Post-CMP cleaners for tungsten at advanced nodes

Ruben R. Lieten, Daniela White, Thomas Parson, Shining Jenq, Don Frye, Michael White — Entegris, Inc.
Lieve Teugels, Herbert Struyf — imec

SCOPE OF WORK

- Design of formulated post-CMP cleaners for W plugs with TiN as barrier liner,
detectricts SiO₂ and Si₅N₃ for use at 10 mm technology node (40 nm metal pitch)

INTRODUCTION

- W bulk and barrier CMP slurries consist of:
  - (a) abrasive particles (fumed alumina or silica: fumed or colloidal)
  - (b) oxidizer (usually H₂O₂): W(VI)O₃ for removal by slurry abrasive
  - (c) H₂O₂ decomposition accelerator
  - (d) W corrosion protection additive
- Particle charge in low pH W CMP slurries are usually positive (isoelectric point, pHₐₐₐ₀ₐ₀ₐ₀ₐ₀ₐ₀ₐ₀ = 6-8 and pHₐₐₐₐₐ₀₀ = 2-4).
- W surface is always negatively charged at pH =3 (pHₐₐₐ₀ₐ₀ₐ₀ₐ₀ = 2.3) → strong electrostatic attraction W surface and residual particles during PCMP cleaning.

Significant surface contamination after CMP: abrasive particles, organic residue, pad debris, metal cations.

RESULTS AND DISCUSSION

- Corrosion: Minimized Galvanic corrosion by using new and specific ligands that adsorb on metal or barrier liner → additional passivation less noble material
- Particle cleaning: Upon mixing with AG-W100, all nanoparticle dispersions reversed charges from positive to negative (Al₂O₃, WO₃) or became more negatively charged (SiO₂, SiC) → strong repulsion (from Zeta Potential)
- Organic residue cleaning:
  - Contamination takes place during post-CMP rinsing with DI water
  - Organics disappeared after 1 cleaning of SiN with AG-W100 (FTR-ATR)
  - Defectivity: 300 nm CMP = better cleaning
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  - AMAT Reflexion® LK polishing tool with integrated brush cleaner (Desica)
  - IC1010 pad, silica abrasive slurry (100 nm particle size), PVA brushes
  - Defect inspection by laser light scattering (SP3, KLA-Tencor Corp.)
  - dAmmonia as reference W and other metals are significantly etched
  - dAmmonia dissolves some of the SiO₂, surface and particles
  - Significant progress in removal of organic residues
  - AG-W100 represents a significant improvement in cleaning
  - CIP2: unique cleaning additive designed to disperse silica and prevent reattachment to SiO₂ surface

TABLE 1: PLANARCLEAN® AG-W100 FORMULATION ADDITIVES LIST – FUNCTION AND MECHANISM

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
<th>Mechanism</th>
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<tbody>
<tr>
<td>A</td>
<td>Non-TMAH pH adjustor</td>
<td>W surface hydroxylation and good wetting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negative surface charge surface of wafer and contamination</td>
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<tr>
<td>B &amp; C</td>
<td>Complexing agents</td>
<td>Surface modification of particles to prevent agglomeration and re-precipitation</td>
</tr>
<tr>
<td>D</td>
<td>Dispersing agents</td>
<td>Prevent aggregation and control etch rate</td>
</tr>
</tbody>
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APPROACH

- Two main cleaning approaches:
  - (1): W surface charge reversal, using cleaning additives able to adsorb at the W surface. Other cleaning additives prevent residue redeposition.
  - (2): Particle charge reversal and electrostatic protection using organic additives → strongly negative charged surfaces → best cleaning.

SUMMARY

- Two main approaches followed: (1) reverse W surface charge; (2) particle charge reversal.
- Latter approach results in strongly negative charged surfaces and best cleaning.
- AG-W100 represents a significant improvement in cleaning.
- CIP2 shows the best performance on W, SiN and SiO₂ blanket.
- This feature enables advanced node W cleaning for memory devices.

Figure 1: Number of defects (particles and organic residue) pareto on Reflexion Entegris
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Number of defects pareto (≥60 nm defects)