Advanced Tungsten CMP with No Pad Conditioning

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• Process Data Using ASP-W3525 Pads

• Process Qualification and Production Results
  • Extended run
  • Contamination data
  • Lot-to-lot consistency

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Background Information

- Entrepix provides professional outsource CMP for everything from prototypes and development work through volume outsource production.

- Desired properties for a tungsten CMP production process:
  - Excellent pad-to-pad and lot-to-lot consistency
  - Reasonable removal rate and very low uniformity
  - Low defectivity
  - Minimal conditioning (zero if possible)
  - Long pad life

- Multiple pads screened and best performance achieved with the psiloQuest ASP-W3525 pad.
Peroxide Concentration Study

RR Study comparing Down-Force @ % H2O2 concentration variations

Polisher: IPEC 472
Slurry: Cabot SSW-2000
• Simplified DOE shows strongest response to oxidizer concentration

• Negative slope for removal rate vs table speed is likely an artifact of simplified design
AMAT Mirra Process DOE Results

- Membrane pressure (downforce) is largest predictor coefficient
- Wide process margin on all other variables tested
- Consistent with trends observed in IPEC 472 data
Least Squares Fit

<table>
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<tr>
<th>Response</th>
<th>W-RR</th>
<th>W-WIWNu</th>
<th>W-Pad temp</th>
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Recent data taken on Ebara EPO222 polisher

- Downforce (DF) has the biggest effect on measured response parameters
- TurnTable (Table Speed) has very minimal effect on the response parameters.
- As expected, tungsten RR (W-RR) increases as Downforce (DF) increases.
- BSP has mild inverse effect on W-RR, W-WIWNu and W-Pad Temperature.
Pad Variability Study

• Polishing data taken across multiple pads
  - Total of 20 ASP-W3525 pads
  - Includes 5 different raw material lots

• Rate and uniformity data taken on 3 monitor wafers per pad
  - All polishing performed on IPEC 472 polisher at psiloQuest apps lab
  - Data compiled into single dataset for comparison

• Demonstrates excellent pad-to-pad consistency across multiple lots
Multi-Lot Removal
Rate Variation

Distributions

P-RR (MIN)

- 2750
- 2700
- 2650
- 2600
- 2550
- 2500
- 2450
- 2400
- 2350

Moments

- Mean: 2532.7365
- Std Dev: 94.865909
- Std Err Mean: 11.027938
- upper 95% Mean: 2554.7151
- lower 95% Mean: 2510.7578
- N: 74
Multi-Lot WIWNU Variation

**Distributions**

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</table>

**Moments**

- Mean: 2.638
- Std Dev: 0.4834226
- Std Err Mean: 0.05778
- upper 95% Mean: 2.753268
- lower 95% Mean: 2.522732
- N: 70
Production Qualification

• **Elements of Rapid Qual Plan**
  - 50-wafer baseline run for blanket film rate and uniformity
  - SIMS/TXRF data showing residual contamination levels
  - Defectivity
  - Device yield on multiple split lots

• **Results**
  - All qualification runs completed in very short timeframe
  - Comparison to in-fab process showed equal or better performance on all critical metrics
First attempt 50-wafer baseline run

Date: March 2004
Polisher: IPEC 472
Pad: psiloQuest
Slurry: Cabot SSW-2000 (diluted 1:1 + 4% H2O2)
Conditioning: None
**Key Points**

- **Comparison to IC1000 shows equal or better performance**
- **All values from Entrepix lab are less than or equal to fab reference**

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Cross section of completed via

- Excellent plug planarity and controlled recess.
- End-of-line device yield equivalent between outsourced CMP and existing qualified fab process.
Blanket Film Qual Data through Pad Life

Cumulative Polish Time = 2,561 minutes
Over 100 production lots across multiple pads showing very repeatable polishing performance
Conclusions

• The psiloQuest ASP-W3525 tungsten CMP pad provides:
  - Excellent pad-to-pad and lot-to-lot consistency
  - Reasonable removal rate and very low uniformity
  - Zero conditioning required
  - Low defectivity
  - Long pad life

• Through Entrepix, the end customer has achieved:
  - Immediate capacity with no capital outlay
  - Product yield equivalent to current fab in-house production
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