CMP COST ISSUES & IMPACT ON CONSUMABLES FOR 450MM
1. We create knowledge and develop unique insights at the intersection of electronic thin film processes and the chemicals industry

2. We help our clients to succeed through our:
   - Experience in global electronics and advanced materials and thin film processing industries:
     - Semi
     - Packaging
     - Nano Technology
     - LCD
     - PV
     - Other
   - Experience in the global chemicals industry
   - Experience at Device Producers
   - Experience at OEMs
   - Global network and capabilities
   - Advanced modeling capabilities
High Confidence Decision Support Services

PLANNING
- Business Analysis
- M&A / Due Diligence
- Diversification / Expansion Planning

OPERATIONS
- Cost Benchmarking
- Competitive Intelligence
- COO Models and Assessment
- Process Technology Assessment

IDEAS TO MARKET
- IP Development
- Value Chain Analysis
- Technology Assessment and Commercialization

MARKETING & SALES
- Market Analysis/Monitoring
- Market Forecasting and Modeling
- Competitive Intelligence
- Customer Perceptions

SINGLE CLIENT SERVICES
Industry Analysis Reports Offered

- CMP Technologies and Markets
- Advanced Thin Films for FEOL and BEOL Applications
- Emerging Materials Opportunities for Advanced Semiconductor Devices – Logic
- Emerging Materials Opportunities for Advanced Semiconductor Devices - Memory
- Advanced Cleaning and Surface Preparation: Technologies and Markets
- Advanced Patterning Forecasting
- Chemicals and Materials for TSV Applications
- Wafer Polishing Technologies and Markets
- Impact of 450mm Wafers on Processes and Materials
- Advanced Materials and Chemicals for Photovoltaic Cells and Modules
• **Materials Market Landscape**
• Major Developments after 2015
• Impact of 450mm on CMP & Conclusions
Materials Market

- Process complexity is driving higher growth in materials demand than the wafer start growth
  - The BOM component of semiconductor sales will increase over the next 5 years

- Photoresist and Ancillaries will show segment growth of 15%, higher than other major segments, and higher than the wafer start growth of 10%.
CMP Consumables Market ($M)

- 2011: $1,615M
- 2012: $1,800M
- 2013: $2,000M
- 2014: $2,200M
- 2015: $2,400M
- 2016: $2,534M

9% CAGR
Growing Importance of Process Materials

Process Materials Requirement as a Percentage of Semiconductor Revenue

- Process Materials
- Forecast
- Average '02-'11
## Electronic Materials Segmentation

<table>
<thead>
<tr>
<th>Materials Segment</th>
<th>Non Differentiated Materials</th>
<th>Specialties / Formulated Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>• Large volume • Consistency • Cost</td>
<td>• Low volume • High service requirements • Proprietary products  • not easily substituted • Purchased for performance • Profit margins are higher</td>
</tr>
<tr>
<td>Key technologies</td>
<td>• High volume manufacturing</td>
<td>• Proprietary formulations • Synthesis • Applications expertise</td>
</tr>
</tbody>
</table>

### Conceptual Business Models

- **EBIT**
- **SG&A**
- **R&D**
- **COGS**
Slurry Supplier Consolidation

- Measure of consolidation
  - 10000 = monopoly

- Little evidence of supplier consolidation. Change not correlated to market growth.

- Tungsten Slurry has been strongly protected by patents.

- Approximately equal numbers of US and Japanese suppliers.
Agenda

- Materials Market Landscape
- Major Developments after 2015
- Impact of 450mm on CMP & Conclusions
## Major Developments after 2015

<table>
<thead>
<tr>
<th>Development</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>450mm wafers</td>
<td>450mm can have a tremendous impact by limiting the number of new fabs built. However, better cost economics can also expand overall semiconductor market growth. Not all suppliers, OEMs and Fabs can invest in this platform. Need to chose development partners carefully.</td>
</tr>
<tr>
<td>New Device Architectures</td>
<td>Both non-planar transistors and new memory technologies will expand opportunities for thin film materials suppliers as well as such related processes as CMP, etch and clean.</td>
</tr>
<tr>
<td>EUV Litho</td>
<td>Can impact photo-ancillaries market, especially spacers used in double patterning.</td>
</tr>
</tbody>
</table>

