Hard Porous Pad™ for Copper Low K CMP

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Outline of the Presentation

• TWI Hard Porous Pad™
• Planarization Capability
• Challenge of low K CMP
• Information of low K wafer
• Results of low K wafers
  – Surface finish
  – E-test results
• Summary
Appearance of Pads

TWI’s Hard Porous Pad

Rodel’s IC1000
## Physical Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Hard Porous Pad</th>
<th>IC 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness / mm</td>
<td>1.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Hardness / shore D</td>
<td>51 – 57</td>
<td>52 - 62</td>
</tr>
<tr>
<td>Density / g/cm³</td>
<td>0.61</td>
<td>0.75</td>
</tr>
<tr>
<td>Compressibility / %</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Rebound / %</td>
<td>75</td>
<td>73</td>
</tr>
<tr>
<td>Modulus / Mpa</td>
<td>250*</td>
<td>300 **</td>
</tr>
<tr>
<td>Pore Size / µm</td>
<td>10 - 100</td>
<td>10 -80</td>
</tr>
</tbody>
</table>

* Bulk modulus from compression measurement; ** storage modulus from DMA @ 40 °C.
Manufacturing Method of Hard Porous Pad

Consistency is not limited by technology (sheet vs cake)

Single layer and continuous manufacturing
Effect of Pad Properties on Polishing Performance

• Removal rate:
  – slurry transport; slurry retention capability
• NU
  – Slurry transport; pad hardness; compressibility
• Defectivity
  – Pad hardness; capability to remove polishing residue
• Planarity / dishing - erosion
  – Pad hardness; modulus; stiffness
• Pad life
  – Conditioning method, thermal stability
Features of Hard Porous Pads

- Excellent lot-to-lot, pad-to-pad consistency
- Open pore structure improves slurry transport
  - Can operate at significantly lower flow rate
  - Better non-uniformity
- Open pore structure becomes easier to remove polishing residue
  - Lower defect
- Requires minimal break-in and conditioning
  - Reduce tool down time
  - Extend conditioner lifetime
  - Longer pad life
Step Height Reduction

Step Height Reduction (TWI Cu-940 / Hitachi C430-A18)

- 10/10 micron
- 50/50 micron
- 100/100 micron

Copper removal only / IPEC 472
SEM Cross-Section Profile

50 / 50 micron structure
Dishing and Erosion

Copper polish: Hitachi C430-A18 (4 psi / 110 rpm)
Barrier polish: Planar 10K-2 (2 psi / 110 rpm for 60 s)

<table>
<thead>
<tr>
<th>Structure (L/S)</th>
<th>Copper polish</th>
<th>Barrier polish</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 X 100</td>
<td>800</td>
<td>&lt;300</td>
</tr>
<tr>
<td>50 X 50</td>
<td>700</td>
<td>&lt;200</td>
</tr>
<tr>
<td>9 X 1</td>
<td>&lt;200</td>
<td>&lt;200</td>
</tr>
<tr>
<td>1 X 1</td>
<td>&lt;200</td>
<td>&lt;200</td>
</tr>
</tbody>
</table>

Results are average of center, mid, and edge die
Challenge of Low K CMP

M. Mills & M. McClear: *Future Fab Int.* Vol 11

Adhesion: barrier / cap; cap / low K; low K / hard mask

Mechanical failure: crack; high defect;
## Low K Material Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spin-On Low K</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Inorganic - Porous</td>
<td></td>
</tr>
<tr>
<td>Dielectric Constant</td>
<td>2.2</td>
<td>CV Dot at 1 MHz</td>
</tr>
<tr>
<td>Modulus</td>
<td>3.50 +/-0.1 (0.6µm)</td>
<td>Nanoindentation</td>
</tr>
<tr>
<td>Hardness</td>
<td>0.35 +/-0.02 (0.6µm)</td>
<td>Nanoindentation</td>
</tr>
<tr>
<td>Pore Size (Average)</td>
<td>2.0 nm</td>
<td>BET</td>
</tr>
<tr>
<td>Stability at 425°C</td>
<td>&lt;1%</td>
<td>ITGA at 425°C (%/hr) post cure in N2 ambient</td>
</tr>
<tr>
<td>Stress</td>
<td>20 MPa ; Tensile</td>
<td>Flexus</td>
</tr>
<tr>
<td>CTE</td>
<td>10 ppm/°C</td>
<td>In-Plane Wafer Curvature</td>
</tr>
</tbody>
</table>

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Integration Scheme for Porous Inorganic Low K

TEOS
Low K
SiN

Cu seed
Barrier
TEOS
Low K
SiN

TEOS
Low K
SiN

EP Cu
Cu seed
Barrier
TEOS
Low K
SiN
CMP Process

- EP Cu
- Cu seed
- Barrier
- TEOS
- Low K
- SiN

Copper Removal
Cabot 5003
2.5 psi / 110 rpm

Barrier Removal
Planar 10K-2 / HS T805
2 psi / 110 rpm
Direct CMP of Blanket Porous Low K Films

- Good adhesion observed between porous low k and oxide cap with barrier slurry polish.
- No scratches observed after CMP.
The absolute resistance difference is due to trench depth. The median resistance of low K is proportional to that of oxide wafer. Barrier slurry has minor effect on distribution profile.
Summary

• Hard Porous Pad has been successfully used for copper / low K CMP
  – Good dishing and erosion
  – Good surface finish
• Hard Porous Pad is compatible with different slurries
  – Different barrier slurries has minimal effect on resistance