Performance Impact of Critical Chemical Quality on Latest Technology Node

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Samsung S.LSI MOC

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   - Control Limits
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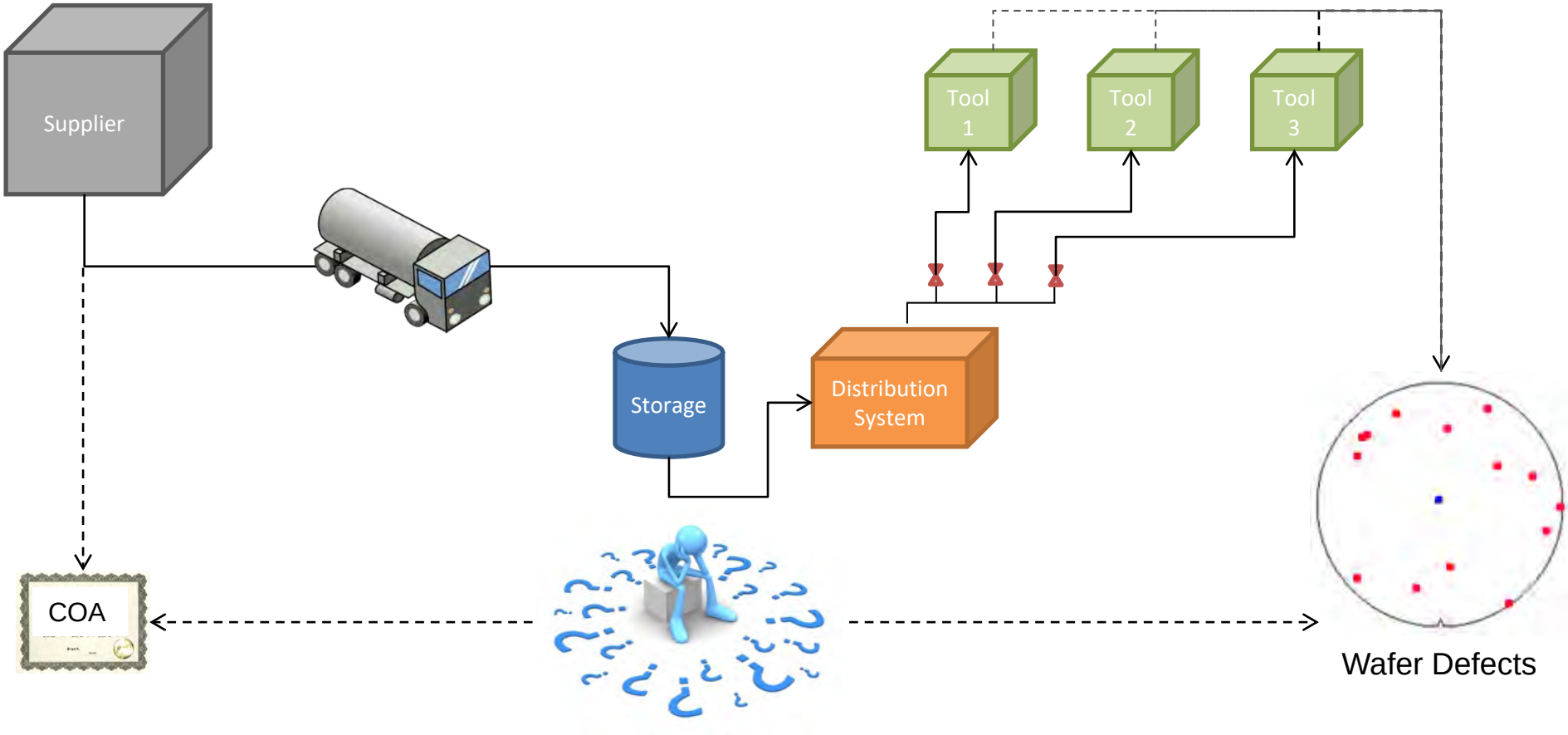
Introduction



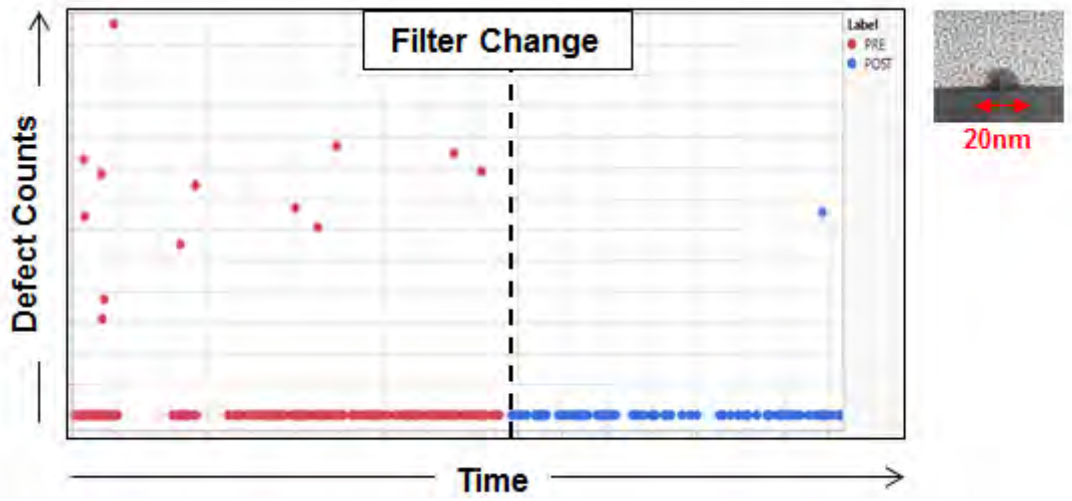
Difficult to link on wafer performance to supplier COA!!

- Hundreds of variables between COA and wafer defect

How do we improve material quality?

Introduction

Evidence of chemical particles escaping filtration impacting wafer defects → **Yield ↓**

