Semiconductor Industry in China

E. Jan Vardaman
President and Founder

- TRACK INNOVATION
- IDENTIFY TRENDS
- ANALYZE GROWTH
- INFLUENCE DECISIONS

RELEVANT, ACCURATE, TIMELY
China Today

- China’s population (1.387 B)
- China’s GDP expected to grow 6.5% in 2017 (revised down from 6.9%)
- Slow growth in China impacts world economy
  - Recent data indicates China’s economy is slowing

![China GDP Annual Growth Rate Chart](chart.png)
China: The Largest IC Market in the World

- China consumes more than half the world’s semiconductors
  - Estimated to be close to $60B in 2017
  - Mobile sector strong growth driver with OPPO, Huawei, and Vivo top 3 mobile phone suppliers in China’s domestic market in 2016, followed by Apple and Samsung
  - But no Chinese firms are in world’s top 20 semiconductor makers
  - IC Insights estimates that China’s production was only $13B in 2016

- Number of IC houses in China increased from 681 firms in 2014 to 1,362 in 2016
  - Top 5 are Hi-Silicon, Unigroup Spreadtrum RDA, Ingenic Semiconductor, ZTE Microelectronic Technology, Huada Semiconductor

- Plan to change China’s status: “Made in China 2025”
  - Goal for China to become self-sufficient in semiconductors
  - China’s goal for IC design industry to generate $60 billion output and gain 35% share of the global IC design market by 2025
  - Government investment of 120B RMB (US$19.5B) between 2014-2017
  - Local governments and private equity investment 600B RMB ($97.4B)
Semiconductor Makers Located in China

- SK Hynix (memory)
- SMIC (foundry)
- Samsung (memory)
- Hua Hong Semi—or Grace (foundry)
- TSMC (foundry)
- Intel
- Shanghai Huali Microelectronics (foundry)
- China Resources Microelectronics Limited (analog semiconductors)
- Diodes BCD (Bipolar-centric process technology)
  - Diodes purchased BCD Semiconductor for $151 million in Dec. 2012
- XMC (was part of SMIC)
- ASMC (foundry)
China’s Fabless IC Supplier Ranking

Chinese Companies in the Top 50 Fabless IC Supplier Ranking

- HiSilicon
- Spreadtrum
- ZTE Micro
- Datang
- Nari Smart Chip
- CIDC Group
- RDA
- ISSI
- Rockchip
- Allwinner
- Montage

Number of Companies

Source: IC Insights

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China’s Top Smartphone Vendors

Top Five Smartphone Vendors in PRC, Shipments, Market Share, and Year-Over-Year Growth, 2016 Preliminary Data (Units in Millions)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. OPPO</td>
<td>78.4</td>
<td>16.8%</td>
<td>35.3</td>
<td>8.2%</td>
<td>122.2%</td>
</tr>
<tr>
<td>2. Huawei</td>
<td>76.6</td>
<td>16.4%</td>
<td>62.9</td>
<td>14.6%</td>
<td>21.8%</td>
</tr>
<tr>
<td>3. vivo</td>
<td>69.2</td>
<td>14.8%</td>
<td>35.1</td>
<td>8.2%</td>
<td>96.9%</td>
</tr>
<tr>
<td>4. Apple</td>
<td>44.9</td>
<td>9.6%</td>
<td>58.4</td>
<td>13.6%</td>
<td>-23.2%</td>
</tr>
<tr>
<td>5. Xiaomi</td>
<td>41.5</td>
<td>8.9%</td>
<td>64.9</td>
<td>15.1%</td>
<td>-36.0%</td>
</tr>
<tr>
<td>Others</td>
<td>156.7</td>
<td>33.5%</td>
<td>173.4</td>
<td>40.3%</td>
<td>-9.6%</td>
</tr>
<tr>
<td>Total</td>
<td>467.3</td>
<td>100.0%</td>
<td>429.9</td>
<td>100.0%</td>
<td>8.7%</td>
</tr>
</tbody>
</table>

Source: IDC Quarterly Mobile Phone Tracker, Feb 6, 2017
China’s Growing Semiconductor Industry

