Impact of CMP buffing chemistry on defects level for interconnections on CMOS processing

**CMP Users Meeting**

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**D.JEANJEAN**

Damien JEANJEAN
Olivier ROBIN
Sebastien GAILLARD
David GALPIN
Grégoire DUCOTYEY
Frédérique TRENTESEAUX
Olivier HINSINGER

*STMicroelectronics, Crolles – France*
• Motivation of the study
• Buffing step introduction
• Chemistry Buffing step introduction results
  • Defectivity, D0 electrical data
• Discussion on defects removing mechanism
• Conclusions
IC evolution is driven by:
- Cost reduction
- Complexity
- Performances
- Miniaturization

Dimension reductions induce new technological challenges.
Introduction of new interconnect materials have driven the development of new CMP and post-CMP cleaning applications.
Among CMP defectivity catalogue ➔ Slurry balls are potentially serious killer defects

- Why?

- Silica balls used as abrasive in commercially available slurries
  - Ø from 25nm to 120 nm
  - with different solid content %

Size to be compared to the lines width of latest technologies nodes

<table>
<thead>
<tr>
<th>ITRS Roadmap</th>
<th>M1/MX pitch</th>
<th>Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 nm node</td>
<td>M1/MX pitch</td>
<td>130/140nm</td>
</tr>
<tr>
<td>32 nm node</td>
<td>M1/MX pitch</td>
<td>90/100nm</td>
</tr>
<tr>
<td>22 nm node</td>
<td>M1/MX pitch</td>
<td>60/70nm</td>
</tr>
</tbody>
</table>

Silica balls can be left post CMP process: how it impacts the lots processing?
Motivation of the buffing step introduction

- In line defects characterization
  - Defectivity review done post CMP Cu line 1 & post hard mask etch line 2
  - Silica slurry residues let by CMP generate topography on subsequent dielectrics inducing mispatterning

- Defects could generate shorts and metals opens
- POR cleaning solution and benchmark with other chemistry in brushes not enough efficient

Need to address this defectivity ➔ Platen 3 buffing Step introduction
Experiments description

Low pressure Platen 3 buffing
DIW POR is compared to alcalin chemistry dispense

POR acidic chemistry in cleaner is kept

The experiment sequence is
- Over rinse in brush box1 beginning

<table>
<thead>
<tr>
<th>Chemistries</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry</td>
<td>Alkaline</td>
</tr>
<tr>
<td>Buffing step</td>
<td>Alkaline</td>
</tr>
<tr>
<td>Cleaner</td>
<td>Acidic</td>
</tr>
</tbody>
</table>
Major defectivity results on lots

Post CMP def inspection

- Defectivity trend after buffing step introduction
- Huge reduction of corrosion defect type
- No change on other defects types

Post etch hard mask line2 def inspection

- Balls are form previous level embedded
- A) Split lot analysis
  - Slurry balls defects density / 10 vs POR
- B) Defectivity trend after buff introduction
  - Gain confirmed
Majors Yield D0 electric results

M2 Shorts vs M1 split

- Metal 2 Shorts: Split lot analysis
  - Buffing step allows to reduce Metal shorts vs POR

<table>
<thead>
<tr>
<th>M2 shorts vs M1 split</th>
<th>POR</th>
<th>Buffing step</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0 (a.u.)</td>
<td>x</td>
<td>-38%</td>
</tr>
</tbody>
</table>

M2 Opens vs M1 split

- Metal 2 Opens: Split lot analysis
  - Buffing step allows to reduce Metal Opens vs POR

<table>
<thead>
<tr>
<th>M2 opens vs M1 split</th>
<th>POR</th>
<th>Buffing step</th>
</tr>
</thead>
<tbody>
<tr>
<td>D0 (a.u.)</td>
<td>x</td>
<td>-23%</td>
</tr>
</tbody>
</table>
Discussion - Slurry particles removal in 2 steps

Silica particles deposit

- Post POR CMP process, 2 cases:
  - Embedded in Cu-BTA positively charged
  - Free balls on both surfaces

Stage 1: silica particles removing: P3 buffing with alkaline chemistry

- Allowing strong surface repulsion from dielectrics
  - Due to strong negative Zeta potential
    - Zeta Potential values: ~ -80mV, ~ -55mV
  - Weaker effect on Cu-BTA removing

Stage 2: silica particles removing: brush cleaning with acidic chemistry

- Allowing to remove faster Cu-BTA residues
- And the Embedded silica particles
  - Avoid redeposition
  - Weaker effect on free slurry balls
Summary

• New CMP buffing chemistry has been introduced on platen 3

  • The chemistry sequence is then alcalin chemistry on p3 following by acidic chemistry in cleaner

  • Allowing the removing of free slurry balls let on wafers and clusters balls embedded in Cu-BTA residues

    • A longer life brush can be expected

  • A reduction of defects type as corrosion and slurry balls has been measured on lots monitoring the line

• Opens and Shorts D0 level reduction has been measured.

• Buffing P3 impact and results is slurry dependant:

  • Next: Solid abrasive size and BTA content to be carefull in the choice of next technology nodes slurries
Thanks for your attention