Keynote Speech I

Trend of Semiconductor Industry and IEM Opportunities

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Acknowledgements: Jonny Ding and Bernard Jiang

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
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

Revenue by Semiconductor Sector (2015)

OSAT: Out Source Assembly and Test

Unit: US$ Billion

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**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.

**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)*
Growth - IC Market vs. Worldwide GDP

The semiconductor market is dynamic and challenging.

Source: WSTS  Oct 31, 2016

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Taiwan IC Industry Sales

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

2005-2017 CAGR
Taiwan: 7.1%
Worldwide: 3.2%

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)
Semiconductor Industry Overview

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

Enterprise Domain

Ardentec Headquarters (Taiwan)
- Test & IT Technology Development
- Manufacturing Cluster of 4 Sites in Hsinchu

Giga Solution Tech
- Wireless/RF Test Technology Development
- Hsinchu Site

Raytek Semiconductor
- Advanced Packaging Technology Development
- Hsinchu Site

Ardentec Singapore
- Woodlands Site

Ardentec Korea
- Pyeongtaek Site

Ardentec Japan Office (Tokyo)
Recognized by Worldwide Customers

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.

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Evolution of Mobile Phone Communications

1G
- AMPS, TACS
- Analog

2G/2.5G
- GSM, CDMA, TDMA, GPRS, Edge
- Digital
- Narrow Band

3G
- WCDMA, UMTS, HSPA
- Digital
- Broad Band

4G
- LTE, LTE-A
- Digital
- Mobile Broad Band

5G ??
- Digital
- Ubiquitous connectivity
- Fiber-like experience

Data Bandwidth (in kilobits per second)

- 2.4 kbps
- 64 kbps
- 2,000 kbps
- 200,000 kbps
- 2,000,000 kbps

Driving the Future of Automotive Electronics

2015 ATV semiconductor vendor ranking (Power, Sensors, and Microcontroller)

- NXP/Freescale: 14.4%
- Infineon/IR: 9.8%
- Renesas: 9.2%
- STMicro: 7.2%
- TI: 6.4%
- Bosch: 5.1%

Source: IHS 2016

- 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.
Automotive Electronics

- **Dashboard:** Speedometer, Tachometer, Fuel gauge, Temperature gauge, Odometer
- **Advanced Driver Assistant System (ADAS)**
- **Global Positioning System (GPS)**
- **In-Car Entertainment (ICE):** such as Freeview, TV, CDs, DVDs, USB optional surround sound, etc.
- **Bluetooth**
- **Data Communication Module (DCM):** High-speed data communication linking vehicles to the outside environment
- **Battery Management**
- **Motor Control/Inverter**
- **Airbag:** Crash sensors
- **Engine Control**
- **Electric Power Steering (EPS)**
- **Anti-Lock Braking System, Electronic Stability Control (ABS/ESC)**
- **Body Apps:** seat, mirror, sun-roof, HVAC (Heating, Ventilation, Air Conditioning), etc.

Emerging Industry Trends

**Increased Consumerization**

- **New technologies fast pace with**
  - Greater Complexity
  - Increased Performance
  - Higher Density
  - Lower Power Dissipation

**Fundamental driving force:**
- Population
- Connectivity
- New Efficiencies

**WW Semiconductor Revenue Growth**

Near Term Growth rate = 4.8%

- **Automotive -** need lots of electronic systems with heterogeneous functions to get there.
- **Internet of Things -** containing low-power computing engines and heterogeneous functions, will make electronic systems much smarter and, most important, “environmentally aware.”
- **Network traffic -** need solutions for fast, secure, flexible and low-power data transfers.

Source: WSTS & Gartner June 2016
Market Trends of Semiconductors Industry

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

Moore’s Law

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

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

Source: Intel

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Moore’s Law & More

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

Moore’s Law

Compute: Digital content
System-on-chip (SoC)

‘More than Moore’

Interact with user and environment:
Non-digital content
System-in-package/3D Thru-Si-Via
(SiP/3D TSV)

SoC can be component of SiP

Source: ITRS

Semiconductor Technology Roadmap

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<tr>
<td>Logic</td>
<td>14nm</td>
<td>10nm</td>
<td>7nm</td>
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<td>DRAM</td>
<td>20nm</td>
<td>1Xnm</td>
<td>1Ynm</td>
<td>1Znm</td>
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<td>3D NAND</td>
<td>48 layer</td>
<td>64 layer</td>
<td>96 layer</td>
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<td>Emerging Memory</td>
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<td>STT-MRAM</td>
<td>ReRAM, XPoint</td>
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<td>Advanced Package</td>
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<td>Fan Out-WLP / 2.5D, 3D</td>
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Wafer Consumption by Node

