



# SEMICON Europa

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November 2021

# Automotive Semiconductor Reliability – Contamination Management and Maturity of the Ecosystems

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# Entegris at a Glance

A world-class supplier of advanced materials and process solutions for the semiconductor, life sciences, and other high-tech industries



FOUNDED  
1966



HEADQUARTERS  
Billerica, MA



EMPLOYEES  
~5,800



2020 REVENUE  
\$1.9B



PATENTS  
2,550+



## Business Divisions

- Advanced Materials Handling (AMH)
- Microcontamination Control (MC)
- Specialty Chemicals and Engineered Materials (SCEM)

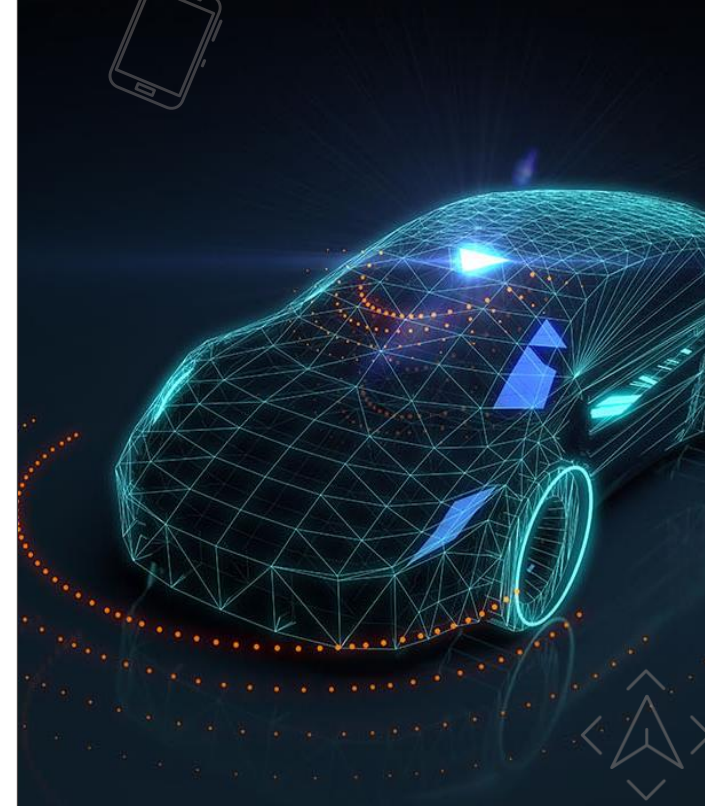
## Our Mission

To help our customers improve their productivity, performance and technology by providing enhanced materials and process solutions for the most advanced manufacturing environments

