Achieving Zero Defect Manufacturing

APRIL 18, 2024

Prasad Bachiraju is senior director and responsible for Onto's enterprise software business' development & product marketing. Prasad joined Onto Defect & Yield Management team 26 years ago as a software engineer. Prasad holds a Master's in computer applications.

Safe Harbor Statement

The information presented herein contains forward-looking statements that relate to anticipated future operating results and performance. These statements are only predictions based on management's current expectations and assumptions, including market size and forecasted growth, Total Available Market (or "TAM"), Served Available Market (or "SAM") and revenue estimates, and necessarily involve risks and uncertainties. We do not assume any obligation to update the information provided. Actual events or results may differ materially from those projected, including as a result of changing industry and market trends, reduced demand for our products, the timely development of our new products and their adoption by the market, increased competition in the industry, price reductions and other subsequent developments and business conditions. Additional information and considerations regarding the risks faced by Onto Innovation are available in our Form 10-K reports for the year ended December 30, 2023, and other filings with the Securities and Exchange Commission.

This presentation includes non-GAAP financial measures which are not intended to be considered in isolation or as a substitute for the financial information prepared and presented in accordance with GAAP. Management uses both GAAP and non-GAAP measures when evaluating the business internally and therefore believes it is important to make these non-GAAP measures available to the financial community. Reconciliations of non-GAAP measures to the most relevant GAAP amounts are included in the appendix section of this presentation.

As the forward-looking statements are based on Onto Innovation's current expectations, the company cannot guarantee any related future results, levels of activity, performance or achievements. Onto Innovation does not assume any obligation to update the forward-looking information contained in this presentation.

Fabs Today

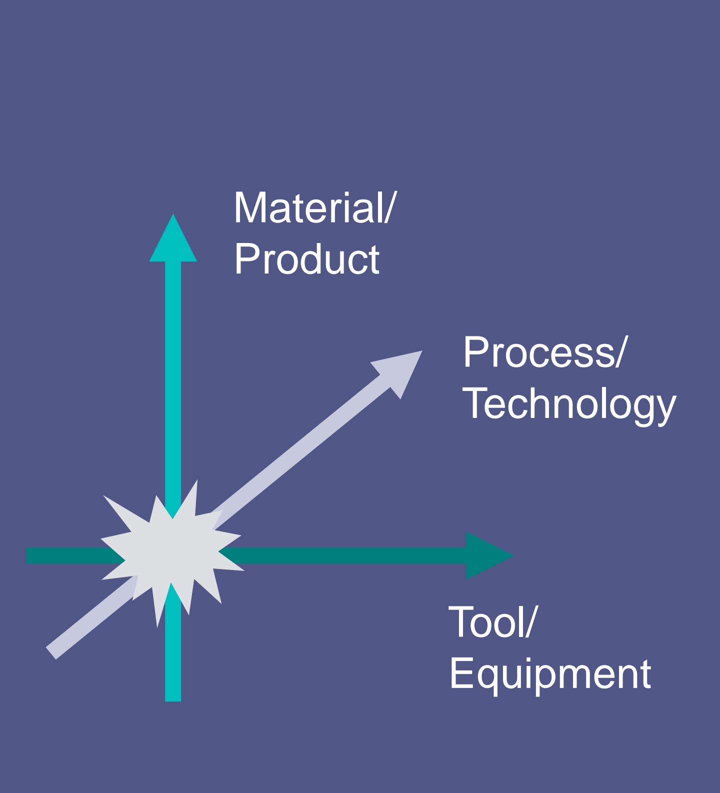
Modern processes have become unimaginably **complex**

Managing your controls are critical to ensuring **performance**

All types of chip providers require **zero defectivity,** reliability & traceability to meet customer requirements