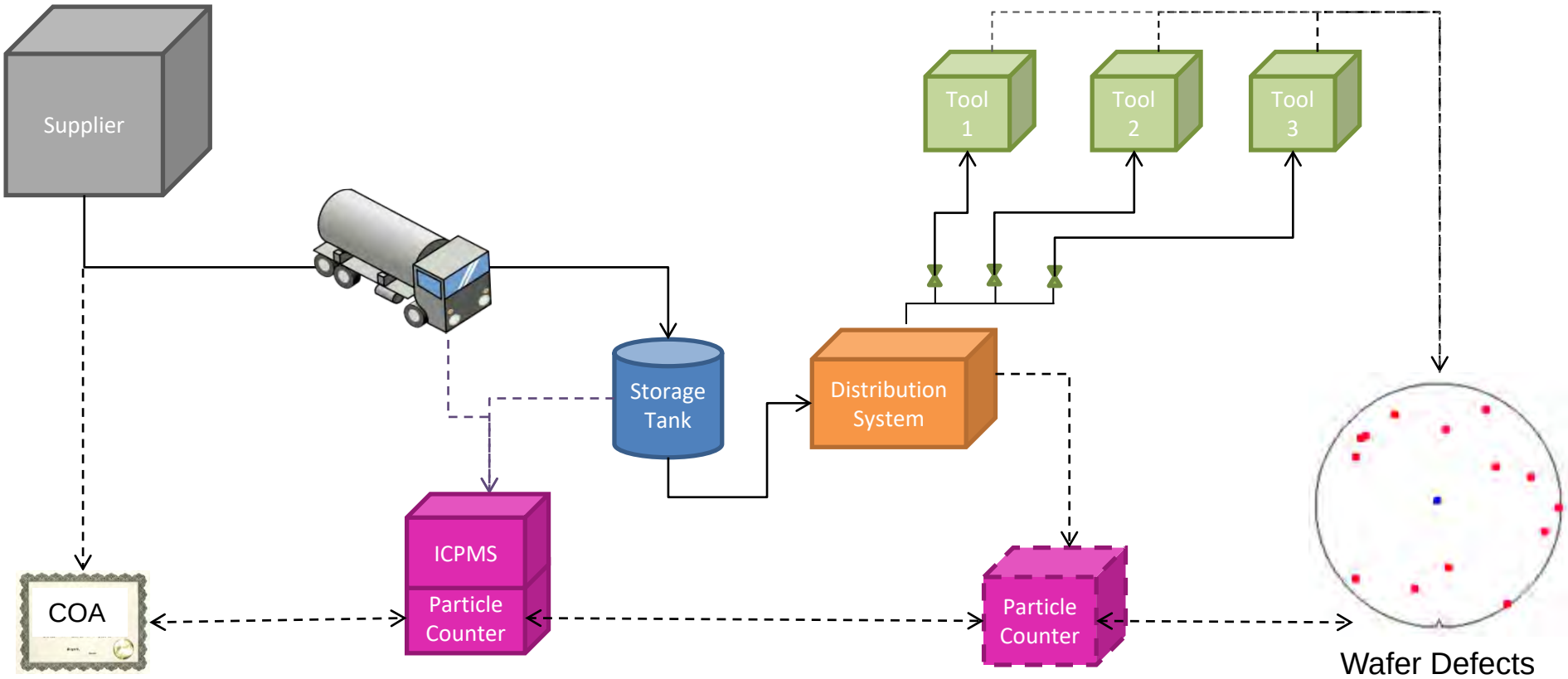


Year of Production	2016	2017	2018	2019	2020	2021	2022	2023	2024
Critical particle size (nm) [1]	14.2	12.6	11.3	10	8.9	8	7.1	6.3	5.6
Liquid Chemicals									
All cleaning chemistries (aqueous and solvent): number of particles/ml >0.065um [1] [11]	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0
All cleaning chemistries (aqueous and solvent): number of particles/ml >0.040um [1] [11]	1.3	0.9	0.7	0.5	0.3	0.2	0.2	0.1	0.1
All cleaning chemistries (aqueous and solvent): number of particles/ml >0.020um [1] [11]	10.7	7.5	5.41	3.75	2.64	1.92	1.34	0.94	0.7
All cleaning chemistries (aqueous and solvent): number of particles/ml >critical particle size [1] [11]	30	30	30	30	30	30	30	30	30

*Source: ITRS

Improvements needed are now beyond existing roadmaps and analytical techniques

Introduction



SAS approach has been to perform an incoming quality inspection (IQC) on critical materials

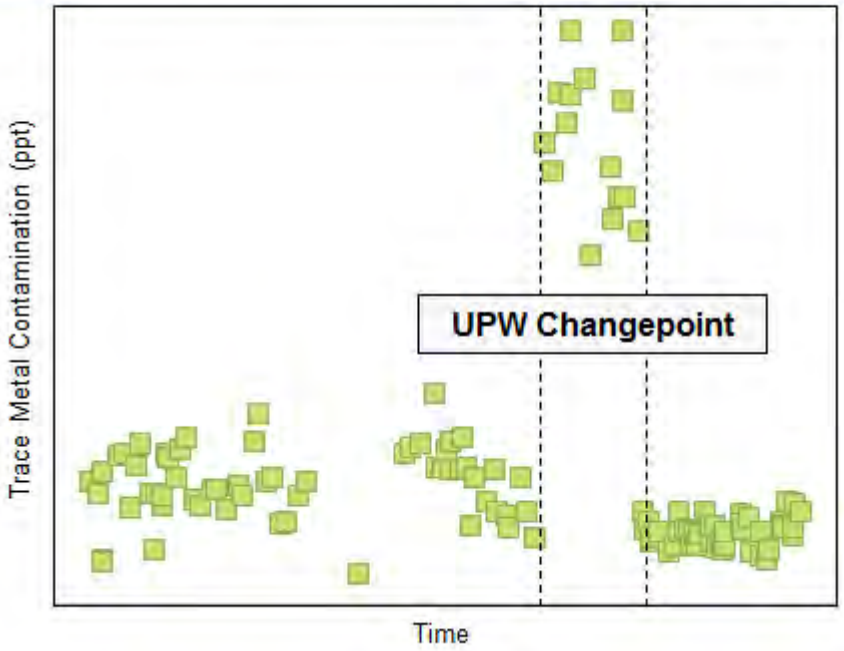
- Recently upgraded particle counters to the latest technology
- Additional monitoring of our distribution systems planned for future

