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

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Outline

Background

Generalized Diagnostics

Examples

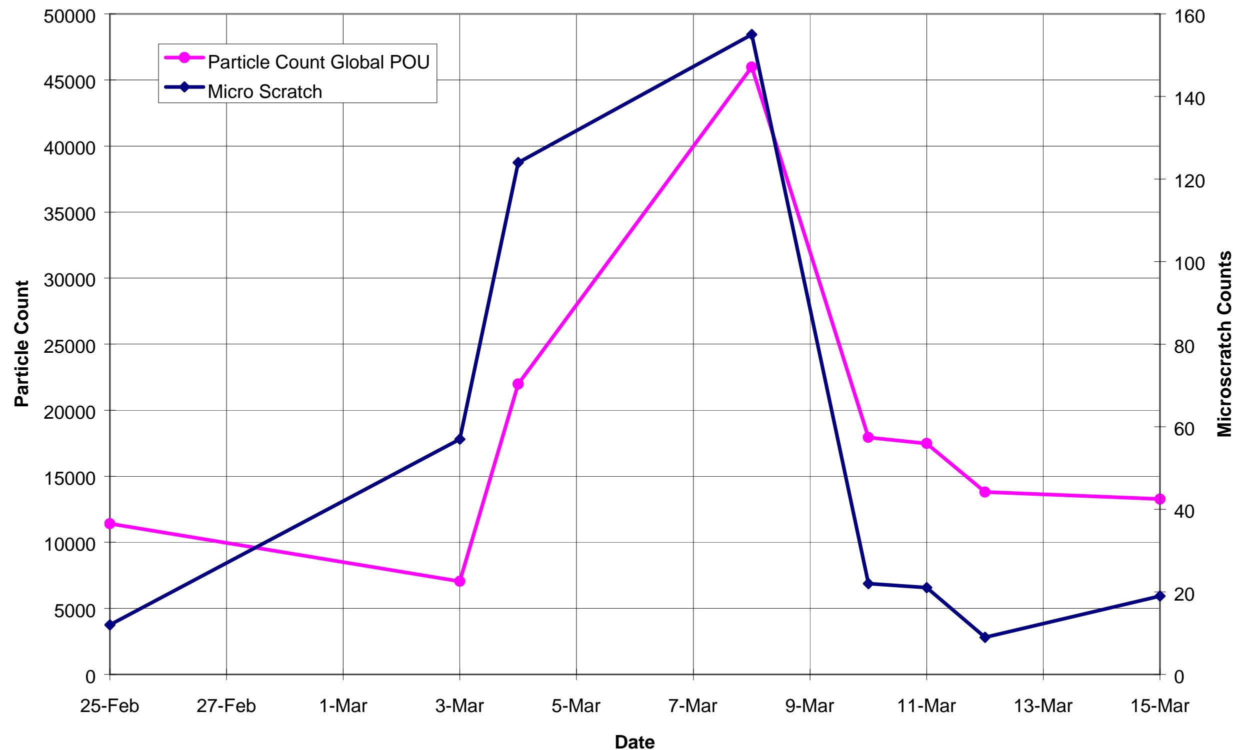
Summary

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

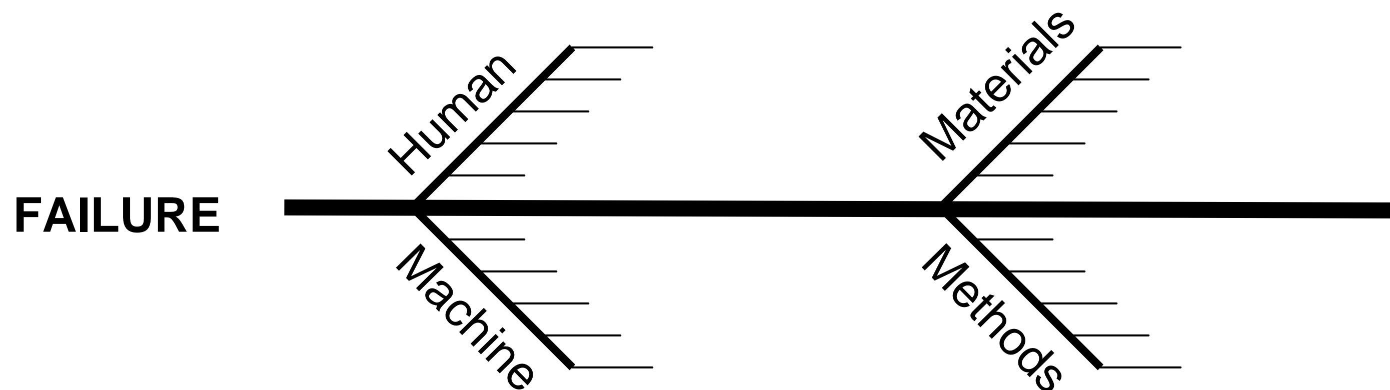


Slurry properties have a DIRECT connection to polished wafer defect metrics.

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)

General Sequence

Failure

A familiar sequence to any fab process engineer …

CMP Process Off Line → Diagnostics & Troubleshooting → Does process pass qual ?

