Probe Card Market Update

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Overview

Probe Card Market

- By Type
- By Application
- Price
- Capacity
- Business Model
- Regional Characteristics
- Industry Consolidation

Semiconductor Market

2017

2018

Summary
2017 was an exceptional year for semiconductors with sales exceeding $400Bn.

Memory revenues increased 60% in 2017 compared to revenues in 2016. Key drivers: DRAM and NAND Flash.
2018 Semiconductor Market Outlook

- **Peak growth in semiconductors reached at end of March 2018**
  - Sales of semiconductors in the last week of March 2018 were 30% higher than the same week in 2017
- **Weakening of demand due to falling memory prices**
- **Underlying demand still strong**
- **Chip inventories at a healthy 1.2 months**
  - Currently growing fast (in line with demand) but could spike if demand drops suddenly
- **Expect growth of 12.5% in 2018**
Semiconductor Memory Market

- DRAM added $30Bn to semiconductor revenues in 2017
- DRAM will be biggest growth driver in 2018
- Weakening NAND prices will affect NAND growth
- DRAM, NAND Flash and NOR Flash are expected to grow in 2018

Revenue Growth: Y16 ~ Y17 and Y17 ~ Y18(E)

- DRAM: 28%
- NAND: 16%
- NOR: 9%

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Semiconductor Non-Memory Market

• Logic markets set to grow steadily
• Graphics processor sales strong due to AI and Blockchain
• Applications processor sales weak as smartphone and tablet sales mature

Revenue Growth: Y16 ~ Y17 and Y17 ~ Y18(E)

- GPU: 14%
- FPGA: 9%
- MCU: 9%
- DSP: 7%
- MPU: 6%
- APU: 5%

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Summary
Probe Card Growth vs. Semiconductor Growth, %

Semiconductor ~ 20% in 2017

Probe Card ~ 17.4% in 2017

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2017 Probe Card Revenues by Type, $M%

Traditional Probe Cards, 15%
- Blade/Tungsten Probe Cards
- Epoxy/Cantilever Probe Cards

Advanced Probe Cards, 85%
- Other Advanced Probe Cards
- Vertical Probe Cards
- MEMS Probe Cards
2017 Probe Card Revenues by Application, $M%

Memory Applications, 36%

Non-Memory Applications, 64%

NAND
DRAM

Other

NOR

SOC, CPU, GPU etc.

High Voltage

RF, Parametric, CMOS Image Sensor

Other
Price Trend of the Most Expensive Probe Cards, $
Capacity Managing

• In 2017, revenues of MEMS probe cards increased at the fastest rate compared to other types: well above average

• In 2017, Technoprobe built a new factory in Italy to support the increasing demand for high-end probe cards

• At the beginning of 2018, JEM decided to invest a new fab to expand their capacity in 2019
Business Model of Buyers

Buy complete probe cards from probe card vendors

Business Model

Buy probe heads & PCBs separately, then assemble
Regional Distribution of Main Suppliers

Main probe card suppliers’ HQ located:
- Europe
- Japan
- Korea
- North America

Supply 90% ($M%) probe cards in 2017
### Regional Performance of Main Suppliers

#### 7 Main Probe Card Regions of Consumption:
China, Europe, Japan, Korea, North America, Singapore, Taiwan

<table>
<thead>
<tr>
<th>Suppliers HQ Location</th>
<th>2(^{nd}) Strongest area in above list (Strongest area ~ locally)</th>
<th>Weakest area in above list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>North America</td>
<td>China</td>
</tr>
<tr>
<td>Japan</td>
<td>Korea</td>
<td>Europe</td>
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<tr>
<td>Korea</td>
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<td>Europe</td>
</tr>
<tr>
<td>North America</td>
<td>Taiwan</td>
<td>Singapore</td>
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</tbody>
</table>
2017 Industry Consolidation

In 2017, total probe card revenues were $1.56B

The top 10 vendors accounted for 80% market share
2017 Customer Satisfaction Survey

Surveyed Categories

<table>
<thead>
<tr>
<th>Company</th>
<th>Product</th>
</tr>
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<tbody>
<tr>
<td>Trust in supplier</td>
<td>Quality of results</td>
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<tr>
<td>Support after sales</td>
<td>Usable performance</td>
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<tr>
<td>Recommend supplier</td>
<td>Uptime</td>
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<tr>
<td>Commitment</td>
<td>Product performance</td>
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<tr>
<td>Partnering</td>
<td>Overall Value</td>
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<td>Field engineering support</td>
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<tr>
<td>Technical leadership</td>
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<tr>
<td>Spares support</td>
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<tr>
<td>Process support</td>
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</table>

THE 2018 HIGHEST-RATED TEST CONNECTIVITY SUPPLIERS

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Rating</th>
<th>VLSI Stars</th>
<th>Highest-Rated Categories</th>
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<tbody>
<tr>
<td>TechnoProbe</td>
<td>9.81</td>
<td>★★★★★</td>
<td>• Support After Sales</td>
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<td></td>
<td></td>
<td></td>
<td>• Trust in Supplier and Partnering</td>
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<tr>
<td>FormFactor™</td>
<td>9.15</td>
<td>★★★★★</td>
<td>• Recommend Supplier</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Technical Leadership</td>
</tr>
<tr>
<td>Nidec SVTCL</td>
<td>9.03</td>
<td>★★★★★</td>
<td>• Partnering</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Commitment</td>
</tr>
<tr>
<td>Xcerra</td>
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<td>★★★★★</td>
<td>• Spares Support</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Support After Sales</td>
</tr>
<tr>
<td>Japan Electronic Materials</td>
<td>8.12</td>
<td>★★★★★</td>
<td>• Partnering</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Recommend Supplier</td>
</tr>
</tbody>
</table>

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- Semiconductor sales slowing in 2018 but it is still expected to be another great year with sales growth of 12.5%.

- As new memory capacity comes on line, rapidly falling memory prices are likely to result in an overall semiconductor sales decline (-3%) in 2019.

- Sales of Analog and Logic chips to grow 8% in 2018 and 2.5% in 2019.

- Driven by the semiconductor market, sales of probe cards are expected to be increase by 7.3% in 2018.