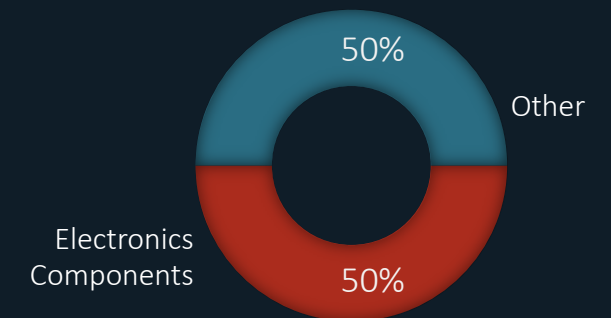


90% of auto innovation is driven by electronics

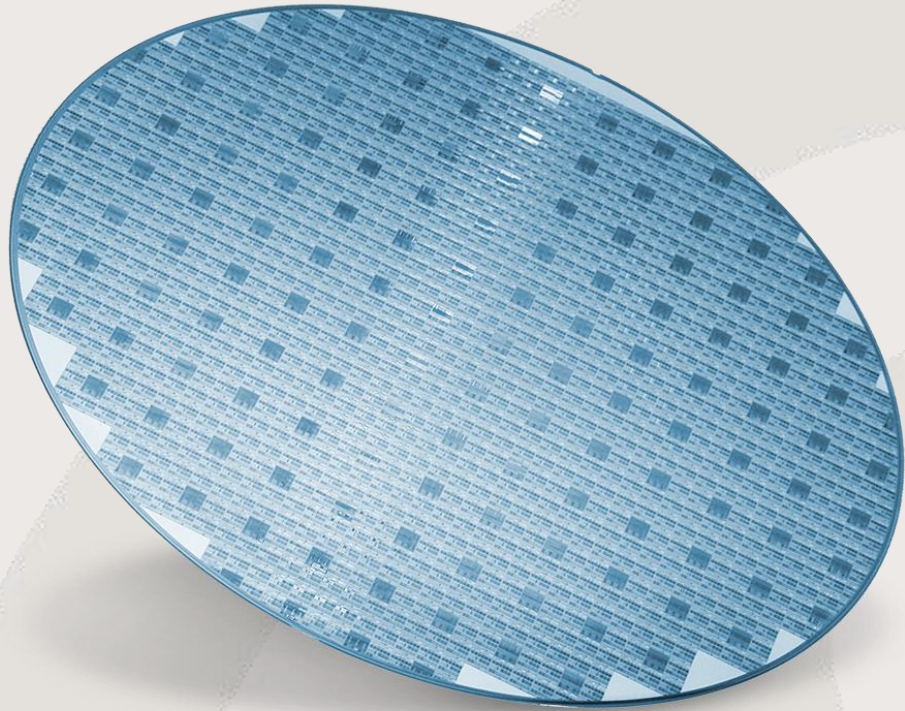
Quality ↔ Speed



Expected 2030 Car Costs



# Are we underperforming or overperforming?



Consumer Electronics

<1,000 ppm

Automotive

100% reliability over 15 years

# The Necessity to Create Frameworks

GAAC – EUROPE CHAPTER

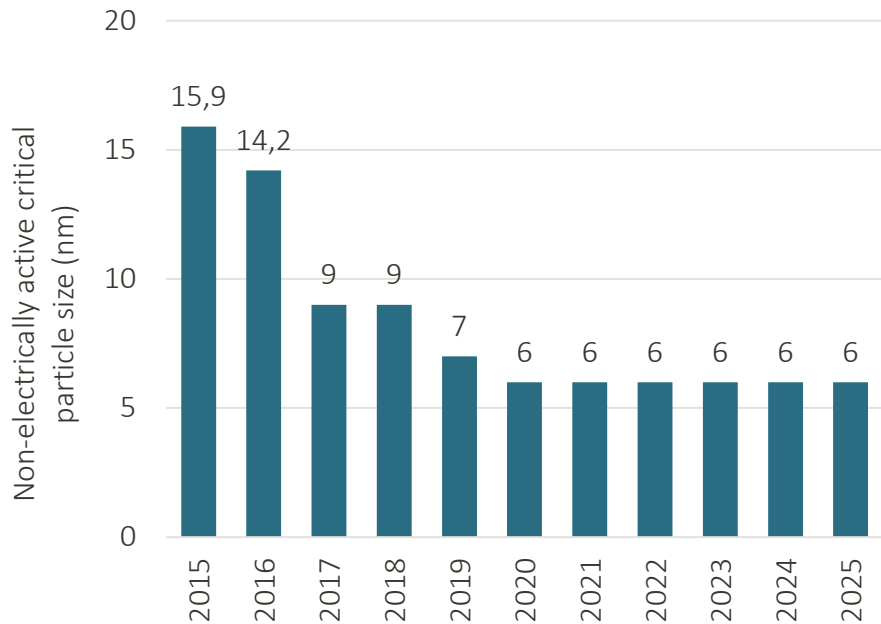


**Automotive Electronics Council**  
Component Technical Committee

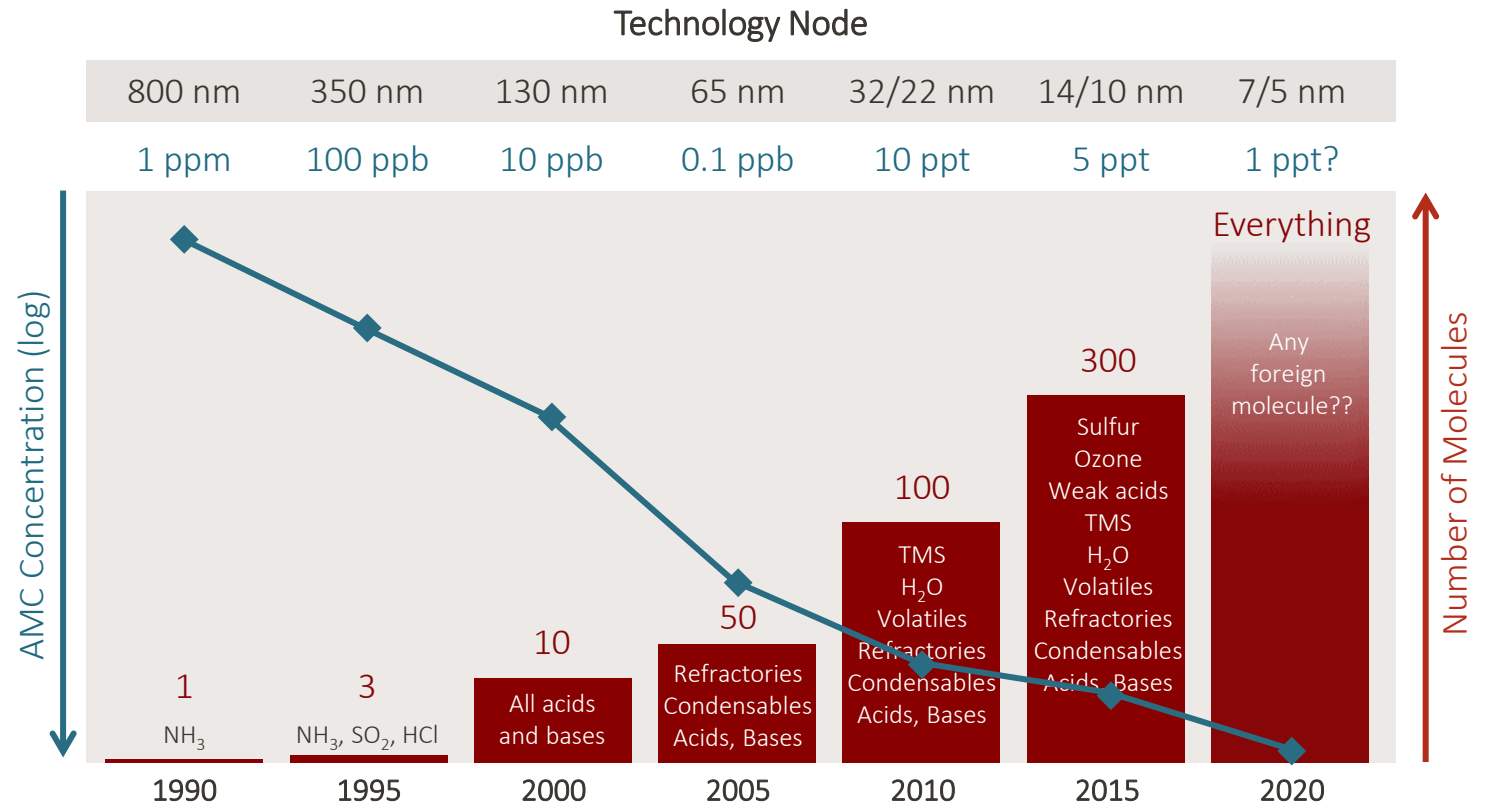
AEC-Q004  
Automotive Zero Defects

Best practices focused on the areas of manufacturing, test, reliability and continuous improvement methods