Yes → Release to Mfg

No → Diagnostics & Troubleshooting

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

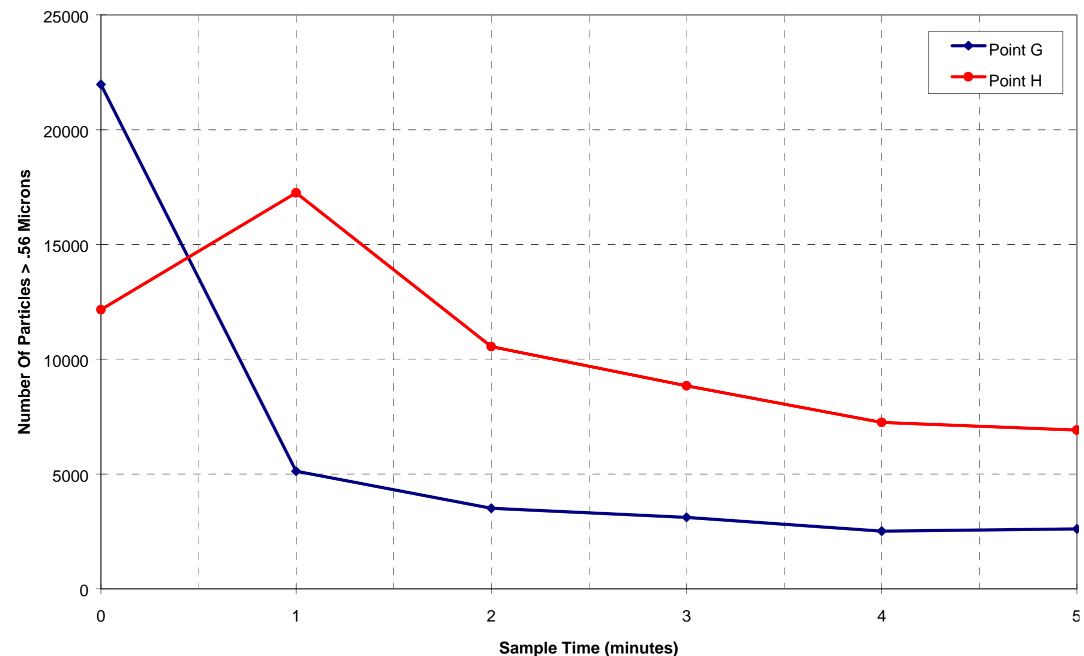
Diagnostic Sequence

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

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

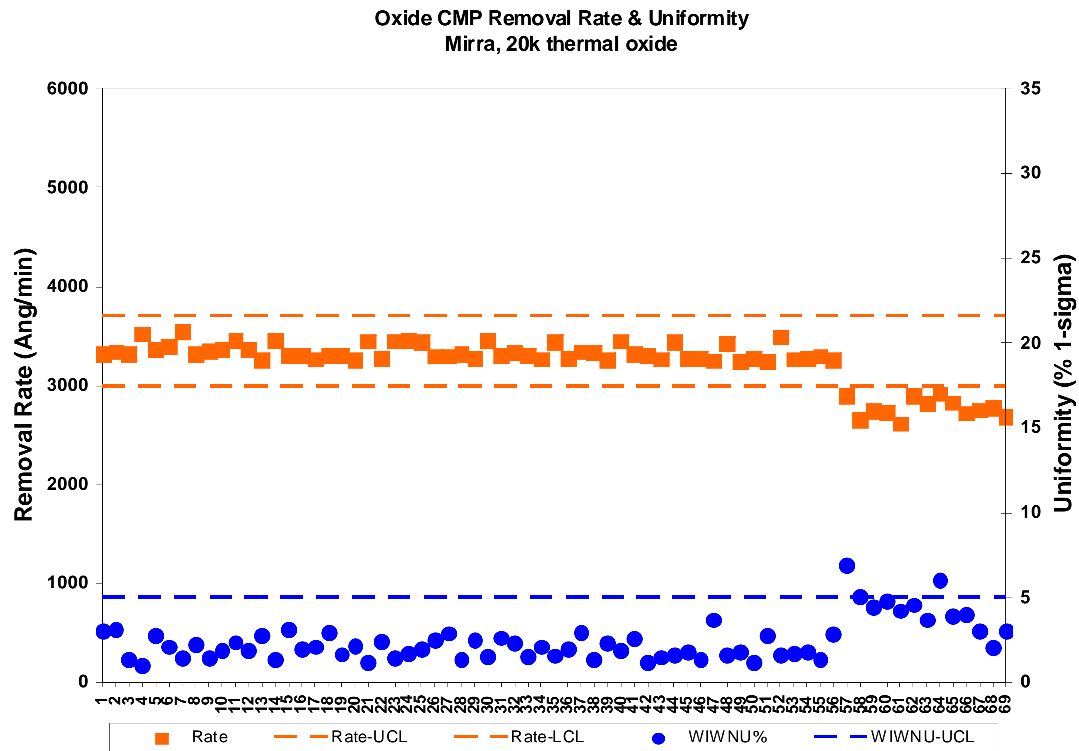
- End of pad life
- Conditioner life
- Filter (if used)
- Peristaltic tubing
