3M™ Trizact™ Pad Conditioners for FEOL Tungsten Plug and Metal Gate Applications

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3M™ Trizact™ Pad Conditioner Marathon Testing

- **W plug process with Trizact™ B5-M990-5S2**
  - 30 hour marathon (TOX dummy wafers and W monitor wafers measured every hour),
  - Consumable set B (ex-situ conditioning):
    - Slurry B/Pad B with
      - 3M Trizact B5-M990-5S2 disk (commercial)
      - Sintered abrasive A165 disk (POR)

- **W metal gate process with Trizact™ B6-M990-5S2**
  - 20 hour marathon (TEOS and W monitor wafers measured every hour)
  - Consumable set B (ex-situ conditioning):
    - Slurry B/Pad B with
      - 3M Trizact B6-M990-5S2 (experimental)
      - Sintered abrasive A165 disk (POR)
Conditioner Description

• B5-M990-5S2 (MC3113)
  - Nominal Primary Tip height 160µm
  - ~5% Primary tips
  - Complex Multi-faceted structure
  - Aspect ratio: sharp

• B6-M990-5S2 (MC3112)
  - Nominal Primary Tip height 160µm
  - ~5% Primary tips
  - Complex Multi-faceted structure
  - Aspect ratio: sharper

Commercial

Experimental
Trizact™ B5-M990-5S2 and B6-M990-5S2 PWR and SF BenchTop Data

PWR, SF: Trizact B6 > Trizact B5.
Tool Conditions (Bulk W Test) (P1 and P2) – 300 mm AMAT Reflexion™

Polish Head and Platen Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platen Speed</td>
<td>73 rpm</td>
</tr>
<tr>
<td>Head Speed</td>
<td>67 rpm</td>
</tr>
<tr>
<td>High wafer df</td>
<td>RR=3.8, Z1=3.3, Z2=1.6, Z3=1.4, Z4=1.3, Z5=1.3 psi</td>
</tr>
<tr>
<td>Slurry Flow Rate</td>
<td>300 mL/min</td>
</tr>
<tr>
<td>Head Sweep</td>
<td>Sinusoidal sweep, 10 zones</td>
</tr>
<tr>
<td>Zones</td>
<td>7.00 to 8.02 inches</td>
</tr>
<tr>
<td>Slurry</td>
<td>W slurry B</td>
</tr>
<tr>
<td>Pad</td>
<td>Pad B</td>
</tr>
<tr>
<td>Polish Head</td>
<td>Contour</td>
</tr>
<tr>
<td>Dummy Wafers</td>
<td>Thermal Oxide</td>
</tr>
<tr>
<td>Rate Monitor</td>
<td>W wafer</td>
</tr>
</tbody>
</table>

Conditioner Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Speed</td>
<td>81 rpm</td>
</tr>
<tr>
<td>Sweep</td>
<td>Linear sweep, 19 sweeps/min</td>
</tr>
<tr>
<td>Zones</td>
<td>2.5&quot; (a) to 12.75&quot; (b)</td>
</tr>
<tr>
<td>Conditioning Time</td>
<td>60 secs (100% ex-situ)</td>
</tr>
<tr>
<td>Cond downforce</td>
<td>9 lbs</td>
</tr>
<tr>
<td>Break-in Cond downforce</td>
<td>9 lbs for 30 mins (in DIW, ex-situ)</td>
</tr>
</tbody>
</table>

Note (a) may require adjustment to avoid collision with polish head

Note (b) disk must not travel beyond 12.75"

All consumables and parameters including the downforce on the wafer (1.3 psi vs 2.5 psi) for this test selected based on customer’s input
Marathon Test With Slurry B and Pad B Trizact™ B5-M990-5S2 and SA A165 (ex-situ)

Extended Run Process Results: W RR and NU, 3M Trizact B5, SA A165, 9 lbs CDF, 1.4 psi Wafer df, W Slurry B, Pad B

W Slurry B and Pad B (ex-situ conditioning) – Longer life and more stable RR/NU with Trizact B5 vs SA A165.
Pad Wear Rate (PWR) and Surface Finish Using Laser Groove Depth Analysis (LGDA) for Trizact® B5-M990-5S2, and SA A165 with Pad B and Slurry B at 30 hrs

Pad wear rate was at least 3 to 4 times higher with SA A165 vs Trizact B5. Surface finish was the same.
SEM Images – Trizact™ B5 after Marathon Test (Ex-situ Conditioning)

CVD Coating is intact after 30 hours of ex-situ conditioning (100%) with Trizact B5
Pad Asperity Distribution Analysis (A165, Trizact™ B5 –M990-5S2), Pad B, Slurry B, Ex-situ at 30 hours

Pad abruptness, lambda is higher and asperity truncation is smaller with pad associated with Trizact B5-M990-5S2 compared to pad conditioned with SA A165 at 30 hours.
Trizact™ Pad Conditioner: Tungsten Gate CMP Process Development

- W Metal Gate or Buff (20% ex-situ conditioning; 9 lbs df, 1.4 psi wafer df)
  
  - Slurry B/Pad B/ Trizact B6-M990-5S2
  - Benchmark: A165 conditioning disk (POR)
  - Performance Target: Stable TEOS RR (250 A/min)
  - Consumable Life Target: Conditioner: 20 hours; 7000 wafers (Current baseline (~3 hours; 1000 wafers)
Trizact B6 rate remained stable throughout the test close to the target rate of 250 A/min. The rate drops off with A165 primarily due to pad balding.
W Metal Gate - TEOS Removal Rate Profiles – Pad B, Slurry B,

Similar TEOS RR profiles between Trizact B6 and SA A165 (POR)
EOL Marathon Test With W Metal Gate Process With Trizact™ B6-M990-5S2 Disk, Pad B and Slurry B – Oxide RR and NU

TEOS Removal Rate vs Conditioning Time
3M Trizact B6
Pad B, Slurry B, 9lbs DF, 1.4 psi, 20% exsitu conditioning

Stable Oxide RR and NU with Trizact B6 disk at target rate = 250 A/min
EOL Marathon: Metal Gate Process With Trizact™ B6-M990-5S2 Disk Pad B, Slurry B- W RR and NU

Stable W RR and NU with Trizact B6 disk at target rate ~ 600 A/min
SEM Image of Trizact™ B6-M990-5S2 after EOL Marathon Test

CVD coating showing minimal wear after 20 hours of ex-situ conditioning with Trizact B6-M990-5S2
SUMMARY

- The utility of 3M™ Trizact Pad Conditioners for W plug and metal gate processes is demonstrated.

- A 3M™ Trizact™ Pad Conditioner reduced the pad wear rate by a factor of 3 or more, compared to a traditional SA conditioner, while maintaining the same W rates and non-uniformities for a W plug process with ex-situ conditioning. A corresponding improvement in pad life is expected.

- For W metal gate process, the more aggressive Trizact™ B6 Pad Conditioner was needed to polish and maintain stable TEOS rate.

- A Trizact™ B6 Pad Conditioner was used for about 18 hours in a W metal gate process, maintaining the same TEOS and W removal rates under typical POR conditions. This is expected to lead to a dramatic increase, > 3X, in the number of wafers processed per pad, compared to a conventional SA conditioner.