However, as often seen in this industry, developments are often later than initially anticipated. We do not believe that 450, non-planar transistors and EUV will all be commercialized at the same time or half-pitch.
**Fab Requirement**

### 300mm fabs

- **R&D = 5k wpm**
- **Other = 25k wpm**
- **Flash = 100k wpm**
- **MPU = 30k wpm**
- **DRAM = 60k wpm**
- **ASIC = 30k wpm**

### 450mm fabs

- **R&D = 7.5k wpm**
- **Other = 27.5k wpm**
- **Flash = 150k wpm**
- **MPU = 45k wpm**
- **DRAM = 90k wpm**
- **ASIC = 45k wpm**

Source: Semiconductor Silicon Demand Forecast - revision 1107
450mm Wafer Ramp Expectation

WW Silicon demand by wafer size
New Architectures - Logic

Device scaling roadmap

Performance (power x delay)

- Ge/III-V, VFET, TFET, NW, Graphene...
- Wires
- FinFET
- Gate-first
- Gate-last
- FUSI
- USJ
- Strain
- High-k, Metal Gate
- 32-22/20
- Multi-gate
- 22/20-15
- >130

Benefits

- Ultra-thin body with RSD
- Extension of planar technology (less disruptive to manufacturing)
- Improved RDF (low doped channel)
- Excellent channel control
- Potential for body bias
- Compatible with RSD technology

Sources: IMEC, Intel
**New Architectures - Implementation of 3-D**

**3D NAND Flash Schemes**
# TSV Scenarios – More Moore

<table>
<thead>
<tr>
<th>Category</th>
<th>2010 - 2015</th>
<th>2016 - 2020</th>
<th>2021 - 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRAM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOGIC</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>NAND</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![TSV Wafer Forecast](source: HMCC)

Source: HMCC
Long Range Device Mix Forecast

Total 300 and 450mm wafers
Agenda

• Materials Market Landscape
• Major Developments after 2015
• Impact of 450mm on CMP & Conclusions
ASIC – CMP Consumables

36% CMP Consumable cost increase per wafer

<table>
<thead>
<tr>
<th>Year</th>
<th>CMP Consumable $/wafer</th>
<th>CMP Fab spend ($M) @50k WSPM</th>
<th>HP, nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>$30.00</td>
<td>$20.00</td>
<td>30</td>
</tr>
<tr>
<td>2015</td>
<td>$20.00</td>
<td>$30.00</td>
<td>35</td>
</tr>
<tr>
<td>2020 - 1.2X Flow, etc</td>
<td>$10.00</td>
<td>$40.00</td>
<td>40</td>
</tr>
<tr>
<td>2020 - 1.5X Flow, etc</td>
<td>$5.00</td>
<td>$60.00</td>
<td>45</td>
</tr>
</tbody>
</table>

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ASIC – Wafer Costs

300mm

2010

0%

$2,000.0

$4,000.0

$6,000.0

$8,000.0

$10,000.0

$12,000.0

2015

16.64%

% increase

2010 - 1.2X Flow, etc.

Yielded Wafer Cost ($)

2020 - 1.2X Flow, etc.

138.76%

450mm

2020 - 1.5X Flow, etc.

0.06%

% increase

0% 20% 40% 60% 80% 100% 120% 140% 160%

300mm

$0.0

$2,000.0

$4,000.0

$6,000.0

$8,000.0

$10,000.0

$12,000.0

450mm

2020 - 1.5X Flow, etc.

0.06%
Fab Requirements - ASIC

Total # of Fabs in Operations Across All Nodes

- 300mm ASIC
- 450mm ASIC
CMP Slurry & Pad Requirements ($M) - ASIC

7.3% Overall CAGR

9.4% 10 year CAGR – 300mm

3.1% 450mm CAGR
Conclusions

• TSV is an immediate opportunity

• New device types will be coming within 5 years

• Long term CMP growth ($ basis) is still attractive @ 7+% from 2010 to 2015

• 300mm still has strong growth trajectory

• 450mm consumables will represent a significant part of the market by 2025