Source: IHS, Semiconductor Silicon Forecast Tracker Q2, 2016

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Global Wafer Capacity

Source: Global 200mm Fab Outlook, preliminary July 2016, SEMI
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Mega Trends of Semiconductor Industry

- Trend in Semiconductor Market and Applications
- Trend in Semiconductor Technologies
- Trend in Business Model and Supply Chain
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**Industry Observation**

**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.

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**Semiconductor Business Model’s Evolution**

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

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<td>IDM</td>
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<tr>
<td>System/IC Design</td>
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<td>Fab</td>
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<td>Assembly &amp; Test</td>
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<td>Assembly &amp; Test</td>
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<td>Foundry</td>
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<tr>
<td>Contract Assembly &amp; Test (OSAT)</td>
<td>System/IC Design</td>
<td>Turnkey Flow</td>
</tr>
</tbody>
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Vertically integrated

- Going Fab-lite

- System Company

- Design Services

- IP

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Mega Trends of Semiconductor Industry

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## 2015 Semiconductor Ranking

(With Revenue & Market Share)

<table>
<thead>
<tr>
<th>IDM</th>
<th>Fabless</th>
<th>Foundry</th>
<th>Assembly &amp; Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.7B USD</td>
<td>16.0B USD</td>
<td>26.439B USD</td>
<td>4.90B USD</td>
</tr>
<tr>
<td>21.1%</td>
<td>17.7%</td>
<td>56.6%</td>
<td>19.2%</td>
</tr>
<tr>
<td>37.9B USD</td>
<td>8.42B USD</td>
<td>5.019B USD</td>
<td>2.85B USD</td>
</tr>
<tr>
<td>15.5%</td>
<td>9.3%</td>
<td>10.7%</td>
<td>11.2%</td>
</tr>
<tr>
<td>16.4B USD</td>
<td>6.70B USD</td>
<td>4.464B USD</td>
<td>2.61B USD</td>
</tr>
<tr>
<td>6.7%</td>
<td>7.4%</td>
<td>9.5%</td>
<td>10.2%</td>
</tr>
<tr>
<td>13.88 USD</td>
<td>5.46B USD</td>
<td>2.67B USD</td>
<td>1.44B USD</td>
</tr>
<tr>
<td>5.7%</td>
<td>6.0%</td>
<td>5.7%</td>
<td>5.6%</td>
</tr>
<tr>
<td>11.5B USD</td>
<td>4.63B USD</td>
<td>2.236B USD</td>
<td>1.37B USD</td>
</tr>
<tr>
<td>4.7%</td>
<td>6.1%</td>
<td>4.8%</td>
<td>5.4%</td>
</tr>
<tr>
<td>9.16B USD</td>
<td>3.99B USD</td>
<td>1.268B USD</td>
<td>1.32B USD</td>
</tr>
<tr>
<td>3.7%</td>
<td>4.4%</td>
<td>2.7%</td>
<td>5.2%</td>
</tr>
<tr>
<td>6.81B USD</td>
<td>3.27B USD</td>
<td>0.961B USD</td>
<td>0.85B USD</td>
</tr>
<tr>
<td>2.8%</td>
<td>3.6%</td>
<td>2.1%</td>
<td>3.3%</td>
</tr>
<tr>
<td>6.80B USD</td>
<td>2.99B USD</td>
<td>0.87B USD</td>
<td>0.68B USD</td>
</tr>
<tr>
<td>2.8%</td>
<td>3.3%</td>
<td>1.9%</td>
<td>2.6%</td>
</tr>
<tr>
<td>6.54B USD</td>
<td>2.88B USD</td>
<td>0.736B USD</td>
<td>0.67B USD</td>
</tr>
<tr>
<td>2.7%</td>
<td>3.2%</td>
<td>1.6%</td>
<td>2.6%</td>
</tr>
<tr>
<td>5.70B USD</td>
<td>2.21B USD</td>
<td>0.65B USD</td>
<td>0.59B USD</td>
</tr>
<tr>
<td>2.3%</td>
<td>2.4%</td>
<td>1.4%</td>
<td>2.3%</td>
</tr>
</tbody>
</table>

Source: Gartner/IC Insights

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

- **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.

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**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