# Pervasive Contamination



Critical particle size and total metals identified by the IRDS roadmap



AMC contamination concerns by technology node

A range of contaminants that cannot be seen

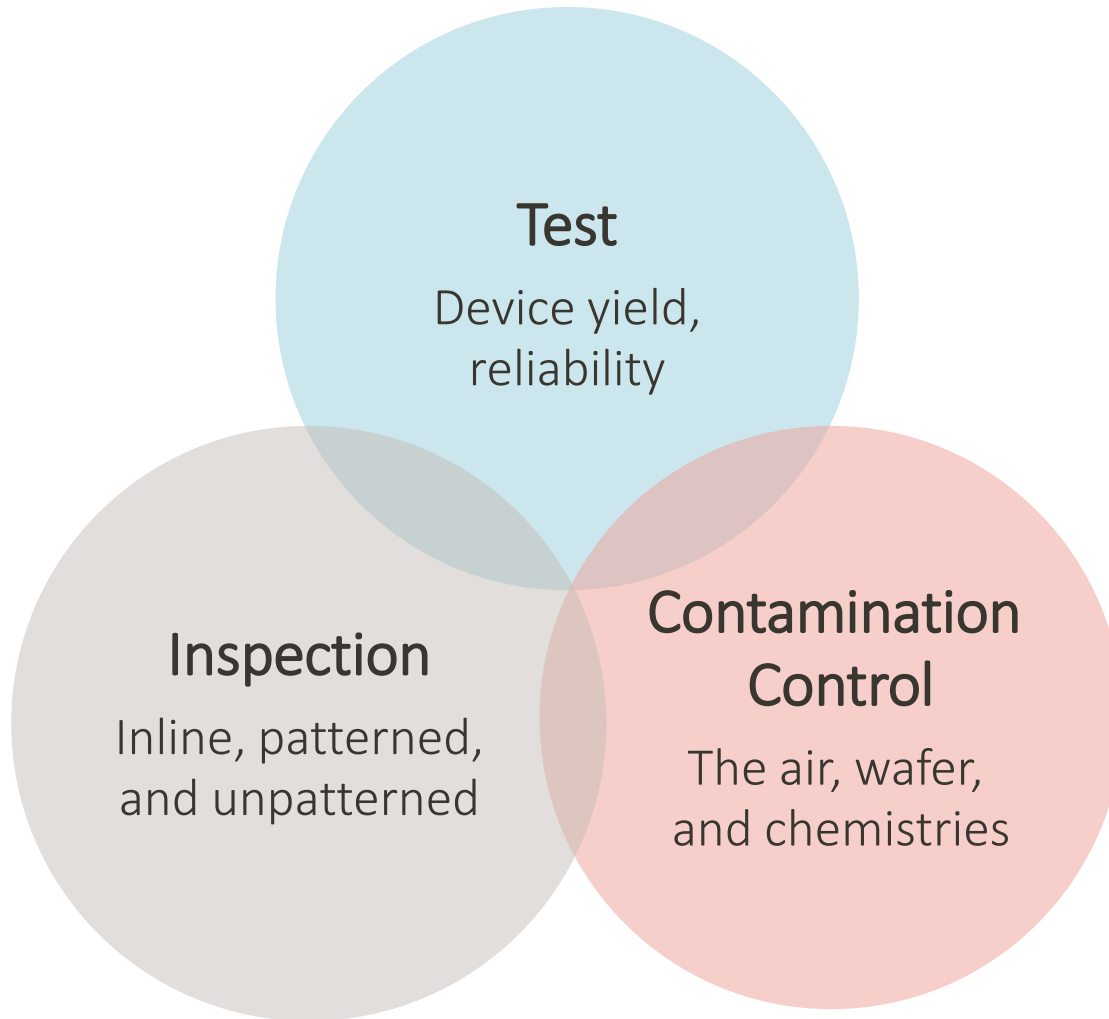
“Absence of evidence is not evidence of absence”

