SEMI Equipment and Materials Outlook

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Industry Research & Statistics Group at SEMI in San Jose, California

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Outline

- Fab Investments and Equipment Spending
- Market Outlook
  - Fab Materials
  - Packaging Materials
- Market Summary
Fab Investments & Capacity
Fab Equipment Spending—Driven by Foundry and Memory

Source: SEMI World Fab Forecast March 2015
Volume Production Per Node - Slowdown in transition

Volume Production Technology Node Transitions

Source: data collection of SEMI World Fab Forecast reports (June 2014)
200mm Fab Capacity - Foundry share is expanding

Larger share for Foundries and Analog/Discrete

Capacity 200mm Fabs in 2005
4.8 million wpm

Capacity 200mm Fabs in 2015
5.26 million wpm

Volume fabs only, excluding LED and EPI

Source: SEMI World Fab Forecast
Foundries - Ramping capacity in 2015 & 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity (Millions wpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>2.12</td>
</tr>
<tr>
<td>2011</td>
<td>2.19</td>
</tr>
<tr>
<td>2012</td>
<td>2.27</td>
</tr>
<tr>
<td>2013</td>
<td>2.29</td>
</tr>
<tr>
<td>2014</td>
<td>2.28</td>
</tr>
<tr>
<td>2015</td>
<td>2.37</td>
</tr>
<tr>
<td>2016</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Source: SEMI World Fab Forecast
Equipment Outlook
Capital Equipment Market - Volatile cycles in the past

Source: SEMI and SEMI/SEAJ year end historical reports, SEMI forecast update March 2015
Regional Semiconductor Equipment Markets

Source: SEMI March 2015

2015= ~$42 Billion

<table>
<thead>
<tr>
<th>Region</th>
<th>2014E $B</th>
<th>2015F $B</th>
<th>% Chang</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>2.4</td>
<td>2.9</td>
<td>20%</td>
</tr>
<tr>
<td>China</td>
<td>4.4</td>
<td>4.7</td>
<td>7%</td>
</tr>
<tr>
<td>ROW</td>
<td>2.2</td>
<td>2.4</td>
<td>10%</td>
</tr>
<tr>
<td>Japan</td>
<td>4.2</td>
<td>4.4</td>
<td>5%</td>
</tr>
<tr>
<td>North America</td>
<td>8.2</td>
<td>7.2</td>
<td>-12%</td>
</tr>
<tr>
<td>Korea</td>
<td>6.9</td>
<td>8.3</td>
<td>22%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>9.4</td>
<td>12.2</td>
<td>29%</td>
</tr>
<tr>
<td>Total Regions</td>
<td>37.5</td>
<td>42.0</td>
<td>12%</td>
</tr>
</tbody>
</table>

Totals may not add due to rounding
Secondary Fab Equipment Market Size

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2014F</th>
<th>% Y-o-Y Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Fab Equipment</td>
<td>$25,364</td>
<td>$29,870</td>
<td>17.8%</td>
</tr>
<tr>
<td>Secondary Fab Equipment</td>
<td>$1,590</td>
<td>$1,520</td>
<td>-4.4%</td>
</tr>
<tr>
<td>Total Fab Equipment</td>
<td>$26,954</td>
<td>$31,390</td>
<td>16.5%</td>
</tr>
<tr>
<td>Secondary Equipment as a % of Total</td>
<td>5.9%</td>
<td>4.8%</td>
<td></td>
</tr>
</tbody>
</table>

Source: SEMI Secondary Fab Equipment Report
200mm Secondary Fab Equipment -
Foundries boosting 200 mm spending

2013
- IDM, Other: 68%
- Foundry: 32%

2014E
- IDM, Other: 49%
- Foundry: 51%

Source: SEMI Secondary Fab Equipment Report
Market Outlook- Fab Materials
Emerging Device Structures - Require new materials; new processes

Source: Techcet (www.techcet.com)
Material Technology Opportunities

2014 to 2019 Technologies Opportunities

- MPU
  - Multi-patterning Dielectrics will be used for smallest dimension features <28nm
  - High k Gate Dielectric used with Metal Gate Electrode
- DRAM – 1X, 1Z
  - Aggressive scaling, requiring more multipatterning
- Flash
  - 2D - 16nm gates requiring more multipatterning
  - Transition to 3D NAND similar challenges to MPU for 3D structures but with larger design rules, > 20nm.
- More/Better: MP Dielec., Etch, Cleans, Litho, ALD
Global Silicon Wafer Shipment Trends

Silicon Area Shipments by Diameter
(from the wafer suppliers to the fabs)

