



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 paper accepted
 - Joint publication: IM Flash Technologies & Vantage
 - Fab management has approved release
 - Details of fab correlation data will be presented in November

- ▶ Metadata: data about data
 - The lessons learned from this customer fab experience, combined with others, are the subject of this presentation

SlurryScope Experimental Setup

▶ Slurry Information

- Ceria based slurry
- 1-5% solids at point of use dilution
- Median particle size: ~ 150 nm
- Slurry flow rate target: 15 ± 1 mL/min

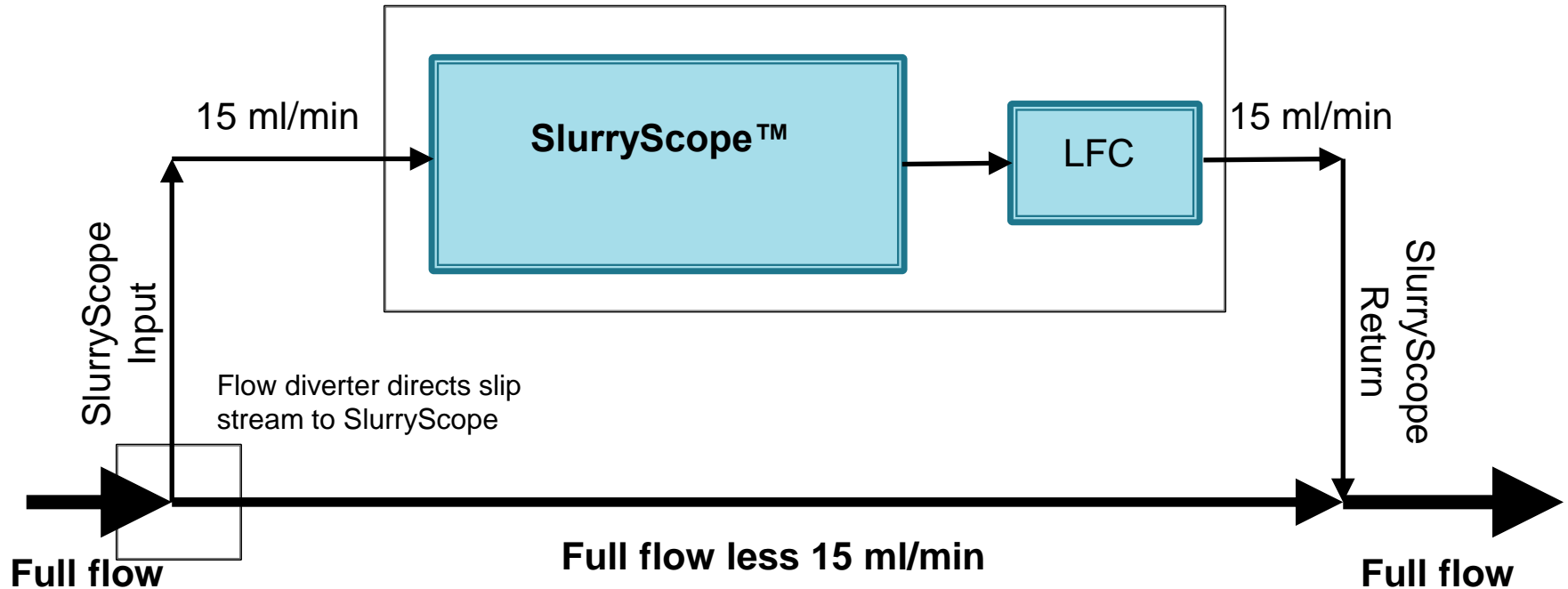
▶ Phase 1

- SlurryScope placed under the platen
- Sample taken at slurry input to the polisher before the POU filter
- Data collection triggered by the pneumatic signal used to open slurry valve supplying the polisher
- ~1 minute data collection with **1 second accumulation interval**
- Stop data collection when slurry flow drops below 14 mL/min

