

# Have the Semiconductor Industry Grow Again

Jim Walker  
IMAPS GBC Conference  
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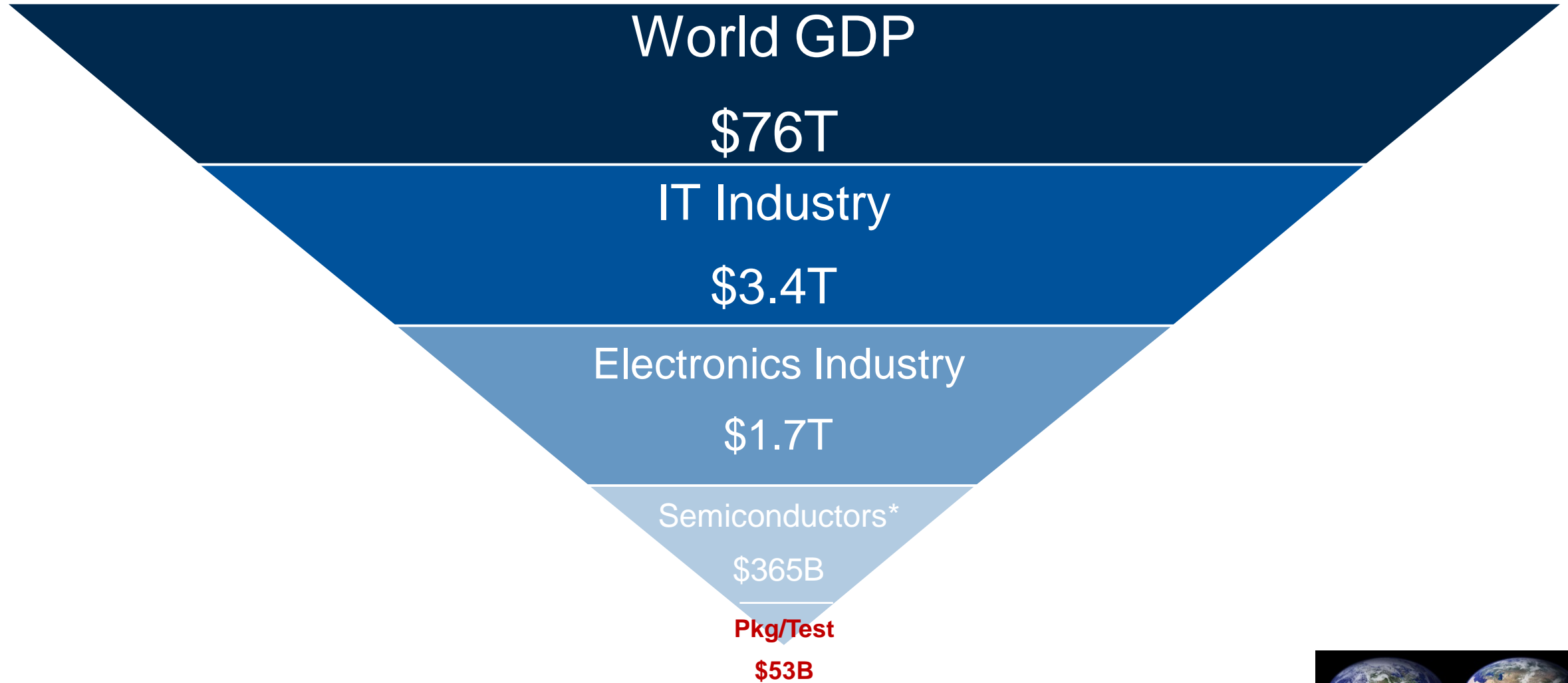


**HELLO**  
**Semiconductors Are**

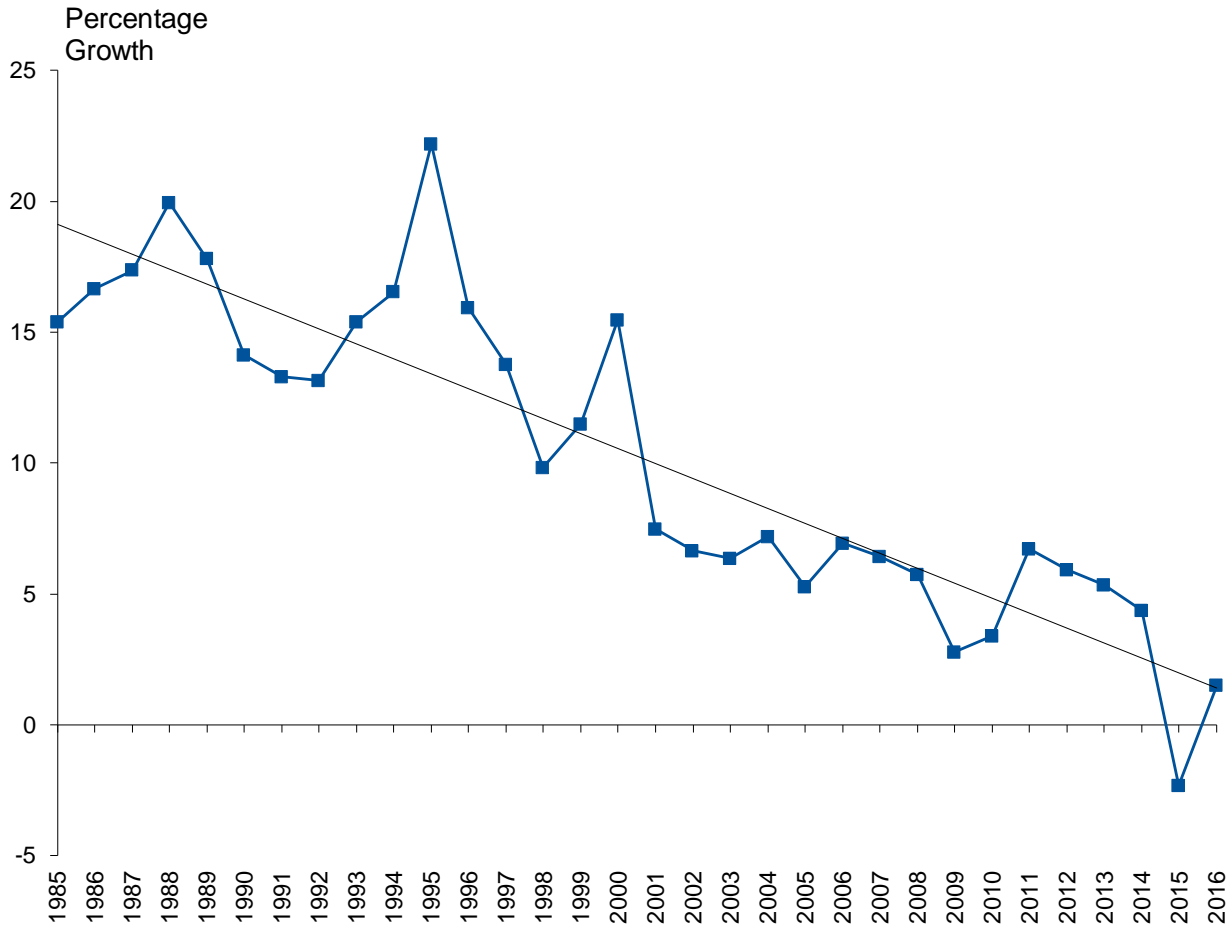
**HERE TO STAY!**

# Semiconductors Are More Relevant Today Than Ever

## - The Emergence of IoT -



# Semiconductor Industry Growth Trend, 1985 - 2016



Semiconductor 10-Year Growth Rate and Trend Line, Worldwide, 1985-2016

- Long-term industry revenue growth rates have fallen from 15% to 5%
- Foundry now supplies close to 45% of all non-memory semiconductors.
- 35% of WW semiconductor revenue is from mobile phones, ultramobiles (including tablets) and PCs
- IoT will drive high-volume, **BUT** low-value silicon in many applications adds little semiconductor revenue to TAM



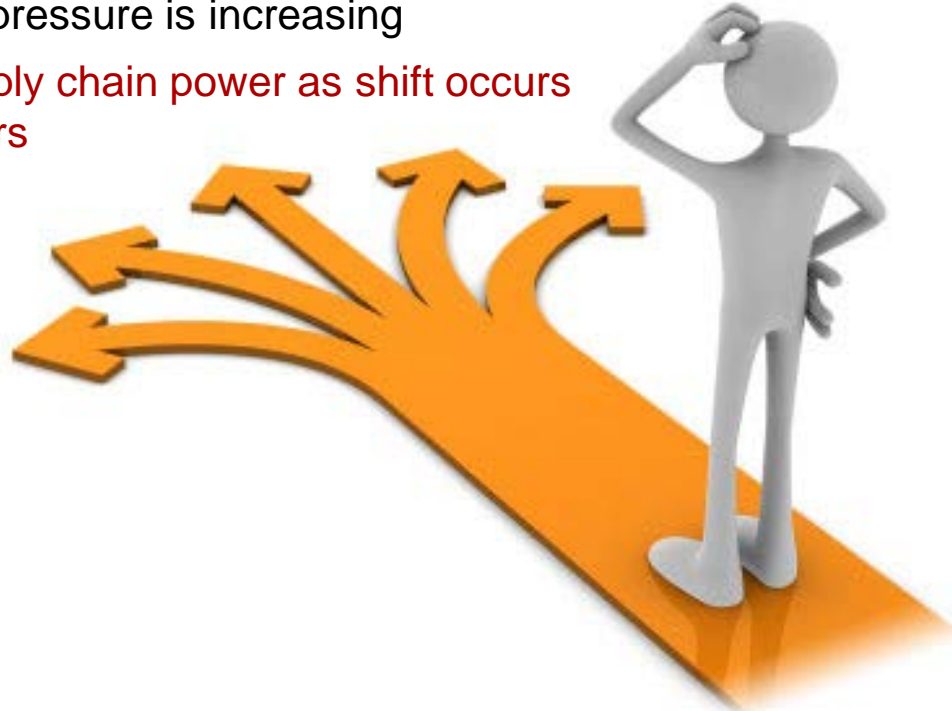
# Are We “Muddling Through”, or Can We Get Moving Again?

