Hard Porous Pad™ for Copper CMP

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Thomas West, Inc.
Introduction – Pad Classification

- Solid Polyurethane Sheet
  - Example: IC2000
- Polyurethane with void
  - Isolated void; e.g., IC1000, FX 9
  - Interconnected void
- Polyurethane with abrasive
  - Fixed abrasive pad / table
- Felt impregnated with polyurethane
  - TWI: 817, 813, hard porous pads; Rodel: Suba series
  - Pad properties can be tailored for specific application by adjusting porosity, ratio of polyurethane to fiber.
- Poromeric
  - TWI: BP-30; Rodel: Politex;
# Evolution TWI Porous Pads

<table>
<thead>
<tr>
<th>Year</th>
<th>Pad</th>
<th>Density / g/cm³</th>
<th>Hardness / Shore D</th>
<th>Compressibility / %</th>
<th>Rebound / %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>W plug 817</td>
<td>0.35</td>
<td>70 (A)</td>
<td>4.5</td>
<td>85</td>
</tr>
<tr>
<td>1997</td>
<td>W plug 813</td>
<td>0.37</td>
<td>30 - 35</td>
<td>2.4</td>
<td>76</td>
</tr>
<tr>
<td>2000</td>
<td>W plug 711</td>
<td>0.59</td>
<td>49 - 55</td>
<td>2.3</td>
<td>85</td>
</tr>
<tr>
<td>2002</td>
<td>Ox, STI, Cu &amp; W 830 &amp; 940</td>
<td>0.61</td>
<td>51 - 57</td>
<td>2.2</td>
<td>75</td>
</tr>
</tbody>
</table>

pad

Thomas West Inc.

Materials Development for Process Excellence
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.
Impact of Fiber on Pad Properties

• Create continuous pore (inter-connect pore)
  – RR, NU, defect

• Improve mechanical properties of pads*
  – Hardness: 51 – 57 for hard porous pad; ~46 for IC 1000 if density = 0.61 g/cm$^3$.
  – Modulus: IC 1000’s storage modulus will become 200 Mpa if the density = 0.61 g/cm$^3$.

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
Lot-to-Lot Consistency

Process Stability

Pads used at fab A and B are from different lots.
Pad-to-Pad Consistency

Icues-5001 (P1) / 10K-2 (P2) / Mirra @ 3 psi

Stdev ~ 200 A/min

Platen 1 Cu RR

Platen 2 Cu RR

Platen 2 TEOS RR
Slurry Flow Rate Impact on Performance

![Graph showing slurry flow rate impact on performance with data points for Process A and Process B. BKM ~200 ml/min.]

Hard Porous Pad can operate at wide range of slurry flow rate.
Polishing behavior does not follow Preston at full process range.
Performance Stability

Marathon Baseline

Fixed time + EPD

baseline pad life ~300

Icue-5001 / Mirra
Pattern Wafer Performance

Icue-5001 for copper removal / 10K-2 for barrier removal / Mirra
Compatible with Different Slurries

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

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

Copper removal only / IPEC 472
For Barrier Removal Application

<table>
<thead>
<tr>
<th>H$_2$O$_2$ Process</th>
<th>1.20% Cu TEOS</th>
<th>2.00% Cu TEOS</th>
<th>3.00% Cu TEOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 psi; 93/87; 150 ml/min</td>
<td>184 526</td>
<td>169 474</td>
<td>376 403</td>
</tr>
<tr>
<td>2 psi; 93/87; 200 ml/min</td>
<td>291 558</td>
<td>313 431</td>
<td></td>
</tr>
<tr>
<td>3 psi; 93/87; 150 ml/min</td>
<td>620 884</td>
<td>546 768</td>
<td></td>
</tr>
</tbody>
</table>

Selectivity can be tuned by changing:
- Peroxide concentration
- Slurry flow rate
- Process parameters
Summary

<table>
<thead>
<tr>
<th>Wish list</th>
<th>Hard Porous Pad offers:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance:</strong></td>
<td><strong>Performance:</strong></td>
</tr>
<tr>
<td>Good RR and NU</td>
<td>Excellent consistency</td>
</tr>
<tr>
<td>Low defect</td>
<td>Good RR and NU</td>
</tr>
<tr>
<td>Low dishing and erosion</td>
<td>Low dishing and erosion</td>
</tr>
<tr>
<td>Easy to use (conditioning)</td>
<td>Easy to use (conditioning)</td>
</tr>
<tr>
<td>Stable performance</td>
<td>Very stable process</td>
</tr>
<tr>
<td><strong>Cost:</strong></td>
<td><strong>Cost:</strong></td>
</tr>
<tr>
<td>Long pad life</td>
<td>High throughput</td>
</tr>
<tr>
<td>Minimal slurry flow rate</td>
<td>Longer pad life</td>
</tr>
<tr>
<td>Cheap</td>
<td>lower slurry usage</td>
</tr>
<tr>
<td>Gentle conditioning</td>
<td>Longer conditioner life</td>
</tr>
</tbody>
</table>