

Keynote Speech I

Trend of Semiconductor Industry and IEM Opportunities

Chi-Ming Chang, Ph.D.
Co-Founder and President
Ardentec Corporation, Taiwan

Fellow, CIIE (Taiwan)

Acknowledgements: Jonny Ding and Bernard Jiang

Dec 8, 2016

Copyright © 2016 Ardentec Corporation. All rights reserved.

Ardentec
A testing partner you can trust

Outlines



■ Semiconductor Industry Overview

- Semiconductor Industry Eco System
- The Importance of Semiconductor Industry
- About Ardentec

■ Mega Trends of Semiconductor Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
- The Players

■ Summary – Embracing the Reality of Life

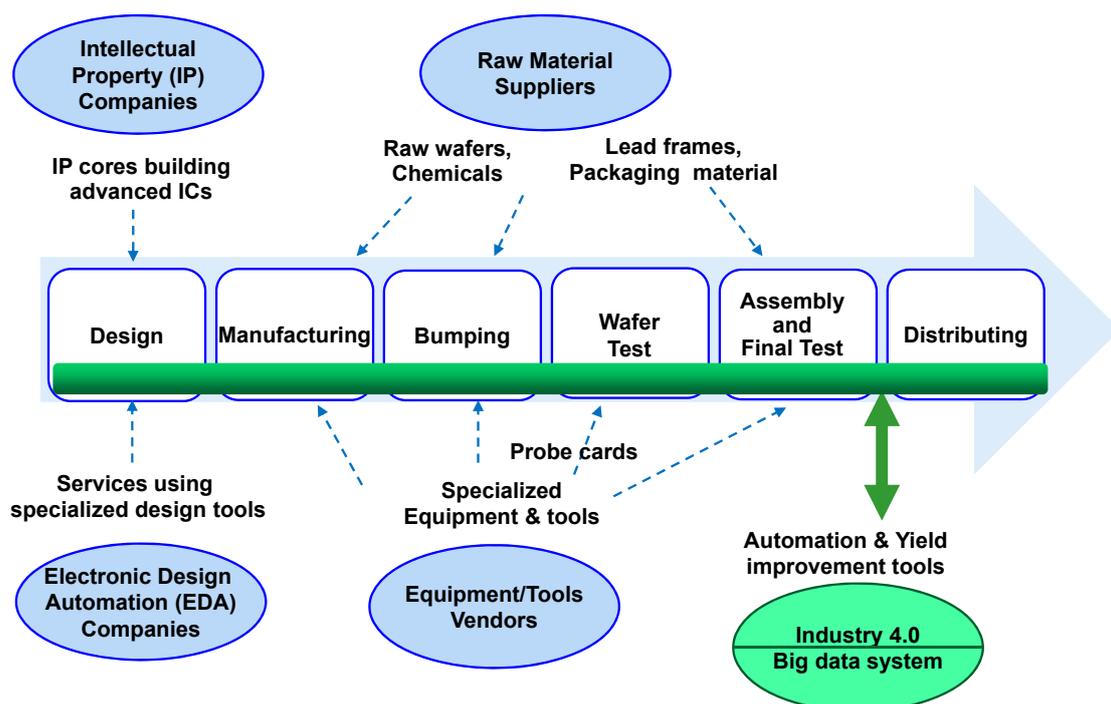
- Asia – Center of Semiconductor Supply Chain and Market
- Opportunities for IEM

Semiconductor Industry Overview

- Semiconductor Industry Eco System
- The Importance of Semiconductor Industry
- About Ardentec

Copyright © 2016 Ardentec Corporation. All rights reserved.

Semiconductor Industry Eco System



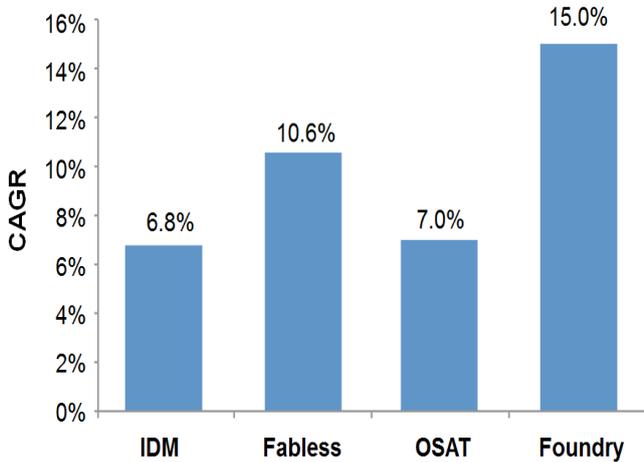
Copyright © 2016 Ardentec Corporation. All rights reserved.

Growth in the Semiconductor Ecosystem



- A Global Value Chain forged by complexity and competition, with Operating Models responding to change
- An Ecosystem completed by supporting activities, with differentiation driven by demand

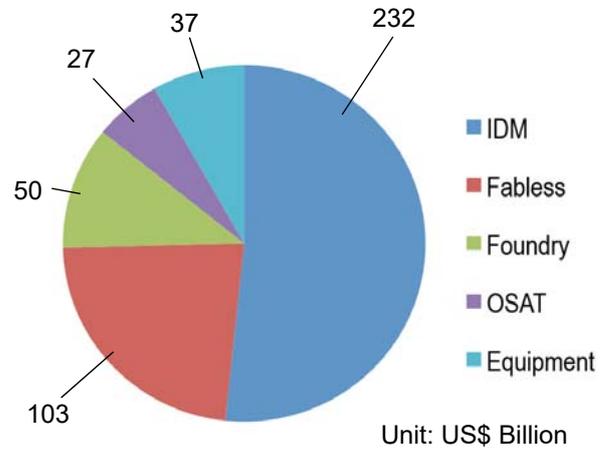
Growth in the Semiconductor Ecosystem (2009~2015) CAGR: Compound Annual Growth Rate



Source: SIA

Revenue by Semiconductor Sector (2015)

OSAT: Out Source Assembly and Test



Unit: US\$ Billion

Copyright © 2016 Ardentec Corporation. All rights reserved.



Trend of Semiconductor Industry and IEM Opportunities Semiconductor Industry Overview

Semiconductor Industry Overview

- Semiconductor Industry Eco System
- The Importance of Semiconductor Industry
- About Ardentec

Copyright © 2016 Ardentec Corporation. All rights reserved.



Importance of Semiconductor Industry

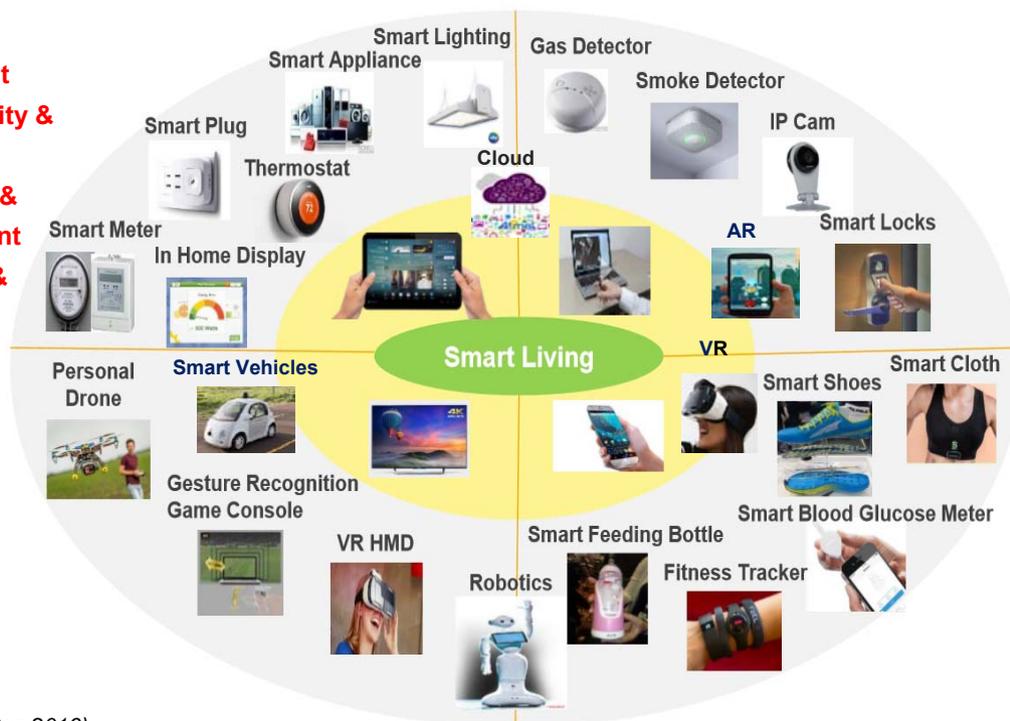
- Semiconductor technology and devices are considered as **lifeblood** of many fundamental technology advances in recent decades.
- The semiconductor industry is recognized as a **key driver for economic growth** in its role as lever and enabler in the whole electronics value chain.
- As new and innovative applications emerge, semiconductors are required to evolve further.
- The **fast-paced change and innovation requirements** coupled with **potential handsome financial returns** attract many talented people to participate in the development of this industry.

