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

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NCCAVS CMPUG
July 09, 2014

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Outline

▸ Groundrules

▸ Production Conditions

▸ Principles Confirmed
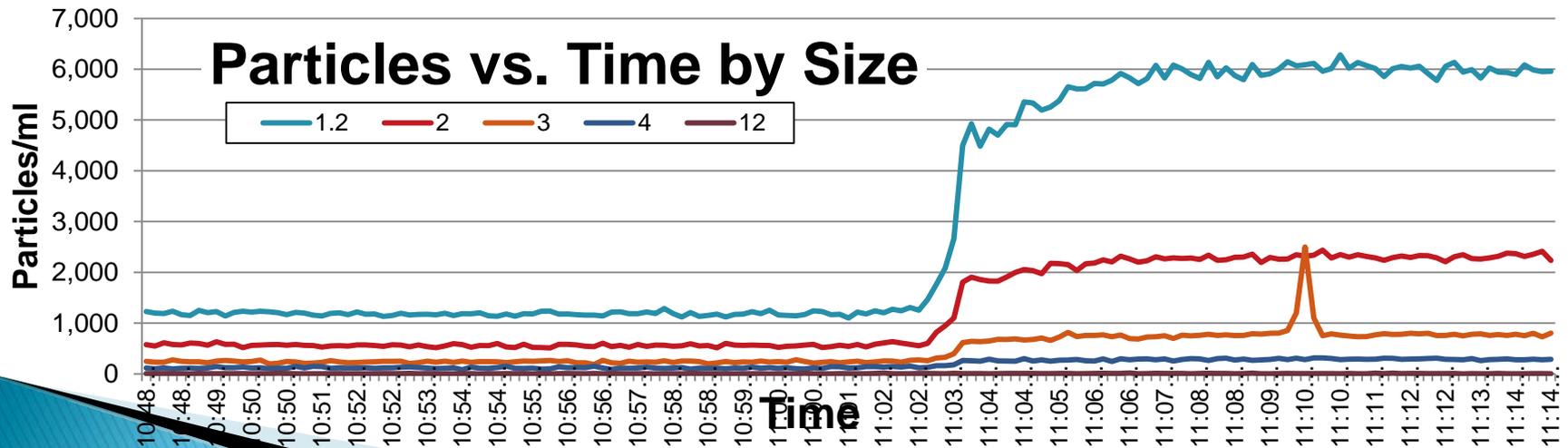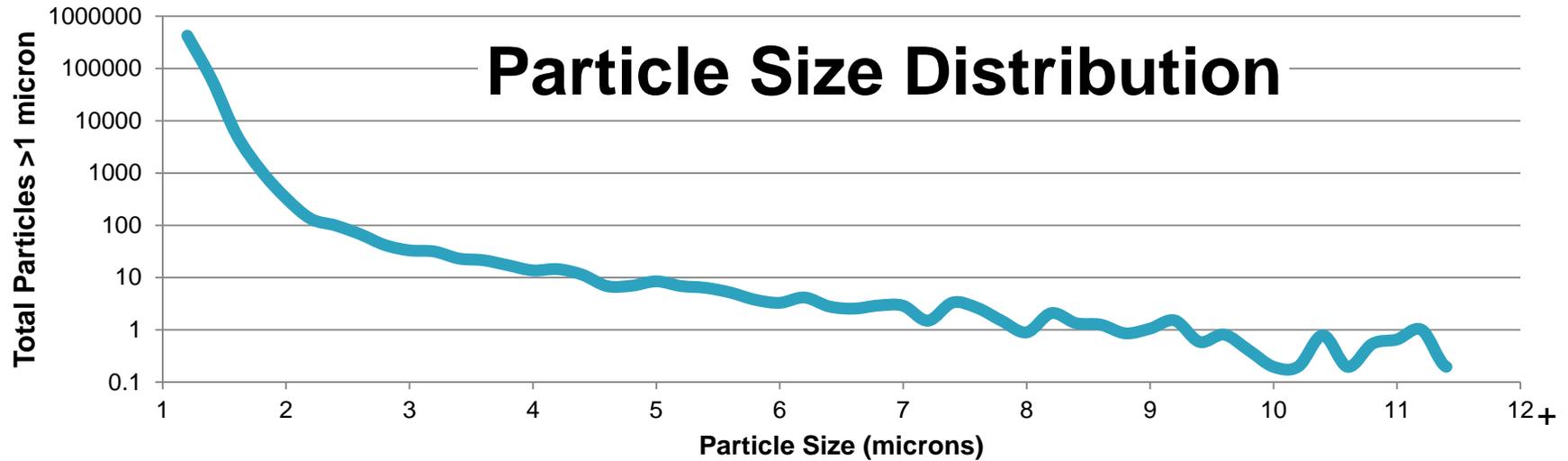
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Groundrules