Supplier Impact to Material Quality

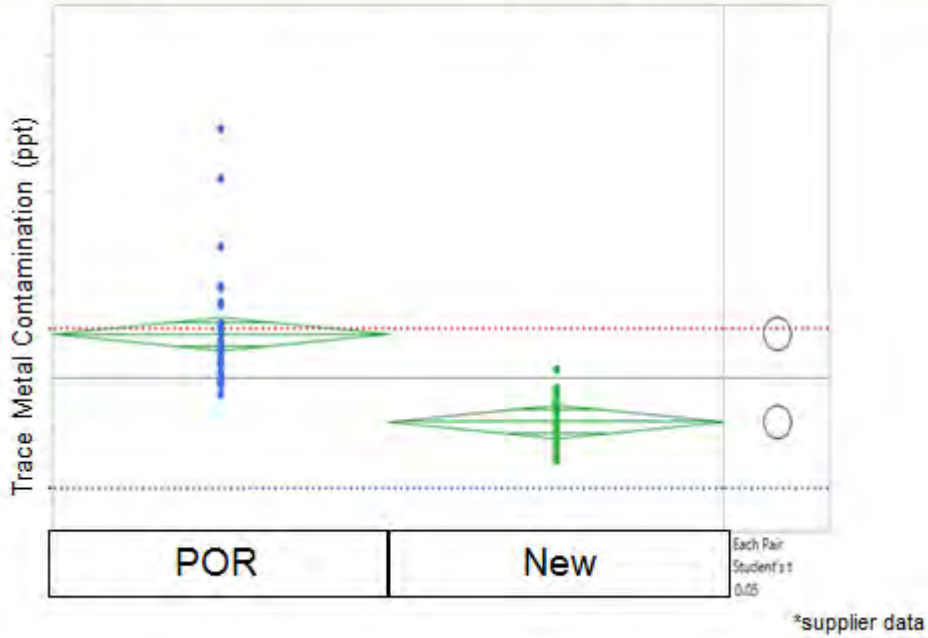
Supplier Challenges

Raw Material Contribution to Material Quality

Trace metal elevation in H2SO4 from UPW changepoint



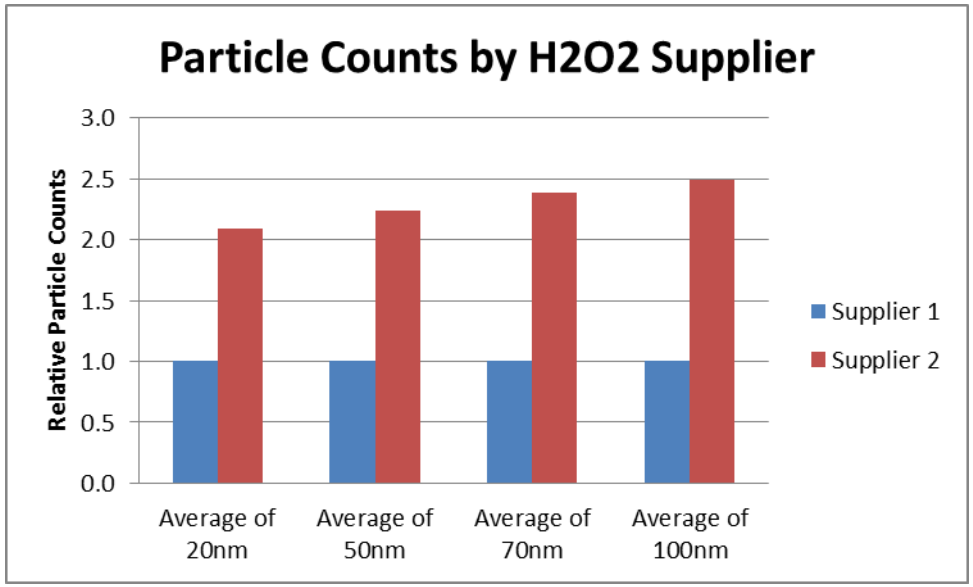
UPW improvement that will make majority of final product*

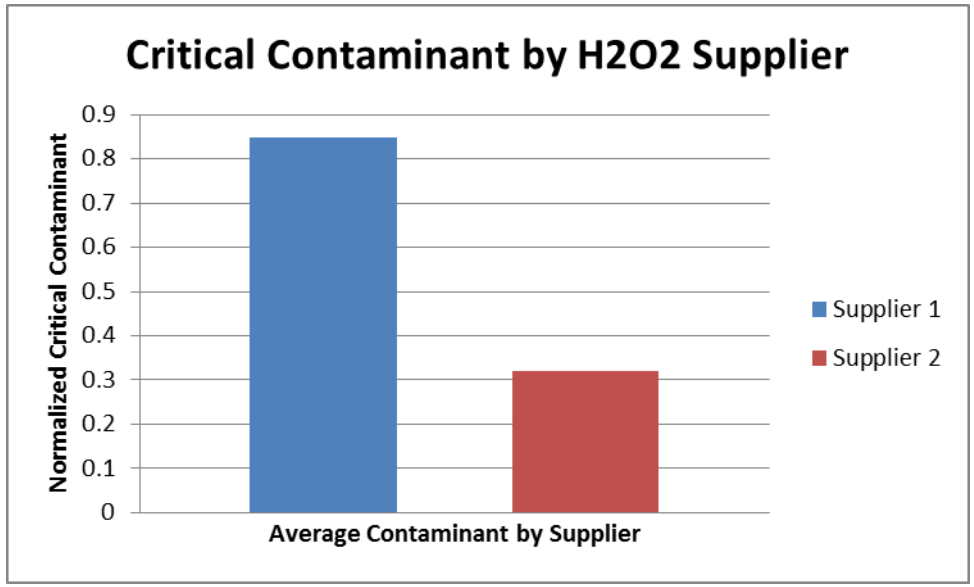


Challenge:
Raw material management and improvement
Changepoint management – Plan, Do, Check, Act, must include raw materials

Supplier Challenges

Chemical Supplier to Supplier Differences





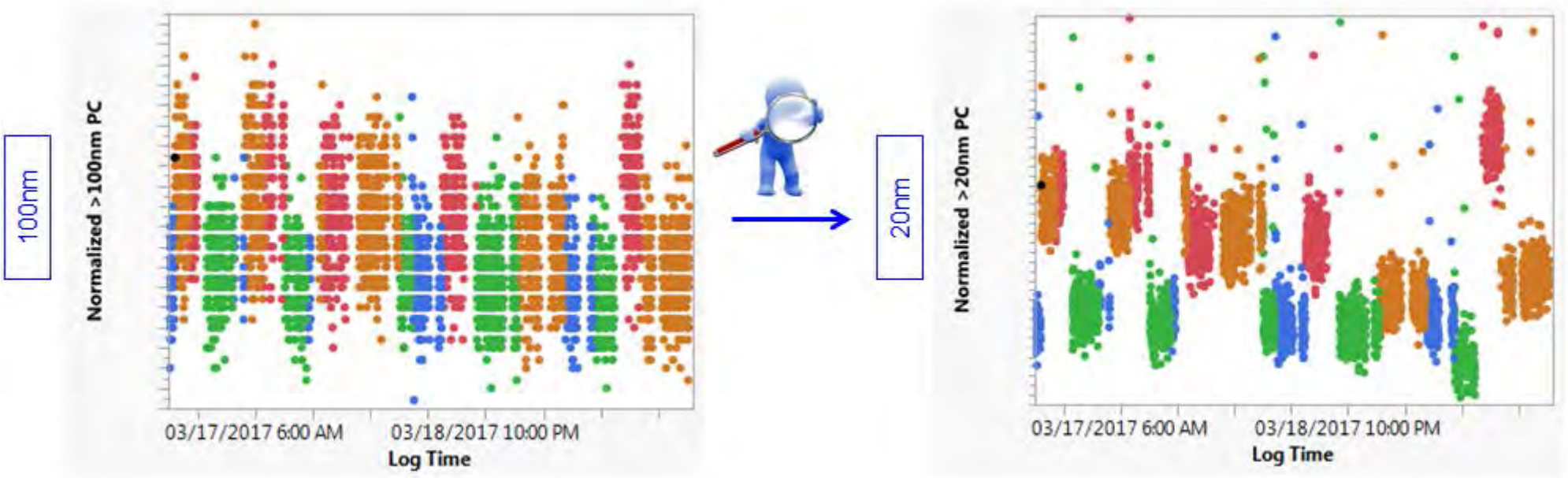
Which supplier has better quality?
Which contaminant impacts wafer quality more?