Copyright © 2016 Ardentec Corporation. All rights reserved.

Innovation – Life Enrichment/Convenience

These are what we have today for Smart Living...

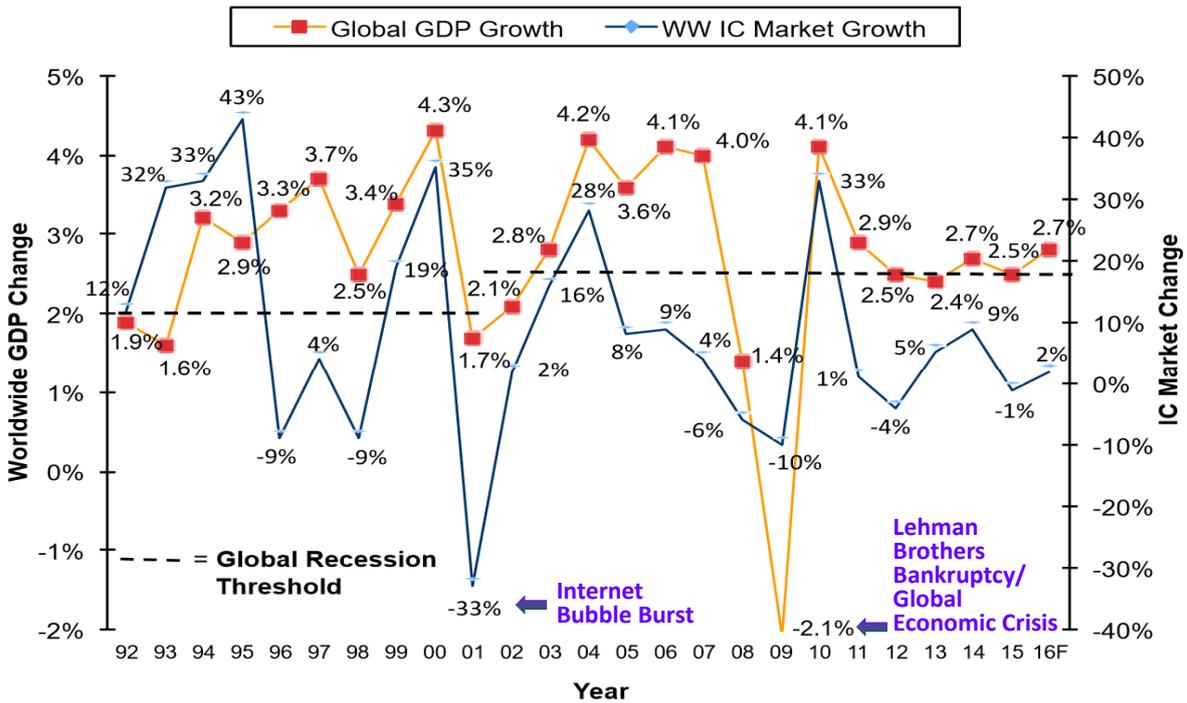
- Energy management
- Home security & safety
- Information & entertainment
- Healthcare & fitness



Ref: ITRI/IEK (Sep 2016)

Copyright © 2016 Ardentec Corporation. All rights reserved.

Growth - IC Market vs. Worldwide GDP

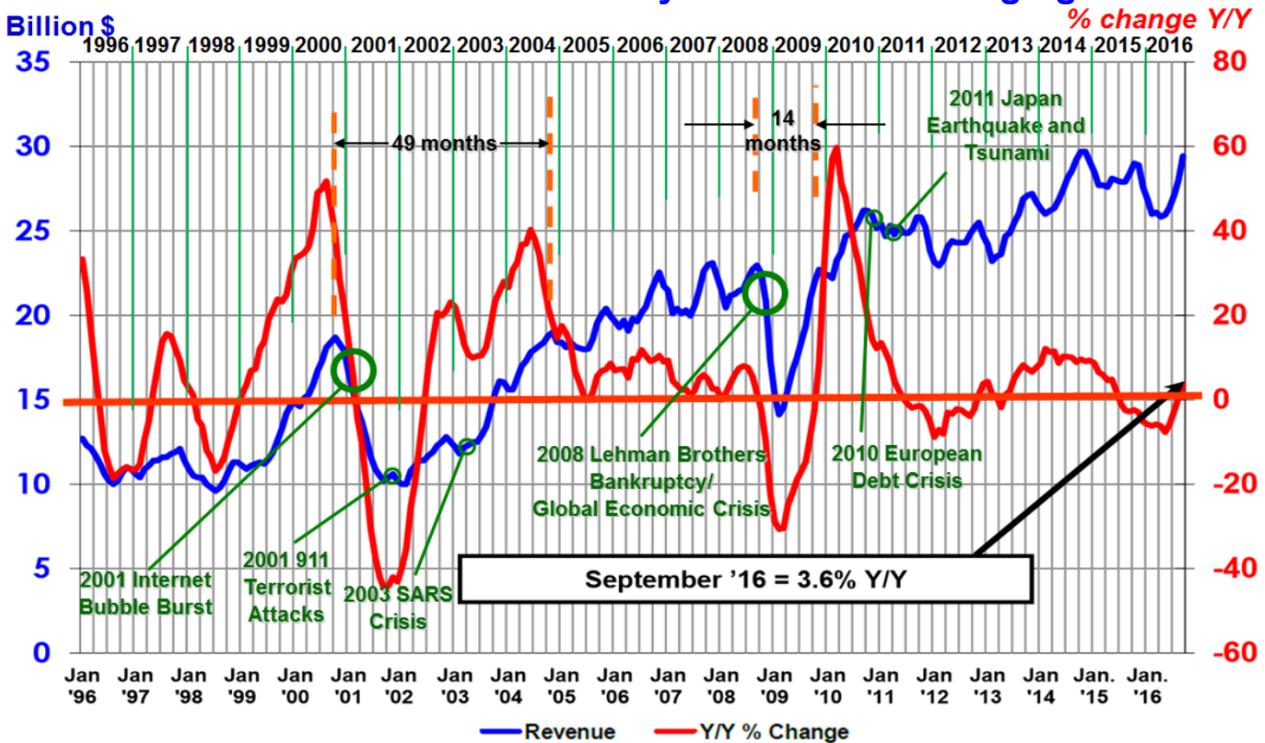


Source: IC Insights

Copyright © 2016 Ardentec Corporation. All rights reserved.

Worldwide Semiconductor Revenues & Growth

The semiconductor market is dynamic and challenging.