## RISKS

- Growth in mature, high-volume markets is slowing down
- Practically no growth in last 2 years
- Traditional semiconductor business model profits are reducing
- Design and manufacturing costs are becoming prohibitive
- Commoditization pressure is increasing
- OEM's losing supply chain power as shift occurs to service providers

## OPPORTUNITIES

- Identify new growth markets & new engagement models
- Find new ways to design, develop and sell
- Exit saturated market segments that are oversupplied
- Invest in a high-level of differentiation
- **Focus on the solution & the ecosystem; not just the chip**



# Presentation Overview

- Semiconductor Market Status and Forecast
- Growth Markets and Industry Consolidation
- Semiconductor Packaging and the OSAT Marketplace
- The Future of Semiconductors, Manufacturing and Outsourcing

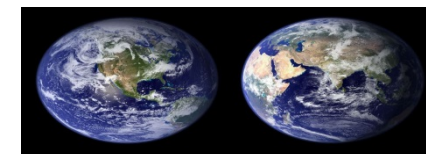


# Top Level Forecast Growth

<u>Revenue Growth (%)</u>	<u>2016</u>	<u>2017</u>
Global Real GDP	+ 2.2	+2.6
U.S. Real GDP	+1.5	+2.2
Elec. Equipment <sup>1</sup>	+ 1.1	+3.4
Semiconductor <sup>2</sup>	+1.5	+7.2
Foundry	+8.6	+6.9
OSAT/SATS	+1.4	+8.5
Capital Spending	+5.1	+2.9
WL Equip. Spending	+7.9	+6.0
WFE	+8.1	+5.7
WL PAE	+3.9	+10.7

<sup>1</sup> Production revenue

<sup>2</sup> Excluding solar



*World Level Packaging Concepts*

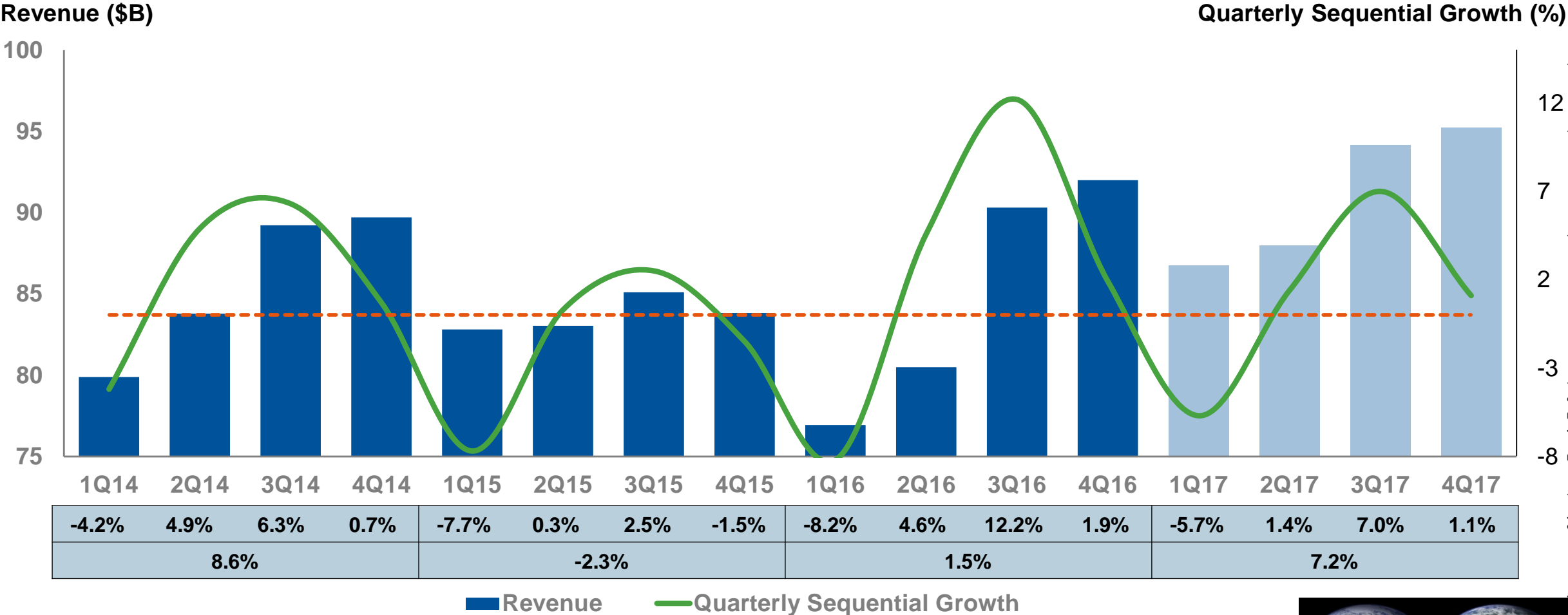
# Semiconductor Forecast Highlights

- Semiconductor revenue for 2017 expected to increase around 7%.
- Memory and application-specific standard products (ASSP) growth momentum from 2<sup>nd</sup> half of 2016 continuing into 2017.
- Both DRAM and NAND contribute the most to the forecast growth in 2017. Supply/demand dynamics tightening and prices are increasing.
- ASSPs represent 18% of the total forecast increase in 2017. Prices are increasing and higher content growing in key applications, including the IoT.
- iPhone 7 momentum increasing, positively impacted by Samsung Galaxy Note7 problems and additional corporate issues (1/3 of Note7 users opt for refund vs. exchange).





# Semiconductor Quarterly Revenue : Dismal First Half 2016, Second Half Growth Gives Momentum into 2017



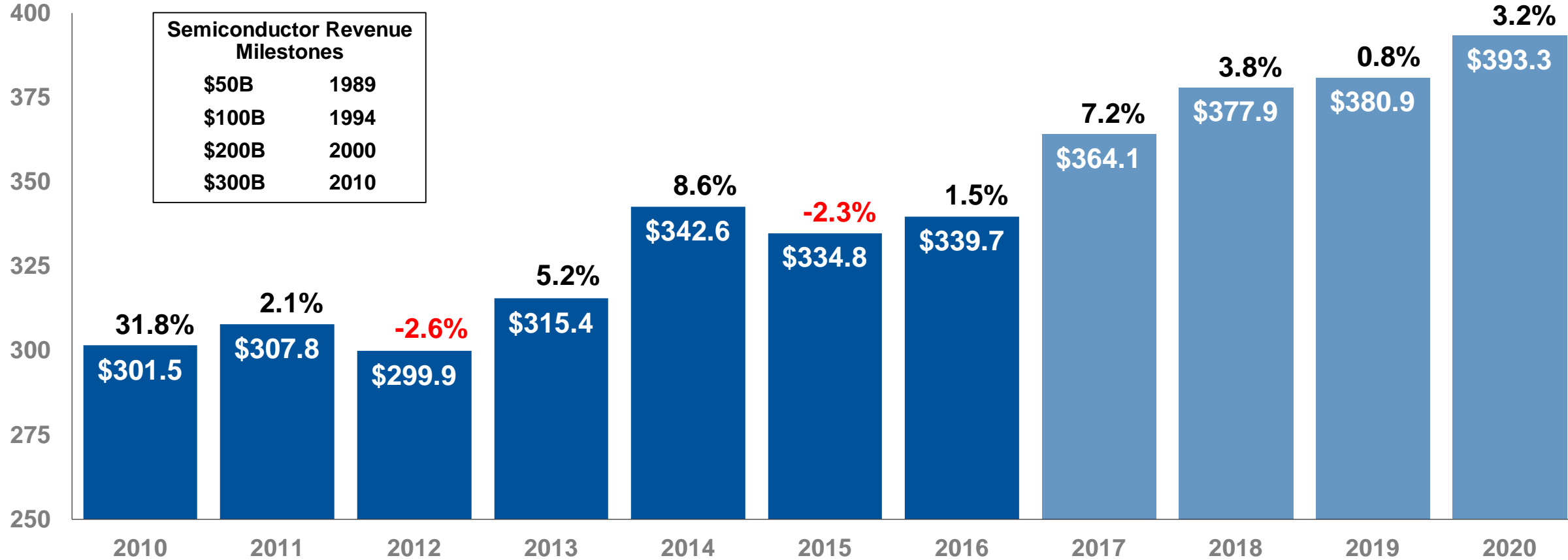
Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



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# Worldwide Semiconductor Revenue Forecast: 2016 Became Positive Late in Year, 2017 Gets Stronger