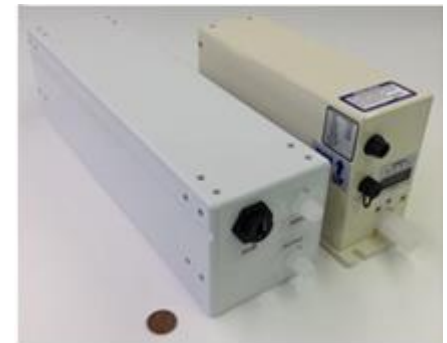
▶ Phase 2

- Sample taken in the CMP tool chase
- Continuous data collection with **10 second accumulation interval**

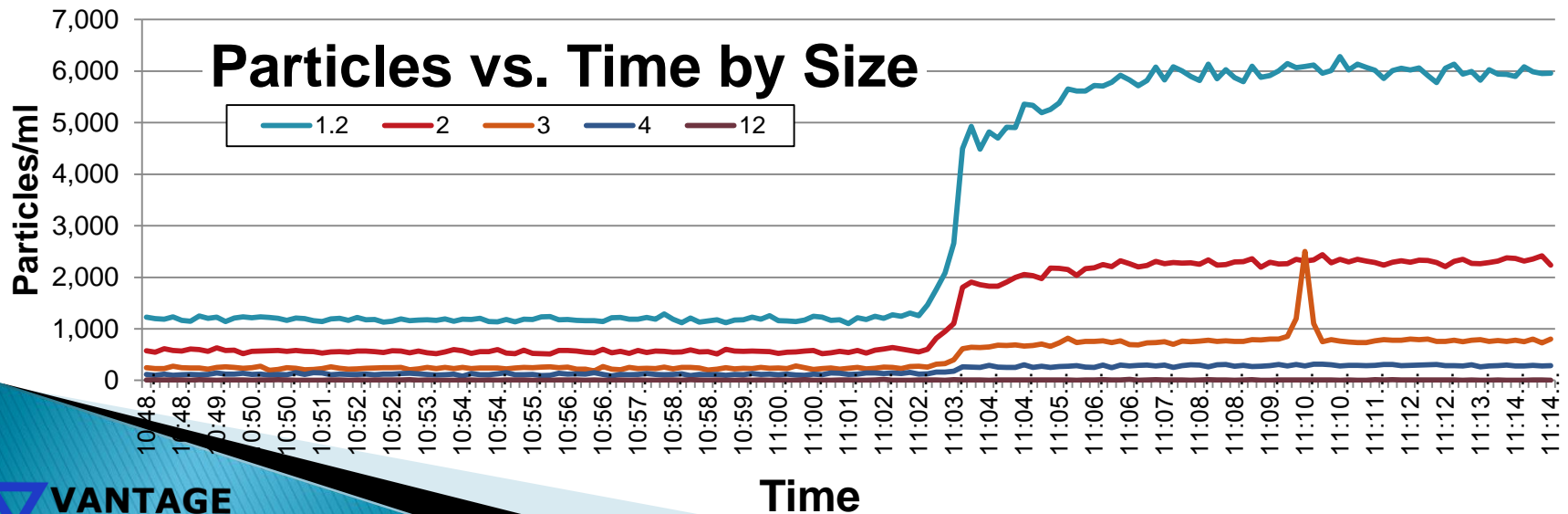
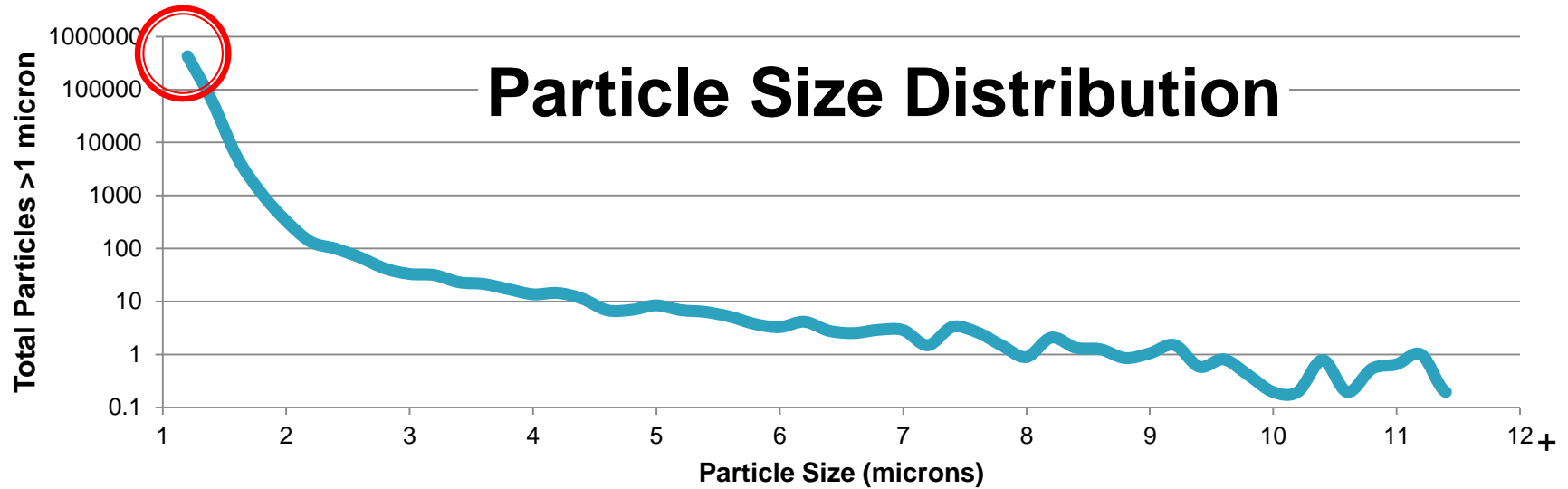
Vantage SlurryScope™ LPC Monitor