- Calibration drift
- Valve (post-loop)
- Pump (if present)

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

Example #2

Observations

- Oxide CMP
- Rate qual failure
- Simultaneous shift in uniformity
- Series of similar qual fails on multiple tools
- No shift in defects



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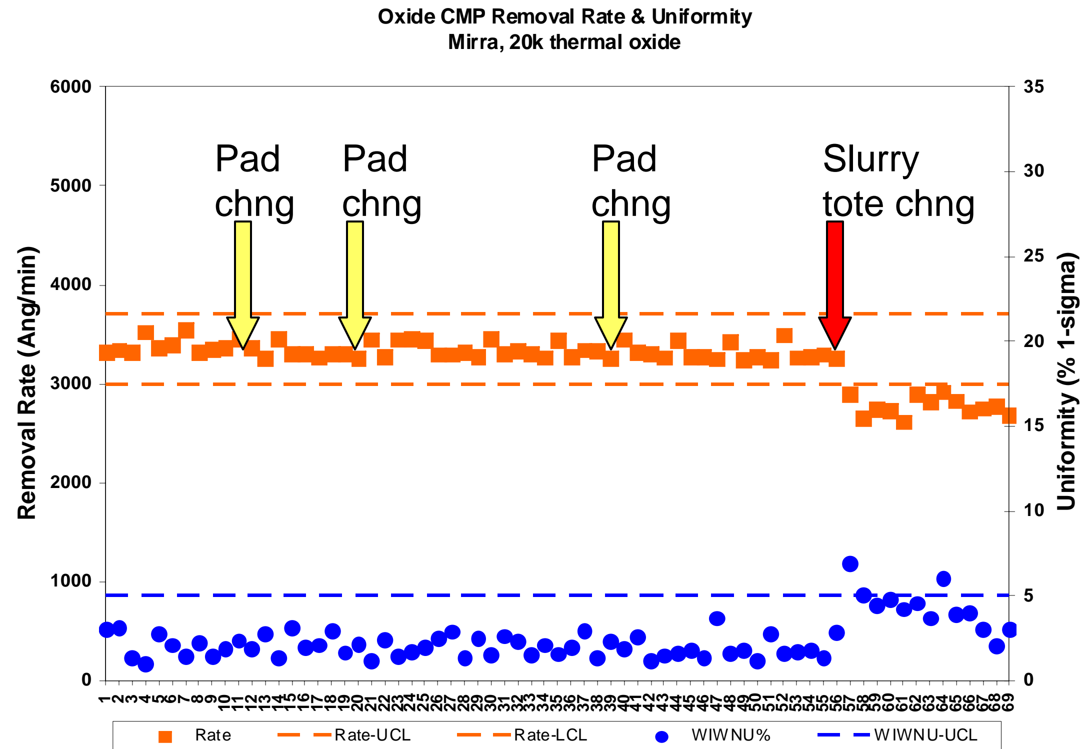
Solution #2