Martin J. Rees, astrophysicist





# Addressing Weak Links in Auto Reliability

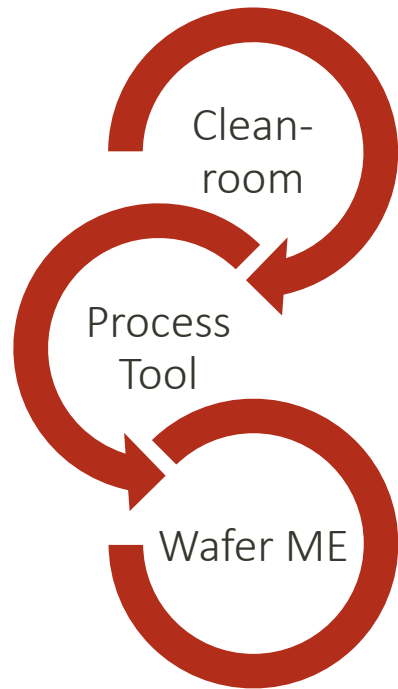


Improve baseline and  
reduce excursions



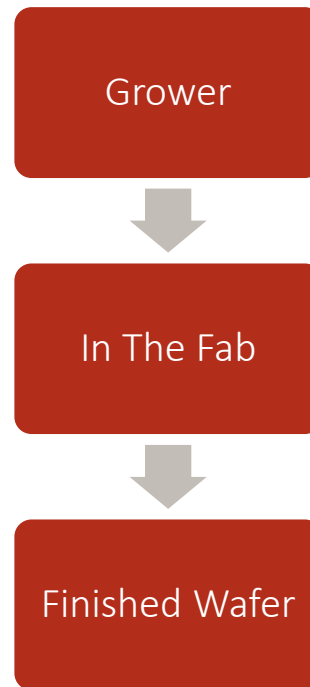
# Contamination Management Strategy

## The Air



AMC Control

## The Wafer



Wafer Management

## The Chemistries



Clean Delivery

# Third Generation of Contamination Control

At the junction of fabs, tool makers, wafer growers, and chemical manufacturers

Air   Equipment   Materials						
Implant	Lithography	Deposition	Dry Etch	Wet Clean	CMP	Fab Facility
Safe Gas Delivery Systems	Advanced Photoresist Packaging	CVD/ALD Precursors	Gas Diffusers	Formulated Cleans	Formulated Cleans	Advanced FOUPs
Electrostatic Chucks	Filtration and Dispense	Copper Plating	Gas Filters	Liquid Filtration	Liquid Filtration	AMC Filtration
Gas Purification	Gas/Liquid Purification	Gas Filtration and Purification	Gas Purification	Fluid Handling and Sensing	Brushes And Pad Conditioners	Bulk Chemical Delivery
Specialty Gases	Reticle Pods	Fluid Handling and Sensing	Specialty Coatings	Containers	Particle and Flow Monitoring	Wafer Shippers

- Specialty Materials
- Filtration and Purification
- Materials Handling

# How does the ecosystem perform?

	Contamination Control Solution	Location A	Location B	Location C	Location D	Location E
Lithography	Bulk Solvent Purification	●	●	●	●	●
	Resist Packaging		●	●	●	●
	Dispense Pumps	●	●	●	●	●
	POU Filter – Resist	●	●	●	●	●
	POU Filter/Purifier – Solvent	●	●	●	●	●
	Reticle Pod		●	●	●	●
	AMC Filter	●	●	●	●	○
Etch and Clean	Bulk Filter	●	●	●	●	●
	POU Filter – FEOL	●	●	●	●	●
	POU Filter – BEOL	●	●	●	●	●
	Metal Purification DIW	●	●	●	●	●
	Metal Purification IPA	●	●	●	●	●
	Post-Etch Clean		●	●	●	●
CMP	Bulk Filter	●	●	●	●	●
	Particle Monitoring	●		●	●	●
	Concentration Monitoring			●	●	●
	CMP FEOL POT Filter	●	●	●	●	●
	CMP BEOL POT Filter	●	●	●	●	●
	Pad Conditioner	●	●	●	●	●
	Brush	●	●	●	●	●
	Post-CMP Clean	●	●	●	●	●
Deposition	CVD Deposition Precursor Delivery	●	●	●	●	●
	Plating Chemistries		●	●	●	●
	Cu Plating Filtration		●	●	●	●
Implant	GeF4	●	●	●	●	●
	Insitu cleaning gas					
	Gas AsH3	●	●	●	●	●
	Gas PH3	●	●	●	●	●
	Gas BF3	●	●	●	●	●
Fab Facility	Bulk Gas Purification			●	●	●
	AMC Filter		●	●	●	●
	FOUP or SMIF Pods	●	●	●		●
	Finished Wafer Shipper (HWS)					●

