Ultra High Purity Chemical Challenges

Daniel Stucky

Samsung Austin Semiconductor

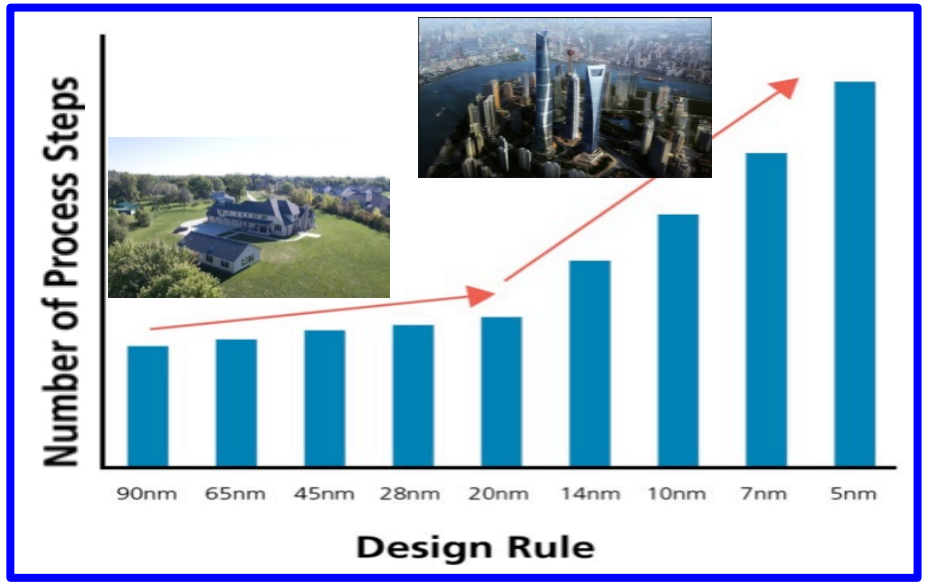
5/31/2018

Overview

- Introduction
- Defense Lines & Excursion Prevention
  - Semiconductor defense line management
  - How can suppliers prevent excursions?
- Organic Contamination Quality Control
  - Current quality risks
  - New quality control method
- Conclusion