- **Domestic foundry growth**
  - Yangtze River Storage Technology (YRST), Fujian Jin Hua Integrated Circuit and a joint venture set up by GigaDevices Semiconductor and the Hefei city government of China’s Anhui province establishing DRAM production (supported by Tsinghua Unigroup)
  - Tsinghua Unigroup received $22 million in financing from the China Development Bank

- **>$70 billion spent of semiconductor equipment and materials in China from 2004 to 2014**

- **SEMI reports that 14 new semiconductor fabs will be established in China this year**
  - Expected to be world second-largest fab equipment spending region
  - Spending projected to exceed $10 billion in 2018
  - Some slow-down from previous estimates, but still growing

- **China’s government wants to establish domestic equipment industry, but most of the advanced tools are supplied by Applied Materials, ASML, KLA-Tencor, LAM, TEL, and others**

- **Equipment vendors depend on sales in China**
  - Lam Research has 20 projects implemented at customer sites and 4,000 systems installed at fabs
  - CEO of LAM Research expects 2X wafer fab equipment spending from 2014 to 2019
## New Fab Activity in China

### New Fabs & Lines Beginning Construction

<table>
<thead>
<tr>
<th>Region</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Americas</td>
<td>1 Analog</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>2 Memory</td>
<td>1 MEMS</td>
</tr>
<tr>
<td></td>
<td>1 MEMS</td>
<td>2 Foundry</td>
</tr>
<tr>
<td></td>
<td>2 Foundry</td>
<td>1 Power</td>
</tr>
<tr>
<td></td>
<td>1 Analog</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 LED</td>
<td></td>
</tr>
<tr>
<td>Europe &amp; Mideast</td>
<td></td>
<td>1 Power</td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td>1 Memory</td>
</tr>
<tr>
<td>Korea</td>
<td>1 Memory</td>
<td></td>
</tr>
<tr>
<td>SE Asia</td>
<td>1 LED</td>
<td>2 Analog</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 LED</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1 Foundry</td>
<td>1 LED</td>
</tr>
</tbody>
</table>

### Potential Capacity in 300mm
- (excluding LED)
- **369,000 wspm** for 2016
- **200,000 wspm** for 2017

Probabilities 60% or higher. All capacities in 300mm equivalents.

Source: World Fab Forecast report, preliminary July 2016, SEMI.
The Rising Share of China Capacity
12.8% CAGR from 2015 to 2020

Source: SEMI World Fab Forecast, March 2017

Disclaimer: The forecast is based on current announcement and is subject to change depending on actual execution.

Source: SEMI World Fab Forecast, March 2017
Surging Fab Investment
Foundry and Memory Take the Lead

China Fab Spending by Product Type

US$ Million

Disclaimer: The forecast is based on current announcement and is subject to change depending on actual execution.

Source: SEMI World Fab Forecast, March 2017
## SEMI® 2016 Equipment Forecast

### Source: SEMI September 1st Update

<table>
<thead>
<tr>
<th>Region</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016F</th>
<th>2017F</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>3.38</td>
<td>4.37</td>
<td>4.90</td>
<td>7.22</td>
<td>7.05</td>
</tr>
<tr>
<td>Europe</td>
<td>1.92</td>
<td>2.38</td>
<td>1.95</td>
<td>1.74</td>
<td>2.64</td>
</tr>
<tr>
<td>Japan</td>
<td>3.38</td>
<td>4.18</td>
<td>5.49</td>
<td>4.60</td>
<td>5.14</td>
</tr>
<tr>
<td>Korea</td>
<td>5.22</td>
<td>6.84</td>
<td>7.46</td>
<td>6.30</td>
<td>8.29</td>
</tr>
<tr>
<td>North America</td>
<td>5.27</td>
<td>8.16</td>
<td>5.12</td>
<td>4.74</td>
<td>5.07</td>
</tr>
<tr>
<td>SEA/ROW</td>
<td>2.08</td>
<td>2.15</td>
<td>1.97</td>
<td>3.33</td>
<td>3.35</td>
</tr>
<tr>
<td>Taiwan</td>
<td>10.57</td>
<td>9.41</td>
<td>9.63</td>
<td>9.94</td>
<td>9.98</td>
</tr>
</tbody>
</table>