Source: WSTS Oct 31, 2016

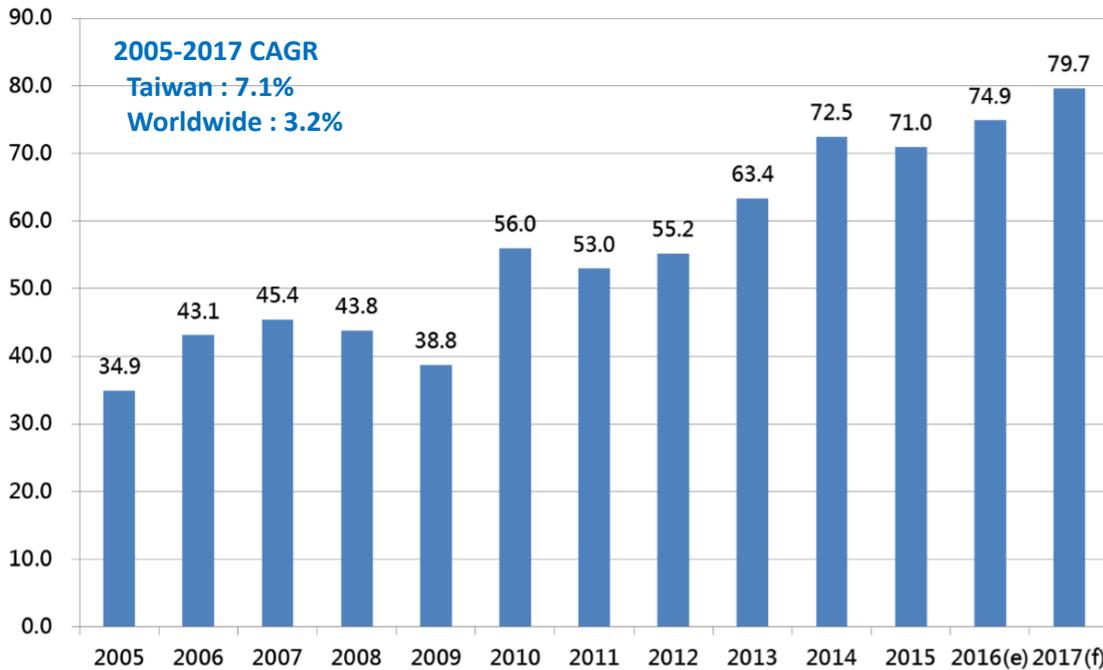
Copyright © 2016 Ardentec Corporation. All rights reserved.

Taiwan IC Industry Sales



Taiwan IC industry outperformed worldwide in last 10 years, and about to reach \$74.9B in 2016.

Billion USD



Source: TSIA ; ITRI/IEK (Aug 2016)

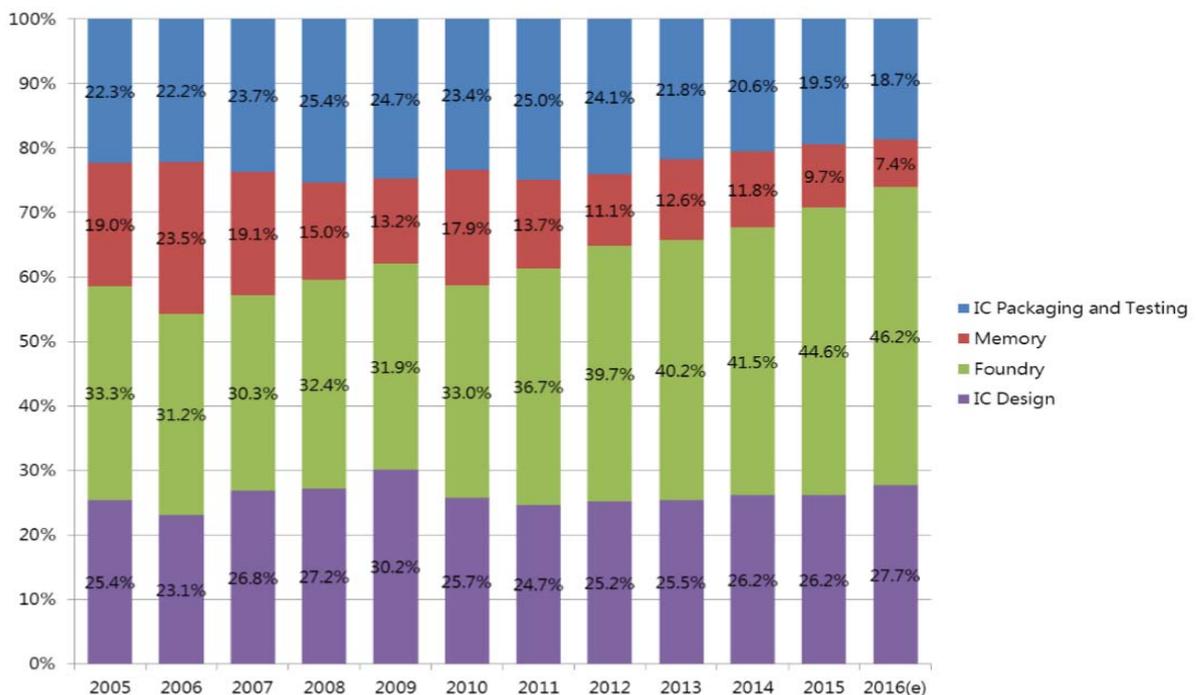
Copyright © 2016 Ardentec Corporation. All rights reserved.



Taiwan IC Production Value Distribution



Foundry contributes the most to Taiwan IC industry, with fabless and packaging & Testing the 2nd and the 3rd, respectively.



Source: TSIA ; ITRI/IEK (Aug 2016)

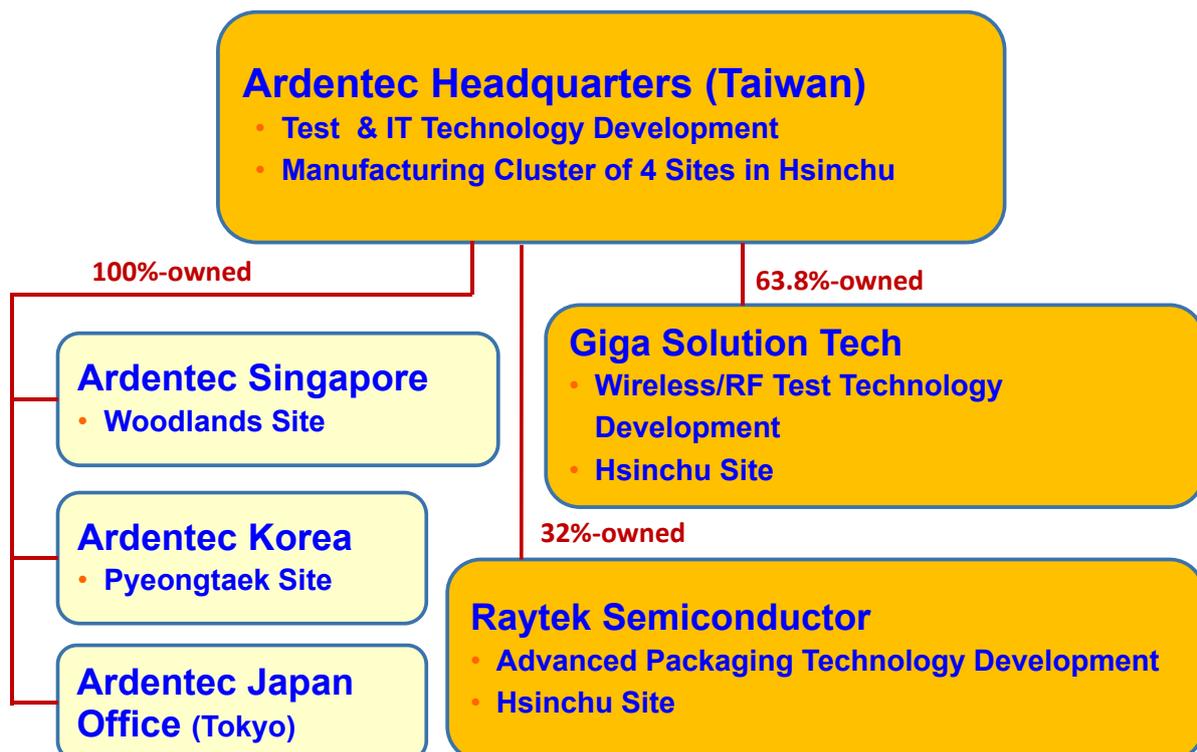
Copyright © 2016 Ardentec Corporation. All rights reserved.