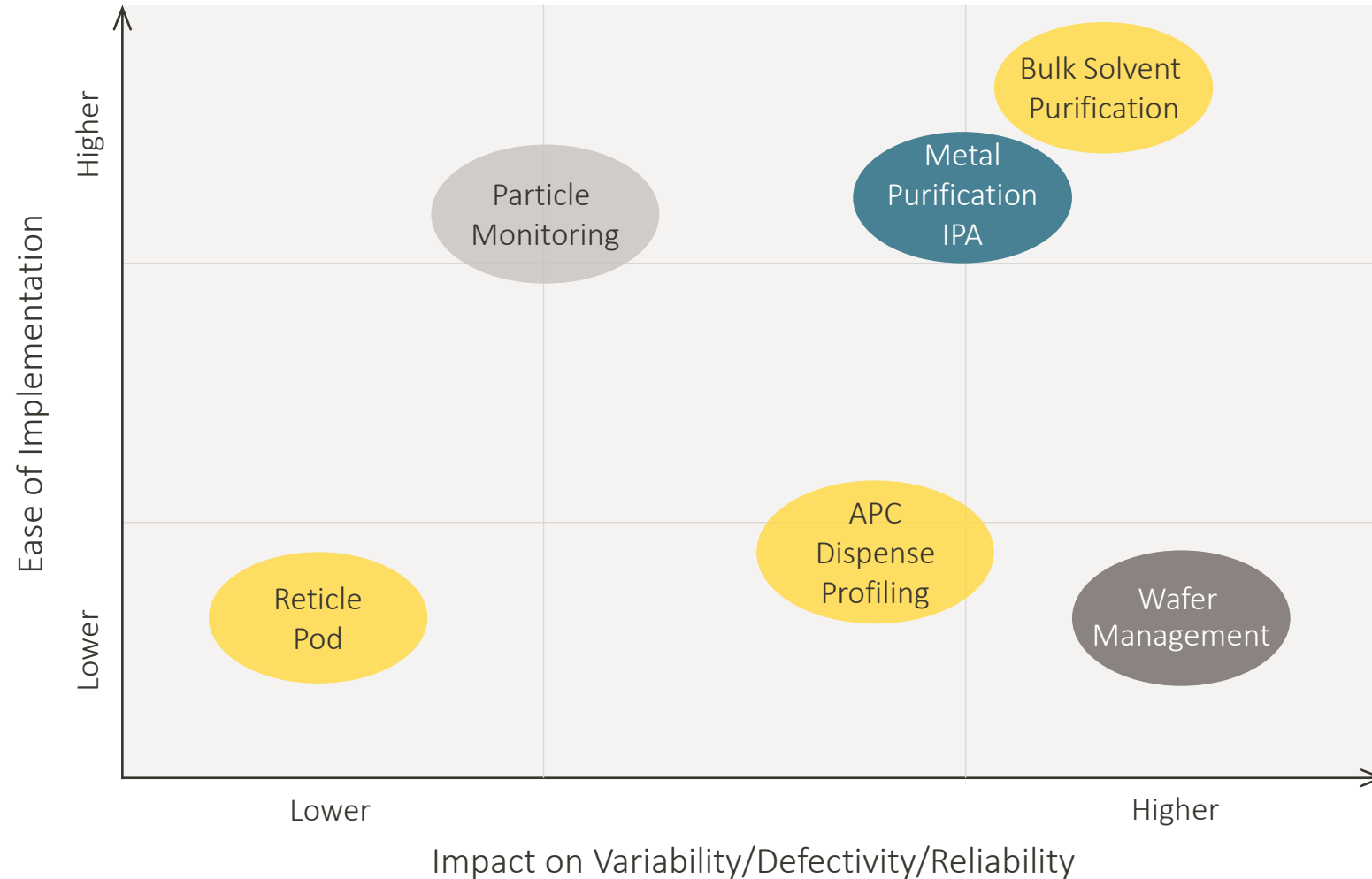
## Benchmark for contamination control

- A list of reference
- A comparator
- A tool
- An indicator of maturity

When compared to the optimized solution, the current solution in place:

- Not adequate
- Can be improved
- Equal or better
- Not known

# Benchmark – Hot Topics for Location X

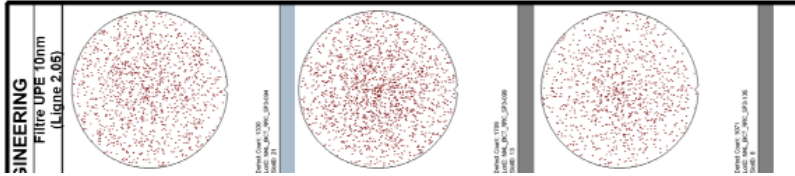


# Metallic Purification in Photo Litho

## Problem Statement

At resist reduced consumption (RRC) solvent prewet step, the **EC solvent** brings an **extra source of defects**, which can be trapped at the Si-Resist interface

SP3 with std UPE filter



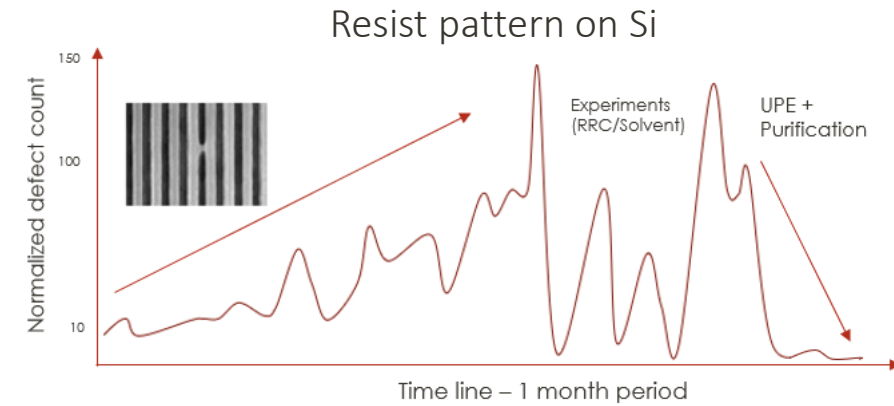
## Approach Taken

Single line open (SLO) defect density correlates with a drift of metal compounds concentration in incoming EC\_solvent

The benefit of using ultraclean pre-wet solvent are clearly identified and have been discussed in literature

Ultra pure solvent can be obtained by purifying solvent at POU or improving EC\_solvent specifications from supplier