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



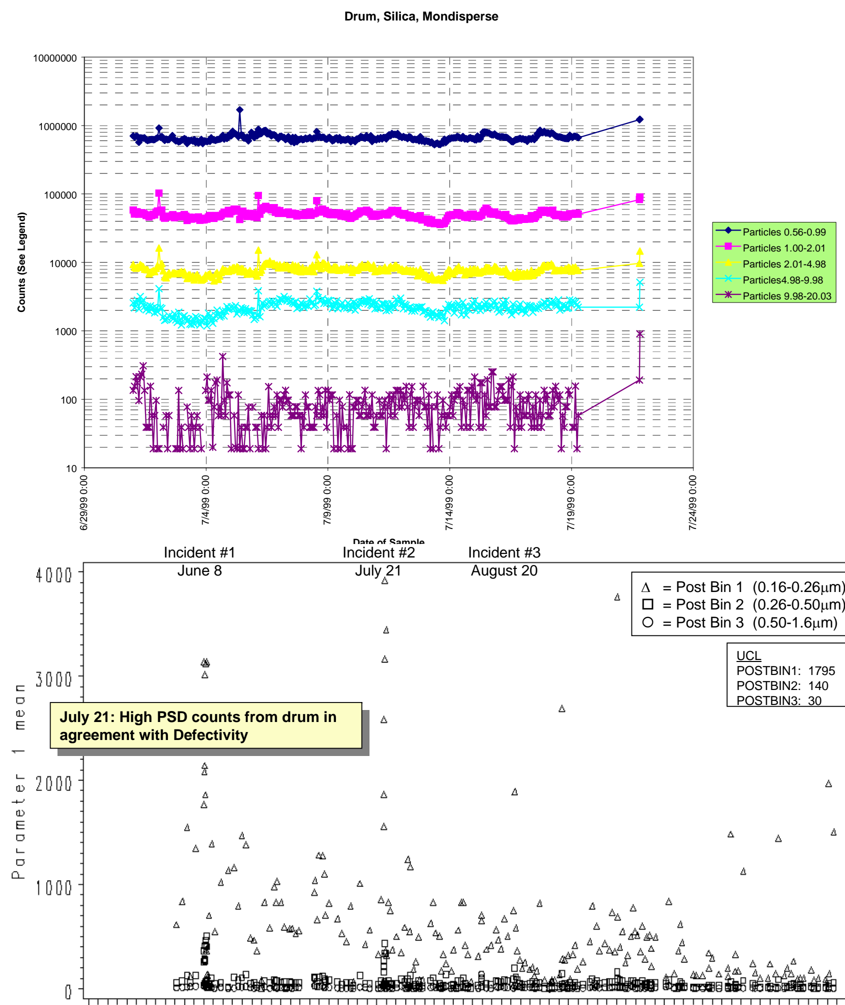
Long Term Improvements

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

Example #3

Observations

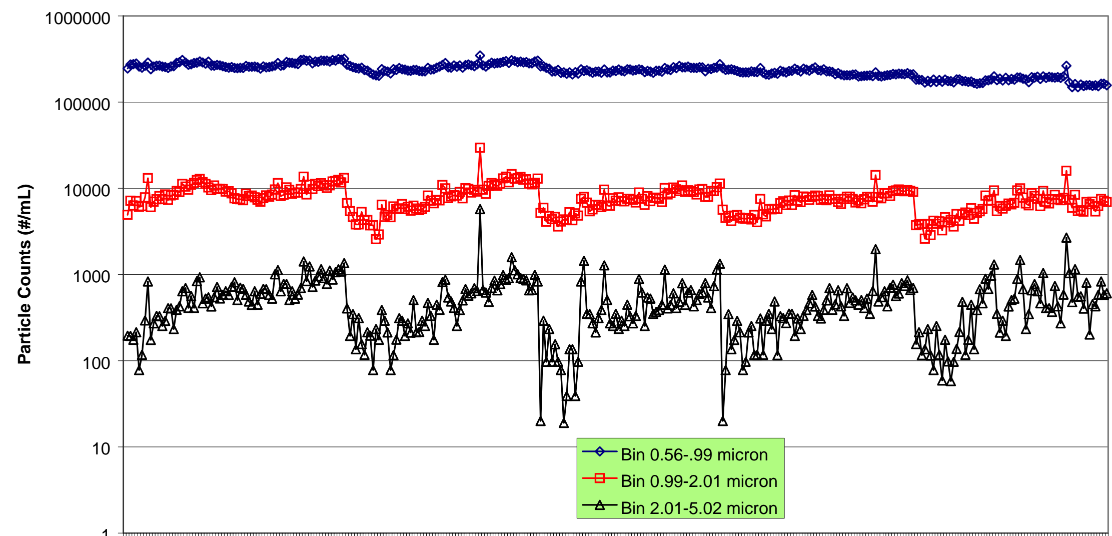
- Particle monitor installed for passive data collection
- Small random spikes in 2um and 5um bins correlate with wafer level defect qual data
- No commonality to tool, pad changes, etc.
- Coincided with a fraction of drum changes