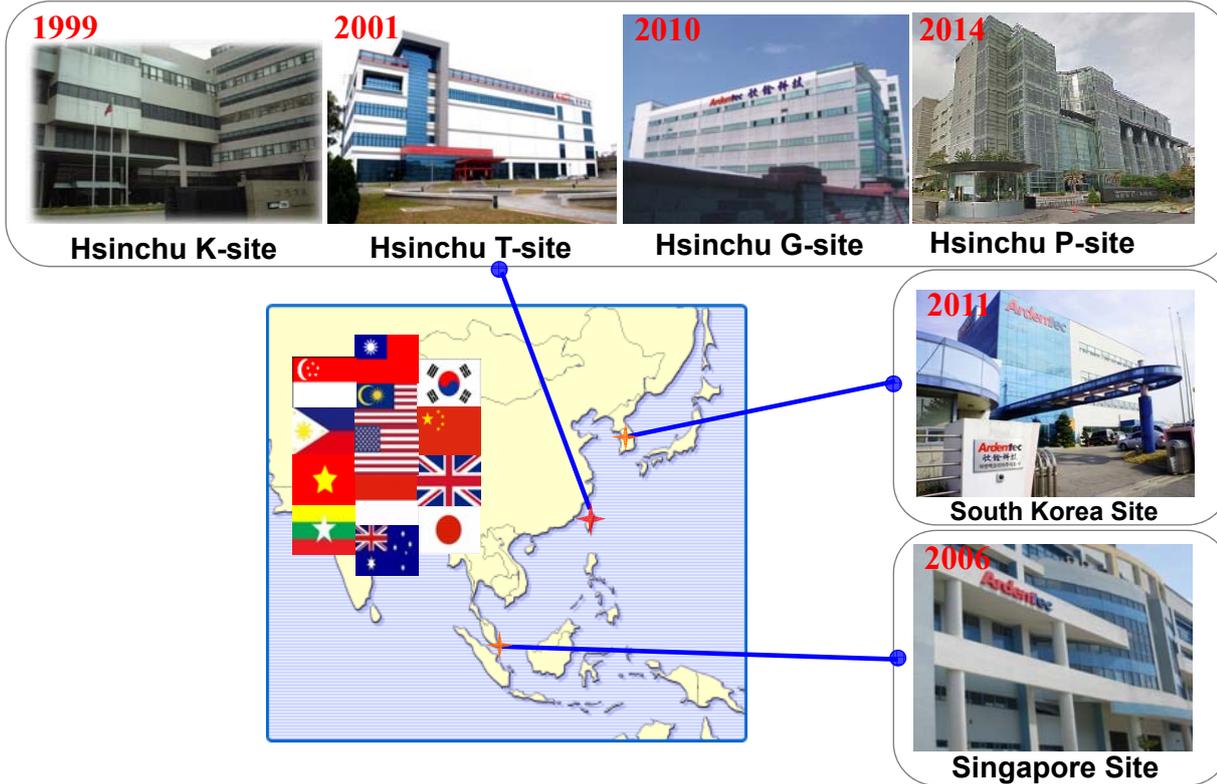
Semiconductor Industry Overview

- Semiconductor Industry Eco System
- The Importance of Semiconductor Industry
- About Ardentec

Enterprise Domain

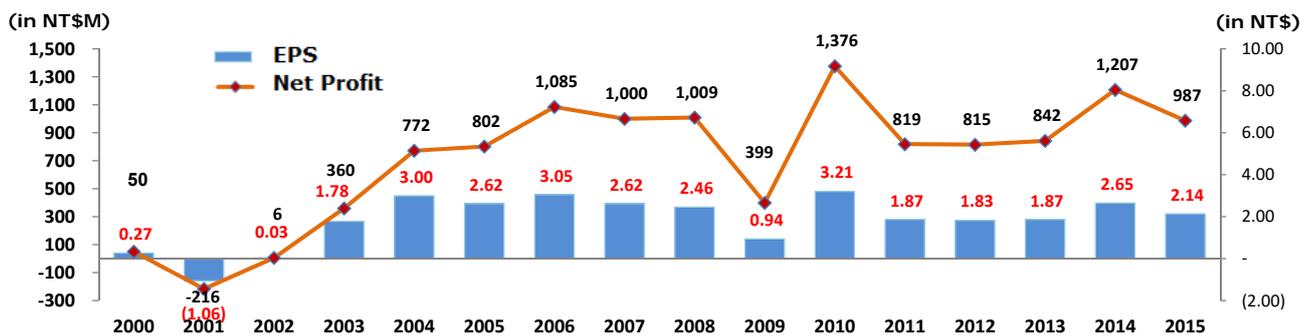
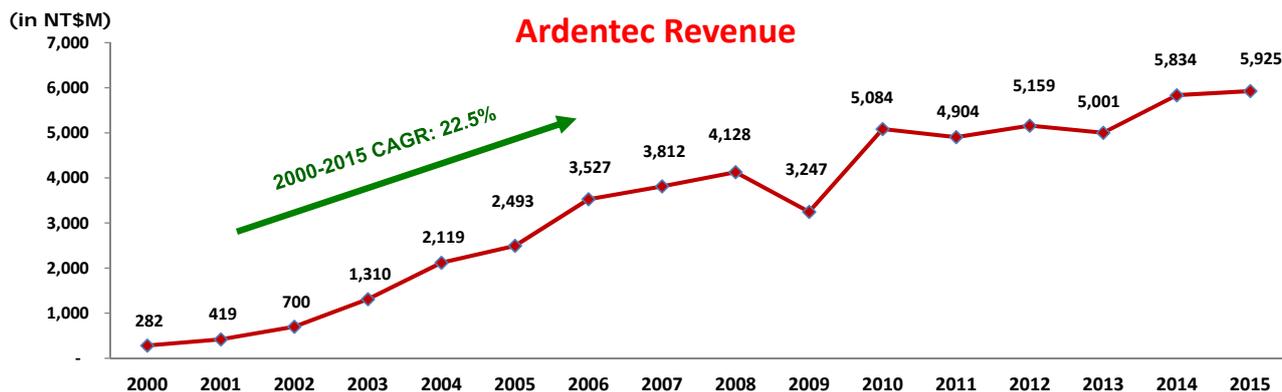


Ardentec's Factory Site Map



Copyright © 2016 Ardentec Corporation. All rights reserved.

Revenue Growth (Consolidated)



Copyright © 2016 Ardentec Corporation. All rights reserved.

From US IDM and Fabless

- Won the 2013 Supplier Excellence Award from a US-based leading IDM in April 2014, the third time awarded since 2004.
- Received the 2014 Distinguished Performance Supplier Award from a US-based leading IDM in April 2014 which is an encouragement for our further extension and enlargement to automotive markets.
- Received the 2015 Diamond Supplier Award from a US-based leading IDM in June 2015.
- Received 2014 “Best in Class” Supplier Award from the US-based leading provider of flash memory storage solution in Nov 2015, the third time awarded since 2008.