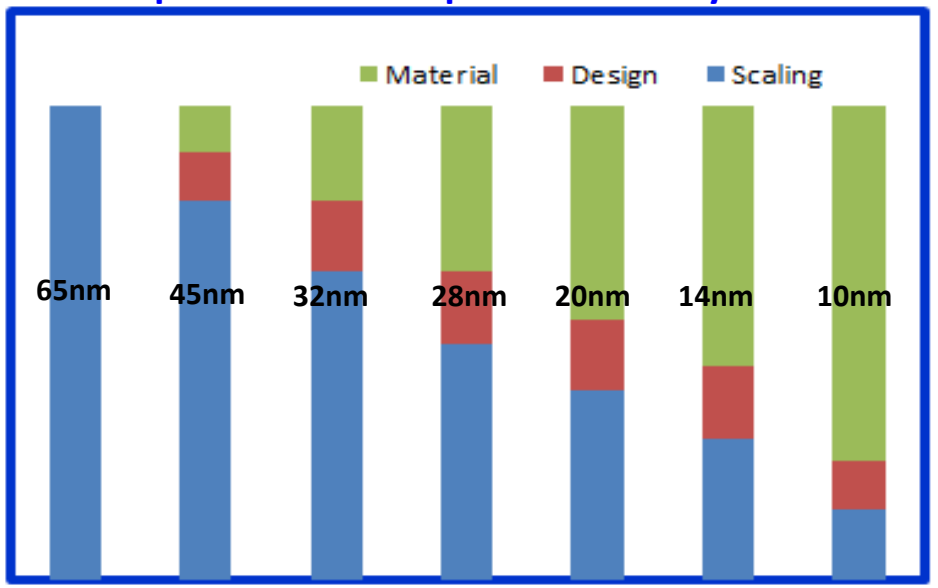
Introduction

Multifold increase in process complexity



Sources: google, KLA-Tencor

Impact of material performance by node



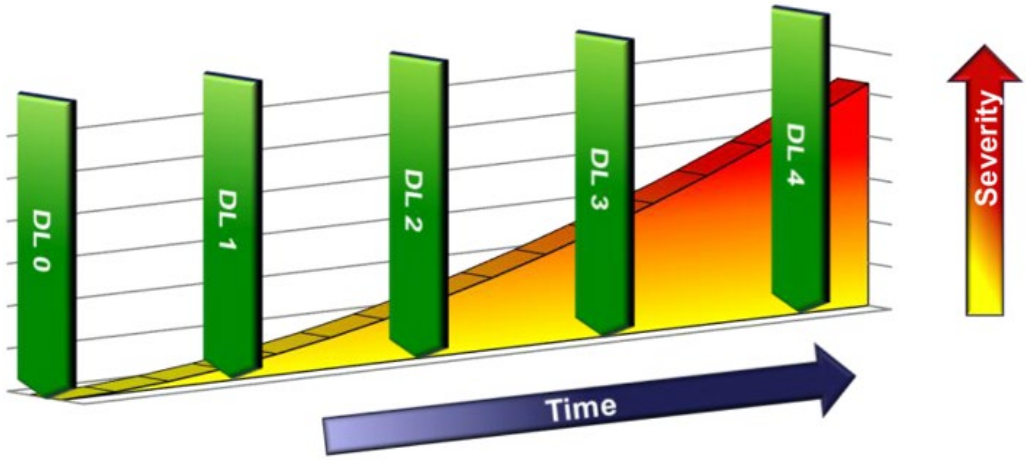
Source: Entegris

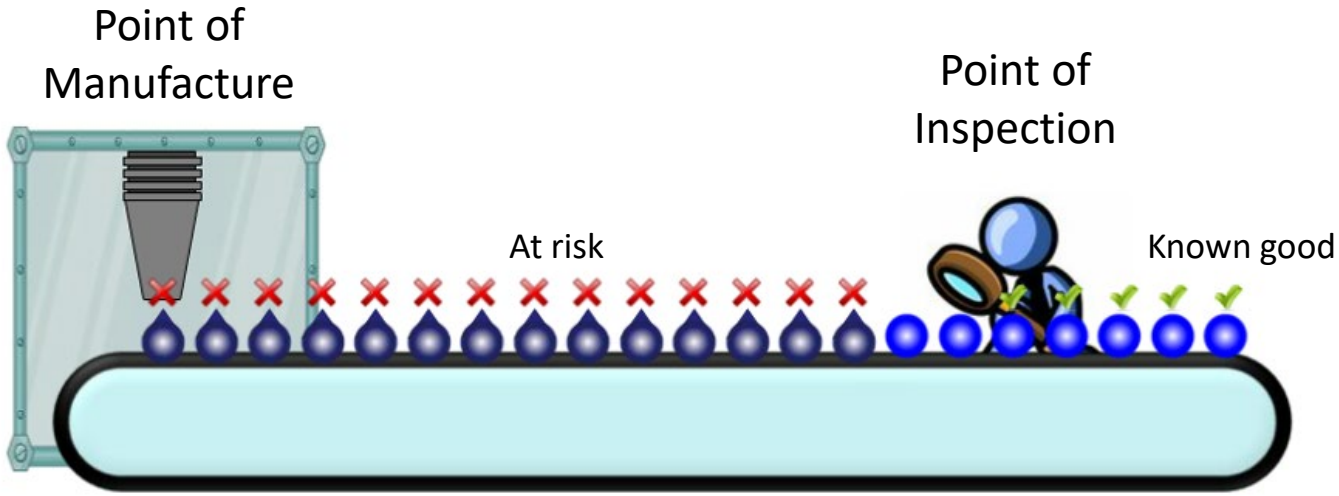
- Processes becoming more complex
- Devices and Fab metrology more sensitive
- Larger raw material impact to wafer defects & yield

Chemical Excursion Prevention

Chemical Excursion Prevention

- Defense Lines
  - System working as a barrier against attack
  - DL0: preventative – best & most important
  - If defense line fails, impact grows
  - Early detection is key!

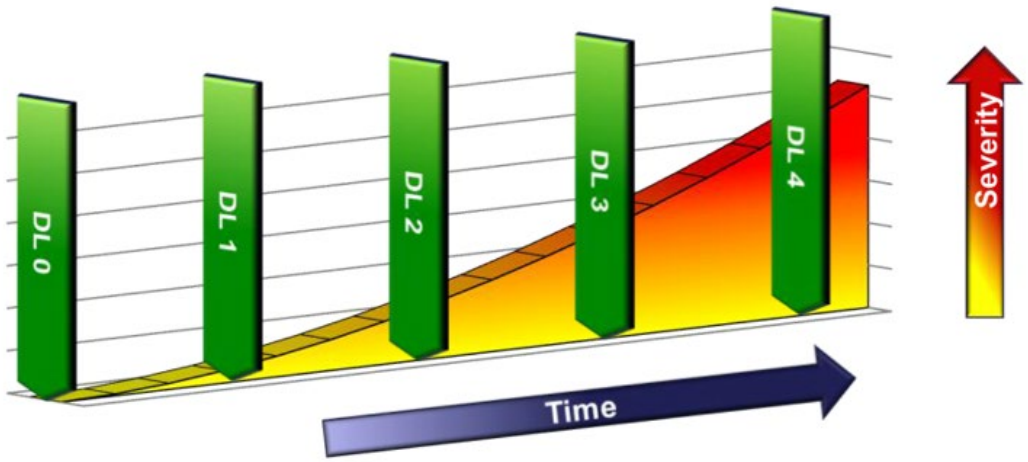




Defense Line	Fab Example	Wafers at Risk
DL0	PM, SOP	0
DL1	Point of Failure: Single wafer/lot	1
DL2	Point of Failure: Multiple wafer/lot	10's
DL3	Downstream Step	100's
DL4	Wafer Fab Out	1000's

Chemical Excursion Prevention

- Defense Lines
  - Different for each part of supply chain
  - Raw material suppliers should understand their defense lines and risks



Defense Line	Fab: Process	Fab: Material	Material Supplier
DL0	PM, SOP	Supplier Manufacturing	Incoming raw material
DL1	Point of Failure: Single wafer/lot	Supplier CoA	Process interlock (flow, pressure, temp, etc)
DL2	Point of Failure: Multiple wafer/lot	Fab IQC	Process or tank analysis data
DL3	Downstream Step	Wafer Inline	CoA
DL4	Wafer	Fab Out	Customer Issue

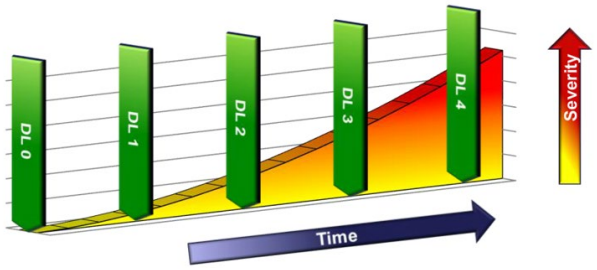
Goal:
Push containment up to DL0!