Challenge: Know and understand critical contaminants and strive for best quality

Analytical Challenges

Analytical Challenges

How can we remove what we can't see?



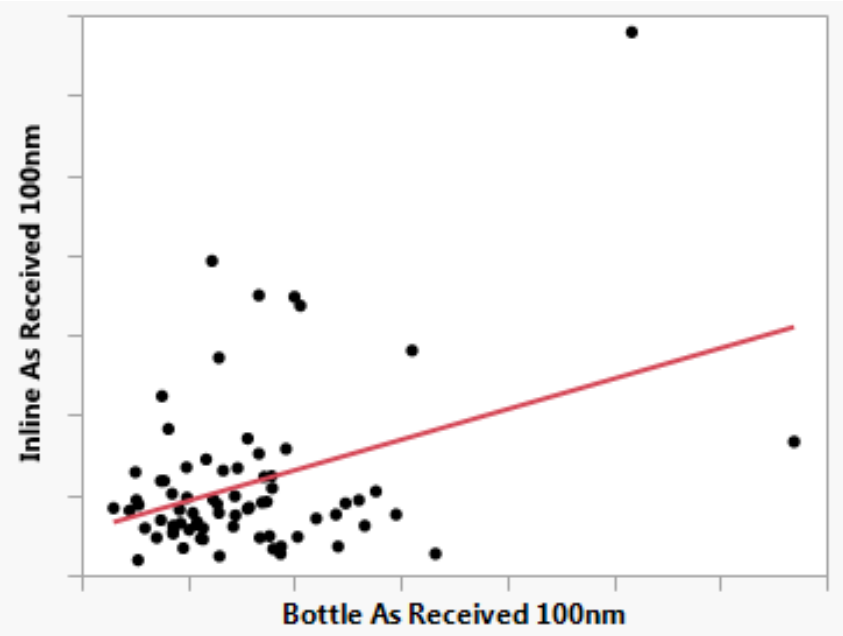
Detection levels for particles and critical contaminants must be lowered in order to see differences impacting critical technology nodes

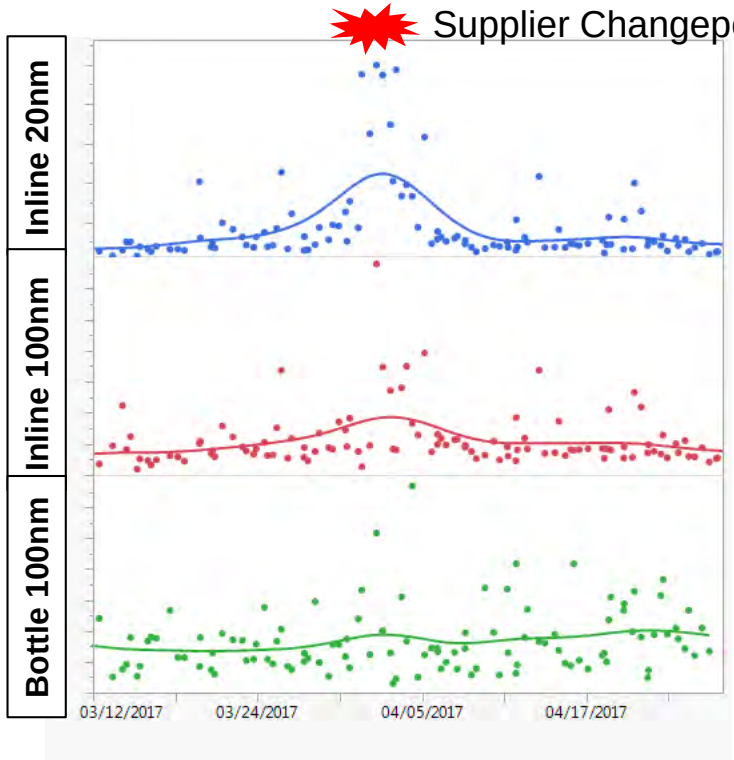
Challenge:
Suppliers should be evaluating newest analytical techniques for continuous improvement
Analytical techniques need advances to detection limits to catch up to the industry

"Absence of evidence is not evidence of absence!" **- Carl Sagan, Astronomer**

Analytical Challenges

Inline Sampling vs Offline Sampling?





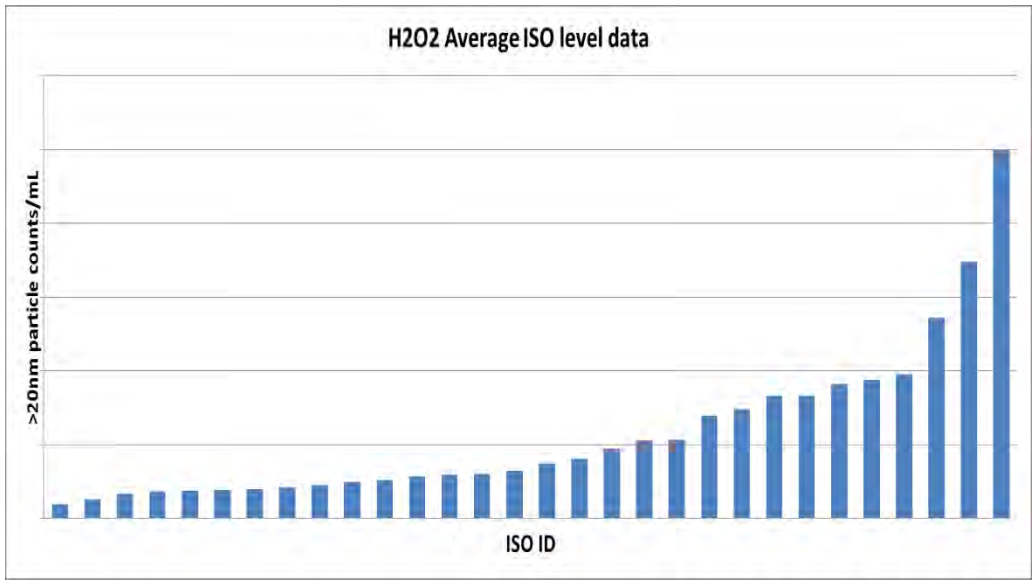
Inline and offline (bottle) samples are not well correlated due to variability of manual methods
Bottle samples miss real signals due to variability in measurement

Challenge:
Install inline analytical techniques where available and proven (PC, ICPMS)