From European IDM

- Won the 2014 Appreciation Award from a European-based leading IDM in Oct 2014.
- Received 2014 Excellent Service and Outstanding Support Award from a European-based leading IDM in Mar 2015.
- Received 2015 Outstanding Performance and Excellent Support Award, awarded from an European-based leading IDM in Sep 2015.
- Received 2015 Outstanding Performance Supplier Award in the category of silicon foundries, awarded from an European-based leading IDM in Oct 2015.
- Received 2015 Best Subcon Service Supplier Award from a European-based leading IDM in May 2016.
- Received the Best EWS OSAT Strategic Partnership Awards for both Singapore and headquarters sites from a European-based leading IDM in Sep 2016.

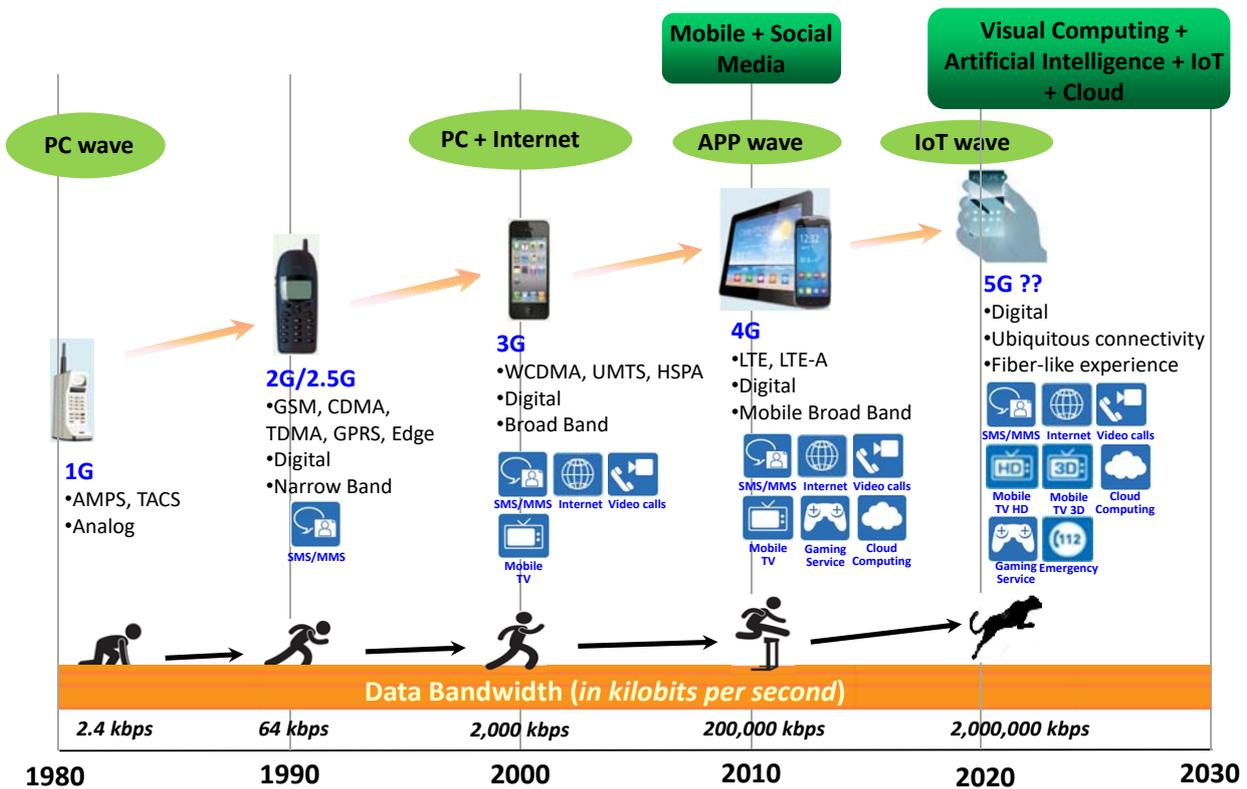


Trend of Semiconductor Industry and IEM Opportunities Mega Trends of Semiconductor Industry

Mega Trends of Semiconductor Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
- The Players

Evolution of Mobile Phone Communications



Copyright © 2016 Ardentec Corporation. All rights reserved.

Driving the Future of Automotive Electronics



- Autonomous vehicles enable the next phase in auto safety through the development of Advanced Driver Assistant Systems (ADAS) and become economically feasible through improvements in lasers, MEMs, and ICs.
- Automotive quality control is an extremely important part of the production process.
- Strive to be better and better. Zero Defects (ZD) is Tier-1 automotive supplier's measure of success.

Copyright © 2016 Ardentec Corporation. All rights reserved.

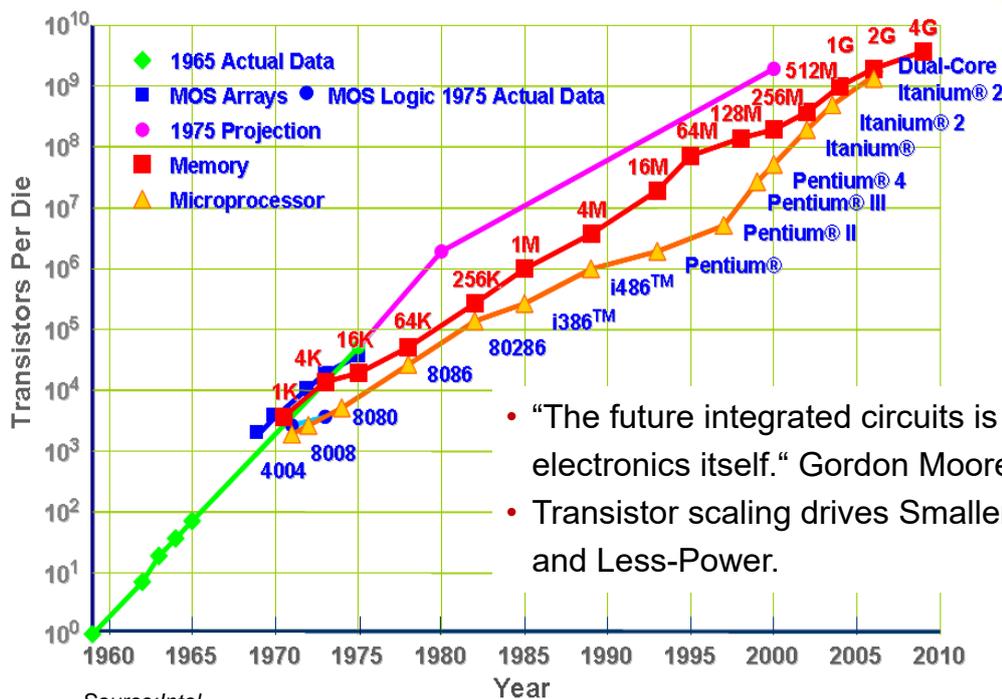
Market Trends of Semiconductors Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
- The Players

Copyright © 2016 Ardentec Corporation. All rights reserved.