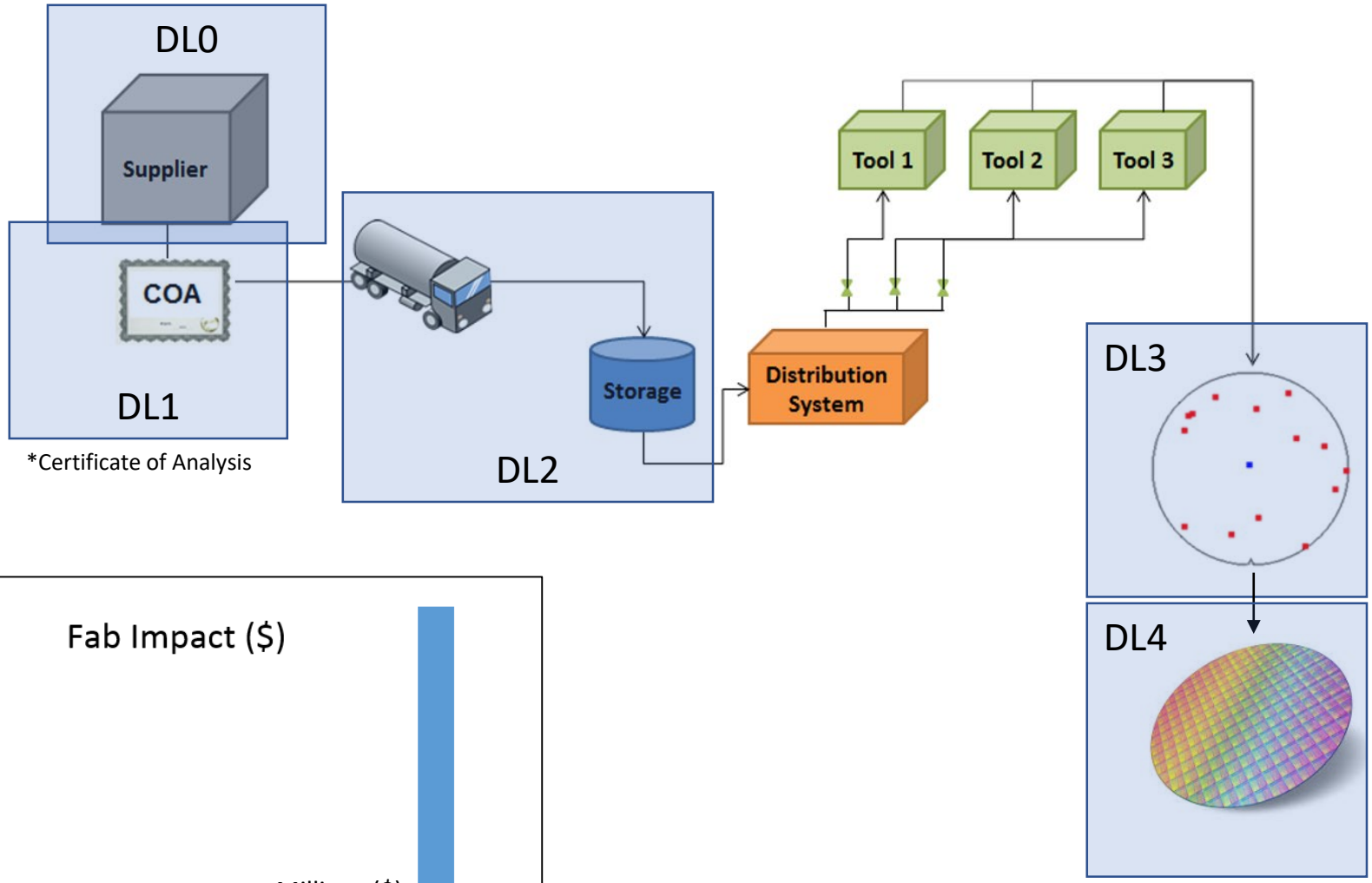
Chemical Excursion Prevention

SAMSUNG

Fab Material Defense Lines

Defense Line	Fab: Material
DL0	Supplier Manufacturing
DL1	Supplier CoA
DL2	Fab IQC
DL3	Wafer Inline
DL4	Wafer Fab Out