## Results



## Lessons Learned

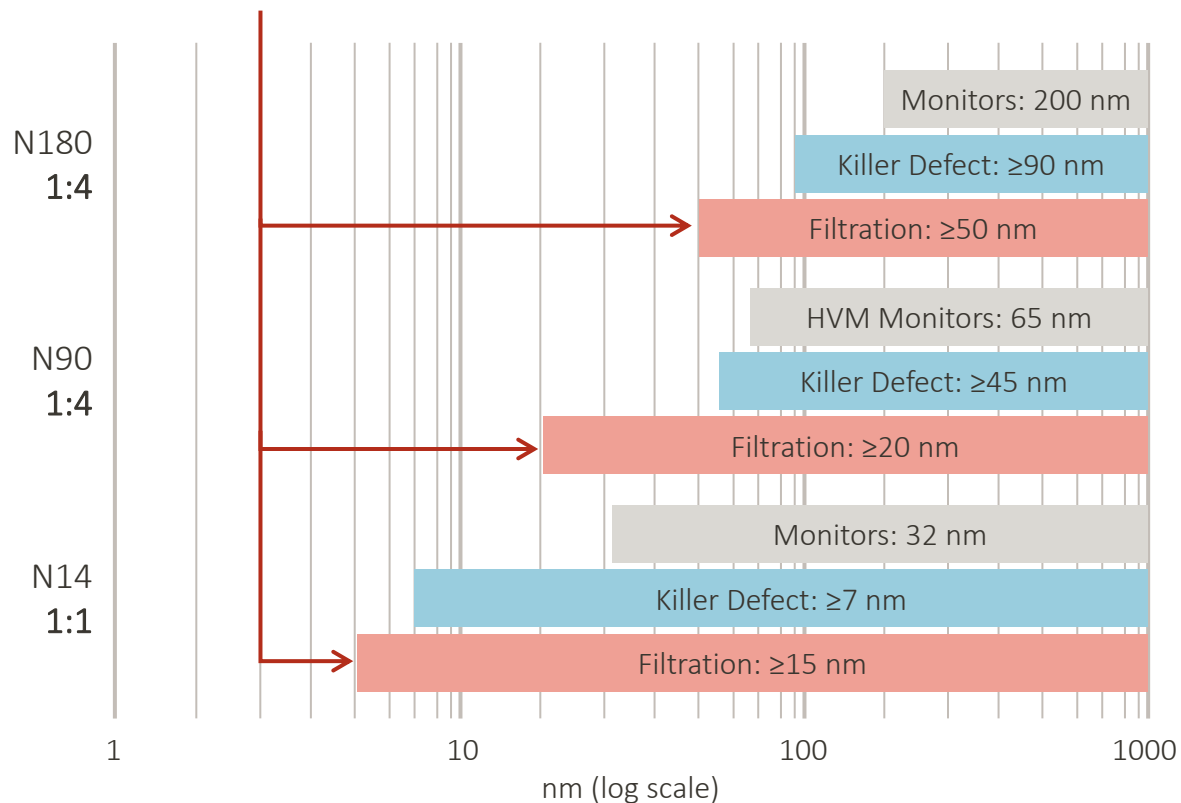
Upgrade **particle filtration stage** from 10 nm UPE to **3 nm UPE**

Widespread usage of **solvent purification** and UPE 3 nm filtration at POU for improvement of stack defectivity

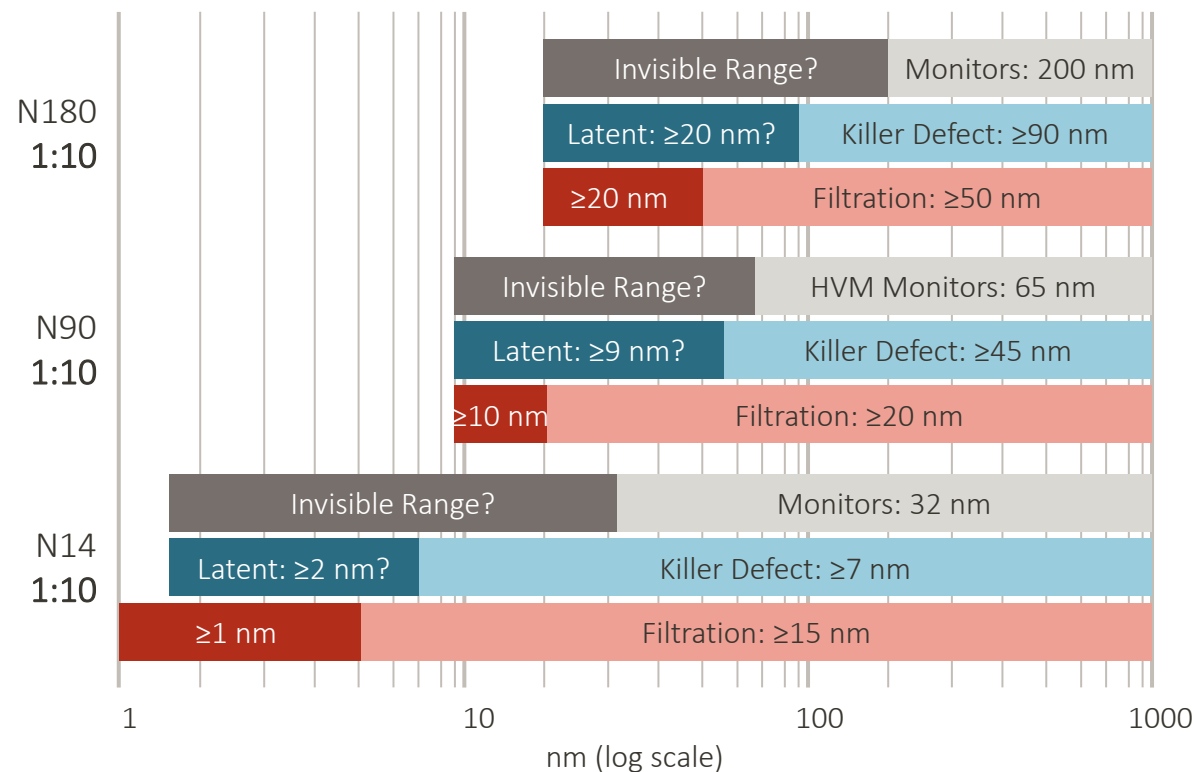
Upgrade facilities solvent filtration into purification

# New Filtration Strategies with Auto IC

Historical Filtration Strategies with "1:4 Rule"