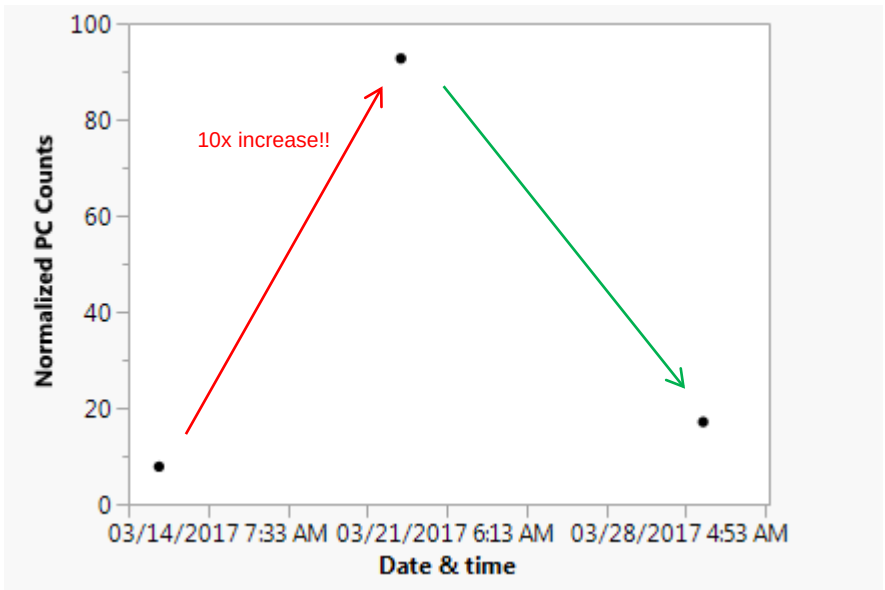
Packaging Impact to Material Quality

Packaging Challenges

Container to container and fill to fill variation is huge!



Example of one ISO delivered 3 times

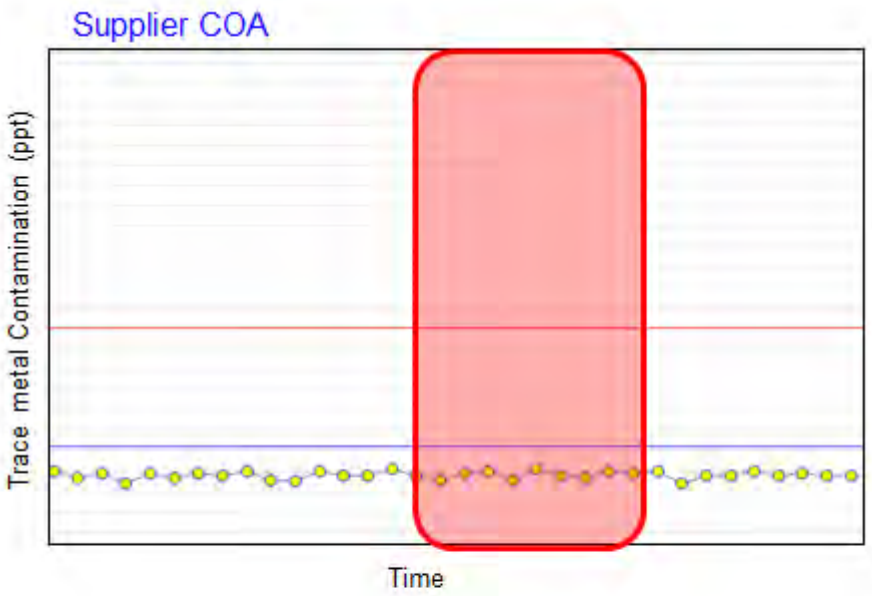


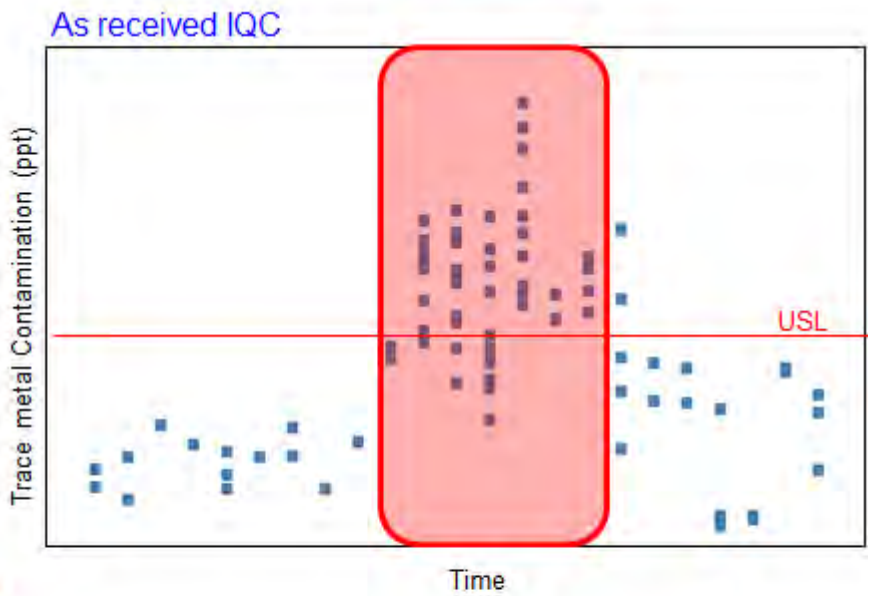
Challenge: Continuously improve packaging

- **Know and understand failure modes**
- **Implement periodic testing (ie "road test")**
- **Understand filling procedural variation**