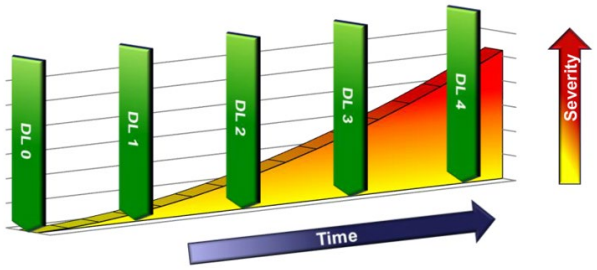


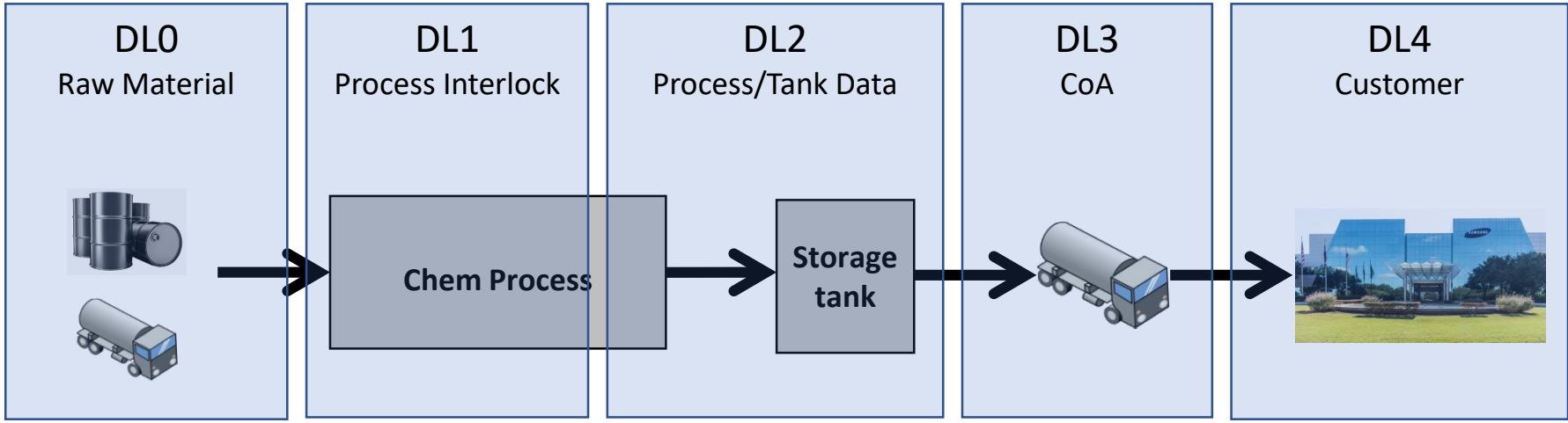


Chemical Excursion Prevention

Supplier Defense Lines

Defense Line	Material Supplier
DL0	Incoming raw material
DL1	Process interlock (flow, pressure, temp, etc)
DL2	Process or tank analysis data
DL3	CoA
DL4	Customer Issue





DL0
- CoA
- On-site analysis
- Filtration / Purification
- Improvement road map
- Supplier selection
- BCP

DL1
- Advanced process control
- Changepoint management
- Instrumentation
- Parts/equipment management

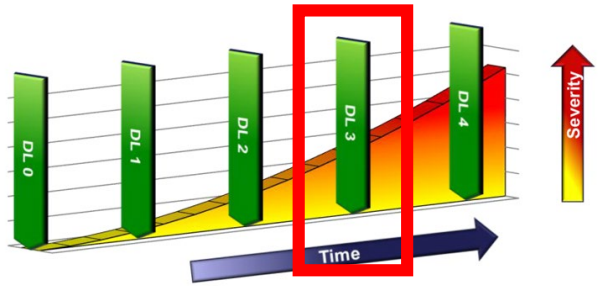
DL2
- Filtration
- Recirculation
- Process (pre-filter) quality monitoring

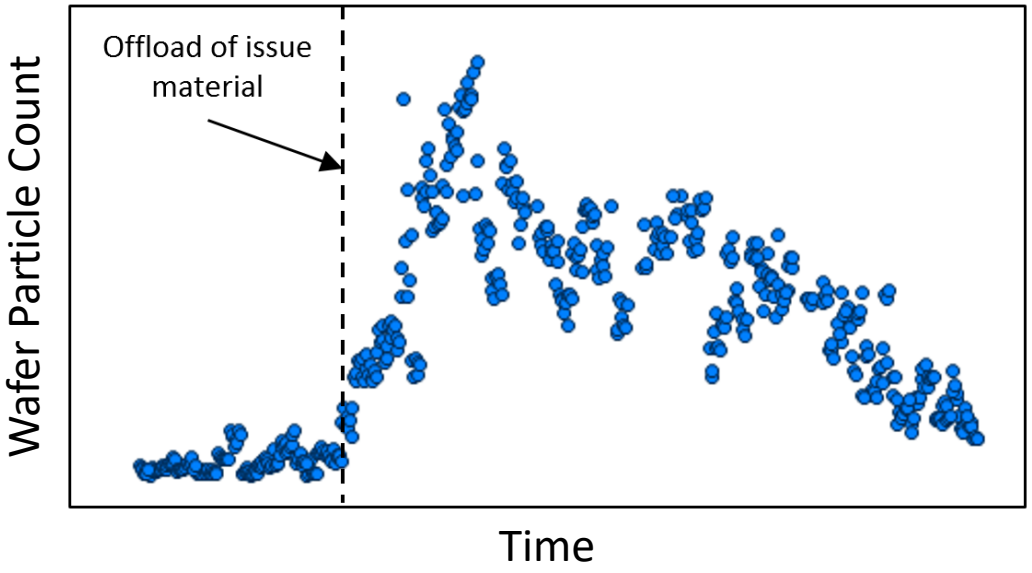
DL3
- Advanced instruments
- Inline, not grab sample
- Detection limits
- Control limits
- Trend monitoring

Chemical Excursion Prevention

Chemical contamination excursion example

- Supplier process equipment failed, generated particles
- Not detected on supplier CoA
  - On wafer: very small particles (majority <30nm)
- Contaminated Fab supply system



