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

Single Tool

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

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
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)
Example #3

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

![Graph showing particle counts over time with specific incidents and their respective particle sizes and counts.]

July 21: High PSD counts from drum in agreement with Defectivity
Solution #3

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

Trend Analysis
- SLURRY PARMS
  - Slurry pH
  - Density (or S.G.)
  - Concentration [X]
- WAFER DATA
  - Rate / Uniformity
  - Defects (qual)
  - Defects (on product)

Fix and Verify
- SERVICE OPERATIONS
  - System settings
  - Pump rebuild life
  - Batch transfers
  - Drum switchovers
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**

**FAILURE**
- Human
  - Inadvertent change
  - Data entry error
  - Wrong recipe
- Machine
  - Valve or pump fail
  - Peristaltic tubing
  - Leaks
  - Calibration drift
  - Control system
- Methods
  - Contamination
  - Poor process optimization
- Materials
  - End of filter life
  - Slurry pot life
  - Pad / conditioner life
  - Slurry lot
  - Slurry lot
  - Poorly designed loop
  - PM frequency or scope
  - Insufficient monitors
  - Inadequate tool clean

**Things that make you go HMMM …**
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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