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

- End of pad life
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- Sudden onset ?
- Slurry lot change
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- Test wafer lots
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SLURRY PARMS
- Slurry pH
- Density (or S.G.)
- Concentration [X]

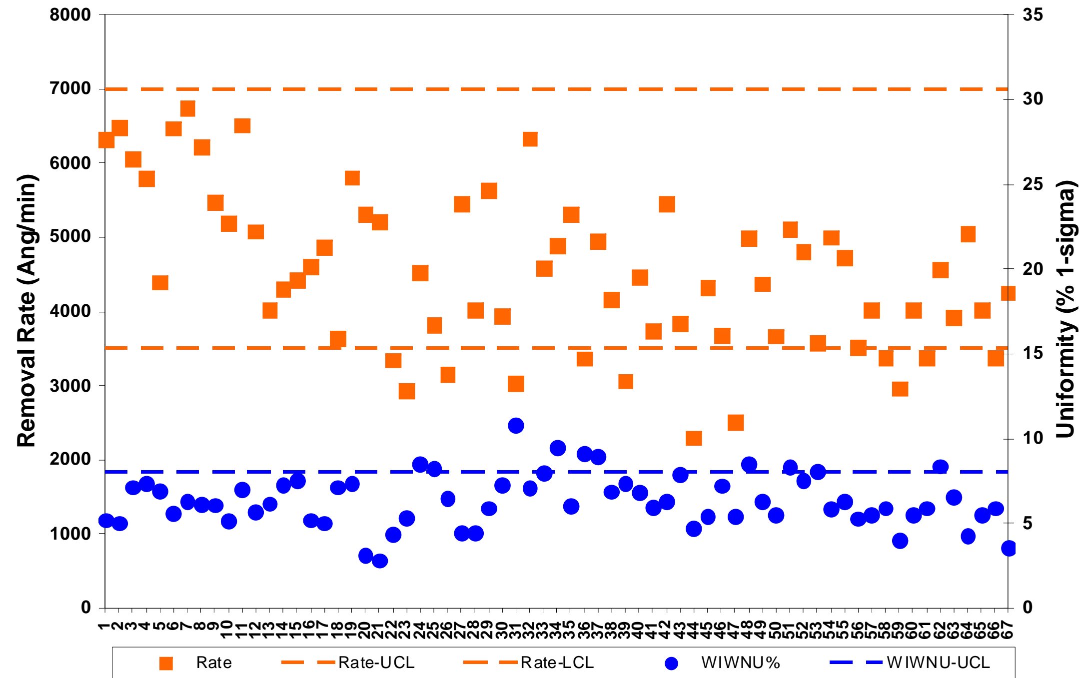
WAFER DATA
- Rate / Uniformity
- Defects (qual)
- Defects (on product)