Big Data

Data Integration Is The Starting Point For Any Digital Transformation



FDC / APC / R2R

Multi-Factory Data

Material Process History

Product Specs

Production Test Data

Tool History

Production Inline Metrology

PROCESS

SUBFAB

Supply Air Pl

Central Clean Aisle

Tool Bays

Exit/Equip. Corridor

Scrubber Deck

RAH

Process Metrology

Defect Data

Process Consumables

Tool Metrology / Quals

Transport Carrier History

Enterprise Software Ecosystem

Onto Software is the Connective Tissue for Power Manufacturing Process

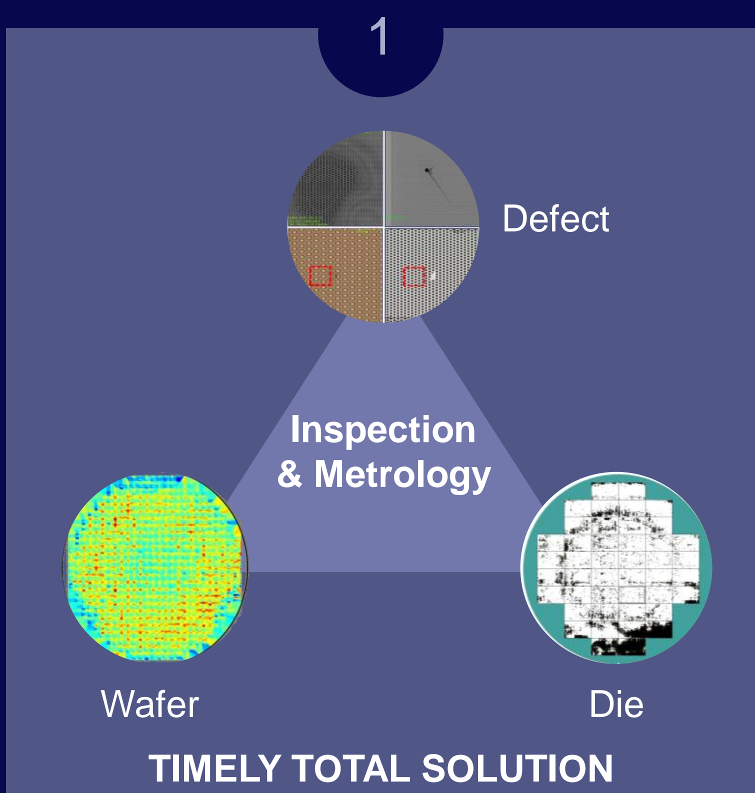
FDC
DASHBOARD
RUN-TO-RUN
YIELD OPTIMIZER
TRUEADC
YIELD
REVIEW
DEFECT
PATTERN
STEPFAST
AUTOSHELL
CONTROLWORKS

CONTROL
BI
ANALYZE
AUTOMATE
CLASSIFY

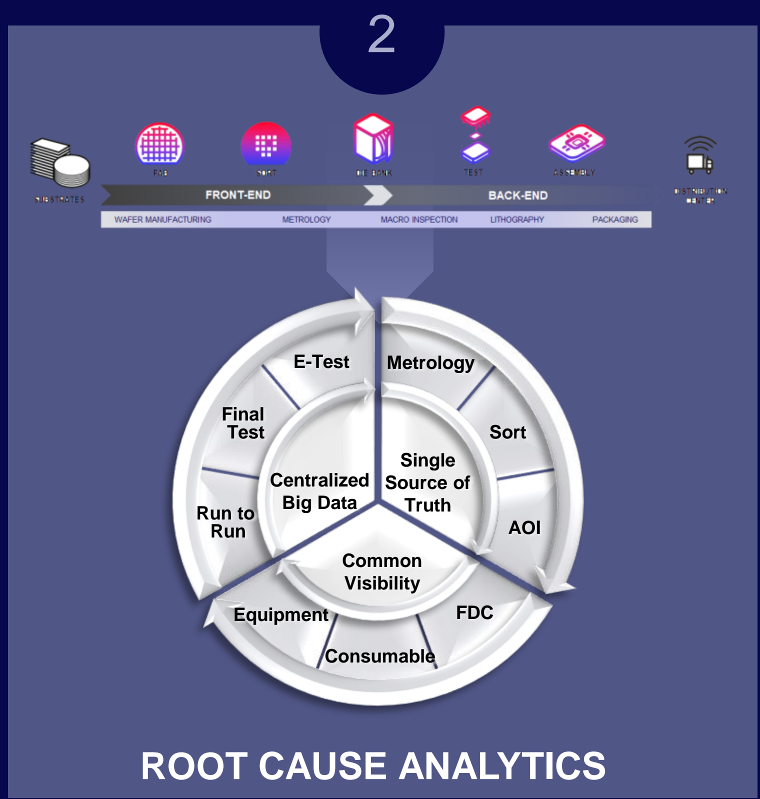
Achieving Zero Defects in Semiconductor Device Manufacturing