- ▶ Continuous, real-time measurement @ 15 ml/min
- ▶ Detection range 1 - 10+ μm in 0.2 μm increments or 0.8 - 4+ μm in 0.1 μm increments
- ▶ Undiluted POU CMP slurry



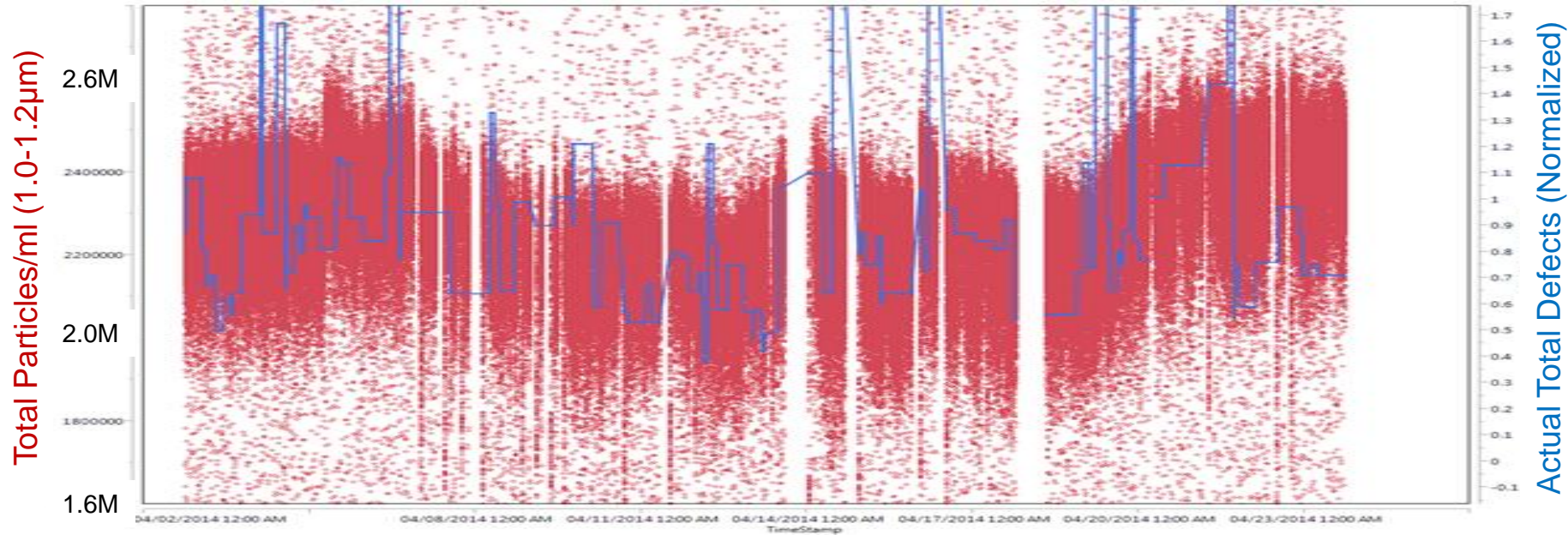
SlurryScope Data Modes



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
 - Continuous, real-time measurement $<0.8\mu\text{m}$ by any method remains an unsolved technical challenge

Current Customer Data - Preview



- ▶ Expanded LPC vertical scale (particles / mL)
- ▶ Normalized total defect data