Packaging Challenges

Contamination leaching from drum material during transport



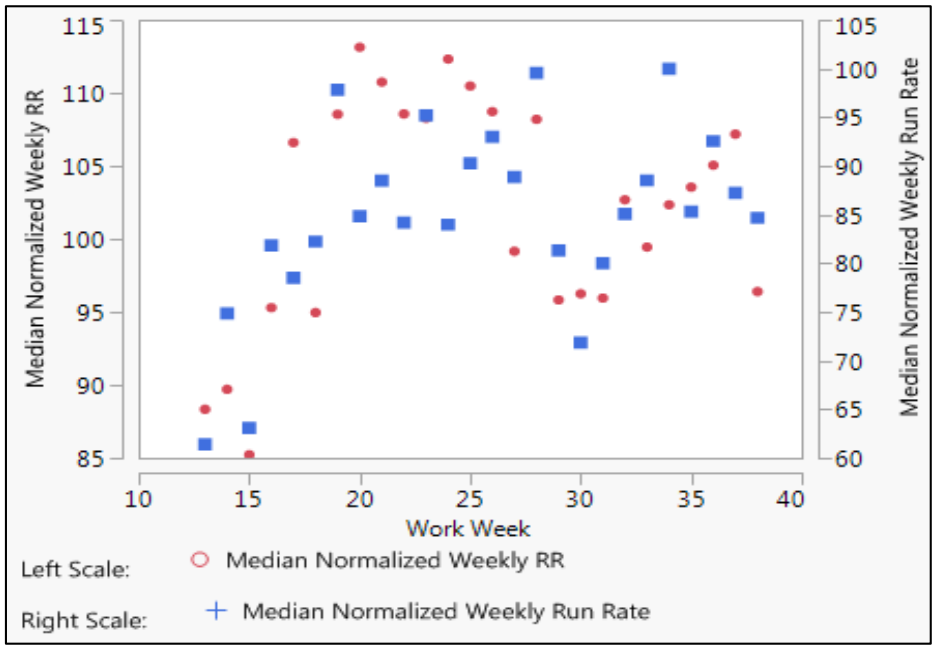


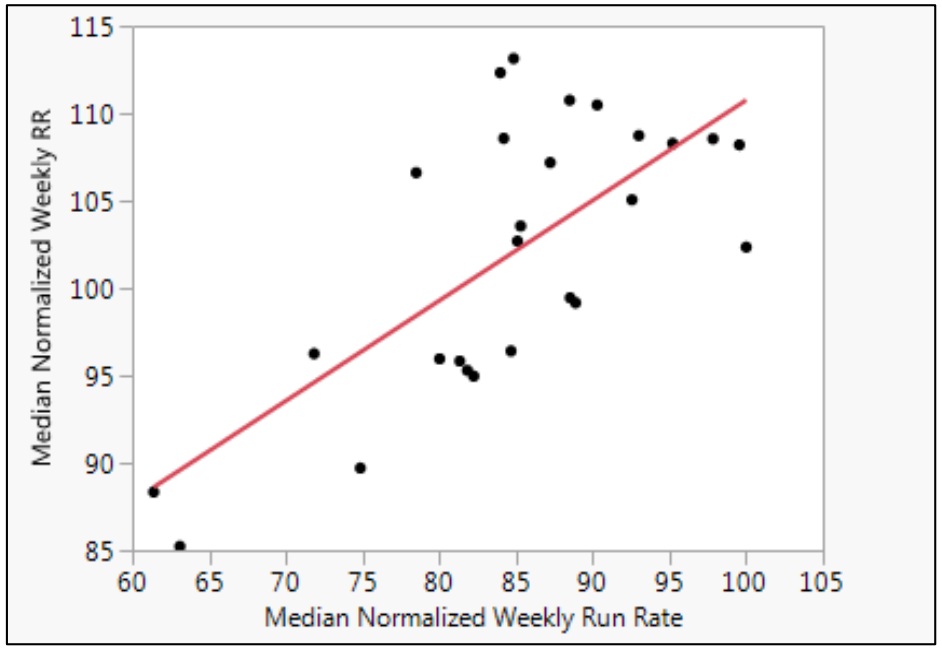
Challenge: Understanding packaging contribution to particles and contaminants

Fab Chemical Delivery Challenges

Fab Delivery Challenges

Problem: CMP Removal Rate variation of ±15% experienced during HVM that was cyclical and not aligned to any material or consumable change



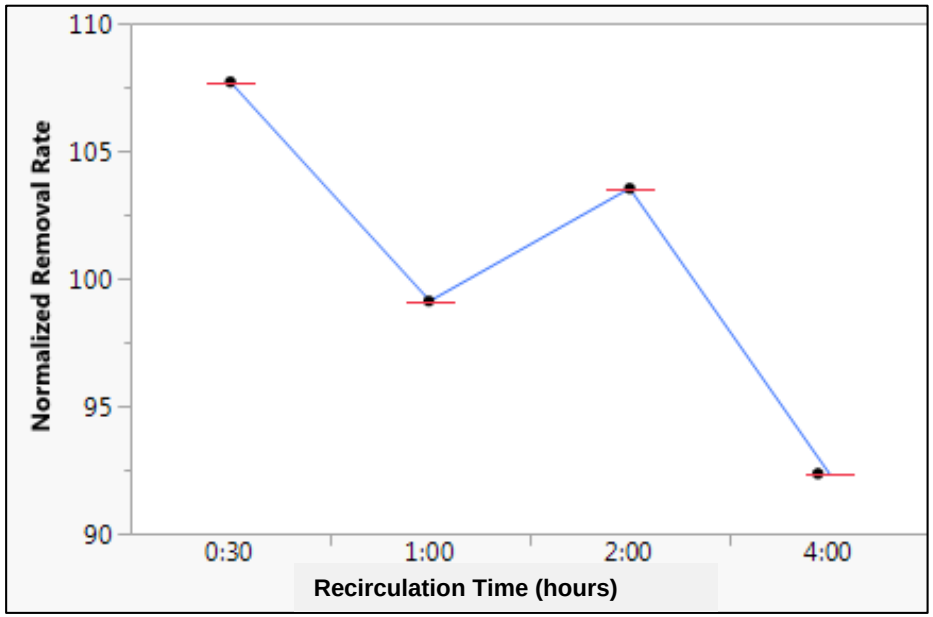


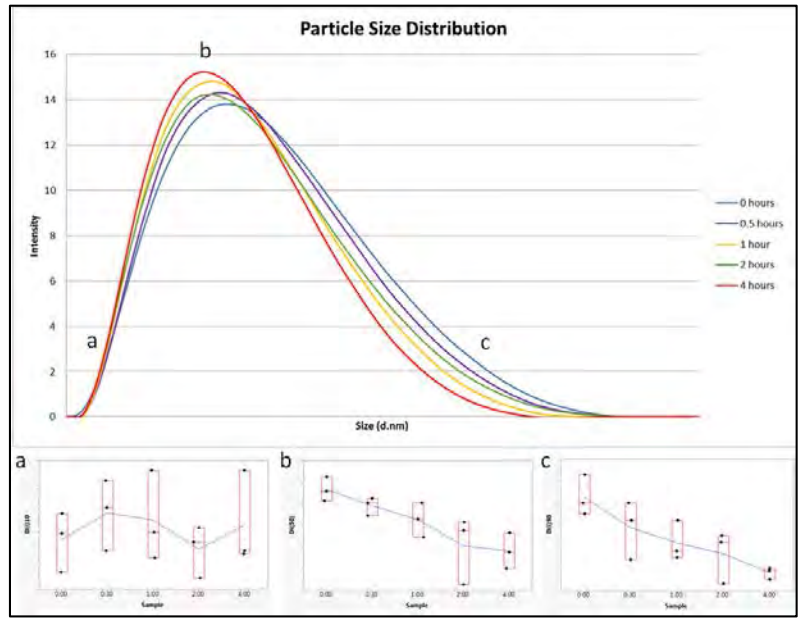
Wafer step moves were utilized as an indicator of the slurry demand from the CMP tools

↑ Slurry Demand = ↓ Recirculation & Filtration

Fab Delivery Challenges

Experiment performed on single CMP tool with slurry pump cart to eliminate other contributing factors





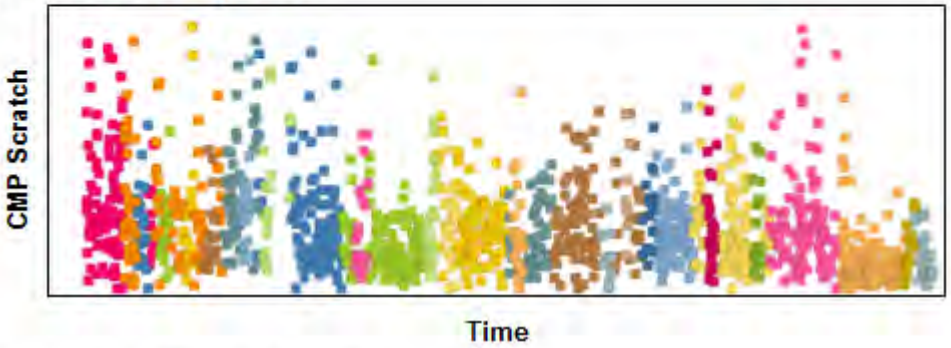
- 3.8% drop in removal rate with increased recirculation time
- 4.4% drop in mean particle size of abrasive