Source: Rose Associates 1991 to 1994; SEMI SMG 1995 to 2014; SEMI Forecast
<table>
<thead>
<tr>
<th>US$ Millions</th>
<th>Actual</th>
<th></th>
<th>Forecast</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
<td>2015F</td>
<td>2016F</td>
</tr>
<tr>
<td>Silicon Wafers$^1$</td>
<td>$7,932</td>
<td>$7,990</td>
<td>$8,267</td>
<td>$8,495</td>
</tr>
<tr>
<td>Photomasks$^2$</td>
<td>3,136</td>
<td>3,219</td>
<td>3,306</td>
<td>3,438</td>
</tr>
<tr>
<td>Photoresists</td>
<td>1,220</td>
<td>1,374</td>
<td>1,401</td>
<td>1,514</td>
</tr>
<tr>
<td>Photoresist Ancillaries$^3$</td>
<td>1,428</td>
<td>1,711</td>
<td>1,779</td>
<td>1,886</td>
</tr>
<tr>
<td>Wet Chemicals$^4$</td>
<td>995</td>
<td>1,059</td>
<td>1,117</td>
<td>1,107</td>
</tr>
<tr>
<td>Gases</td>
<td>3,319</td>
<td>3,481</td>
<td>3,561</td>
<td>3,675</td>
</tr>
<tr>
<td>Sputter Targets$^4$</td>
<td>598</td>
<td>629</td>
<td>641</td>
<td>691</td>
</tr>
<tr>
<td>CMP Slurry &amp; Pads$^5$</td>
<td>1,436</td>
<td>1,569</td>
<td>1,678</td>
<td>1,758</td>
</tr>
<tr>
<td>Other/New Materials$^6$</td>
<td>2,588</td>
<td>2,945</td>
<td>3,178</td>
<td>3,415</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$22,652</strong></td>
<td><strong>$23,977</strong></td>
<td><strong>$24,928</strong></td>
<td><strong>$25,979</strong></td>
</tr>
<tr>
<td><strong>% Growth</strong></td>
<td></td>
<td>5.8%</td>
<td></td>
<td>4.0%</td>
</tr>
</tbody>
</table>

Totals may not add due to rounding

Source: SEMI Materials Market Data Subscription January 2015
Wafer Fab Materials Forecast Notes

1. Silicon wafers include merchant sales value only; includes SOI wafers; no reclaim wafers
2. Includes captive market
3. Includes resist removal chemicals, developers, anti-reflective coatings, contrast enhancers, edge bead removers, adhesion promoters, etc.
4. Source is Linx Consulting LLC, includes precious metals
5. Estimates for IC applications only
6. Includes low k dielectrics, copper plating solutions, dielectric precursors, organometallic precursors, etc.
7. All forecasts in current dollars
8. Source for all data is SEMI, unless otherwise indicated

Source: SEMI Materials Market Data Subscription February 2015
Regional Fab Materials Markets

2015 = $24.9 Billion

<table>
<thead>
<tr>
<th>Region</th>
<th>2014E $B</th>
<th>2015F $B</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan</td>
<td>5.3</td>
<td>5.6</td>
<td>5%</td>
</tr>
<tr>
<td>Japan</td>
<td>4.5</td>
<td>4.6</td>
<td>2%</td>
</tr>
<tr>
<td>Korea</td>
<td>4.4</td>
<td>4.7</td>
<td>5%</td>
</tr>
<tr>
<td>Americas</td>
<td>4.3</td>
<td>4.4</td>
<td>3%</td>
</tr>
<tr>
<td>Europe</td>
<td>2.4</td>
<td>2.5</td>
<td>4%</td>
</tr>
<tr>
<td>China</td>
<td>1.7</td>
<td>1.8</td>
<td>6%</td>
</tr>
<tr>
<td>ROW/Southeast Asia</td>
<td>1.4</td>
<td>1.4</td>
<td>3%</td>
</tr>
<tr>
<td>Total Regions</td>
<td>24.0</td>
<td>24.9</td>
<td>4%</td>
</tr>
</tbody>
</table>

Totals may not add due to rounding

Source: SEMI Materials Market Data Subscription February 2015
Market Outlook - Packaging Materials
# Worldwide Packaging Materials Forecast

<table>
<thead>
<tr>
<th>US$ Millions</th>
<th>2013</th>
<th>2014</th>
<th>2015F</th>
<th>2016F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadframes</td>
<td>$3,342</td>
<td>$3,476</td>
<td>$3,476</td>
<td>$3,455</td>
</tr>
<tr>
<td>Organic Substrates</td>
<td>7,408</td>
<td>7,612</td>
<td>8,196</td>
<td>8,586</td>
</tr>
<tr>
<td>Ceramic Packages</td>
<td>2,006</td>
<td>2,075</td>
<td>2,157</td>
<td>2,174</td>
</tr>
<tr>
<td>Encapsulation Resins</td>
<td>2,451</td>
<td>2,712</td>
<td>2,922</td>
<td>3,187</td>
</tr>
<tr>
<td>Bonding Wire(^2)</td>
<td>4,151</td>
<td>3,385</td>
<td>3,260</td>
<td>3,189</td>
</tr>
<tr>
<td>Die Attach Materials(^3)</td>
<td>666</td>
<td>704</td>
<td>734</td>
<td>752</td>
</tr>
<tr>
<td>Others(^4)</td>
<td>374</td>
<td>409</td>
<td>451</td>
<td>500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$20,398</strong></td>
<td><strong>$20,373</strong></td>
<td><strong>$21,196</strong></td>
<td><strong>$21,843</strong></td>
</tr>
<tr>
<td><strong>% Growth</strong></td>
<td><strong>-0.1%</strong></td>
<td><strong>4.0%</strong></td>
<td><strong>3.1%</strong></td>
<td><strong>3.1%</strong></td>
</tr>
</tbody>
</table>