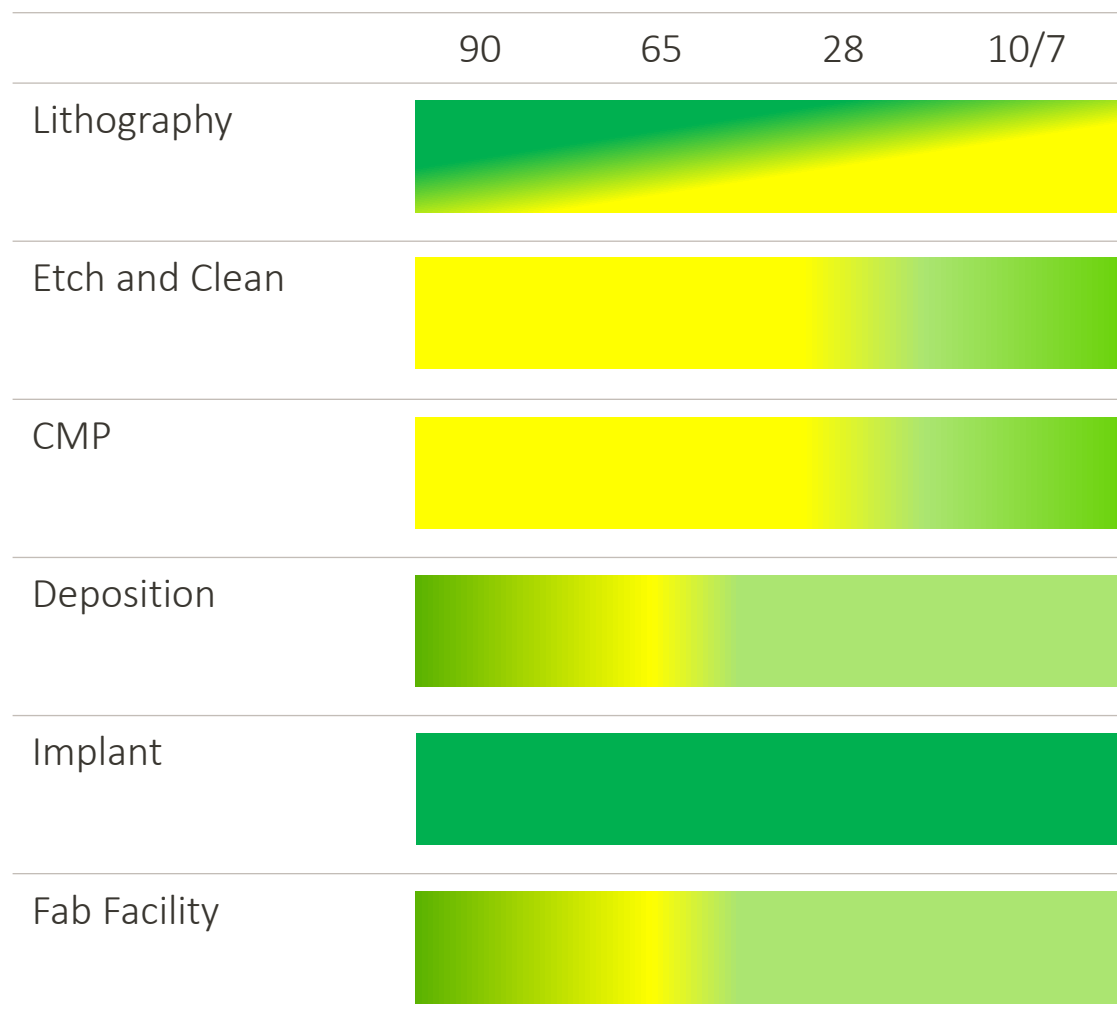
Improvement of Latent Defect Management with "1:10 Rule"