Challenge: Design for high volume manufacturing
- **Abrasive distribution filtering characteristics should be well understood**

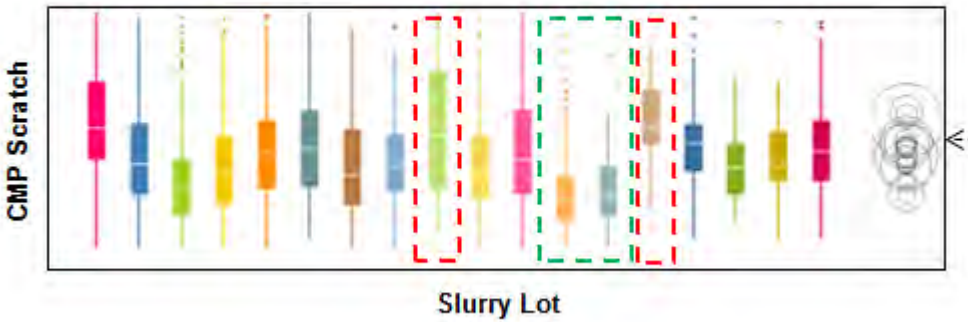
Fab Delivery Challenges

Quantifying material impact on process: Slurry batch to batch variation

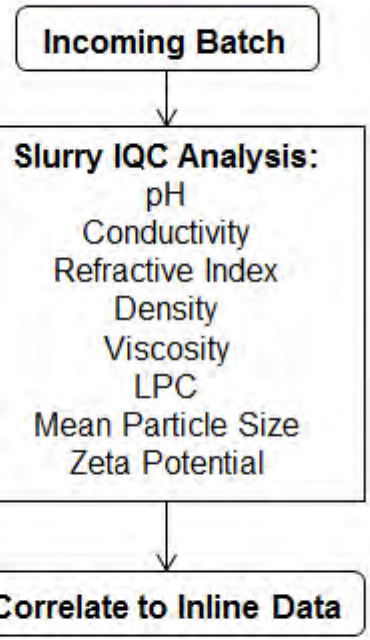
CMP Scratch by time



CMP Scratch by Slurry Lot

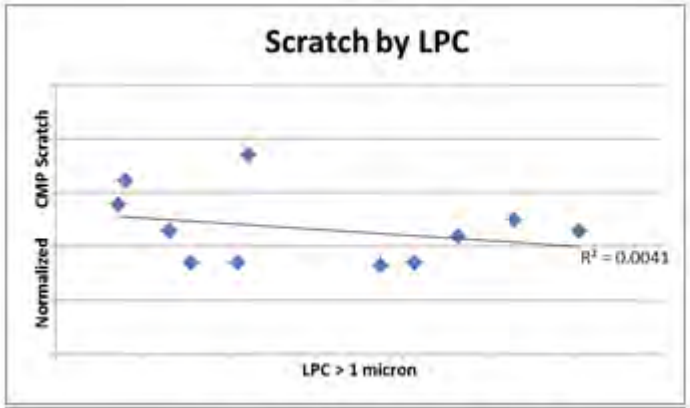


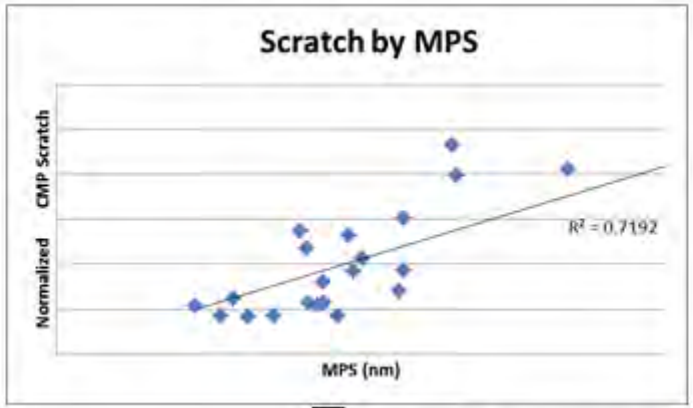
Slurry IQC Process

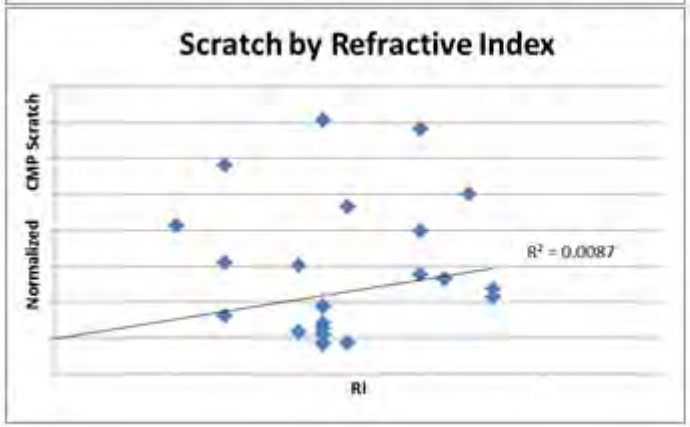


Fab Delivery Challenges

Quantifying material impact on process is not always an easy task







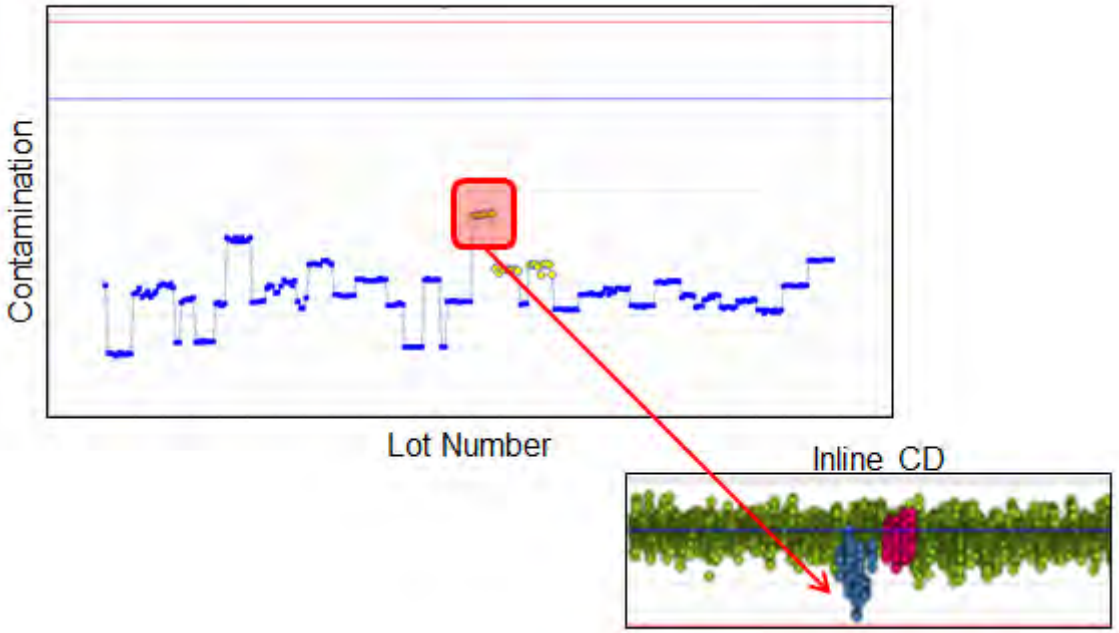
Kicked off improvement project with supplier