Billions of Dollars and Revenue Growth

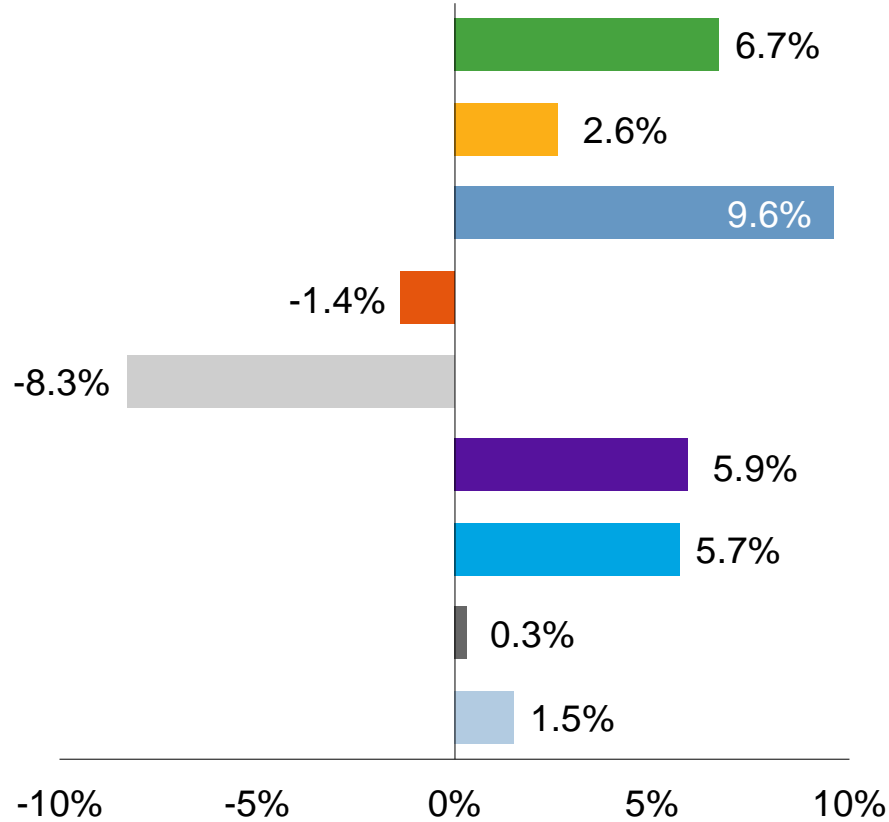


Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



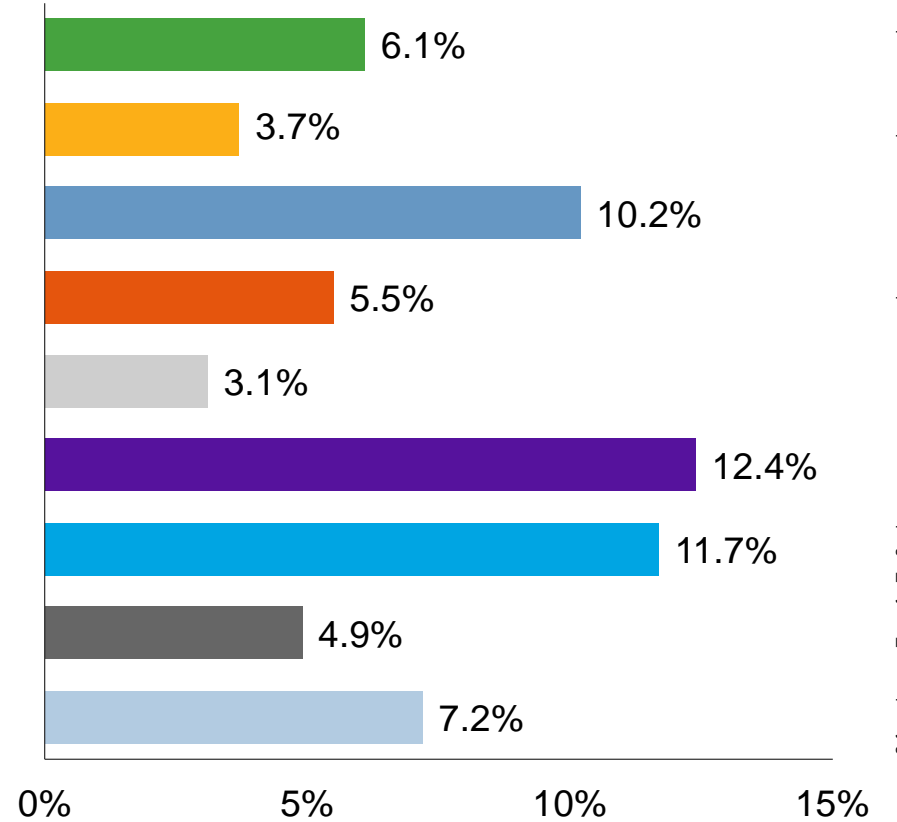
# Applications: 2016 Mixed Growth Year, 2017 Consistent Growth

2016 Revenues \$339.7 billion  
1.5% Growth



Share	Share
9.5%	9.4%
5.3%	5.2%
29.0%	29.8%
10.7%	10.5%
28.1%	27.0%
6.3%	6.6%
9.9%	10.3%
1.2%	1.1%
100.0%	100.0%

2017 Revenues \$364.1 billion  
7.2% Growth

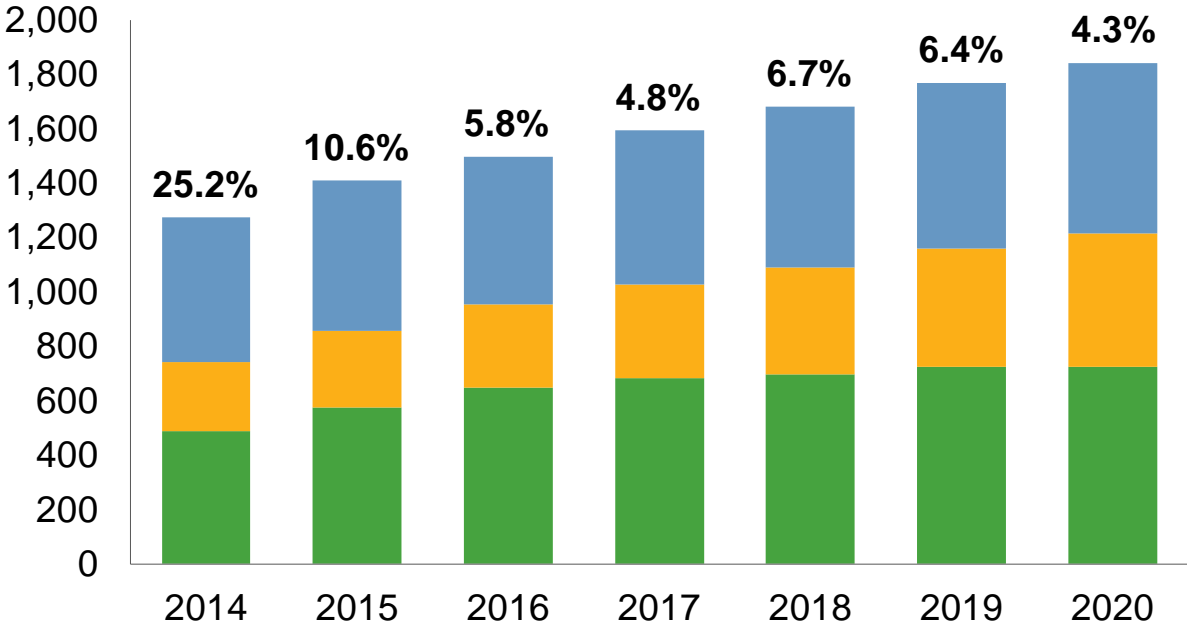


Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



# Smartphone: Production Forecast

Smartphone Unit Production (Millions of Units)



Semi Revenue and Share of Market (Billions of Dollars)

67.8	75.7	85.7	96.0	97.7	94.9	94.7
19.8%	22.6%	25.2%	26.4%	25.9%	24.9%	24.1%

■ Basic Smartphone ■ Utility Smartphone ■ Premium Smartphone

- 2016 smartphone units increased 5.8%.
- 2017 unit growth rate for premium smartphones units lower but partially compensated by increases in basic and utility smartphones.
- Strong rebound in premium smartphones starting in 4Q17 driven by the 10<sup>th</sup> anniversary iPhone. This will carry into 2018.
- Chinese OEMs remain strong:
  - Huawei, Vivo and Oppo are gaining market share and are looking to expand outside of China
  - Chinese phone service carriers are pushing LTE smartphones with subsidies.
- Apple rebounding in 2017; Samsung experiencing more difficulty.

Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



# Chinese OEMs Lead the Smartphone Market Growth

Thousands of units	<u>1H2016</u>	<u>2012 YR</u>	<u>2013 YR</u>	<u>2014 YR</u>	<u>2015 YR</u>	<u>CAGR</u>
Samsung	157,930	205,767	299,795	307,597	320,220	16%
Apple	96,024	130,133	150,786	191,426	225,851	20%
Huawei	59,532	27,169	46,609	68,081	104,095	56%
Oppo	34,602	3,072	10,983	20,501	39,489	134%
Xiaomi	30,579	2,811	13,423	56,529	65,619	186%
Vivo	28,242	2,480	11,163	20,416	35,291	142%
LG	24,914	25,814	46,432	57,661	60,346	33%
Lenovo	24,328	21,699	43,905	81,416	72,748	50%
ZTE	23,336	26,825	37,880	41,073	49,965	23%
TCL	14,145	5,328	16,416	36,470	40,512	97%

Source: Gartner 10/2016"

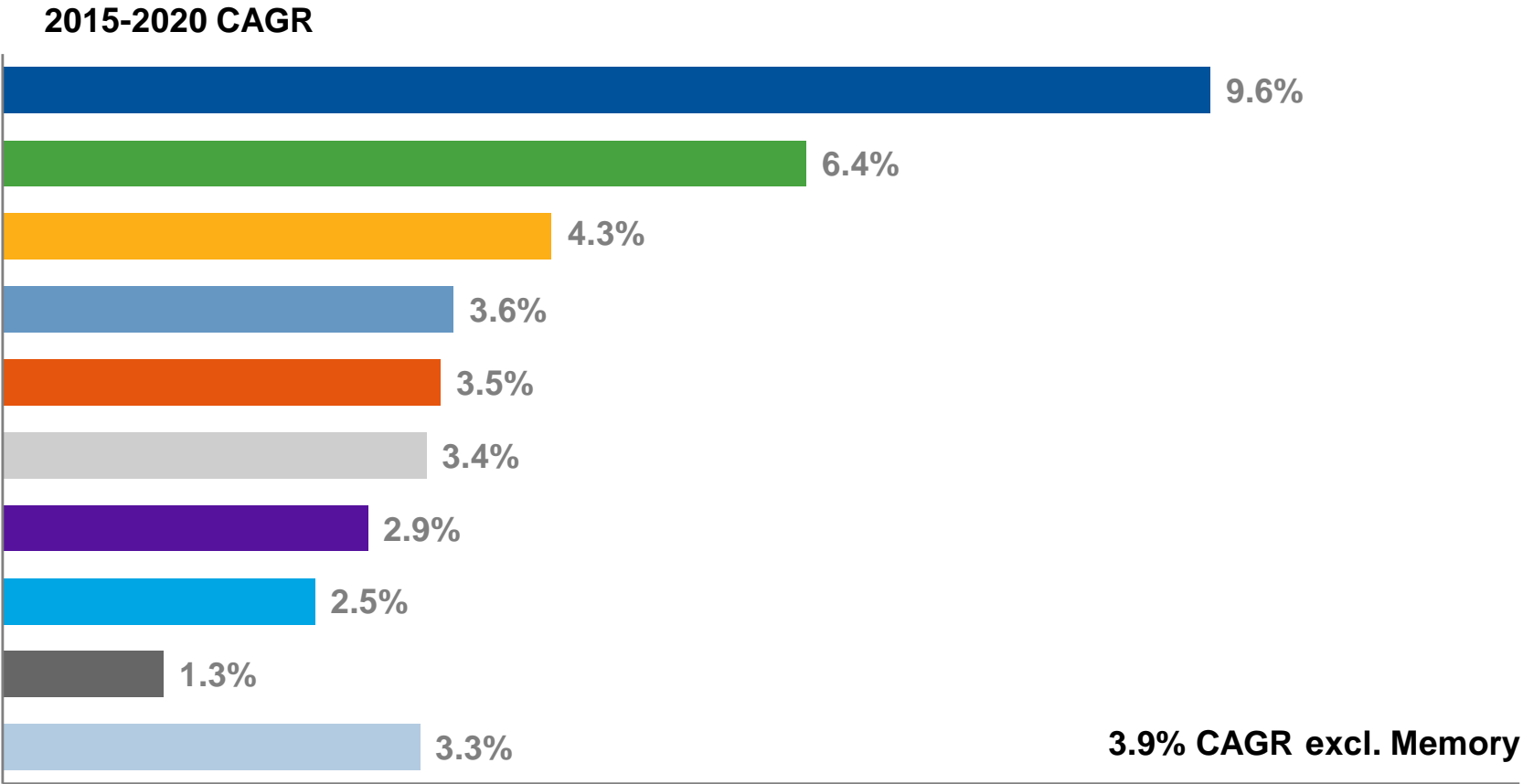


*World Level Packaging Concepts*

# Device Market – 5 Year Revenue Growth: 2015-2020

## Nonoptical Sensors Lead the Percent Growth — Memory Lags

	2020 Revenue	Share
NOS/MEMS	13,231	3.4%
Opto	36,638	9.3%
ASIC	27,624	7.0%
Micro	72,566	18.5%
Analog	24,955	6.3%
Discrete	20,867	5.3%
ASSP	99,103	25.2%
GP Logic	13,826	3.5%
Memory	84,480	21.5%
<b>Total Semi.</b>	<b>393,290</b>	<b>100.0%</b>



Note: Some columns do not add to totals shown due to rounding; Revenue figures are in US dollar millions.

ASSP = application-specific standard product; ASIC= application-specific integrated circuit; GP = general purpose; NOS = non-optical sensor

Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



World Level Packaging Concepts

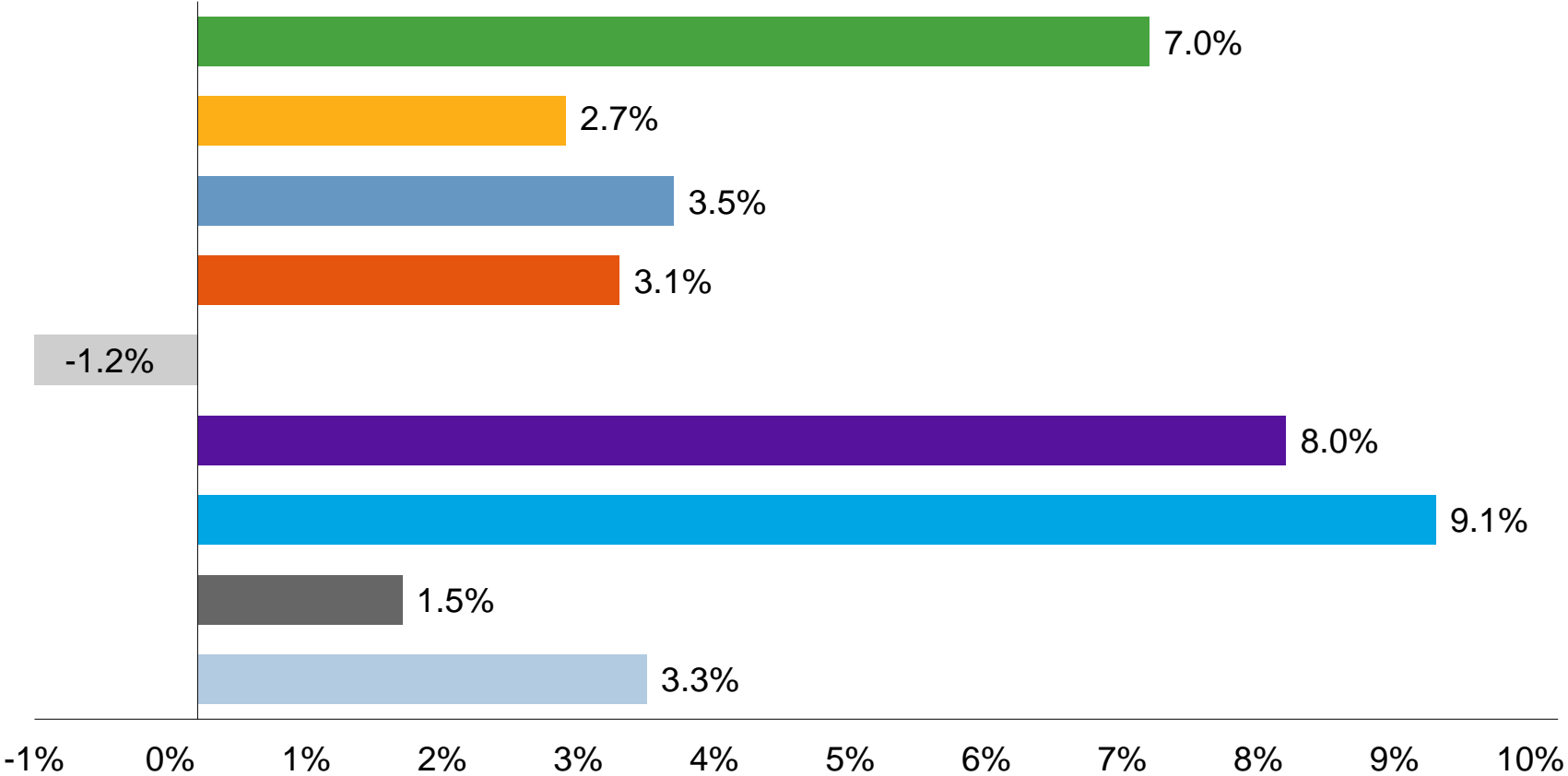
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# Application Markets – 5 Year Revenue Growth: 2015-2020

## Industrial, Storage, Automotive Lead the Way

	2020 Revenue	Share
Automotive	42,445	10.8%
Wired	20,122	5.1%
Wireless	106,690	27.1%
Consumer	42,692	10.9%
Compute	97,996	24.9%
Storage	29,631	7.5%
Industrial	49,426	12.6%
Mil/Aero	4,290	1.1%
<b>Total Semi</b>	<b>393,290</b>	<b>100.0%</b>

CAGR 2015 - 2020



Source: Gartner "Semiconductor Forecast Database, Worldwide, 4Q16 Update"



