Silicon Valley CMP Users Group

June 5, 2002

For confident decisions in a complex world™
SEMICONDUCTOR EXPERIENCE (Selected)

- Acids, Etchants and Cleaners
- Dielectrics
- CMP Consumables
- MOCVD Precursors
- Dual Damascene Processing
- Integration schemes
- Gate-stack materials
- Cost of ownership
- Removers
- Metals
Current consumables market
CMP: CURRENT STATE OF INDUSTRY

FABS

- Tools
- Conditioner
- PADS
- Slurries
- Brushes
- Filters
- Dispense
- Waste Water

Dominated by AMAT
Changing channels
Dominated by Rodel
Dominated by Cabot
Dominated by Rippey
3-4 Suppliers
Opportunities to add value?

Other considerations
- Application – Specific tools and consumables
- Cost of Ownership
- Regional shifting to global business models
- Will tool suppliers get into consumables
- Integration of slurry producers in particles
- No integration plays in pads
Current state of consumables market . . .

Market-share leaders:
- Cabot down 8-9% from a year ago, and down 18% from the record performance seen in late 2000, BUT...
  - Current quarter-to-quarter sales have flattened
  - Latest quarterly volume up 2.6%, though prices down 1.8%
- Rohm and Haas (Rodel parent) reported Electronics business down 26% as of 1Q02, BUT...
  - Still profitable
  - Includes the photoresist business
  - Slight increases in business noted in 1Q02

The sky isn’t falling:
- Volatility in consumables less than half that of equipment
- Technological fundamentals still spell strong growth
- But competition is heavier, especially in oxide slurries
Competing market trends . . .

**Price competition in oxide slurries:**
- Oxides becoming commodity-like
- More competitors, especially from Asia
- Price erosion

**Focus on technology, not pricing, elsewhere:**
- Tough integration challenges remain
- Copper CMP
- Fabs relying on established leaders

**Bottom line: Price is crowding out technology effect:**
- 250- and 180-nm nodes still very popular
- Bracing for tungsten-slurry price competition
North American market share declining...

- Cabot saw 62% of sales outside U.S. in 2001
- In 2002, the percentage is up to 65%
- Most of the share re-allocation is going to Asia
Pad sector active with new development . . .

Several new entrants:
• PPG Industries
• Madison Filter
• Psiloquest
• Others expected

Continuing developments by leaders:
• Rodel photo-patterned thermoplastics pads
• Thomas West “Right Pad”
• Both developments point to more options in hardness v.s. softness in pads

Still a Rodel stronghold, BUT:
• Pad market appears to be the most active in terms of competitive development
Consumables outlook
GLOBAL GROWTH IN CMP OPERATIONS BY DEVICE CATEGORY, 2000 - 2005

Million minutes undergoing CMP

Logic | Memory | Other

2000  | 2001   | 2002   | 2003   | 2004   | 2005   

0     | 100    | 200    | 300    | 400    | 500    |

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As CMP matures the number and types of planarizations will shift from oxide to metal . . .

![Percent metal CMP graph](image-url)
Fumed silica dispersions will continue to grow rapidly but will lose share to other types of CMP slurries over the next five years...
Other major consumables in CMP are pads, brushes and filters. Together they account for approximately one-half of the total consumables market . . .
CMP has been a process standard since the 250-nm design rule was passed, over five years ago, but its continued use “as we know it” is by no means certain.

**Alternatives include:**

- CMP without abrasive slurry
  - Abrasive-free polishing solutions
  - Electropolishing
- Fixed-abrasive pads
- Non-CMP planarization
  - Contact planarization
  - Planar etch
  - Press & Peel dielectrics
Contact planarization involves the use of a lens blank to flatten a sacrificial layer, which is cured with UV and then etched away . . .

**Source:** J.A. Prybala, Lucent Technologies, AVS 2nd Intl Conf., Feb, 2000
Press and Peel technology from ASET. Together with DSN, can deposit dielectrics without any need for planarization.
CMP without abrasive slurry...

Abrasive-free polishing (AFP)
- Hitachi HS-C, with $\text{H}_2\text{O}_2$, for copper bulk only
- Rodel Reactive Liquid, also for copper bulk
- AMAT claims solutions for copper bulk and finishing

Electropolishing
- NuTool combines electrodeposition with pad polishing, with or without slurry
- ACM Ultra SFP (Stress-Free Polishing)
  - No pads or slurry
  - Aimed at low-k integration
What if planar deposition wins big?...

- Base case projects token planar deposition in 2003-2005
  - Penetration limited to MPUs, SoCs, DSPs
- If (a BIG IF) just those categories go all to planar deposition, slurry market drops 18%
  - It couldn't happen this fast!!!

![Graph showing data trends over years with two lines, one labeled Base case and the other Do away with Cu CMP.](image-url)
Integration challenges ahead...

- **Not just metal CMP will occur**
  - Expect dishing, hence an oxide buff
  - Expect low-k exposure to slurry

- **Pay attention to platen pressure**
  - Too much might destroy a low-k film
  - Can be used to advantage in “smart” slurries
  - Pressure profile across the head needs control and understanding

- **Implementing low-k while reducing cost-of-ownership**
More Integration Challenges to CMP . . .

300-mm wafers could lead to a reduction in the volume of consumables
- By one estimate, average slurry usage rises from 560 ml/wafer to only 650 ml/wafer -- only a 20% increase for a >200% increase in polishing area

Low-k dielectrics require special care
- Dense versions are now commercial
- Porous versions will go commercial 2006-2008

Copper
- Numerous grades with custom selectivities
Low-k dielectrics
Low-k Roadmap delay...

![Graph showing k-Value over years](image-url)
<table>
<thead>
<tr>
<th>Classification</th>
<th>Material class</th>
<th>CVD</th>
<th>Spin-on</th>
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<tbody>
<tr>
<td>Premetal</td>
<td>Inorganics</td>
<td>BPSG</td>
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<td>Interlayer dielectric (ILD)</td>
<td>Inorganics</td>
<td>SiO$_2$, FSG</td>
<td>Polyphenylene, polyarylene, PTFE, others</td>
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<tr>
<td></td>
<td>Organics</td>
<td>PTFE, FLAC</td>
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<tr>
<td></td>
<td>Silico-organics</td>
<td>SiOC</td>
<td>HSQ, SOG, silsesquioxanes, siloxanes, others</td>
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<tr>
<td>Cap/hard mask/etch stop layers</td>
<td>Inorganics</td>
<td>SiN$_x$, others</td>
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<tr>
<td></td>
<td>Organics</td>
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<tr>
<td></td>
<td>Silico-organics</td>
<td>SiC</td>
<td>Proprietary polymers</td>
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CVD v.s. spin-on, continuing debate...

% CVD

0.0% 20.0% 40.0% 60.0% 80.0% 100.0%


Kg basis
$ basis
Depositions