- ▶ 3 weeks of data
- ▶ Blank spaces in data when not polishing

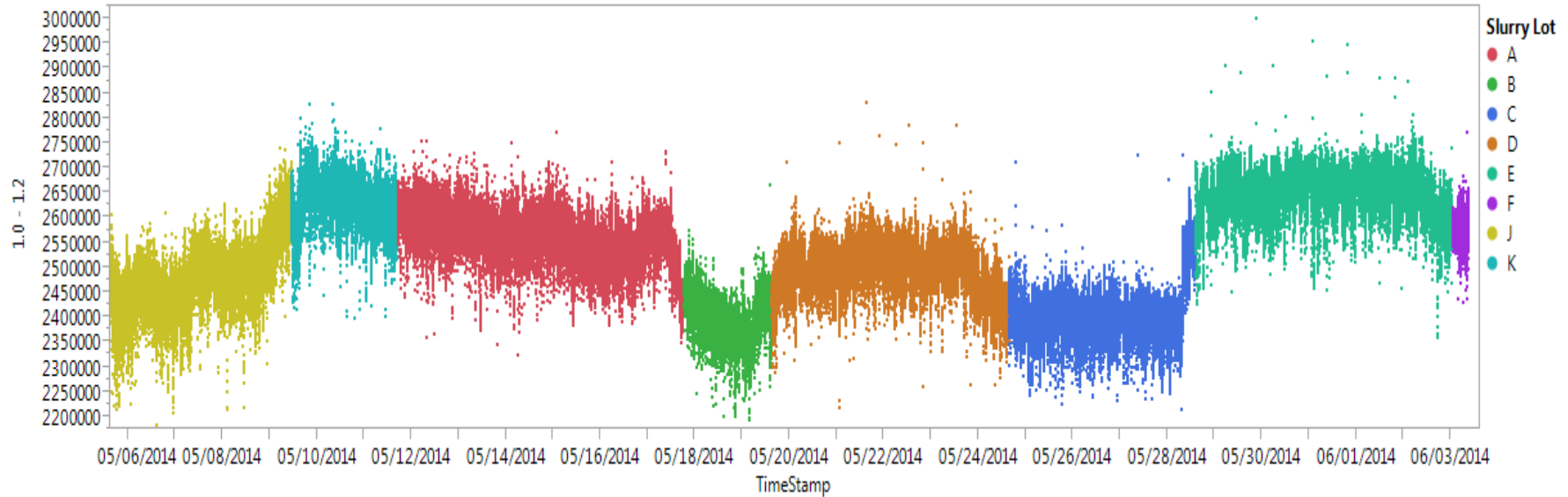
Principle #2 Confirmed

- ▶ 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

Phase 2 SlurryScope Data

Bivariate Fit of 1.0 - 1.2 By TimeStamp



Raw Data

- ▶ Reduced noise in measurements
 - Longer accumulation interval (10 sec vs 1 sec)
 - Continuous flow of slurry rather than start/stop with slurry dispense on wafer
- ▶ Data shows variation as each new slurry lot begins to mix into slurry loop