# Outsourcing Services: Foundry and OSAT/SATS Market Forecast

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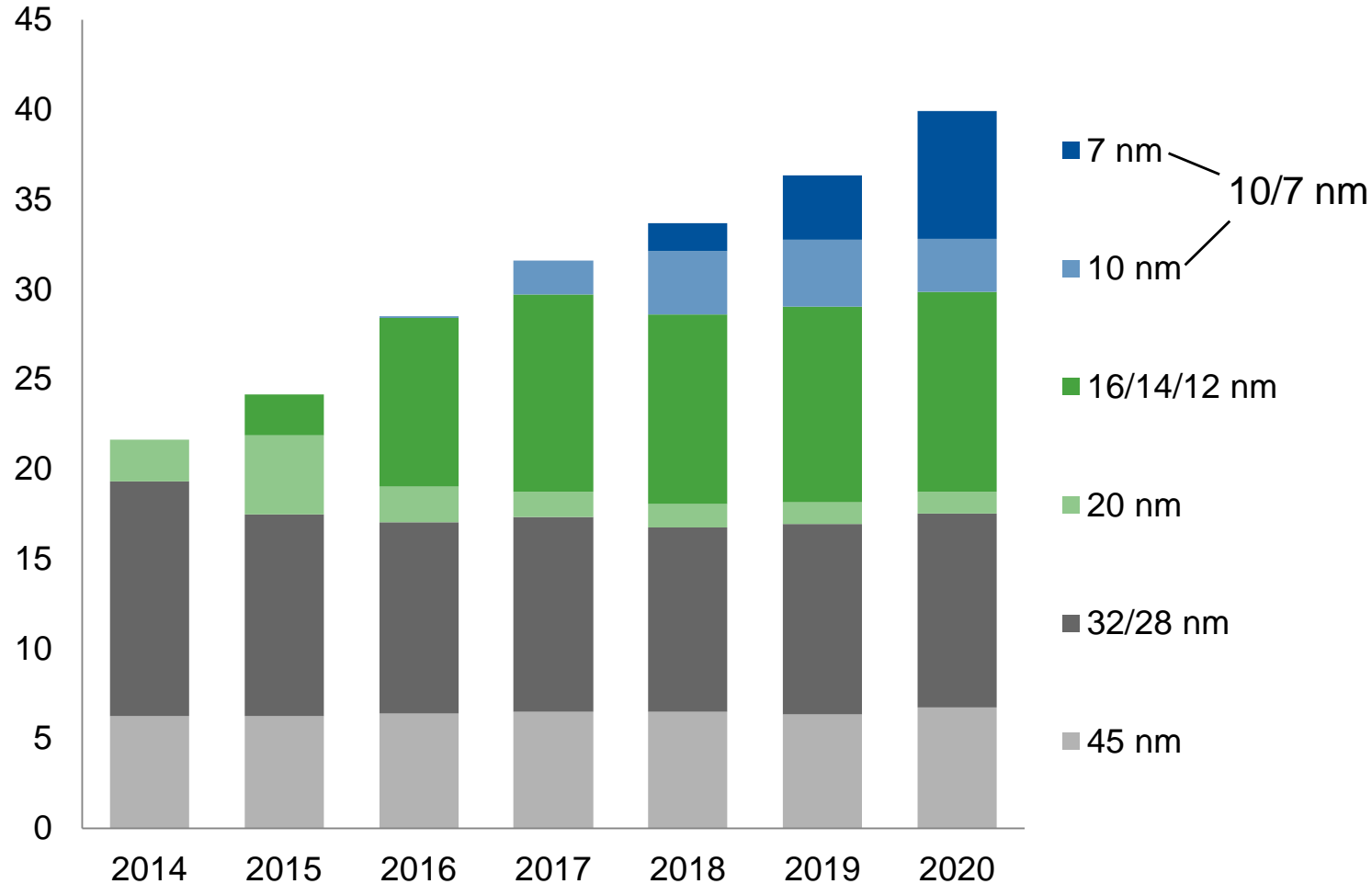
# Foundry Forecast Assumptions

- Foundry outlook improved in 2016 and continues in 2017. Higher demand of leading node wafers from Apple supply chain. 6.9% growth to \$56.8 billion in 2017.
- Chinese foundry capacity will more than double from 1.5 million 300mm equivalent wafers a year in 2016 to 4.0 million wafers in 2020
- Foundries are defending their market share by offering more options on sub-16nm leading technologies and reduction in wafer prices
- Chinese investment in foundry will begin to affect memory market from 2018-2020.
- Foundries will increase the allocation of investment in production and technology development to US region, in response to the new US president.



# Foundry Revenue Forecast - Advanced Process Nodes

Billions of Dollars



- Revenue from the 16/14/12 nm wafers is increased in the current forecast
- More options of advanced technologies are offered by foundries
- 12nm is considered as a shrunk version of 16nm
- Competition in winning 7nm customers becomes intensified by large foundries



World Level Packaging Concepts

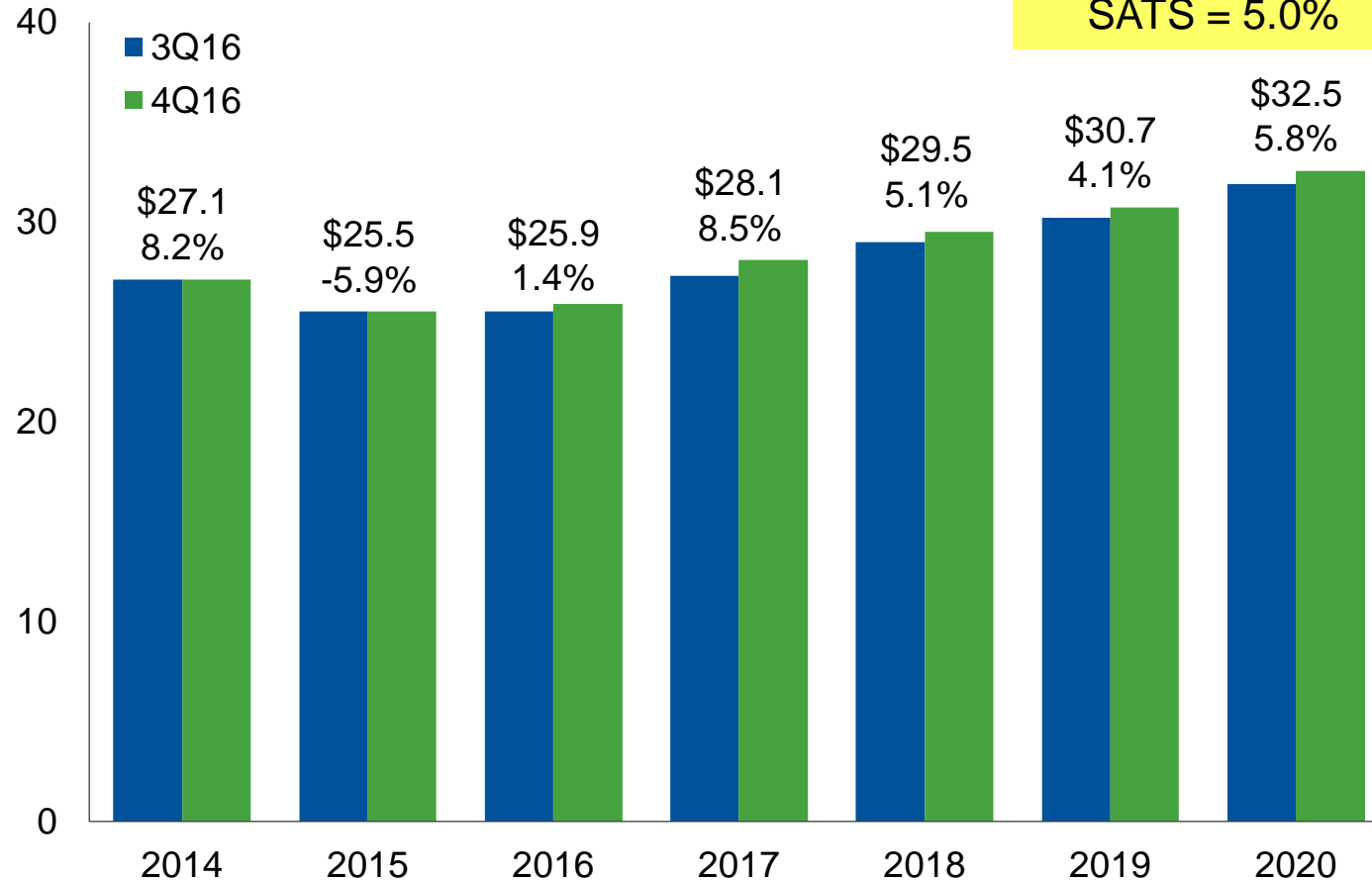
# OSAT/SATS 2017 Forecast

- Test services and memory packaging drive first half 2017 growth. Record monthly revenues for many SATS/OSAT companies in last 6 months of 2016.
- Test growth rate increasing faster than packaging. System complexity rising.
- 8.5% growth in 2017 coming from Apple supply chain, Foundries, SiP-FOWLP growth and IDM partnerships for outsourcing.
- Wafer-based packaging processes are now mainstream. FOWLP is the fastest growing package since intro of SMT in mid 1980's. Foundry now a competitor in addition to companies within the SATS market, Process leverage, cost reduction and pricing are key.
- China is the growth market for semiconductor manufacturing, with \$100 billion supplied by China Gov't, including M&A and JV. Expansion into China by SATS companies continues, as engineering expertise and supply chain infrastructure are fully developed in the area.