Source: SEMI Materials Market Data Subscription January 2015

Totals may not add due to rounding
Semiconductor Packaging Materials
Forecast Notes

1. Source is TechSearch International. Includes PBGA, PPGA, LGA, and CSP laminate substrates and flex BGA and CSP substrates
3. Includes die attach film (tape) materials
4. Other includes solder balls and wafer level package dielectrics
5. Source for all data is SEMI, unless otherwise indicated
6. All forecasts in current dollars

Source: SEMI January 2015
Packages for Mobile Devices

- Touch screen controllers: quad flat no-lead (QFN), fine pitch ball grid arrays (FBGA)
- Antenna: ceramic land grid array (CLGA), QFN
- Power amplifiers: LGA (with laminate substrate), typically wire bond moving to flip chip
- RFIC: FBGA, flip chip BGA (FC-BGA), wafer level package (WLP), Fan-out WLP (FO-WLP)
- Modem IC: FC-BGA, stacked die package (FC and WB), package-on-package (PoP)
- Application processor: FC-BGA, bottom package of PoP
- NAND flash: FBGA
- Power management IC (PMIC): FC-BGA, WLP
- WiFi/Bluetooth: CLGA, LGA (with laminate substrate), WLP
- Near Field Communications (NFC): FBGA
- Sensors: LGA
Bonding Wire Material Transition:
*Cu-type & Ag are ~56% of the market*

- Industry now spending ~$2.6 billion less/year on wire compared to 2010
- IP issues around PCC and Ag alloy
- Shift to Cu, PCC, and Ag drives changes in mold compound material

Source: SEMI and TechSearch International - *Global Semiconductor Packaging Materials Outlook*
Regional Semiconductor Packaging Materials Markets

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<thead>
<tr>
<th>Region</th>
<th>2014E $B</th>
<th>2015F $B</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROW/Southeast Asia</td>
<td>5.29</td>
<td>5.55</td>
<td>5%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>4.28</td>
<td>4.46</td>
<td>4%</td>
</tr>
<tr>
<td>China</td>
<td>4.18</td>
<td>4.40</td>
<td>5%</td>
</tr>
<tr>
<td>Japan</td>
<td>2.71</td>
<td>2.72</td>
<td>0%</td>
</tr>
<tr>
<td>Korea</td>
<td>2.56</td>
<td>2.68</td>
<td>5%</td>
</tr>
<tr>
<td>Europe</td>
<td>0.70</td>
<td>0.73</td>
<td>4%</td>
</tr>
<tr>
<td>Americas</td>
<td>0.65</td>
<td>0.66</td>
<td>2%</td>
</tr>
<tr>
<td>Total Regions</td>
<td>20.37</td>
<td>21.20</td>
<td>4%</td>
</tr>
</tbody>
</table>

Totals may not add due to rounding

Source: SEMI Materials Market Data Subscription January 2015
Summary

Fab Investment & Capacity
- Fab investments are expected to show continuous growth into 2015 led by foundry and memory manufacturers.
  - *Foundries expand 200mm capacity*

Equipment Outlook
- Solid recovery in overall equipment spending for 2014; expect growth to continue in 2015

Materials Outlook
- Advanced devices and packaging require new materials
- Materials market to top $46 billion in 2015
  - *Single-digit silicon area shipment growth this year and next*
Participate in SEMI’s Data Collection Programs

- Semiconductor Equipment
- PV Equipment
- Mass Flow Controllers
- Photoresist and Photoresist Ancillaries
- Electronic Gases
- Leadframe
- Silicon
- Polysilicon
Market Reports/Databases

Fee-based Reports

**Semiconductor Equipment**
- SEMI Secondary Fab Equipment Report New
- Equipment Market Data Subscription (EMDS)
- Book-to-Bill Report
- Historical WWSEMS (1991-2013)
- Historical Book-to-Bill (1991-2013)

**Semiconductor Materials**
- Material Market Data Subscription (MMDS)
- Photomask Report * (Mar ’15)
- Silicon Reclaim Wafer Report * (Mar ’15)

**Fabs / Foundries**
- World Fab Forecast
- FabFutures
- World Fab Watch

**Semiconductor Packaging**
- Global Semiconductor Packaging Materials Outlook ‘13/’14
- China Semiconductor Packaging Market Outlook (Q1 ’15)
- Global Semiconductor Packaging Materials Outlook ‘15/’16 (Q4 ’15)

**Notes:**
* These reports are included FREE with the purchase of the MMDS report, but also available as separate reports.
Market Research Reports

**LED**
- Opto/LED Fab Watch
- Opto/LED Fab Forecast
- China LED Fab Industry Report

**Photovoltaic**
- Worldwide PV Equipment Market Statistics (Book-to-Bill) Report

**Components**
- Mass Flow Controllers
Check Us Out!

Contact:

Dan Tracy: dtracy@semi.org

Resources

www.semi.org/marketinfo
www.semi.org/fabs