



Field Validation of Sub-Micron Defect Correlation with ≥ 1 Micron Particle Behavior in Undiluted POU CMP Slurry

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Outline

- ▶ Groundrules
- ▶ Production Conditions
- ▶ Principles Confirmed

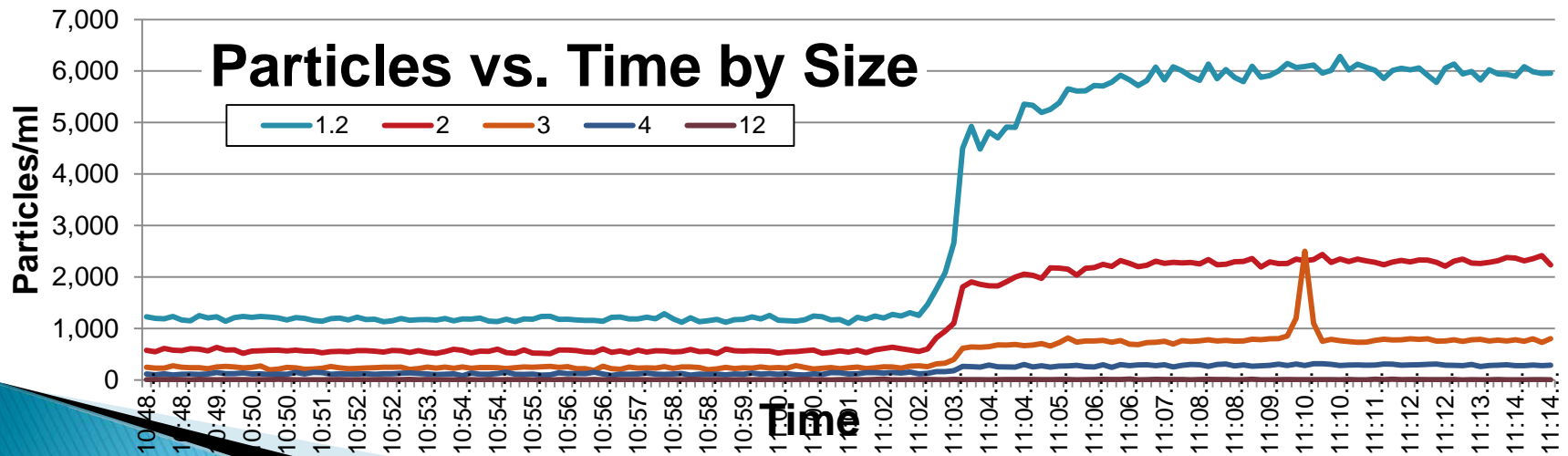
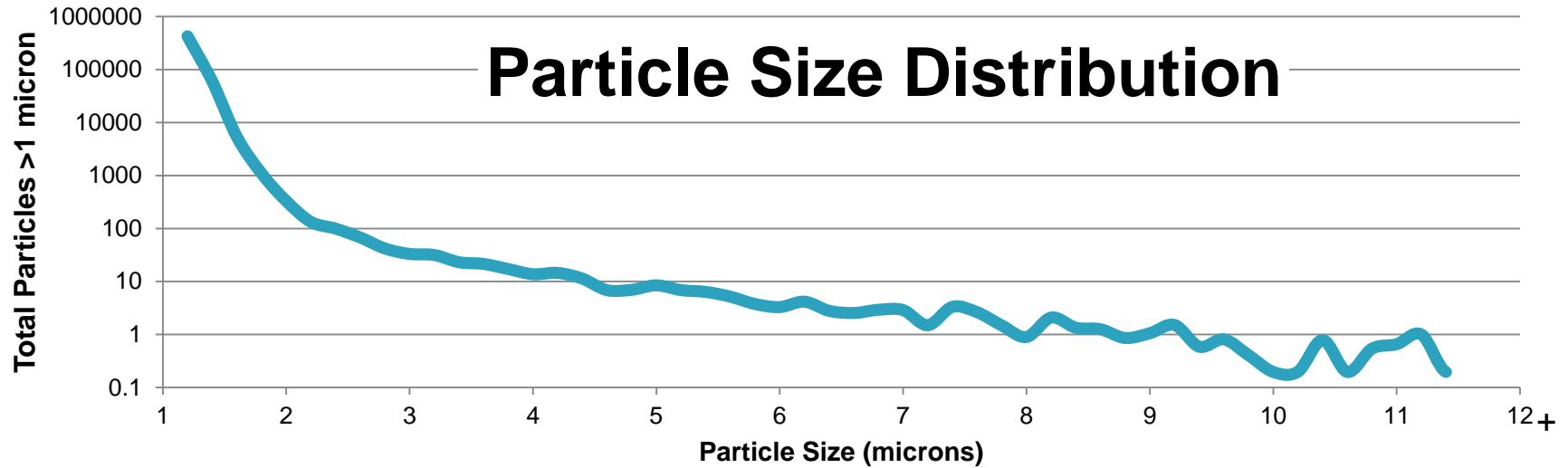
Groundrules

- ▶ ICPT 2014 abstract acceptance pending
 - Customer management has approved release
 - Details of fab correlation data will be released at that time
- ▶ Metadata: data about data
 - The lessons learned from this customer fab experience, combined with others, are the subject of this presentation