Moore's Law

The number of transistors per square-inch doubles each 18 months

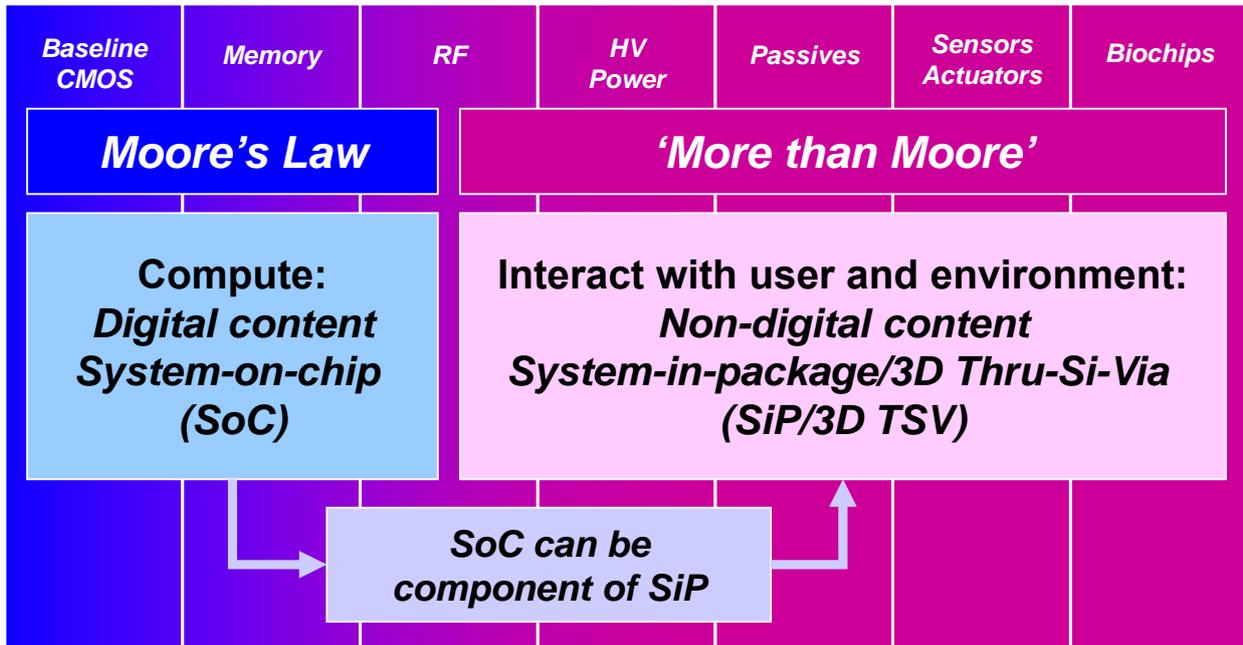


Gordon Moore
Co-founder of Intel 1965

- “The future integrated circuits is the future of electronics itself.” Gordon Moore – 1965
- Transistor scaling drives Smaller, More, Faster, and Less-Power.

Copyright © 2016 Ardentec Corporation. All rights reserved.

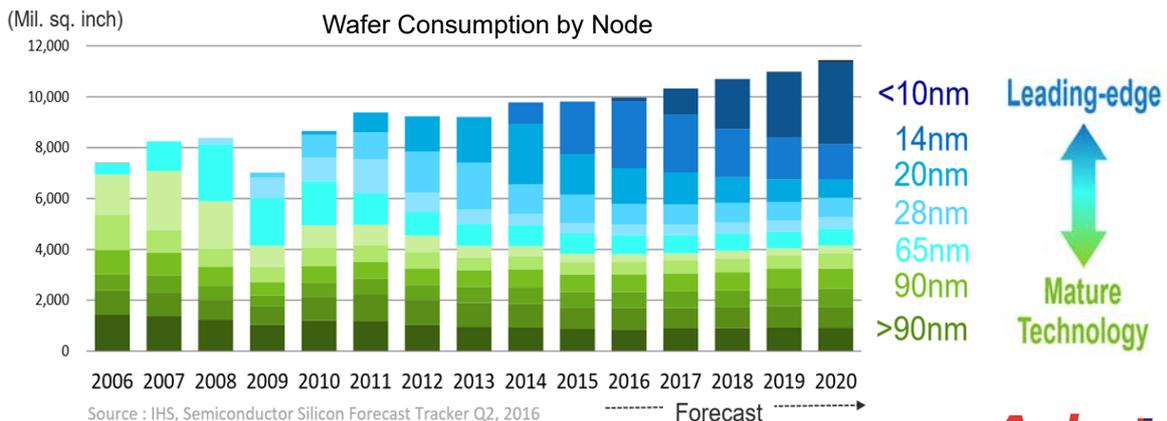
Pursuing Moore's Law extension, SiP/3D-TSV is right on the track.



Source: ITRS

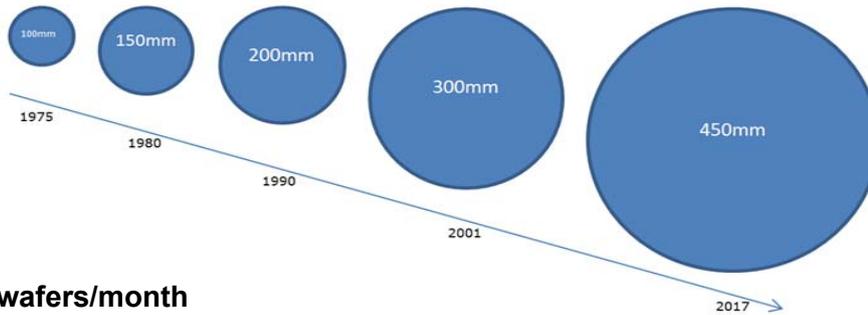
Copyright © 2016 Ardentec Corporation. All rights reserved.

Semiconductor Technology Roadmap

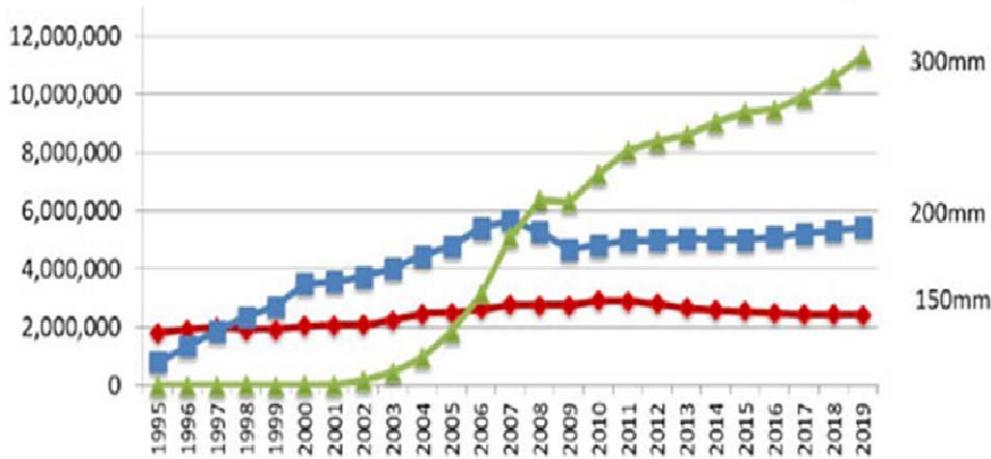


Copyright © 2016 Ardentec Corporation. All rights reserved.

Global Wafer Capacity



200mm-Eq wafers/month



Source: Global 200mm Fab Outlook, preliminary July 2016, SEMI

Copyright © 2013 Ardentec Corporation. All rights reserved.