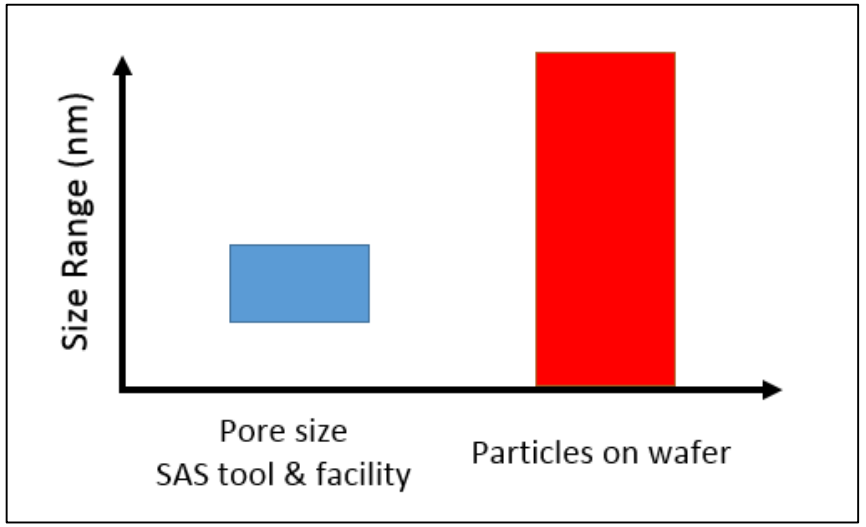


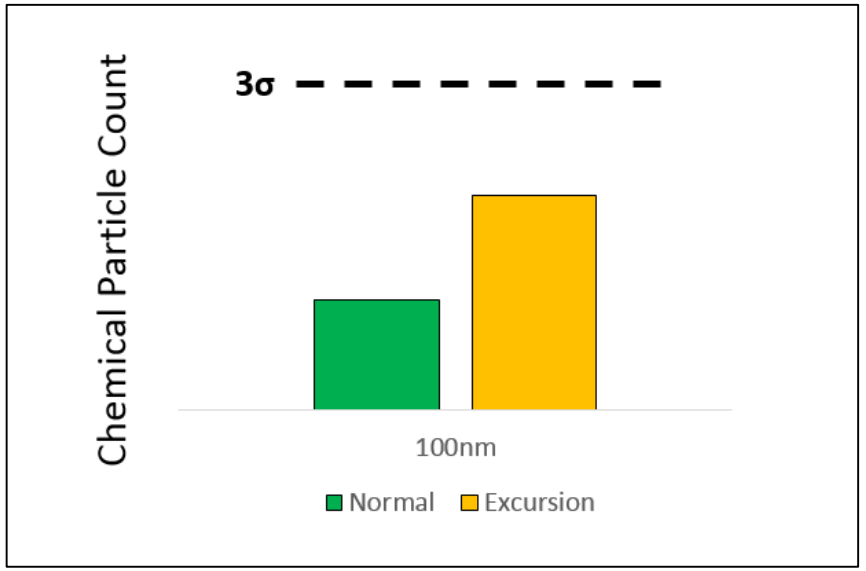
DL0	Supplier Manufacturing	No equipment abnormality detected
DL1	Supplier CoA	Very small particles not on CoA
DL2	Fab IQC	Monitoring not sensitive enough Shift within UCL
DL3	Wafer Inline	**Defect signal detected**
DL4	Wafer Fab Out	Wafers contained

Chemical Excursion Prevention

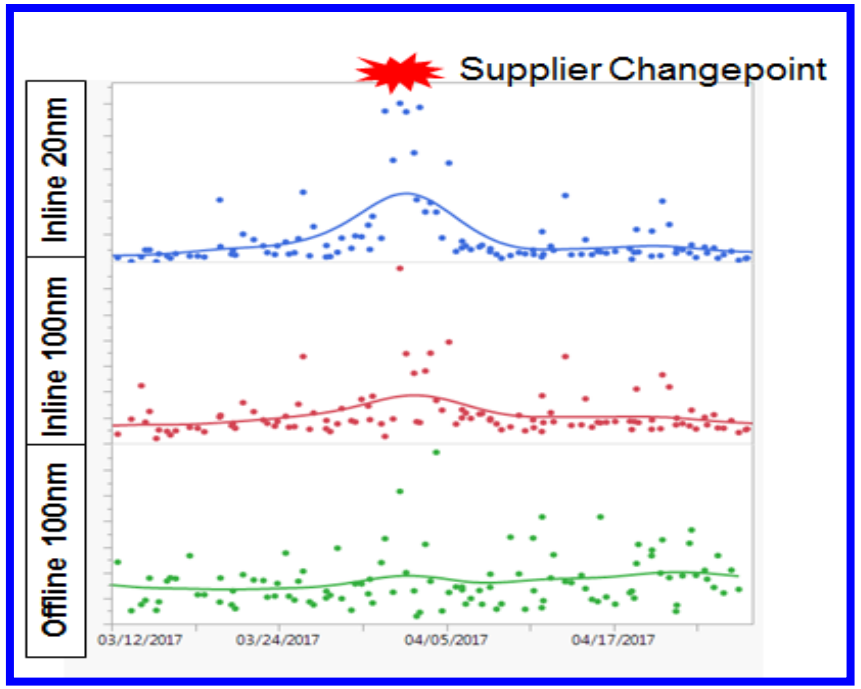
- Several learnings from the excursion
- Some Examples:

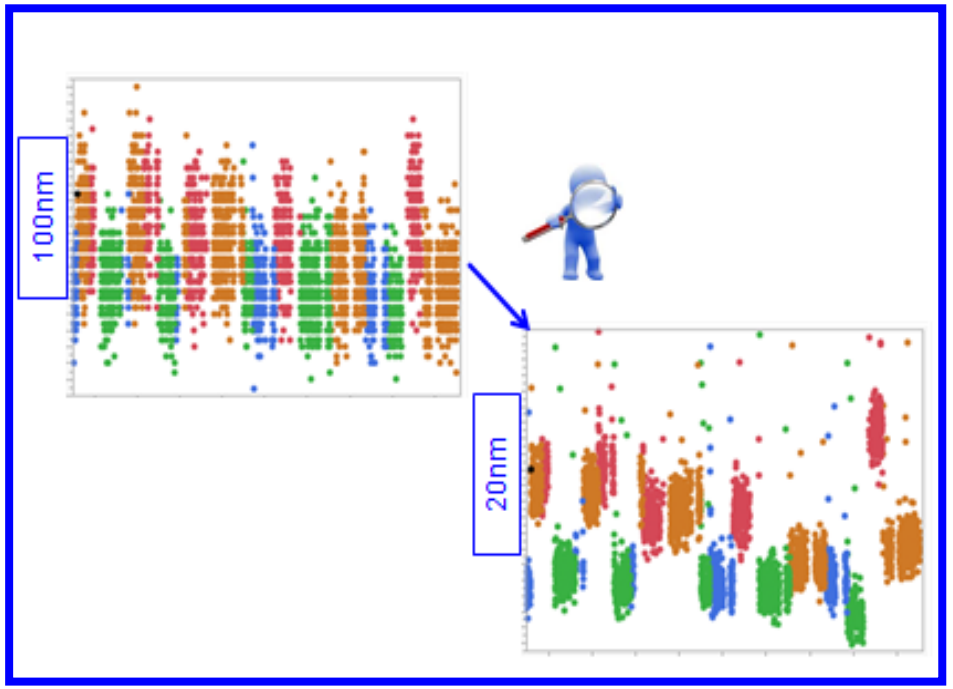
	Learning	Industry Need
1	Many particles on wafer larger than SAS filter pore size	Better characterization of filter pore size & particle removal
2	Elevated particles in chemical process. Larger particles removed by filters but very small particles remained.	Particle monitoring needed in supplier process before filter, not just post-filter or final package
3	Larger bin sizes did not detect issue	Inline particle monitoring at small bin size needed





Chemical Excursion Prevention

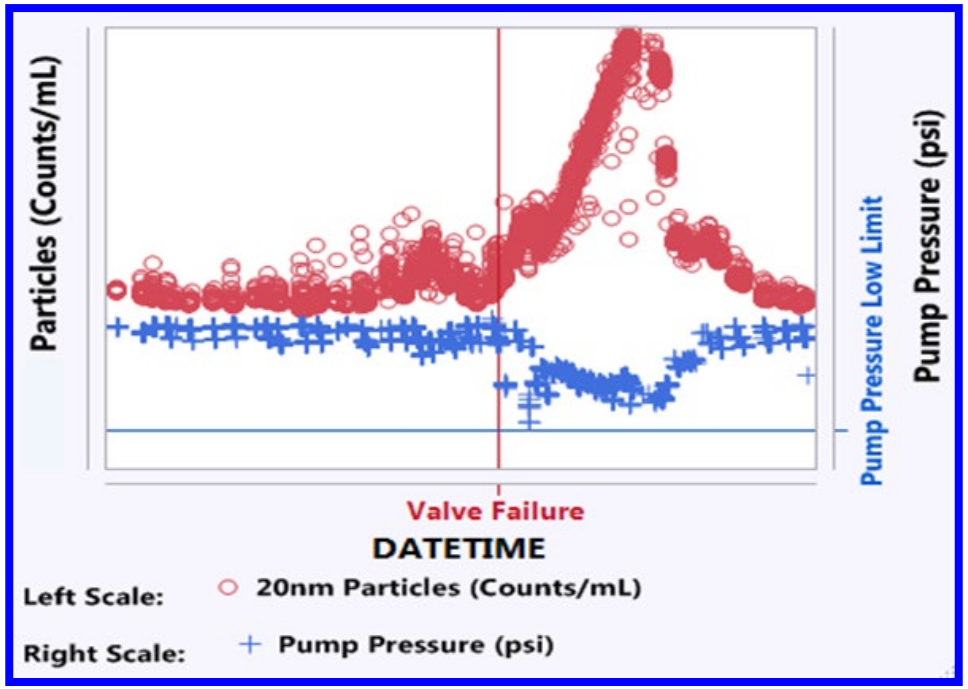




Defense Line example: Chemical process equipment monitoring

- Previous particle monitoring methods are obsolete
  - More sensitive detection needed to prevent excursions
- Supplier changes can be detected using improved analytical techniques
- Change management is critical to stable quality

Chemical Excursion Prevention



Defense Line example: Chemical process valve monitoring

- Real time, early detection of failing equipment
- Allows additional time for replacement scheduling before complete failure
- Proactive, not reactive!

