Keeping Your CMP Slurry From Being A Pain in the As-Probed Die Yield
Outline

Background

Generalized Diagnostics

Examples

Summary
Background

• Components of successful CMP
  – Polisher+pad+slurry+conditioning+wafer+film+luck
• Process has been in manufacturing for >15 yrs
  – Excursions and deviations still occur
  – Control limits on most wafer metrics keep shrinking
  – Downtime is costly … scrap is even more costly!
• Slurry is a key factor for all major CMP processes
  – Removal rate, selectivity, roughness, dishing, erosion, defect density, etc. can all be affected by slurry
  – Storage and distribution are critical
Why is this important?

Higher large particle counts (LPC) = higher defects

Slurry properties have a DIRECT connection to polished wafer defect metrics.

Downtime and scrap both have a high cost.
Fishbone Diagram

Things that make you go HMMM …

- A helpful brainstorming tool
- Results easily transfer to FMEA (if desired)
A familiar sequence to any fab process engineer …

The key is to find root cause and get back on line as quickly as possible!
Diagnostic Sequence

- End of pad life
- Conditioner life
- Filter (if used)
- Peristaltic tubing
- Calibration drift
- Valve (post-loop)
- Pump (if present)

Single Tool → Fix and Verify
Example #1

Observations
- Toolset running stable
- One idle polisher was brought back on line and failed defect quals on successive tries
- LPC tail shows delta between slurry loop and sample at platen

Solution
- Perform PM on tool
- Returned to baseline so further action not required
Diagnostic Sequence

Single Tool
- End of pad life
- Conditioner life
- Filter (if used)
- Peristaltic tubing
- Calibration drift
- Valve (post-loop)
- Pump (if present)

Multi-Tool Commonality
- Sudden onset?
- Slurry lot change
- Loop filter change
- Test wafer lots
- Operating setpoints
- Pumps
- Valves

Fix and Verify
Example #2

Observations

• Oxide CMP
• Rate qual failure
• Simultaneous shift in uniformity

• Series of similar qual fails on multiple tools
• No shift in defects
Solution #2

Diagnostics

• Label possibly related events on chart
• Clear timing with new slurry lot (new tote)

Short Term “Fix”

• Purge / flush / refill
• Recharge with a different slurry lot

Long Term Improvements

• Improved control at slurry manufacturer
• In-line monitoring for pH and S.G. (% solids)
Observations

- Particle monitor installed for passive data collection
- Small random spikes in 2um and 5um bins correlate with wafer level defect qual data
- No commonality to tool, pad changes, etc.
- Coincided with a fraction of drum changes
Diagnostics

- Loose commonality to certain lots of slurry
- Filtration tests promising

Short Term “Fix”

- Purge / flush / refill
- Transfer filter
- Continue monitoring

Long Term Improvements

- LPC and defect qual data correlation confirmed
- Early flag for engineering on any OOC data point at transfer
Diagnostic Sequence

Single Tool
- End of pad life
- Conditioner life
- Filter (if used)
- Peristaltic tubing
- Calibration drift
- Valve (post-loop)
- Pump (if present)

Multi-Tool
- Sudden onset?
- Slurry lot change
- Loop filter change
- Test wafer lots
- Operating setpoints
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Trend Analysis
SLURRY PARMS
- Slurry pH
- Density (or S.G.)
- Concentration [X]

WAFER DATA
- Rate / Uniformity
- Defects (qual)
- Defects (on product)

SERVICE OPERATIONS
- System settings
- Pump rebuild life
- Batch transfers
- Drum switchovers

Fix and Verify
Example #4

Observations

- Tungsten CMP
- Random qual failures
- Some recovery after pad changes

- Observed on multiple tools

- No shift in defects
Solution #4

Diagnostics

- Plot with trend line
- Assay slurry [H2O2]
  - Fresh mix
  - In loop

Short Term “Fix”
- Purge / flush / refill
- Manual [H2O2] monitor

Long Term Improvements
- Avoid excess day tank volume (keep turnovers reasonable)
- In-line monitoring for [H2O2] and auto-dose replenishment
**[H2O2] Decay**

**Bench Test**
- Single batch of tungsten slurry
- Target mix 3% H2O2
- Circulated in clean loop with data point taken every 10 min.

**Result**
- Strong [H2O2] decay observed over roughly 12 hours
- Similar effects occur in global loops, though possibly with different time constants depending on design
• Partially completed fishbone for particle qual failures

GROUPINGS OF POSSIBLE ROOT CAUSES

- Human
  - Inadvertent change
  - Wrong slurry/chemical
  - Data entry error
  - Wrong recipe
  - Valve or pump fail
  - Peristaltic tubing
  - Leaks
  - Calibration drift
  - Control system

- Machine

- Materials
  - Contamination
  - End of filter life
  - Slurry pot life
  - Pad / conditioner life
  - Slurry lot

- Methods
  - Poor process optimization
  - Poorly designed loop
  - PM frequency or scope
  - Insufficient monitors
  - Inadequate tool clean

Things that make you go HMMMM …
Summary

• Slurry is one of the most critical ingredients for maintaining a consistent CMP process
• When excursions occur (and they do), the key is to find the problem quickly
• Follow a systematic troubleshooting approach
• Design (or redesign) slurry delivery methods to minimize risks AND accumulate the proper data for efficient troubleshooting
Thank you

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