on importing technology
- Goal is to achieve 20% CAGR by 2020 and domestic production/consumption reaches 70%

Foundry semiconductor manufacturing

Expansion by domestic companies like SMIC, HuaHong Grace, Haulai semiconductor focused on the development of advanced logic technologies used in communications, consumer and computing applications

Expansions by multinationals into China but limited by international regulations on the level of technology transfers that can be implemented (Globalfoundries, Powerchip, UMC, TSMC)

Memory semiconductor manufacturing

Expansions by multinational companies transferring owned I.P (Hynix, Samsung, Intel)

Development of a domestic memory suppliers (YRST, Rui-Li Integrated Circuits, Tsinghua Unigroup)

Manufacturing expansions in China will require additional demand in order to fill

- Foundry expansions are primarily 300 mm and focused on more advanced technology nodes

SMIC – Beijing fab expansions Fab B2 35,000 waf/mo initial production 2016 full capacity planned by end of 2017

- Shenzhen Fab expansion Fab 10 40,000 waf/mo (targeted 65 nanometer and 40 nanometer)
- Shanghai fab expansion 70,000 waf/mo initial production in 2018 (targeted 14 nanometer)
- Tianjin fab expansion 100,000 8-inch waf/mo

Shanghai Huali – 40,000 waf / mo, initial production 2018 (targeted 28, 14 nanometer)

Powerchip – Hefei facility 40,000 waf/mo, initial production 2018 (150, 110, 90 nanometer for DDIC)

TSMC – Nanjin facility 20,000 waf/mo, initial production Q3, 2018 (targeted 16 nanometer)

UMC – Xiamen facility initial capacity 50,000 waf/mo. capable of 100,000 waf/mo., initial production 6,000 waf/mo.
(Targeted 40 nanometer and 28 nanometer)

Globalfoundries – Chengdu, China Initial tools ~10,000 waf /mo. Total capacity ~30,000 waf/mo., production 2019

Memory expansions in China will present challenges to global supply / demand balance

- **Stability in the memory market was achieved only when the number of companies participating in the market was minimized**
 - > Samsung and Hynix (M14 & Wuxi) are both expect to increase capacity within existing sites in 2017
 - > Hynix has also announced a new NAND Flash fab in Cheongju, Chungcheongbuk-do to be operational in 2019

Intel – 3D NAND Flash 60,000 waf / mo.

YMTC – NAND Flash facility 300,000 waf/ mo production forecast

Phase I: 100,000 wafers/ month 3D NAND Flash, 48 layer (Forecast end of 2018)

Phase II: 100,000 wafers / month 3D NAND Flash (Forecast end of 2019)

Phase III: 100,000 wafers / month DRAM (Forecast end of 2020)

Tsinghua Unigroup – DRAM and Logic Forecasting to start construction in 2017

Chengdu (Sichuan province)

Nanjing (Jiangsu province)

Summary

- **In 2017 the global economy should provide a tail-wind to the semiconductor industry**
 - > Consumers are eagerly anticipating the latest handsets with several new features
- **IHS anticipates that the total semiconductor revenue for 2017 will grow by approximately 12.1%**
 - > Memory ASP increases are inflating the overall revenue industry growth. (6.5% without Memory)
- **Mergers and acquisitions will continue to drive consolidation throughout semiconductor supply chain**
 - > Companies are positioning themselves for future growth by focusing on selective markets such as automotive, consumer electronics (smart home), and industrial power management
- **Next generation demand drivers are still several years away from impacting manufacturing**
 - > Next generation wireless communication 5G will start limited trials in 2018
 - > Automotive autonomous driving, 5G, and cloud (data center) computing together make up the next wave of electronics demand
- **Chinese domestic manufacturing expansion poses a serious short-term challenge to the supply and demand balance within the semiconductor industry**
 - > Manufacturing capacity for specific technology platforms will take several years to fill

Thank You

April, 2017

• **Len Jelinek, Director & Chief Analyst**