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

Example #4

Observations

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



- Observed on multiple tools
- No shift in defects

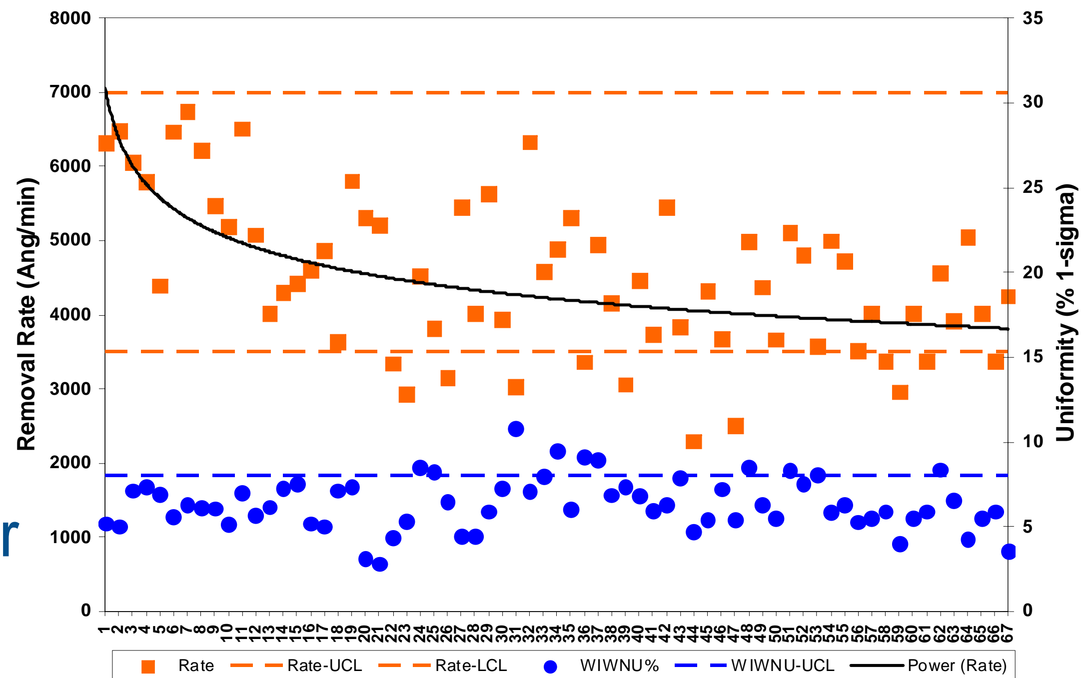
Solution #4

Diagnostics

- Plot with trend line
- Assay slurry [H_2O_2]
  - Fresh mix
  - In loop

Short Term "Fix"