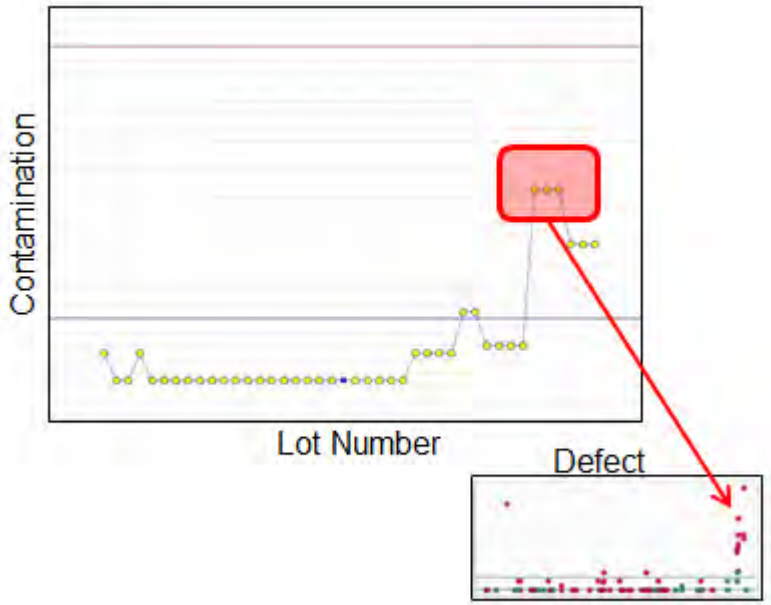
- MPS not necessarily the cause of scratch
- Supplier finds abrasive raw material properties that correlate to scratch performance
- Currently testing theories with supplier

Challenge:
Fab: Continuously checking correlations to fab data, feeding back to supplier, and testing any findings

Control Limits

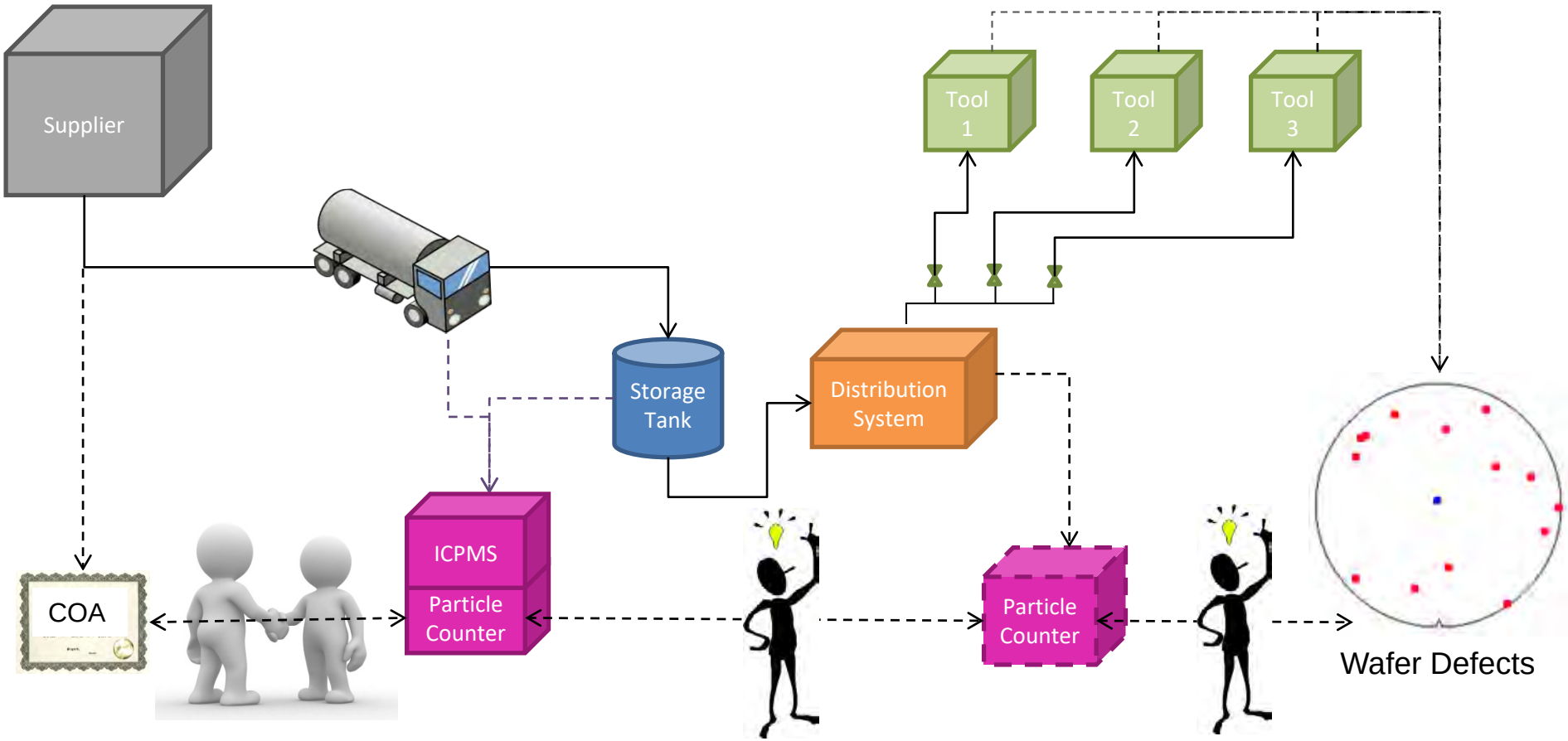
Historically, control limits are based on supplier process capability.
Learnings from latest technology node where in control/spec materials caused shifts inline





Challenge:
Control limits must be based on technology needs, not supplier capability
Collaborative efforts are needed between fabs and suppliers to determine needs

Summary



Material quality improvements are critically needed for latest technologies

- Collaborative efforts are needed between suppliers and fab
- Suppliers must pursue BOB quality, analytical, and packaging methods
- Fabs must continuously FIND and SHARE learnings with suppliers

Questions?