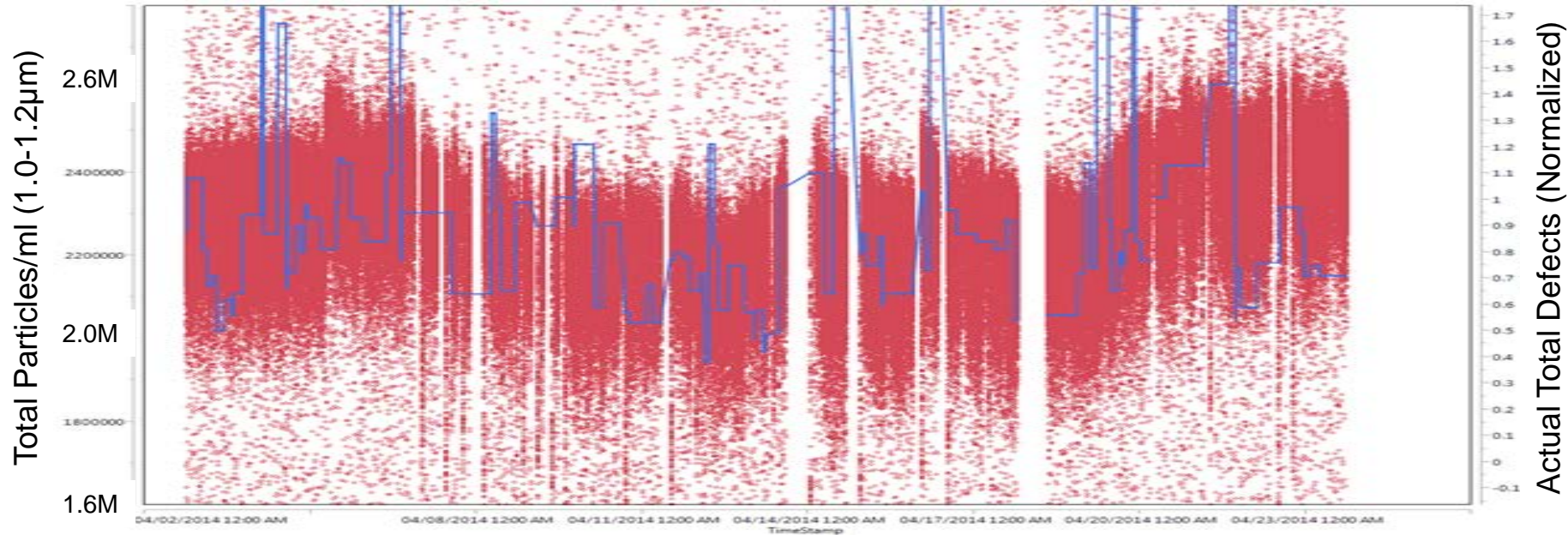
Production Conditions

- ▶ Chip manufacturing operation, fab floor
- ▶ Ceria slurry
- ▶ SlurryScope measuring inside the CMP tool *before* the POU slurry filter
- ▶ Continuous monitoring for 3 weeks during each wafer polish operation
- ▶ Correlation of LPC data to subsequent physical and electrical defect data for each wafer
- ▶ Standard statistical methods for complex data sets

SlurryScope Data Modes



Current Customer Data - Preview



- ▶ Expanded LPC vertical scale
- ▶ Normalized total defect data in blue
- ▶ 3 weeks of data along X-axis
- ▶ Blank spaces in data when not polishing

Principle #1 Confirmed

- ▶ Particle counts in the 1.0-1.2 μm size bin are a good proxy for what is happening in the majority sub-micron particle size distribution
 - For systemic slurry issues, large particles track the behavior of sub-micron particles
 - Continuous, real-time measurement of particles $>0.8\mu\text{m}$ in undiluted slurry is well demonstrated by SlurryScope
 - Comparable measurement $<0.8\mu\text{m}$ by any method remains an unsolved technical challenge

Principle #2 Confirmed

- ▶ There is signal in the noise
 - Small variations in stable LPC are the data that correlates with defects
 - Correlations that can be established over extended periods (several days, weeks) may be *undetectable* over shorter periods (hours, few days)

- ▶ Offline dilution particle data are noisy
 - Small sample size, infrequent measurements
 - Correlation to SlurryScope can be established over extended periods

Principle #3 Confirmed

- ▶ Batch-to-batch and tote-to-tote LPC differences comprise a significant driver for defect trends
 - Customers are asking slurry vendors to adapt methods and report SlurryScope data for QC

- ▶ LPC excursion events are *not* the defect driver in a stable SDS operation
 - Excursions are operational, largely self-inflicted
 - Identify the root cause and *STOP DOING THAT*
 - Defects may be caused by LPC excursions, but these are a separate population from the defects caused by systemic slurry changes

Principle #4 Confirmed

- ▶ The particles removed by filtration are not necessarily those that cause defects
 - SlurryScope measured $>1.0\mu\text{m}$
 - SlurryScope sampling was *before* the POU filter
 - After measurement, slurry passed through POU filter onto the polishing platen
 - *This is the SlurryScope data that correlated with defects*
- ▶ **Say it again:** LPC data for particles $>1.0\mu\text{m}$ is a good proxy for monitoring behavior of the sub-micron majority

Principle #5 Confirmed

- ▶ The smallest particle size bin carries systemic slurry information
 - Correlates with defects
 - Slurry tote and lot changes
 - Slurry pot aging
- ▶ Larger particle size bin data can be used to concurrently monitor operational events
 - Day tank changes
 - Filter changes
 - Pump changes

Final Thoughts

- ▶ One engineer was responsible for fab process operations and sub-fab slurry management
 - No “Upstairs Downstairs” contention
- ▶ The statistical data analysis methods used must be as sophisticated as the data itself
 - Simplistic number crunching can be easily overwhelmed by normal noise levels in the data
- ▶ Once SlurryScope data behavior is characterized in retrospect, methods can be developed for better managing fab operations and reducing defects