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

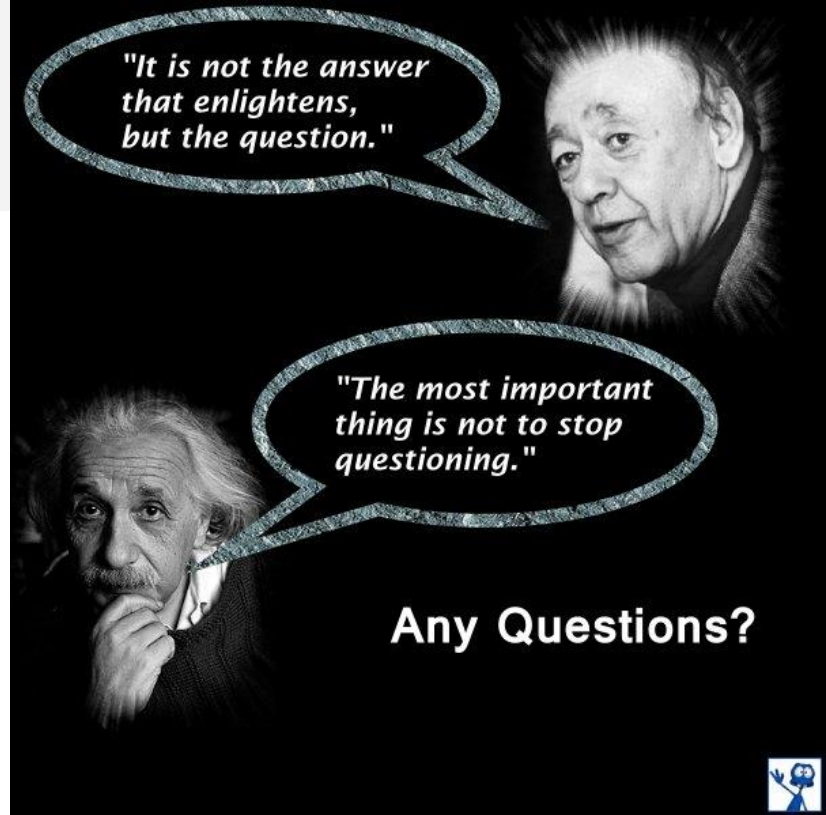
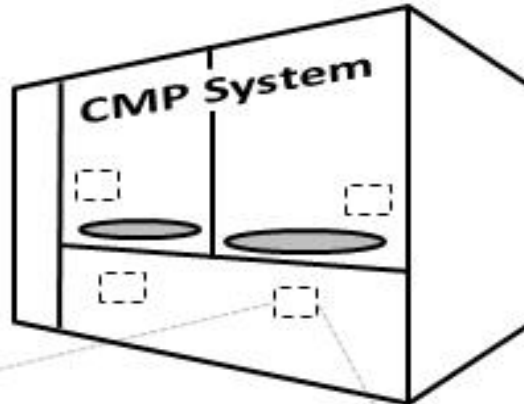
- ▶ The particles removed by filtration are not necessarily those that cause defects
 - SlurryScope measured $\geq 1.0\mu\text{m}$
 - SlurryScope sampling was *before* the POU filter
 - *After measurement*, slurry passed through POU filter onto the polishing platen
 - *This is the SlurryScope data that correlates with defects*
- ▶ **Say it again:** LPC data for particles $\geq 1.0\mu\text{m}$ 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



Special thanks to
IM Flash Technologies, LLC
For their productive collaboration
With Vantage Technologies
On this project