▶ 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
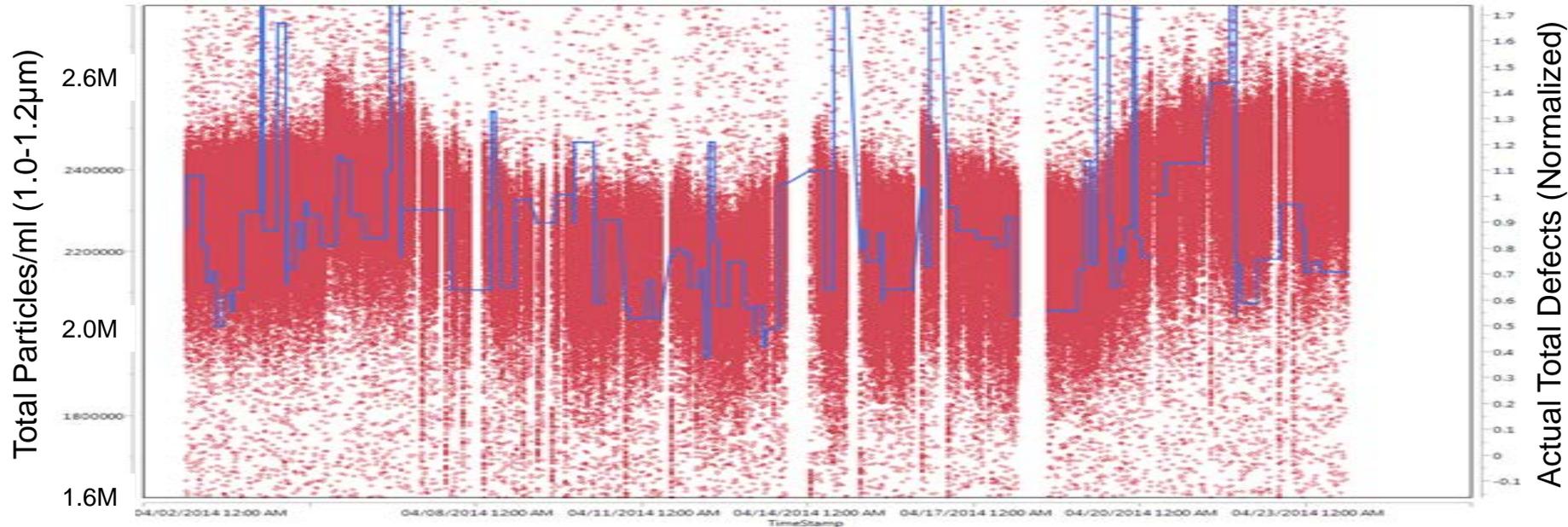
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Production Conditions

- 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

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SlurryScope Data Modes

Particle Size Distribution — chart of Total Particles >1 micron vs. Particle Size (microns)

Particles vs. Time by Size — chart of Particles/ml vs. Time, with series 1.2, 2, 3, 4, 12

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

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Principle #1 Confirmed

▸ Particle counts in the 1.0-1.2μm 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 >0.8μm in undiluted slurry is well demonstrated by SlurryScope
- Comparable measurement <0.8μm by any method remains an unsolved technical challenge

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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

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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

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Principle #4 Confirmed

▸ The particles removed by filtration are not necessarily those that cause defects
  ◦ SlurryScope measured >1.0μm
  ◦ 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 >1.0μm is a good proxy for monitoring behavior of the sub-micron majority

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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

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