Totals may not add due to rounding.
Fab Equipment Spending by Region

China to become 2nd largest Spender in 2018/2019

China was 3rd lowest region

FAB EQUIPMENT SPENDING IN 2015
SOURCE: WORLD FAB FORECAST REPORT, MARCH 2017, SEMI

Taiwan 26%
Americas 14%
China 13%
SE Asia 3%
Korea 23%
Japan 15%
Europe & Mideast 6%

China will be 3rd largest region

FAB EQUIPMENT SPENDING IN 2017
SOURCE: WORLD FAB FORECAST REPORT, MARCH 2017, SEMI

Taiwan 23%
Americas 11%
China 15%
SE Asia 5%
Korea 26%
Japan 12%
Europe & Mideast 8%

Disclaimer: The forecast is based on current announcement and is subject to change depending on actual execution.

Source: SEMI World Fab Forecast, March 2017
China Now the Top Three Regions of Equipment Market

China Capital Equipment Market Share

Source: SEMI EMDS, March 2017
Regional Fab Materials Markets

<table>
<thead>
<tr>
<th>Region</th>
<th>2016F $US B</th>
<th>2017F $US B</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>$2.11</td>
<td>$2.24</td>
<td>6.3%</td>
</tr>
<tr>
<td>Europe</td>
<td>2.46</td>
<td>2.47</td>
<td>0.5%</td>
</tr>
<tr>
<td>Japan</td>
<td>4.41</td>
<td>4.42</td>
<td>0.3%</td>
</tr>
<tr>
<td>Korea</td>
<td>4.65</td>
<td>4.78</td>
<td>2.8%</td>
</tr>
<tr>
<td>North America</td>
<td>4.34</td>
<td>4.33</td>
<td>-0.2%</td>
</tr>
<tr>
<td>SEA/ROW</td>
<td>1.25</td>
<td>1.31</td>
<td>5.2%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>5.43</td>
<td>5.58</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$24.6</strong></td>
<td><strong>$25.1</strong></td>
<td><strong>2.0%</strong></td>
</tr>
</tbody>
</table>

2015 = $24.1 billion

Source: SEMI August 2016

Totals may not add due to rounding
Regional Packaging Materials Markets

China 22%
Europe 3%
SEA/ROW 25%
Korea 12%
North America 3%
Taiwan 22%

2015 = $19.3 billion

<table>
<thead>
<tr>
<th>Region</th>
<th>2016F $US B</th>
<th>2017F $US B</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>$4.42</td>
<td>$4.60</td>
<td>4.2%</td>
</tr>
<tr>
<td>Europe</td>
<td>0.63</td>
<td>0.64</td>
<td>0.5%</td>
</tr>
<tr>
<td>Japan</td>
<td>2.38</td>
<td>2.34</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Korea</td>
<td>2.48</td>
<td>2.48</td>
<td>-0.2%</td>
</tr>
<tr>
<td>North America</td>
<td>0.60</td>
<td>0.59</td>
<td>-1.5%</td>
</tr>
<tr>
<td>SEA/ROW</td>
<td>4.79</td>
<td>4.75</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>4.21</td>
<td>4.19</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Total Regions</td>
<td>$19.5</td>
<td>$19.6</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Source: SEMI August 2016

Totals may not add due to rounding
Assembly and Test Operations in China

Source: SEMI.
2014 Flip Chip Bumping Wafer Capacity by Region

- **Taiwan** accounted for majority of global wafer capacity
- **China’s share of wafer bumping** (normalized wafer share 4%)
  - 17% of 200mm production
  - <1% of 300mm production

### 2014 Flip Chip Bumping Wafer Capacity by Region

<table>
<thead>
<tr>
<th>Region</th>
<th>≤200mm Wafers (K)</th>
<th>300mm Wafers (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan</td>
<td>3,599</td>
<td>4,861</td>
</tr>
<tr>
<td>Korea</td>
<td>672</td>
<td>2,460</td>
</tr>
<tr>
<td>N America</td>
<td>1,726</td>
<td>1,535</td>
</tr>
<tr>
<td>Japan</td>
<td>281</td>
<td>429</td>
</tr>
<tr>
<td>Europe</td>
<td>0</td>
<td>1,540</td>
</tr>
<tr>
<td>China</td>
<td>1,331</td>
<td>35</td>
</tr>
<tr>
<td>SE Asia</td>
<td>84</td>
<td>323</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>7,693</strong></td>
<td><strong>11,183</strong></td>
</tr>
</tbody>
</table>