Trend of Semiconductor Industry and IEM Opportunities Mega Trends of Semiconductor Industry

Mega Trends of Semiconductor Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
- The Players

Foundry and IDM's Go-fab/asset-lite

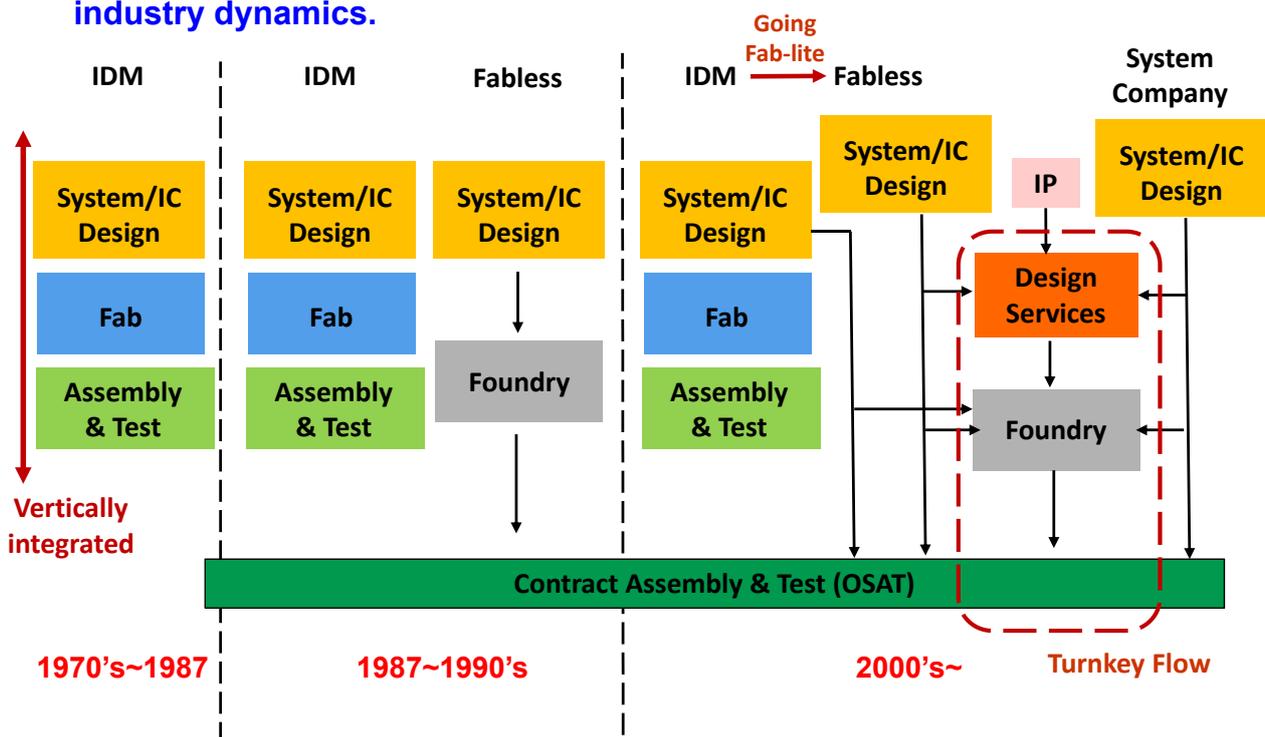
- The rise of mobile has been one of the semiconductor industry's main growth drivers over the past twenty years since wireless-communication chips accounted for about 10% of the overall semiconductor market in 1997.
- The fabless-foundry model has been a critical enabler of this growth and has benefited from it.

Mergers & Acquisitions

- Higher performance and more integration makes improving profits difficult with existing technology.
- Continuously cutting cost is one way manufacturers can compete in a global industry. Another is to leverage economies of scale through mergers and acquisitions.

Semiconductor Business Model's Evolution

Change the business model to survive due to the global semiconductor industry dynamics.



Mega Trends of Semiconductor Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
- **The Players**

Pioneers of the Semiconductor Industry



The Nobel Prize winners for their contributions to Semiconductor Field

The Leaders in Semiconductor Industry

The Nobel Prize in Physics 1956

"for their researches on semiconductors and their discovery of the transistor effect"



William Bradford Shockley (1910~1989) John Bardeen (1908~1991) Walter Houser Brattain (1902~1987)

The Nobel Prize in Physics 2000

"for his part in the invention of the integrated circuit"



Jack St. Clair Kilby (1923~2005)

The Nobel Prize in Physics 2009

"for the invention of an imaging semiconductor circuit - the CCD sensor"



Willard S. Boyle (1924~2011)

The Nobel Prize in Physics 2014

"for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"



Isamu Akasaki (1929~) Hiroshi Amano (1960~) Shuji Nakamura (1954~)

Remembered for developing the planar process of semiconductor devices



Jean Amédée Hoerni (1924~1997)

Credited with the realization of the first integrated circuit



Robert Norton Noyce (1927~1990)



Gordon Earle Moore (1929~)

Co-founder & Chairman Emeritus of Intel, and the author of Moore's law

The founding Chairman of TSMC in 1987, who pioneered the "dedicated silicon foundry" industry.



Chenming Calvin Hu (1947~)

Developed the 3D FinFET transistor in 1999, the most radical shift in semiconductor technology in over 50 year



Morris Chang (1931~)

2015 Semiconductor Ranking

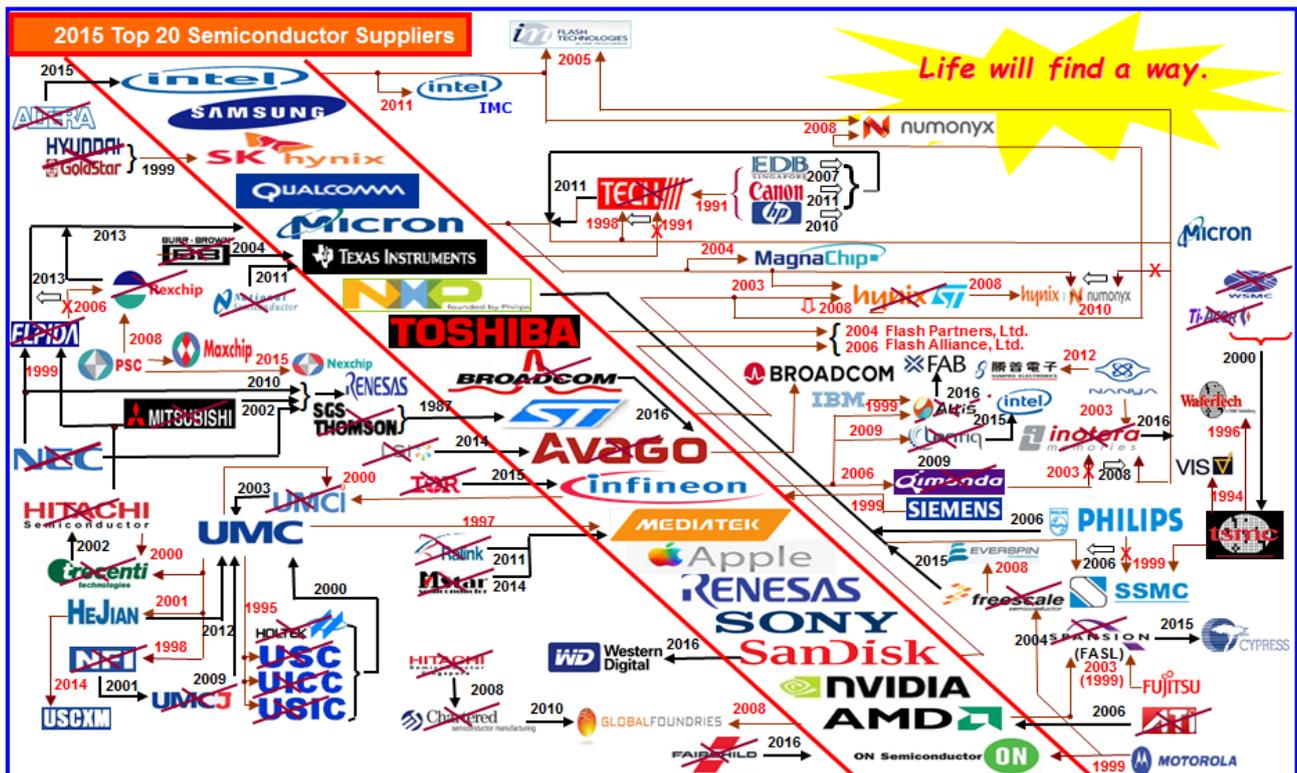
(With Revenue & Market Share)