Three Step Initiatives

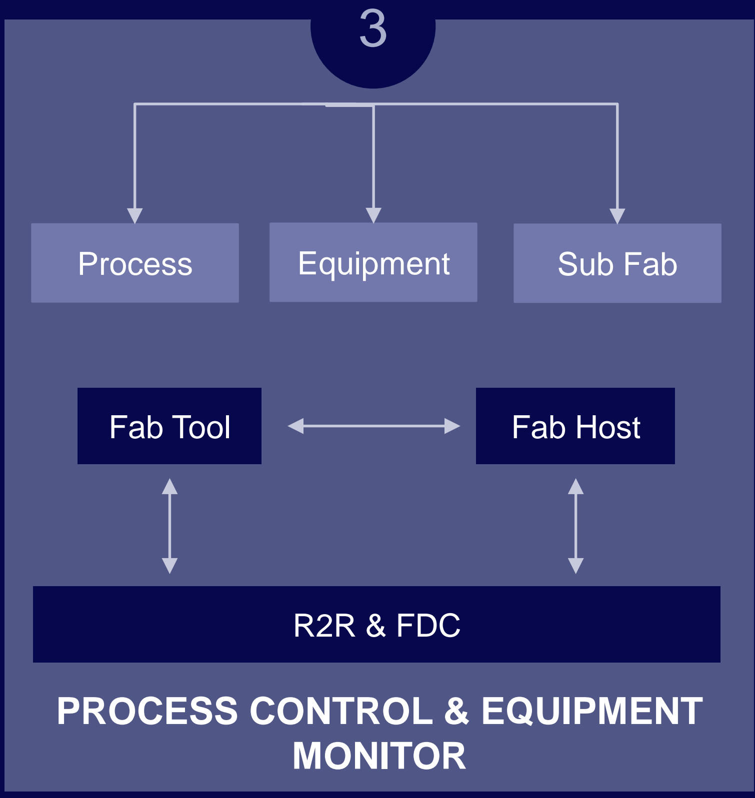
Detect & Classify Defects



Find Defect Sources



Prevention of Defects



Total Solution for Inspection & Metrology

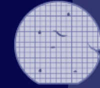
Detect & Classify – Defect Level

TRUEADC®

One ADC for Entire Fab – AOI, SEM, OM/Camera

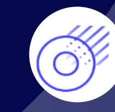
On Tool Real Time ADC

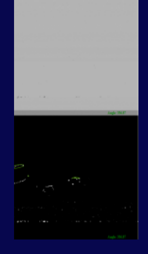
Defect, Die, Shot, Wafer Edge


Whole Wafer Image Front & Backside

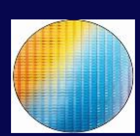