Note: all dimensions related to filtration are an indicator of retention rating



# Maturity of the Ecosystems

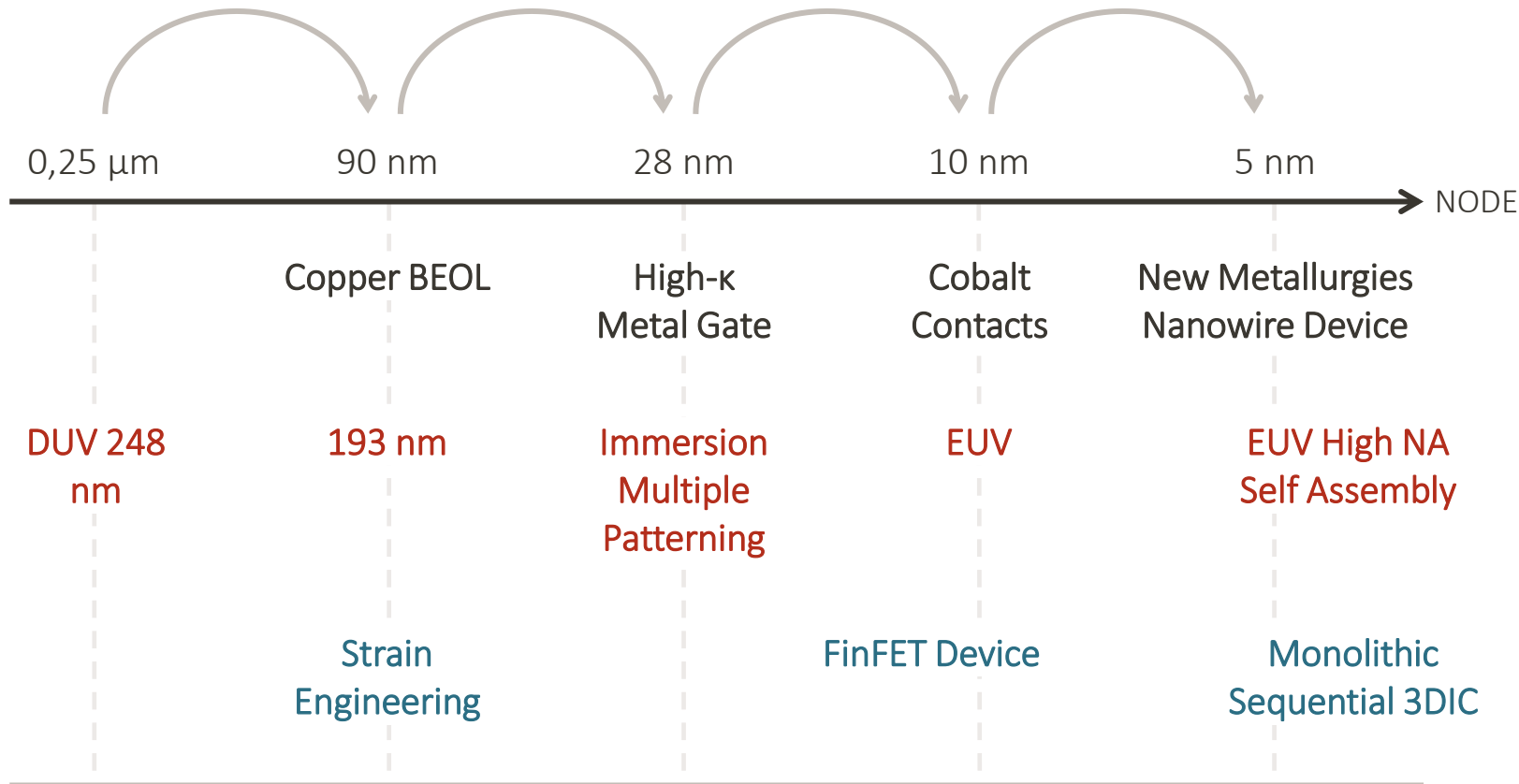


A new engagement model is required

- Minimum 75% of the players have the adequate solution in place
- Between 50% and 75% of the players have the adequate solution in place
- Less than 50% of the players have the adequate solution in place

# Correlation with Technology

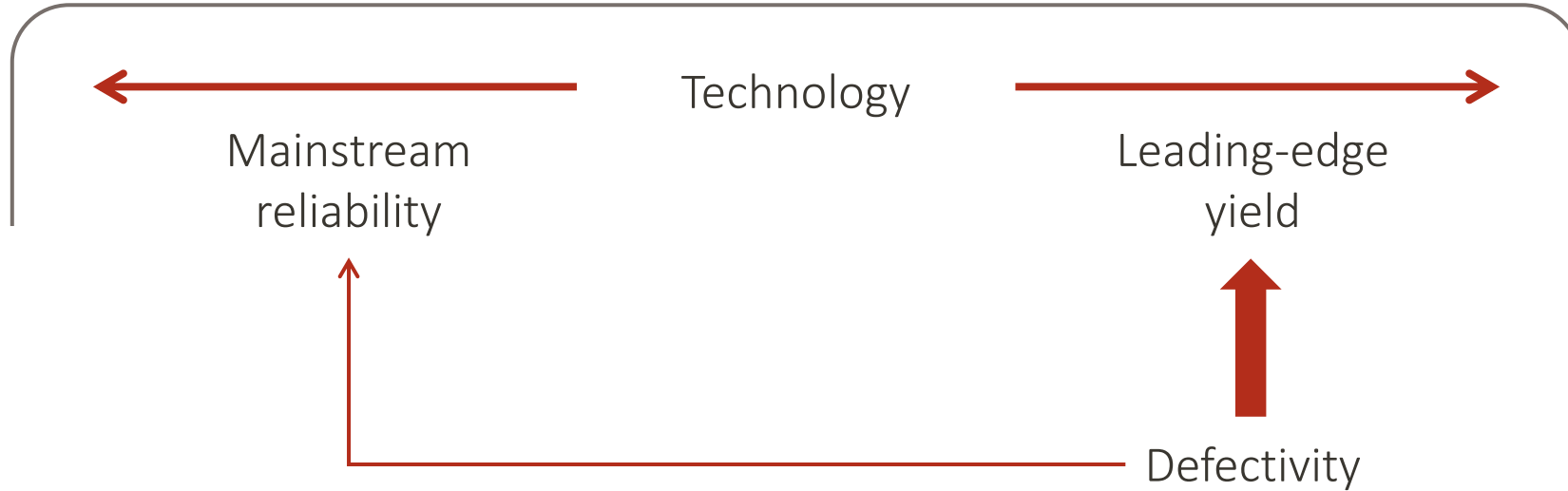
## Logic Technology Inflection Points\*



Major inflection points – a trigger to radical changes

Advanced nodes – greatly impacted by contamination

# Learn and Leverage



Be closer to the technology driver, improve yield, and apply knowledge to mainstream's reliability

# It is only the beginning of the journey...

Optimized solutions in place



Run-to-failure



Proactivity is better

# Designing Quality in the System



Improve total quality without relying solely on inspection and testing

# A New Collaborative Approach

Holistic – Test, inspection and contamination control

“The Air, the Wafer, the Chemistries”

Maintain the strategy over the long term

Links to joint paper and panel discussion:

[A Collaborative Approach for Automotive Electronics \(semiconductordigest.com\)](https://www.semiconductordigest.com)  
April/May 2021 edition

[SEMI – ENTEGRIS – CARIAD SE \(Volkswagen\) Panel Discussion | SEMI](#)  
July 2021



Thank you!

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# Q&A

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