# OSAT/SATS Revenue Forecast

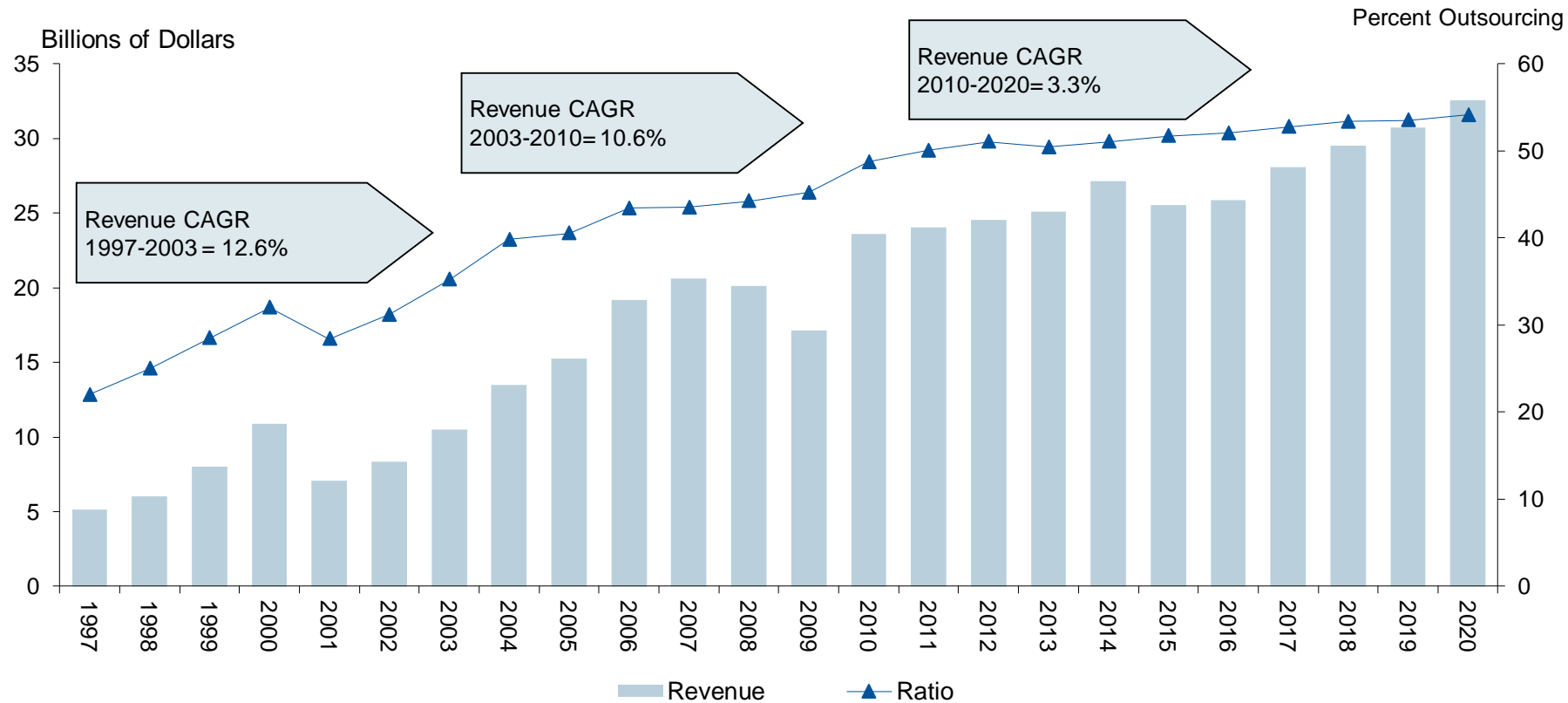
Billions of Dollars and Revenue Growth



- SATS revenue rose in Q4 2016 as inventories depleted and new models of smartphones and holiday buying increased demand.
- SATS competition with foundries for value-added services on bumping, fan-out and wafer level packaging businesses grows as iPhone adopts InFO FOWLP.
- Currency exchange rates fluctuate vs. strong U.S. dollar still causing SATS growth via U.S. dollars to be reduced.



# OSAT/SATS Industry Maturing



- SATS growth is single digits
- No volume “Killer App” growth driver. More customized packaging required in future.
- Typical price decline of 2-5%/yr. for past 20+ years
- Foundry now competing with SATS
- China-based packaging factories supply nearly half of all worldwide packaging value



# Summary: Semiconductor Market

- Semiconductor revenues for 2016 were tepid; 2017 poised for stronger growth.
- Inventory correction of past 2 ½ years is over. Restocking of both semiconductors and finished goods will continue into 2017, adding to growth.
- Memory market supply and demand dynamics are positive for memory vendors who are pushing ASPs higher to recover margins.
- ASP increases and higher content in key applications including the IoT are a key driver for increased revenue forecast for 2017.
- Profit margins are decreasing and a slower growth market is ahead. Companies must pursue alternatives to gain competitive advantage.



BUSINESS AS USUAL  
IS **NOT**  
AN OPTION

# What to Do?

- Increase market share
- Reduce competition, capture higher margins
- Remove barriers to entry and expedite
- Exit market
- Mergers and acquisitions
- Increase chances of success - diversification into new markets
- Modify strategy or business model





# Slower Growth Promotes Industry Consolidation



# Semiconductor M&A Announced in 2016

<u>Company</u>	<u>Acquired/Invested</u>	<u>Date</u>	<u>Price</u>
Qualcomm	NXP Semiconductor	October	47 B
Softbank	ARM Holdings	July	32 B
Analog Devices	Linear Technology	July	14.8 B
On Semi	Fairchild	Sept	2.4 B
Cypress Semi	Broadcom (wireless, IoT group)	April	550 M
Cisco	Leaba Semiconductor	March	320 M
Renesas	Intersil	Sept	3.2 B
GigOptix	Magnum Semi	April	55 M
GlobalWafers	SunEdison Semi	August	683 M
Intel	Movidius	September	400 M
Microchip	Atmel	January	3.5 B
Infineon	Wolfspeed (Div. of Cree)	July	850 M
Sony	Altair Semi	January	212 M
MaxLinear	MicroSemi (wireless Div)	April	21 M



# Packaging & Test: M & A - Investments (2014 – 2017)

- ✓ China WLCSP acquired Gerad Suzhou (2014)
- ✓ Tianshui Huatian buys Flip Chip Technology (2014)
- ✓ Nantong Fujitsu forms JV, acquiring AMD plants in Penang and Suzhou (2015)
- ✓ International Brand Marketing acquires Kingpak Technology (2015)
- ✓ Thailin Semiconductor merges with ChipMOS Taiwan subsidiary (2015)
- ✓ JCET acquires STATSChipPAC (2015)
- ✓ China WLCSP acquires Omnivision facility (2016)
- ✓ ASE and SPIL announce formation of joint holding company (2016)
- ✓ ASE invests in DECA's FOWLP (subsidiary of Cypress).
- ✓ Amkor acquires 100% ownership of J-Devices (2016)
- ✓ Tsinghua Unigroup China forms a joint venture with ChipMOS (2016)
- ✓ Amkor offers to acquire Nanium (2017)



# M&A Highlights For 2017:

- 1) IoT related M&A activity will continue to drive consolidation in MCU, analog and sensor technologies.
- 2) Companies will initiate sale of unprofitable divisions and product lines to prepare themselves for M&A (i.e. make themselves more attractive to be acquired).
- 3) Some divisions of acquired companies will be sold as the result of large acquisitions due to little synergy value in new combined company.
- 4) China companies and government sponsored entities will continue to buy or invest in U.S. and European companies, even as governments institute restrictions.
- 5) OEM's will become more active in M&A as IoT markets develop.
- 6) Top 20 Semi companies sitting on 135 Billion in cash.



# Application Markets and their Packaging Opportunities

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# Emerging and Growth Markets

- Artificial networks and Neural Networks
- Industrial Markets
- Connected Car
- Wearables
- Drones
- Smart Cities
  - Smart Home
  - Smart Building
  - Smart Traffic



# Smart City

## Smart City

### Smart Living

Green Planning  
Climate and Solar Sensors  
**Pollution monitoring**  
Noise Monitoring  
Water quality monitoring

### Planning

Urban Planning

### Smart Home

Energy Management Gateway  
Appliance monitoring/ Control  
HVAC control

### Transportation

**Traffic Mgmt.** Congestion Pricing  
Bridge, road and tunnel mgmt.  
Transport information  
**Real-time Parking** Fare Management  
**Electric Vehicle mmgt** Bike scheme mgmt.  
Illegal Parking Detection

### Safe City

**CCTV** Criminal /terrorism analytics  
Smart law enforcement  
Crowd mgmt.

### Smart Utility

Smart Grid  
Control around Local Energy Production

### Citizen Services

Identity Alerting  
**Tourism services**  
Citizen Portal or Apps

### Education

### Healthcare

### City Control

Irrigation management  
**Street Lighting management**  
**Waste Collection**  
Manhole Cover mgmt.