Multi Engine Approach

Closed Loop Feedback


Real Time Binning & Die Disposition with Discover



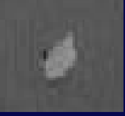
SUBSTRATES

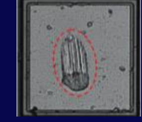


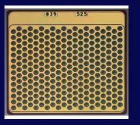
DISTRIBUTION CENTER

FRONT-END

BACK-END

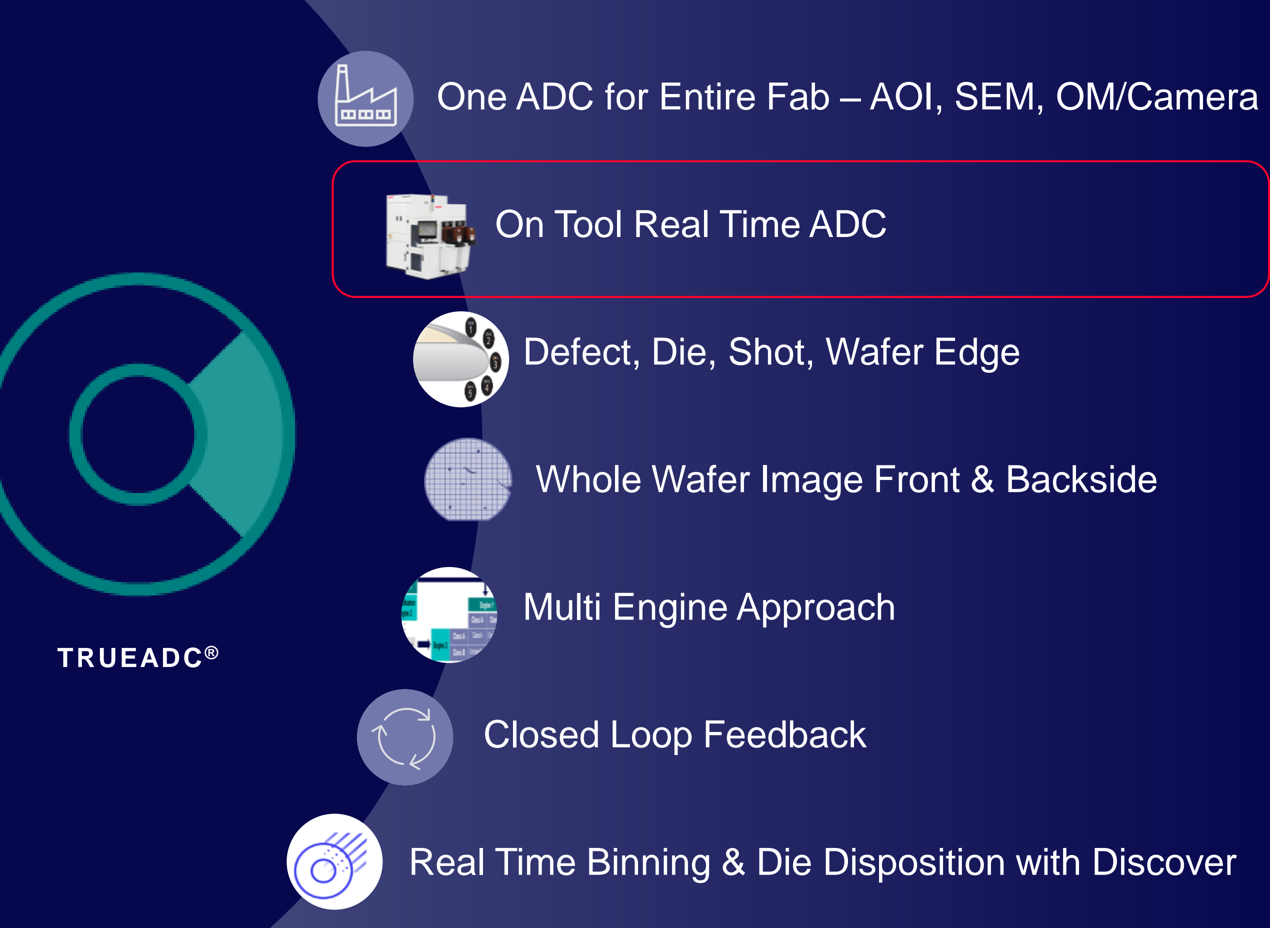




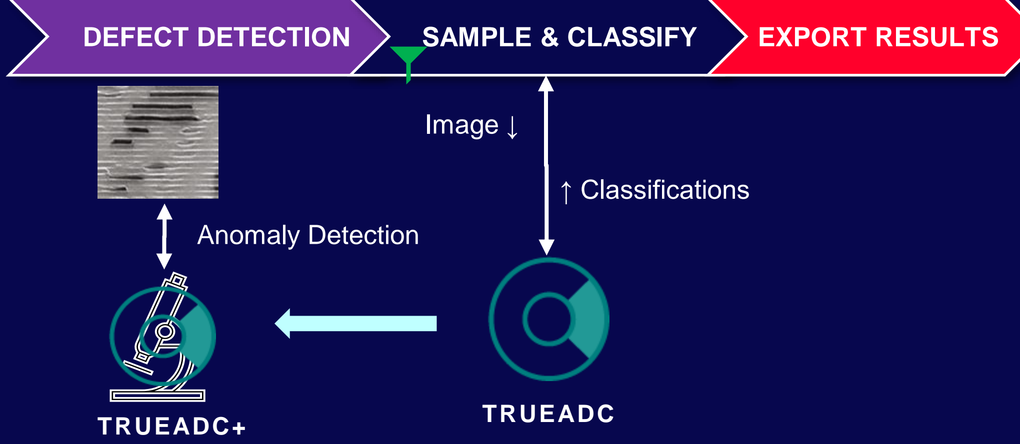


Total Solution for Inspection & Metrology

Detect & Classify – Defect Level



AOI tools running at higher sensitivities result in excessive rates of nuisance and non-visual defects