Organic Contamination Control

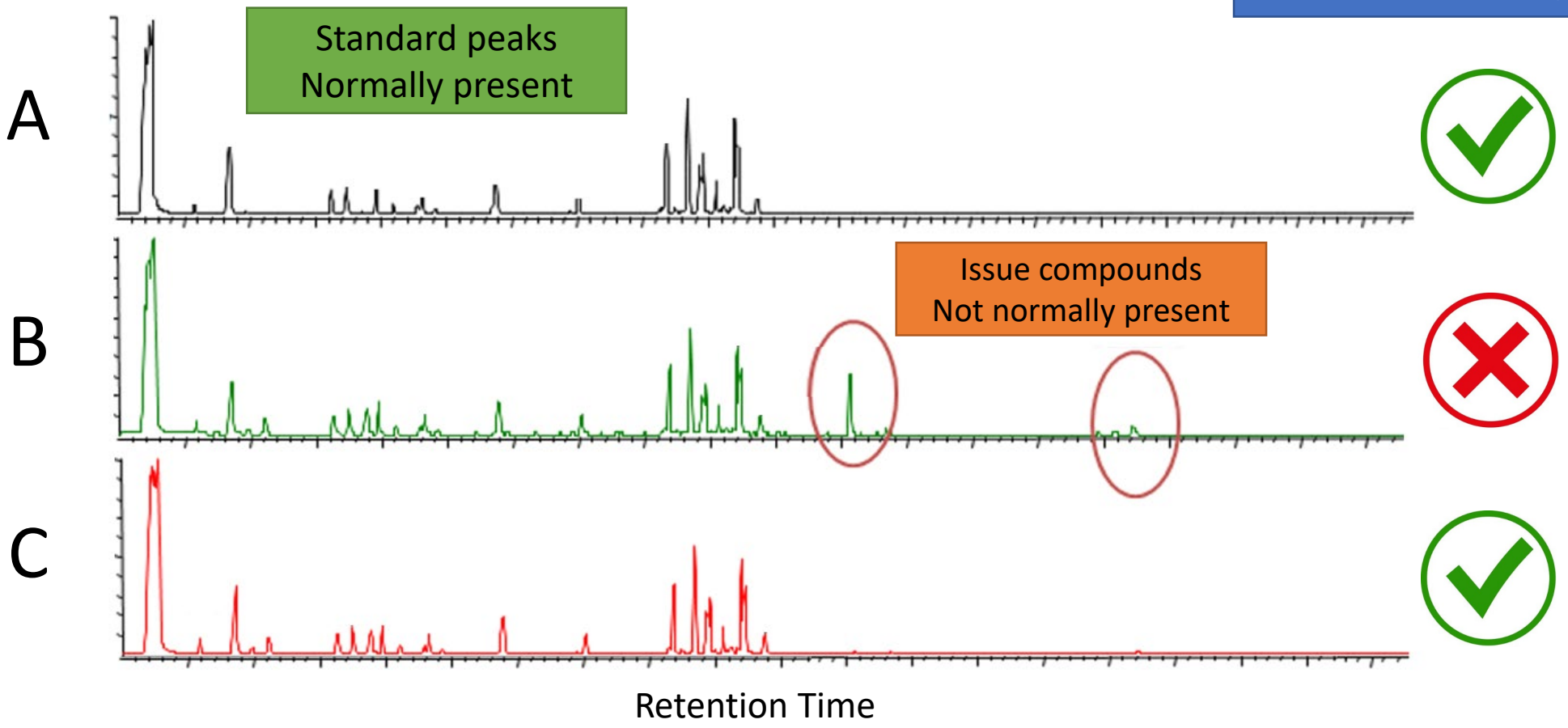
Organic Contamination Control

- Why control organic contamination?
  - Impact to wafer → Defect & Yield loss
  - Supplier & batch variation, supplier changepoints
- Key risk point:
  - New organic contamination not normally present
  - Typically from raw material or supplier process
- Organics not controlled tightly enough
  - **New approach needed!**

Organic Contamination Control

- GC-MS of three sequential batches from same supplier
- Batch B caused large Fab excursion

Need stronger defense lines to catch abnormal organic compounds!

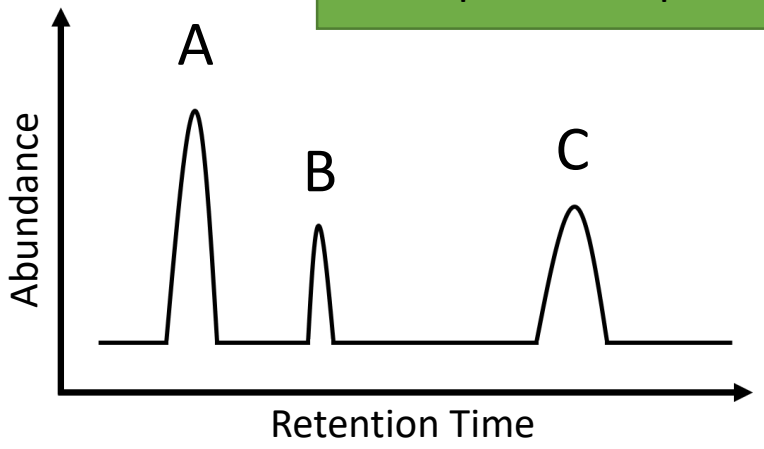


How to detect shift on entire chromatogram?