- Purge / flush / refill
- Manual [H_2O_2] monitor



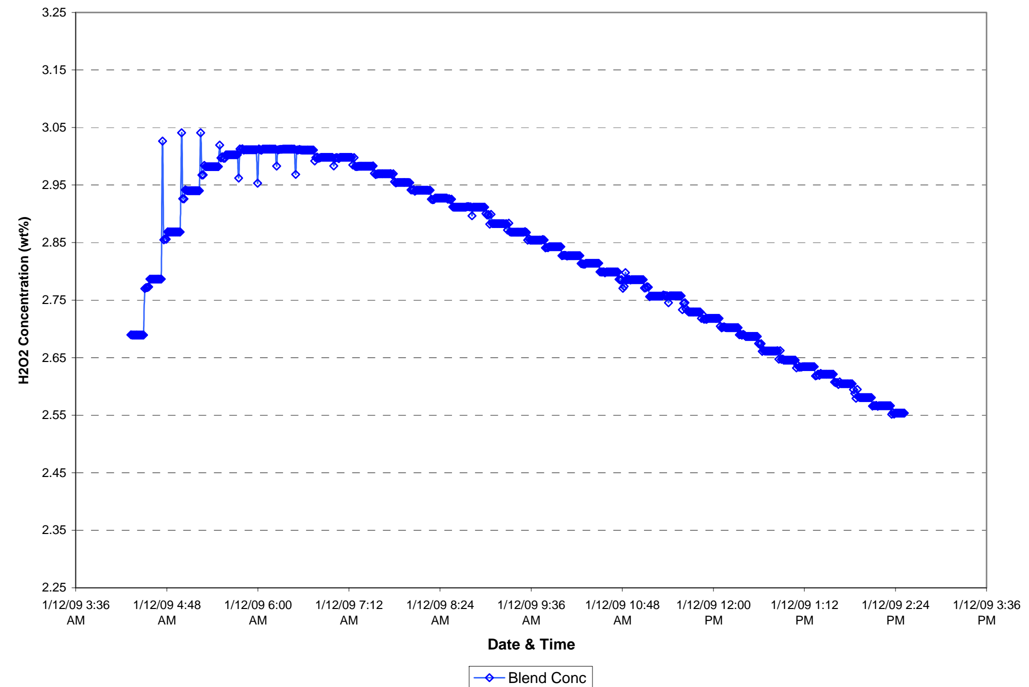
Long Term Improvements

- Avoid excess day tank volume (keep turnovers reasonable)
- In-line monitoring for [H_2O_2] 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.

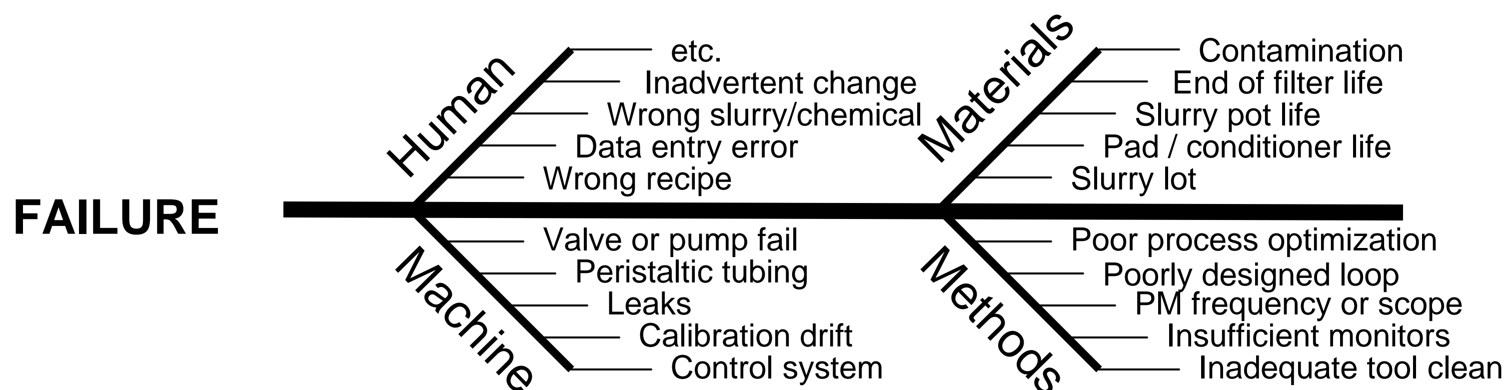


Result

- Strong [H2O2] decay observed over roughly 12 hours
- Similar effects occur in global loops, though possibly with different time constants depending on design

Fishbone Diagram

- Partially completed fishbone for particle qual failures



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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