### Emergency Response

Disaster prediction **Disaster response**

### Smart Building

### Communications and Traditional Services

Broadband and wifi deployments  
Voice services/alerting etc.  
Fleet Mgmt



# Smart Home

- Security (home security systems)
  - Door sensors, cameras internal external, motion sensors, lock and unlock doors, turn lights on and off, garage door
- Home energy
  - Thermostats, lights, PV monitoring, EV charging, Smart meters. sockets
- Entertainment
  - Smart TV, Set top box, Streaming Video, Music, mood lighting, theater lighting.
- Appliances,
  - washer dryer, stove, refrigerator etc.
- Comfort
  - Thermostats, Baby Monitors, water monitoring, leak detection, Co2 Smoke
- Home Health Care
  - Medication Compliance, Assisted Living; Testing and Monitoring; Implants/Prosthesis





# Packaging Opportunities: Driven by IoT, Mobility, Memory, Automotive, and High Performance Computing

## But expanding into other markets possible

- LED Packaging
- Flexible/Printed Electronics
- Discrete Components
- Power Management I.C.'s
- Wafer Bumping for IDM's and Fabless Companies
- SSD
- Storage for the Cloud

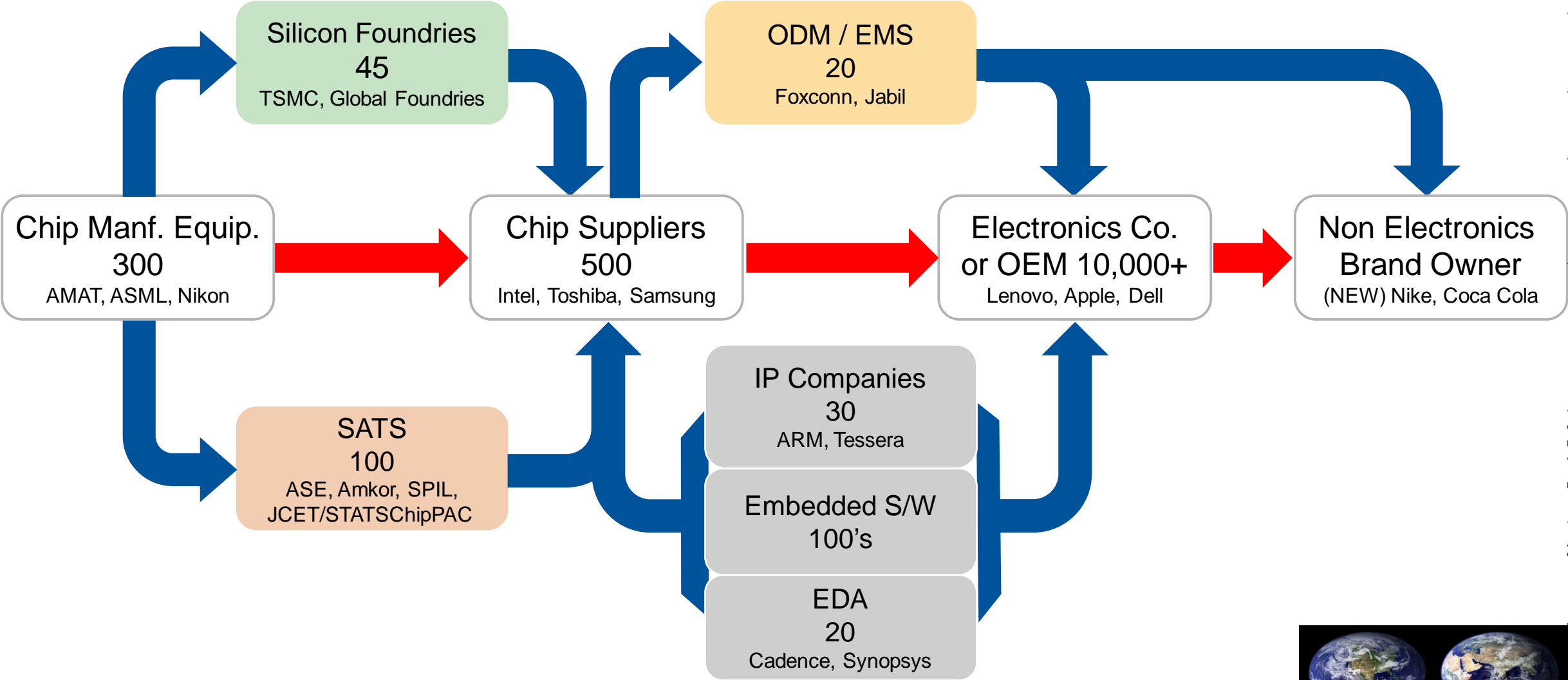


# **Evolving Business Models:**

## **The Future of Semiconductors, Manufacturing and Outsourcing**



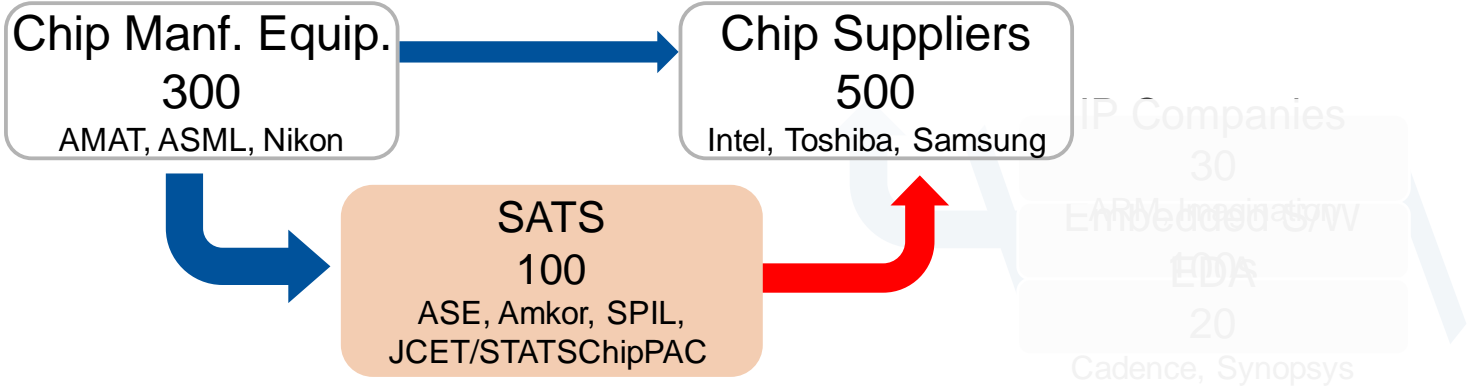
# The Semiconductor Ecosystem



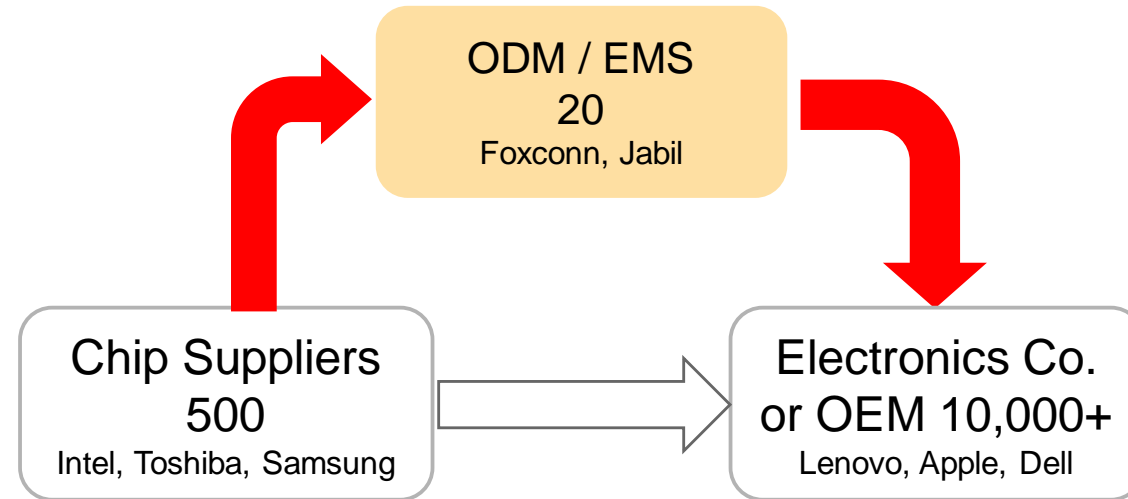
# The Semiconductor Ecosystem – SATS/OSAT

Semiconductor Assembly and Test is increasingly important as Chip Companies try to:

- Put bigger die into a package
- Put more than one die in a package
- Improve their Time to Market
- Lower Costs



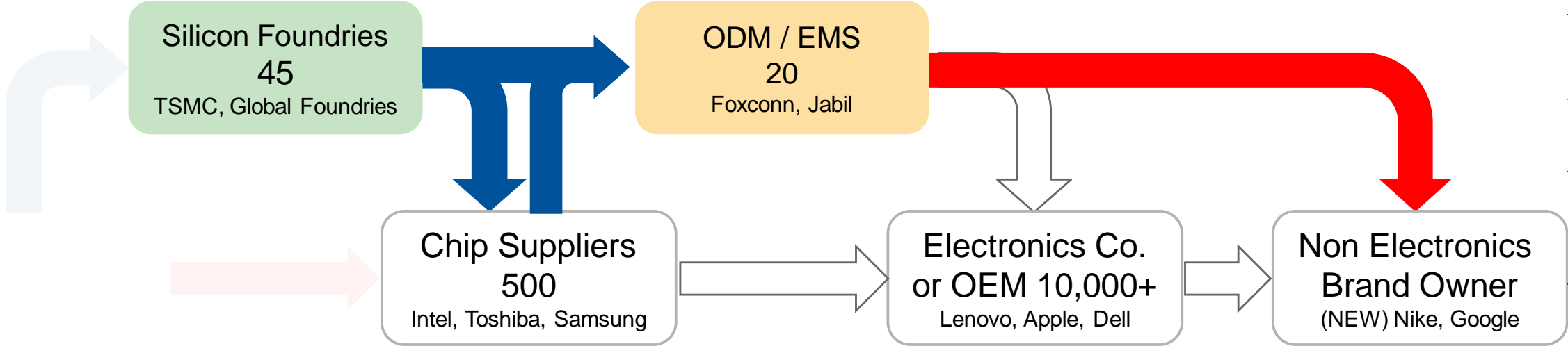
# The Semiconductor Ecosystem – Electronic System Manufacturing



- More and more electronics is now made by 3<sup>rd</sup> party electronics manufacturers (EMS/ODMs).
- These companies (e.g., Foxconn, Wistron, Quanta) reduce costs by scale but they also have an increasing number of business models.
- They now represent the most significant risk and opportunity for chip companies to win or lose semiconductor design – ins.



