CMP Challenges for Ultra Low K Integration

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INTRODUCTION
Graphical interpretation of Moore’s Law
## Commonly referenced dielectric film used in Semiconductor Fabrication

<table>
<thead>
<tr>
<th>Low-k and ULK Dielectric Materials</th>
<th>Approximate k-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td></td>
</tr>
<tr>
<td>SiO2</td>
<td>4.0</td>
</tr>
<tr>
<td>FSG</td>
<td>3.6 - 3.8</td>
</tr>
<tr>
<td>First gen CVD CDO (carbon doped oxide)</td>
<td>3.0 - 3.3</td>
</tr>
<tr>
<td>MSQ / DEMS</td>
<td>2.8 - 3.0</td>
</tr>
<tr>
<td>Organic spin-on</td>
<td>2.6 - 2.9</td>
</tr>
<tr>
<td>Second gen CVD Porous CDO</td>
<td>2.4 - 2.6</td>
</tr>
<tr>
<td>Porous MSQ / PDEMS</td>
<td>2.0 - 2.5</td>
</tr>
<tr>
<td>Air gap (future)</td>
<td>1.4 - 1.8</td>
</tr>
</tbody>
</table>
Current and future potential interconnect module integrations for various technology nodes.

- 130nm
- 90/65nm
- 45nm
- 32nm
**Schematic Description of PDEMS**

**Porous OSG Films by PECVD**
(PDEMS™ ILD Process)

DiEthoxyMethylSilane (DEMS™ ILD Precursor)
Forms organosilicate matrix

C<sub>x</sub>H<sub>y</sub> Organic Porogen Precursor
Forms porogen to enable porous film

PLASMA Substrate

Post-Treatment (UV/Vis)
Removes Porogen
Fortifies Network

Composite OSG - Organic Film
Ref: US 6,583,948 and US 6,846,515

Porous OSG

Ref: ISTC 2007 - ECS
CMP INTERACTIONS
Young’s modulus as a function of dielectric constant for a wide range of low-k and ULK films.
Calculated dielectric constant vs. porosity
Post CMP Cleaning
Post CMP Cleaning Performance Comparison

As Polished with Barrier Slurry

pCMP Clean with good Cleaner

pCMP Clean with bad Cleaner
Effect of Filtration of Copper Slurry on Defectivity Performance

![Graph showing the effect of filtration on copper rate and defectivity performance. The graph compares Cu Rate and DCO Post counts across different filtration splits (5um/5um, 10um/3um, 5um/3um).]
Effect of Filtration of Barrier Slurry on Defectivity Performance

![Bar Chart showing Total LPD counts for different barrier slurries: A, B, C, and D. The chart indicates that barrier slurry A has the highest LPD count, followed by B, C, and D.]
ICPMS data for trace metals on TEOS wafers using 2 different post CMP cleans.

<table>
<thead>
<tr>
<th>SURFACE CONCENTRATION ( x 10^{10} \text{ atoms/cm}^2)</th>
<th>Method Detection Limits</th>
<th>Old Clean</th>
<th>New Clean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aluminum (Al)</td>
<td>0.3</td>
<td>49</td>
<td>9.5</td>
</tr>
<tr>
<td>2. Calcium (Ca)</td>
<td>0.3</td>
<td>4.3</td>
<td>1.4</td>
</tr>
<tr>
<td>3. Chromium (Cr)</td>
<td>0.06</td>
<td>&lt;0.06</td>
<td>0.061</td>
</tr>
<tr>
<td>4. Copper (Cu)</td>
<td>0.02</td>
<td>0.73</td>
<td>1.8</td>
</tr>
<tr>
<td>5. Iron (Fe)</td>
<td>0.1</td>
<td>0.93</td>
<td>0.18</td>
</tr>
<tr>
<td>6. Magnesium (Mg)</td>
<td>0.1</td>
<td>0.37</td>
<td>0.23</td>
</tr>
<tr>
<td>7. Nickel (Ni)</td>
<td>0.05</td>
<td>0.076</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>8. Potassium (K)</td>
<td>0.2</td>
<td>160</td>
<td>200</td>
</tr>
<tr>
<td>9. Sodium (Na)</td>
<td>0.2</td>
<td>3.0</td>
<td>1.4</td>
</tr>
<tr>
<td>10. Titanium (Ti)</td>
<td>0.05</td>
<td>0.18</td>
<td>0.19</td>
</tr>
<tr>
<td>11. Zinc (Zn)</td>
<td>0.05</td>
<td>10</td>
<td>0.098</td>
</tr>
</tbody>
</table>
Defect maps on Coral dielectric using two different cleaning chemistries.

Water-mark Free Drying

Coral wafer cleaned with older generation cleaning chemistry

Coral wafer cleaned with specialized low-K cleaner (CP72B)
(Most of the defects are non-clean related)
FTIR Characterization

Cleaning chemistry does not affect the chemical structure of the dielectric
Commercial Cleaning Chemistry
CP72b Acidic pCMP Formulation

PDEMS film

CP72b is benign to dielectric network.
Future Directions
Acknowledgements

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