IDM 244.5B USD	Fabless 90.6B USD	Foundry 46.7B USD	Assembly & Test 25.5B USD
intel 51.7B USD 21.1%	QUALCOMM 16.0B USD 17.7%	tsmc 26.439B 56.6%	ASE GROUP 4.90B USD 19.2%
SAMSUNG 37.9B USD 15.5%	BROADCOM 8.42B USD 9.3%	GLOBALFOUNDRIES 5.019B 10.7%	Amkor Technology 2.85B USD 11.2%
SK hynix 16.4B USD 6.7%	MEDIA TEK 6.70B USD 7.4%	UMC 4.464B 9.5%	SPIIL 2.61B USD 10.2%
Micron 13.8B USD 5.7%	AVAGO TECHNOLOGIES 5.46B USD 6.0%	SAMSUNG 2.67B 5.7%	STATSchipPAC 1.44B USD 5.6%
TEXAS INSTRUMENTS 11.5B USD 4.7%	NVIDIA 4.63B USD 5.1%	SMIC 2.236B 4.8%	长电科技 1.37B USD 5.4%
TOSHIBA 9.16B USD 3.7%	AMD 3.99B USD 4.4%	Powerchip 1.268B 2.7%	Powertech 1.32B USD 5.2%
infineon 6.81B USD 2.8%	HISILICON 3.27B USD 3.6%	TOWERJAZZ 0.961B 2.1%	J DEVICES 0.85B USD 3.3%
ST 6.80B USD 2.8%	Apple 2.99B USD 3.3%	FUJITSU FUJITSU SEMICONDUCTOR 0.87B 1.9%	U TAC 0.68B USD 2.6%
NXP 6.54B USD 2.7%	MARVELL 2.88B USD 3.2%	VIS 0.736B 1.6%	华天科技 0.67B USD 2.6%
RENESAS 5.70B USD 2.3%	XILINX 2.21B USD 2.4%	华虹-NEC 0.65B 1.4%	ChipMOS 0.59B USD 2.3%

Source: Gartner/IC Insights

Semiconductor's Jurassic Park

Position itself for success in the semiconductor value chain



Source: IHS Technology Apr 4, 2016

Summary – Embracing the Reality of Life

- Asia – Center of Semiconductor Supply Chain and Market
- Opportunities for IEM

Asia, as Center of Semiconductor Supply Chain and Market (1/2)



- Continuously, it has been observed that the growth and excitement of semiconductor industry is in Asia and have good opportunity to last for many years despite potential TRUMP new move.
- In the past ten years, we saw that South Korea became one the strongest semiconductor producer in the world. However, South Korea's position is facing challenges as China aims to boost its own semiconductor manufacturing industry.
- Japan's consumer electronics were once the biggest market for the semiconductor industry. However, Japan did not catch the market of the smartphone trend, and this led to consolidations and bankruptcies of several domestic semiconductor IDM companies. Equipment and material suppliers of Japan will continue to be leaders in the semiconductor industry. Recent M/A of ARM by SoftBank may start a new era for Japan semiconductor industry.
- China becomes the largest semiconductor market and "Made-in-China" policy impacts worldwide semiconductor industry participants.
- The semiconductor industry has the potential to be an engine of strong continued growth for the Southeast Asia economy.

- **Singapore** - Singapore has stood out as a leading supply chain hub with the presence of world-class service providers and home-grown talent equipped with the knowledge of accessing the diverse geographies in Asia. The World Bank ranked Singapore as the No. 1 Logistics Hub in Asia in the 2014 Logistics Performance Index.
- **Malaysia** – Since six out of ten world’s largest semiconductor companies have established their local presence, Malaysia is at the world’s leading location for semiconductor assembly and test operations, accounting for more than 12% of the world installed capacity. The semiconductor industry is the largest contributor comprising more than 40% of Malaysia’s Electronics & Electrical (E&E) exports.
- **India** - The Indian semiconductor industry is estimated to grow by a CAGR of 26.72% over 2013~2020. Especially the design market in India is expected to increase by a CAGR of 29.4% over 2015~2020.
- **Vietnam** - With the semiconductor industry in Vietnam expected to grow at a CAGR of 14.3% over 2014~2019, momentum is growing in this emerging market.



Trend of Semiconductor Industry and IEM Opportunities Summary – Embracing the Reality of Life

Summary – Embracing the Reality of Life

- Asia – Center of Semiconductor Supply Chain and Market
- Opportunities for IEM

Challenges, Opportunities, and Changes

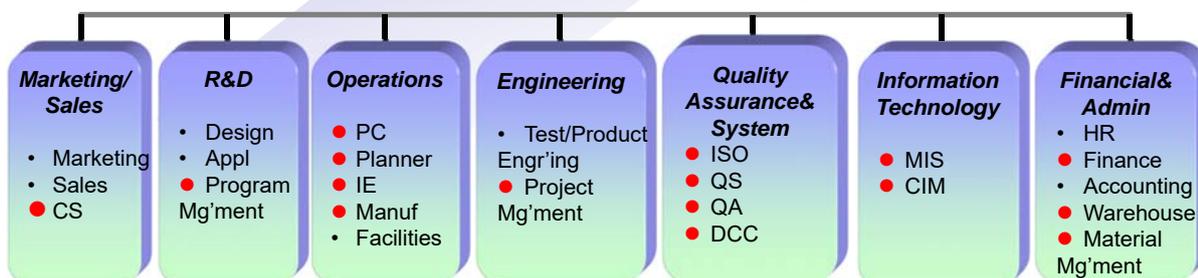
Transforming Today's Industry Challenges into Tomorrow's Opportunities.

- Since 2015 an amazing wave of consolidations struck the semiconductor industry.
- China's electronics industry, backed by its government's deep pockets, try to build a domestic high-tech supply chain.
- The longstanding economics of Moore's Law is being challenged. The Internet of Things (IoT) is a tremendous opportunity for the chip-making business, yet it doesn't involve conventional brutal force scaling leading-edge technology but needs much innovation.
- Business model to success
 - The direction of industry dis-aggregate and re-aggregate depends on whether consolidation or specialization offers the maximum cost savings or some other compelling market reason.

IEMers are demanded in many Semiconductor Companies

- For example, in Ardentec, we use engineers with IEM background in many functions (e.g. quality, manufacturing, material management, CIM, IT, etc.)
- Many functional heads at Ardentec are with IEM advanced degrees. (e.g. GM of Ardentec Singapore, Sr. Director of CIM / Operations / Quality Assurance / Material Management / MIS / Finance(etc.)
- Many other semiconductor companies are also having high level executives with IEM degrees (e.g. tsmc, ASE, SPIL, and PTI)
- Many founders, co-Founders, CEO of semiconductor companies are with IEM degrees. (e.g. Apple, ASE, Ardentec, PTI, Raytek, etc.)
- IEMers are core backbone to semiconductor companies for competitiveness competition.

Where there's a will there's a way for IEMers.



More Opportunity for IEMers



- The semiconductor industry will offer endless opportunity in the next decade, and needs new talent who can think outside of the established framework to take over.
- More young people are encouraged to join Asia's semiconductor industry.
- Characteristics of Young IEMers to have more Opportunity in Asia's Semiconductor Industry:
 - *Possess Basic Knowledge in Production Management/Control, Quality Control/Assurance, Cost Analysis, Information System Analysis & Design*
 - *Above average command of English as a communication tool*
 - *Ability to listen to others and Teamwork Spirit*
 - *Curiosity and capability to identify and define problems*

Enhancement of IEM Higher Education



- How to educate our IEMers more effectively in higher education?
- Management and control in quality/production/cost/IT + **systematic innovation?**
- Finding a solution + **finding/defining a problem?**
- Finding root causes of a problem + **finding opportunities?**
- Content of text books to be **simplified and enriched?**
- Text books + **video/animation media supports** + **commonly used computerized libraries of models/methods?**
- Too thick a book + too long a class period?
- Student interns + **professor sabbatical leave in industry?**
- Bilingual-language capability?
- Manufacturing industry + **Service Industry?**
- Specific domain knowledge acquisition from industrial experts + integration?



THANK YOU