# The Semiconductor Ecosystem – The (Brand) Direct to ODM/EMS Model



A relatively new problem for some OEMs and Electronics Brands – now - is that they are being **BYPASSED** by a direct relationship between the ODM/EMS Co. and a non- electronics Brand Owner buyer who could be in ANY industry.

This model emerged with Operator branded handsets, although those were recognizable as say Nokia or Motorola. But now the situation is more extreme and wearable electronics is a current example.

This is the (Brand) Direct to ODM/EMS business model. Good for Chip Suppliers; bad for traditional electronics companies.

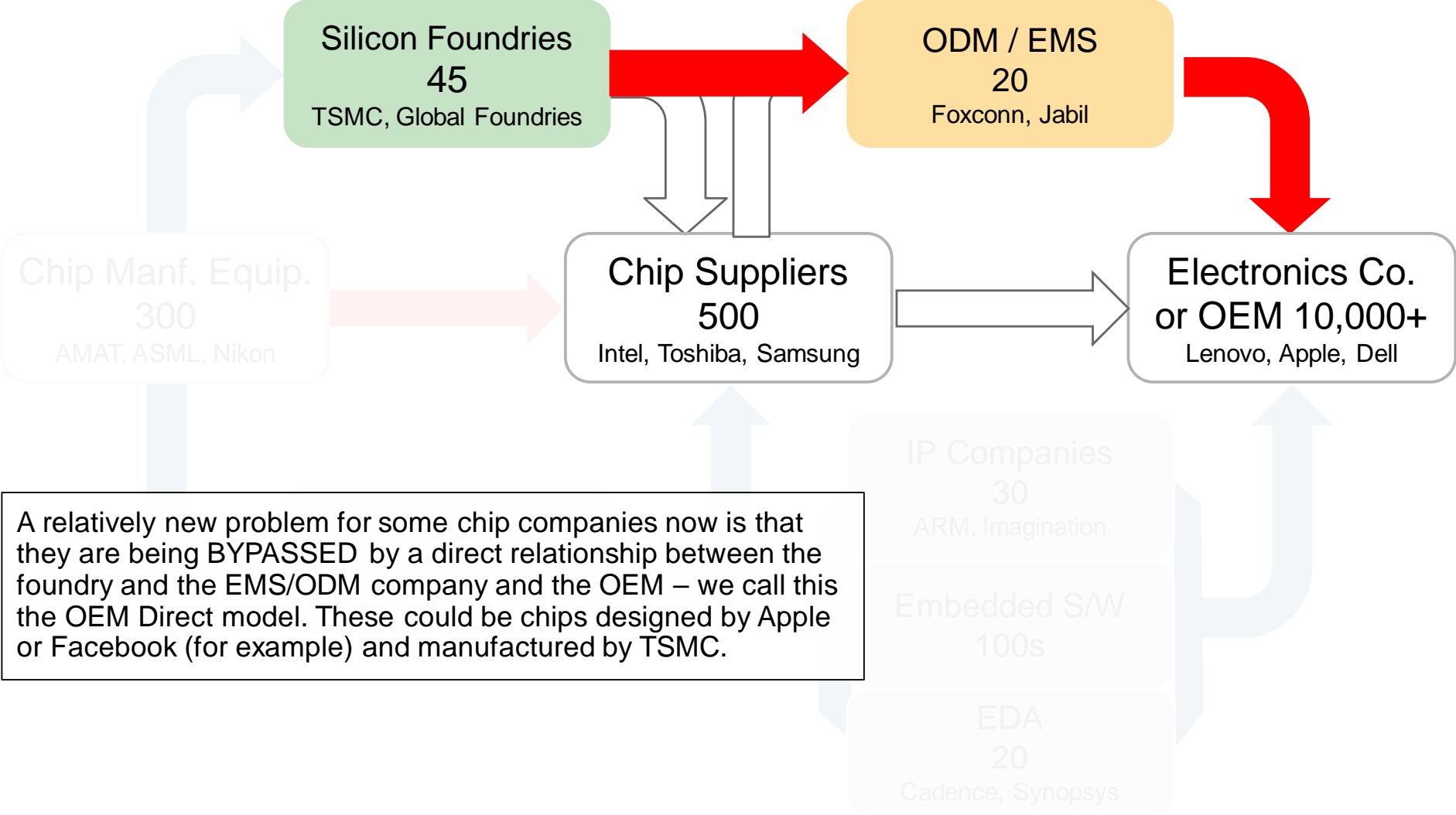
IP Companies  
30  
ARM, Imagination

Embedded S/W  
100s

EDA  
20  
Cadence, Synopsys



# The Semiconductor Ecosystem – The OEM Direct (to Foundry) Supply Model



A relatively new problem for some chip companies now is that they are being **BYPASSED** by a direct relationship between the foundry and the EMS/ODM company and the OEM – we call this the OEM Direct model. These could be chips designed by Apple or Facebook (for example) and manufactured by TSMC.



# Hon Hai/Foxconn Technology Group – Integration via M&A

## E-enabled Components, Modules, Moves and Services (eCMMS).

- Goal to be the vertically integrated, one-stop shopping business model
- (FIT) Foxconn Interconnect Technology (Oct 2013); pre-IPO in 2016
- ShunSin Technology SIP module unit – IPO (Taiwan) in 2015
- Bought Sharp Corporation (largest display corp) in February 2016
- Bought Smart Technologies, May 2016
- Established FIH Mobile Ltd. in 2016 (former Microsoft/Nokia)
- Founded Future Mobility (autonomous electric car) in 2016
- Offer to acquire Toshiba Semiconductor unit – March 2017





# Foxconn – Developing the Integration of Electronic Manufacturing Outsourcing

- “In an exclusive interview with the Nikkei Asian Review on Saturday, the head of the world's largest contract electronics maker [Terry Gou] said that he is working with [Sharp](#), Foxconn's recently acquired Japanese subsidiary, to build semiconductor capabilities.” (Nov 6, 2016).
- Taiwan's Foxconn ([2317.TW](#)), the world's largest contract electronics maker, is "definitely bidding" for the chip business of Japan's Toshiba Corp ([6502.T](#)) and is "very confident" it can buy into it (March 2, 2017).



# Summary and Recommendations



# OSAT/SATS in the Future

- As Chip-to-package (WL-CSP) and package-to-board (SIP) manufacturing technologies continue to converge and overlap, more competition from other market segments for value-added services will increase. (InFO: TSMC; SIP: ASE, Foxconn). **Heterogeneous integration continues Moore's Law.**
- SATS vendors must develop acquisition plans or establish partnerships/joint ventures with foundries, electronics manufacturing service/original design manufacturing (EMS/ODM) companies and/or materials and equipment suppliers. **Vertical integration of Outsourcing grows.**
- **Consolidation must occur.** Still more than 150 companies participate in the SATS industry. 36 have revenue over \$100 million USD. Many SATS companies will not be able to develop the necessary capital required for the increased complexity and wafer-like equipment cost required to stay competitive. The **SATS/OSAT market will stratify** leading edge, specialty niche and sunset/mature packaging services.
- 3D printed customized packages, including embedded components, will result in complete, final systems. **System-on-Package.**
- Consumer applications will no longer depend on the most advanced chip manufacturing technology for product differentiation. **Advanced Packaging will enable complex systems at affordable costs.**



# Semiconductor Industry – Growth in the Future

- The semiconductor industry 10 years from now will still be driven by technology, but it will **not necessarily be leading edge technology**
  - Economics (cost) becomes even more the deciding factor
  - Only a very few applications demanding the ultimate in performance and able to absorb high costs will take maximum advantage of the most advanced technology.
- Being able to utilize the full potential of the most advanced manufacturing technology **will require advances in** memory, **packaging**, architecture, software and design.
  - Primary applications using the most advanced technology will address enterprise level needs: big data analysis, artificial intelligence, high performance networks and servers.
- **Consumer applications will no longer depend on** the most **advanced** chip **manufacturing** technology for product differentiation.
  - High manufacturing costs will force many consumer products to find alternative solutions to deliver desired performance.
  - Advanced Packaging will enable complex systems at affordable costs.
  - Consumer-oriented semiconductor manufacturers will use a variety of technology capabilities to tailor products that closely and economically meet their customer' increasingly diverse needs.
- **New customers** may appear **for leading edge** technology
  - Software and cloud service providers may design their own custom chips to obtain maximum performance at an acceptable cost.