(actual wafer counts, not normalized)

Source: TechSearch International, Inc.
2016 Flip Chip Bumping Wafer Capacity by Region

- Taiwan still accounted for majority of global wafer capacity
- But China seeing major capacity expansion
  - Much of the capacity expansion for Cu pillar bumping
- China’s share of the bumping market increased (normalized wafer share 10%)
  - Almost 30% of 200mm wafer bumping market
  - 4% of 300mm wafer bumping market

Actual Wafer Counts, Not Normalized

<table>
<thead>
<tr>
<th></th>
<th>300mm Wafers (K)</th>
<th>≤200mm Wafers (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan</td>
<td>6,776</td>
<td>3,284</td>
</tr>
<tr>
<td>Korea</td>
<td>3,078</td>
<td>602</td>
</tr>
<tr>
<td>N America</td>
<td>1,567</td>
<td>1,784</td>
</tr>
<tr>
<td>China</td>
<td>642</td>
<td>2,540</td>
</tr>
<tr>
<td>Europe</td>
<td>1,572</td>
<td>0</td>
</tr>
<tr>
<td>Japan</td>
<td>342</td>
<td>263</td>
</tr>
<tr>
<td>SE Asia</td>
<td>378</td>
<td>84</td>
</tr>
<tr>
<td>TOTAL</td>
<td>14,355</td>
<td>8,557</td>
</tr>
</tbody>
</table>

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China OSAT Growth

• China’s OSATs account for major OSAT growth in revenue in 2016 and trend will continue in 2017
  – JCET
  – Huatian
  – Tongfu Microelectronics (formerly Nantong Fujitsu)

• China revenue growth driven by domestic customers and overseas customers
  – Fabless companies increasing plus overseas customers
  – Capacity expansion in advanced packaging, including bumping, fan-in WLP, FO-WLP continues through 2017

FC-CSP  Fan-in WLP  FO-WLP
Major Chinese OSATs’ Share of Top 20 OSAT Revenue

2016: $22.5 billion

Chinese Co's in Top 20
JCET
Huatian Technology
Tongfu Microelectronics

Remaining Companies in Top 20
80%

Chinese Companies
20%

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- China’s OSAT share of revenue will continue to grow
- M&A activity, but also domestic production
OSAT M&A Activity Continues....

1. Amkor acquired Toshiba's A&T operations in Malaysia in July 2013.
2. UTAC acquired Panasonic's A&T operations in Singapore, Indonesia, and Malaysia in June 2014.
3. Tianshui Huatian Technology (TSHT) exercised its option to purchase the remainder of FlipChip International (FCI) in April 2015.
4. JCET acquired STATS ChipPAC in October 2015.
5. Amkor acquired J-Devices in December 2015. J-Devices was set up as a JV with Toshiba in 2009.
6. AOI acquired Teramikros, a subsidiary of Tera Probe, in April 2016.
7. Nantong Fujitsu Microelectronics (NFML), now Tongfu Microelectronics, formed a JV with AMD's A&T operations in Malaysia and China in April 2016. AMD retained a 15% stake.
8. Amkor is expected to complete its acquisition of NANIUM in 2017.
9. ASE is expected to complete its merger with SPIL sometime in 2017.

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Jiangsu Changjiang Electronics Technology (JCET)

• **Established in 1972 and located in Jiangyin, China**
  – 2016 revenue of $2,899 million
  – Founded as Jiangyin Transistor Factory with discrete device assembly in 1986 and IC assembly in 1989
  – Established an IC assembly operation with Philips in 1995
  – Joint venture with Advanced Packaging Semiconductor of Singapore in 2003 for bumping, acquiring it in 2009
  – Established system-in-package (SiP) assembly plant in 2007

• **Business units**
  – Jiangyin Changdian Advanced Packaging (JCAP) provides bumping and WLP assembly services and has a joint venture with SMIC
  – STATS Chip PAC acquired by JCET in 2015

