Rebounds & Magic Triangles

Techcet 2011 CMP Consumables Market Update

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Outline

✪ The Business
✪ The Players
✪ The Buzz
✪ The End
The Business of Semiconductors

Annual Wafer Starts (200mm equivalent)

Window of Opportunity

Source: Techcet Group, April 2011

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The Business of CMP

CMP Slurry Pit of Despair

Source: Techcet Group, April 2011
The Business of CMP

- 2010 revenues match 2007 peak
  - Up 37% over 2009 low
  - 2011 forecast +9% to $1.65B
- Revenue shift
  - More copper & STI
  - Less tungsten & ILD
- CMP recession impacts
  - Leading edge – what recession?
  - One supplier drop out (SemiQuest)
The Players - Slurry

- FujiFilm absorbs 100% of Planar Solutions
- BASF enters the CMP slurry business

- >15 suppliers share $1.03B market
  - Tier 1 – Cabot Microelectronics ~40% share
  - Tier 2 – DANM, Dow, FujiFilm, Fujimi, Hitachi
    - Shares 5% to 11%
  - Tier 3 – Anji, AGC, ATMI, BASF, Bayer, Cheil, Ferro, JSR, Wacker
    - Shares <5%
The Players - Pads

🌟 Investor confidence: new funding rounds
- innoPad $6M, April, December 2010
- NexPlanar $10M Series D, March 2011

🌟 >16 suppliers share $626M market
- Tier 1 – Dow ~80% share
- Tier 2 – Cabot ~5–7% share
- Tier 3 – innoPad, JSR, Praxair, Thomas West
  - Shares 3–5%
- Others – 3M, Fujibo, IVT, KPX, NexPlanar, Rogers, SKC, Toray, Toyo, Toyobo
The Players – Other CMP

- **Pad conditioners**
  - Market size estimates range $200M – $400M
  - 3M & Kinik control over half the market

- **PVA brushes**
  - Market size estimated $30M – $50M
  - ITW & Aion control 80% of the market
  - ~$10M market for HDD

- **Slurry filters**
  - Pall, Entegris & 3M dominate
The Buzz – Magic!

Unexpected Exceptional Performance

Slurry

Pad

Conditioner
Magic Triangles

* Why now?
  ✦ Years of talk about synergy between pad and slurry development produced *nothing*
  ✦ <45nm specs made us look more closely

* Systematic engineering work
  ✦ Designed experiments
  ✦ New products available for evaluation
  ✦ Fab tool time available
  ✦ Fab engineer work product, no R&D transfer
Magic Triangles

Process characteristics
- Less aggressive pad conditioning
- Highly reproducible pad roughness
- Tight slurry PSD

Resulting observations
- Sharp reduction in surface scratches
- Dishing meets aggressive specs
- Exceptional removal rate stability
- Lower CoO (pad life, conditioner life)
Magic Triangles

Specific examples: CONFIDENTIAL

- Patriot Act does not apply
- Enhanced interrogation techniques off limits
  - Slurry-boarding on hold

Magic triangle citations

- Cabot (pads)
- Fujimi
- Hitachi
- innoPad
- Intel
- Morgan
## Magic Triangles vs. ITRS

<table>
<thead>
<tr>
<th>Year of Production</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tbody>
<tr>
<td>DRAM ½ Pitch (nm) (contacted)</td>
<td>52</td>
<td>45</td>
<td>40</td>
<td>36</td>
<td>32</td>
<td>28</td>
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<tr>
<td>MPU/ASIC Metal 1 (M1) ½ Pitch (nm) (contacted)</td>
<td>54</td>
<td>45</td>
<td>38</td>
<td>32</td>
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<td>MPU Physical Gate Length (nm)</td>
<td>29</td>
<td>27</td>
<td>24</td>
<td>22</td>
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<td>Wafer diameter (mm)</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>300</td>
<td>450</td>
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<td>Wafer edge exclusion (mm)</td>
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<td>Scratches</td>
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<tr>
<td>Critical scratch length, ( s_c ) (nm) [Å]</td>
<td>25.8</td>
<td>22.5</td>
<td>20.0</td>
<td>17.9</td>
<td>15.9</td>
<td>14.2</td>
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<td>Critical scratch count, ( S_{cw} ) (#/wafer) [Å]</td>
<td>40.1</td>
<td>40.1</td>
<td>40.1</td>
<td>40.1</td>
<td>40.1</td>
<td>166.3</td>
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<td>Uniformity</td>
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<td>CMP total uniformity (3σ) for removal (%) [Å]</td>
<td>8</td>
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<tr>
<td>CMP uniformity (3σ) within wafer (%) [Å]</td>
<td>6</td>
<td>6</td>
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</tr>
</tbody>
</table>

* Manufacturable solutions exist, and are being optimized*

* Manufacturable solutions are known*

* Interim solutions are known*

* Manufacturable solutions are NOT known*

Magic triangles will contribute to success

- Critical scratch length <20nm, <40/wafer

Source: 2010 Interconnect ITRS
The End

- CMP market has recovered to its pre-recession trajectory
- CMP users and suppliers will both benefit from magic triangle work completed during the recession

- It is time for a CMP Slurry Market Statistics Program
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