Organic Contamination Control

- Traditional method:
  Set control limits on known peaks

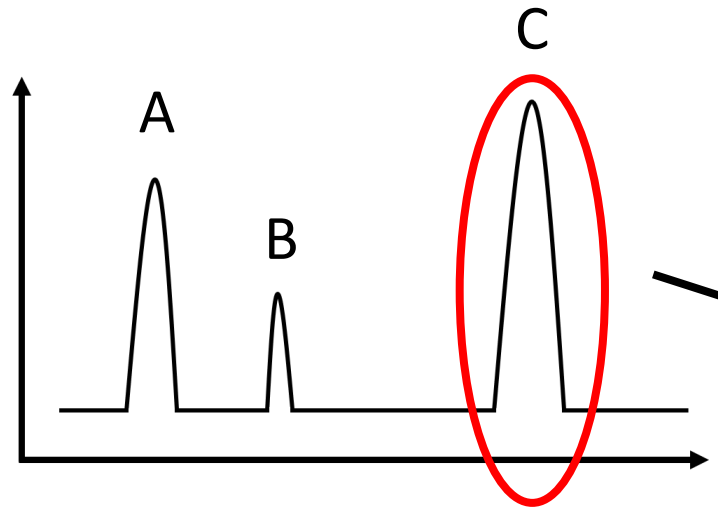
Example GCMS profile



Typical CoA – in control

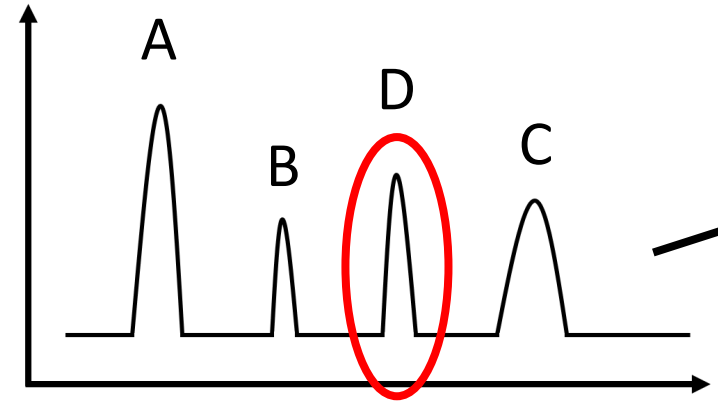
Compound	UCL	Actual Value
A	3	2.5
B	1	0.7
C	1	0.6

* Hypothetical Example Values



CoA out of control
Issue caught!

Compound	UCL	Actual Value
A	3	2.5
B	1	0.7
C	1	4



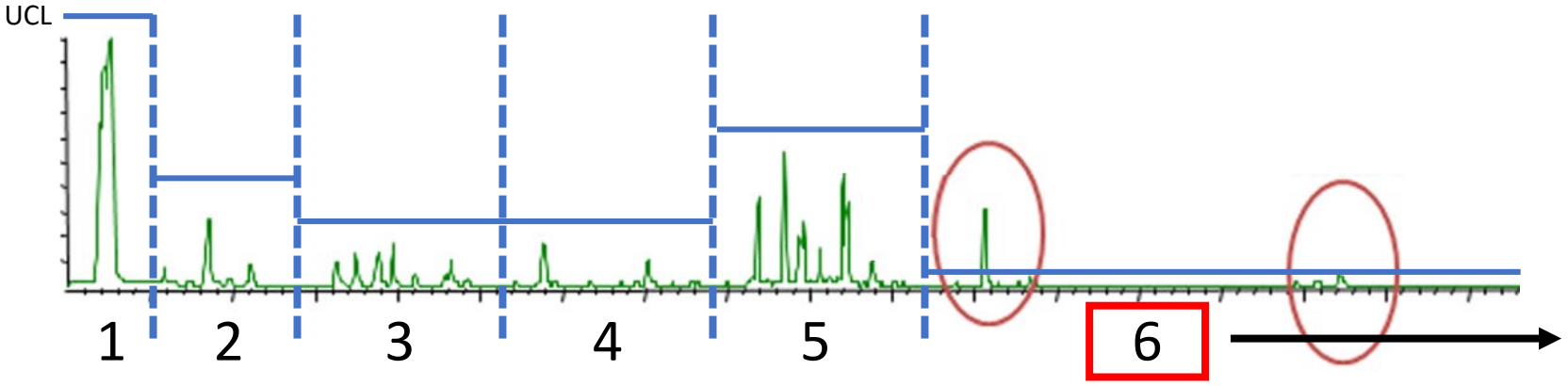
CoA in control
Issue **NOT** caught!

Compound	UCL	Actual Value
A	3	2.5
B	1	0.7
C	1	0.6

How to catch unexpected organics?

Organic Contamination Control

- **Solution:** Group typical peaks into segments
  - Control within each segment (ppb/ppt): 1) Peak max 2) Sum of peaks
  - Flags elevated and non-normal peaks
  - More robust method for controlling organic data



New limits catch the issue!

Segment	Seg. Max		Seg. Sum	
	UCL	Value	UCL	Value
1	12	10	36	30
2	4	3	12	9
3	3	2	9	6
4	3	2	9	6
5	6	5	18	15
6	0.5	4	1.5	6

* Hypothetical Example Values

Conclusion

- Materials becoming more critical to wafer defects & yield
- Excursion prevention is key
  - Strong defense lines can catch issues early
  - Chemical supplier improvements needed
- Organic quality control improvement needed
  - New, more robust method presented

Thank you!