• **Revenue of $2,889 million in 2016**
JCAP Advanced Packaging

**Wafer Bumping:** (AuB, SnB, CuP, CuB, uCuP...)

<table>
<thead>
<tr>
<th>Wafer Level Packaging</th>
<th>Flip Chip/ TSV/ Interposer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FI WLP</strong></td>
<td><strong>2D/2.5D/3D ICs</strong></td>
</tr>
<tr>
<td>BOP</td>
<td>Integration</td>
</tr>
<tr>
<td>2P1M</td>
<td>uCuP Bump</td>
</tr>
<tr>
<td>IPD Embedded</td>
<td>Temporary Bond/ Debond</td>
</tr>
<tr>
<td><strong>FO WLP</strong></td>
<td>Si/Glass Interposer</td>
</tr>
<tr>
<td>Optic WLP</td>
<td>M2M, SiO/SiO etc. Bonding</td>
</tr>
<tr>
<td>MEMS WLP</td>
<td>Stacked/C2W/C2C Assembly</td>
</tr>
<tr>
<td>FI WLP Embedded</td>
<td>W2W Assembly</td>
</tr>
<tr>
<td>J-WLP</td>
<td></td>
</tr>
<tr>
<td>WLFO</td>
<td></td>
</tr>
<tr>
<td>FO -SiP</td>
<td></td>
</tr>
<tr>
<td>FO -3D</td>
<td></td>
</tr>
<tr>
<td>Si-CSM(2D)</td>
<td></td>
</tr>
<tr>
<td><strong>FC ICs</strong></td>
<td></td>
</tr>
<tr>
<td>FC BGA</td>
<td></td>
</tr>
<tr>
<td>FC LDF</td>
<td></td>
</tr>
<tr>
<td>FC Film</td>
<td></td>
</tr>
<tr>
<td>FC SiP</td>
<td></td>
</tr>
<tr>
<td>COF/COG</td>
<td></td>
</tr>
</tbody>
</table>

**RDL - FI WLP**

2P2M  3P3M  4P3M
JCAP’s Encapsulated Chip Package (ECP) provides six-sided protection
- Uses a silicon carrier (backgrind to thin, but carrier remains to control warpage)
- Uses a dry-film lamination process to encapsulate the die
Tianshui Huatian Technology Co., Ltd.

- **Founded in 2003 and based in Tianshui City, Gansu Province**
  - Revenue for Huatian Group increased from $760 million in 2015 to $950 million in 2016

- **Major subsidiaries in advanced package**
  - Huatian Technology (Kunshan) Electronics started mass production in 2011
  - Huatian Technology (Xi’an) started mass production in 2010
  - Shenzhen Huatian MIC Optoelectronics Technology Co., Ltd. with LED production
  - Purchased FlipChip International in 2015

- **Advanced packaging**
  - Image sensors and fingerprint sensors
  - Bumping
    - Wafers level packaging
Tongfu Microelectronics

- Established as Nantong Fujitsu Microelectronics, changed name to Tongfu Microelectronics
  - Joint venture with Fujitsu
  - Fujitsu moved assembly lines to China
  - Revenue for 2016 estimated to be $688 million

- Acquired 85% ownership of AMD’s assembly operations
  - Penang, Malaysia
  - Suzhou, China

- Advanced packaging includes
  - Bumping
  - WLP
National Center for Advanced Packaging

• **NCAP for-profit private company**
  - Established in 2012 to improve domestic capabilities in advanced packaging technologies
  - Located in Wuxi, China with 3,200 square meters of cleanroom space
  - Members include major domestic OSATS such as JCET, Huatian, Tongfu Microelectronics

• **Research areas in semiconductor assembly**
  - Silicon interposer and 3D TSV development focused on assembly
  - FO-WLP
  - Cu pillar bumping
  - System integration
  - RF packaging
  - mmW communication
  - Optoelectronics
  - MEMS/sensors
Challenges for China’s Industry

- High labor turnover rates
  - Difficult to maintain complex process
- Labor shortages in high-tech sector
  - Possible solution increased automation
- Rising wages
- Intellectual property (IP) concerns
- Some overseas companies closing operations in China
  - UTAC for assembly
  - Tripod for PCB manufacturing
  - Others
- Lack of domestic semiconductor equipment makers
Thank you!

TechSearch International, Inc.
4801 Spicewood Springs Road, Suite 150
Austin, Texas 78759 USA
+1.512.372.8887
tsi@techsearchinc.com

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