TRUEADC+ Removes 60% of the noise that impacts throughput & yield loss

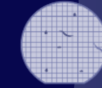
Total Solution for Inspection & Metrology

Detect & Classify – Defect Level

One ADC for Entire Fab – AOI, SEM, OM/Camera

On Tool Real Time ADC

Defect, Die, Shot, Wafer Edge


Whole Wafer Image Front & Backside

Multi Engine Approach

Closed Loop Feedback

Real Time Binning & Die Disposition with Discover

TRUEADC®

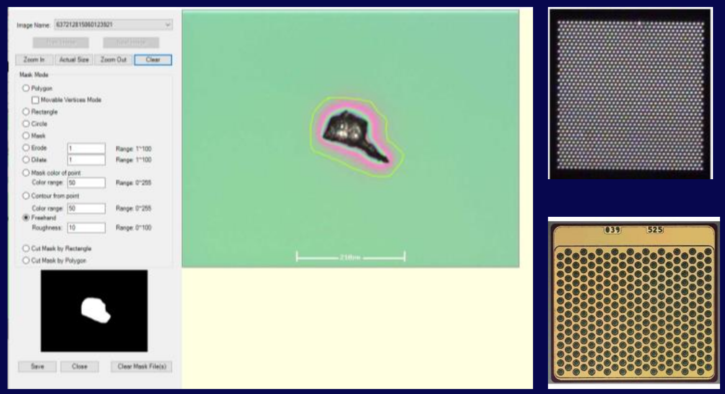
Multi-Engine

Classification Engine 1

Classification Engine 2

Classification Engine "n"

		Engine 1	
		Class A	**Class B**
Engine 2	**Class A**	Class A	Unclassified
	Class B	Unclassified	Class B



LABELLING TOOL

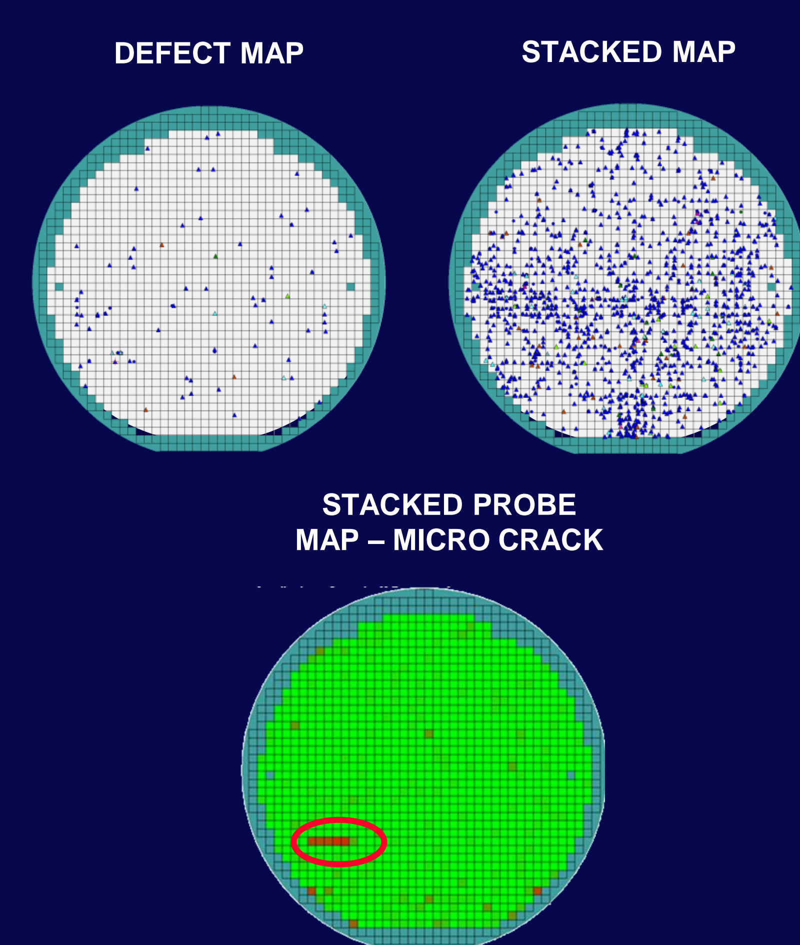
Total Solution for Inspection & Metrology

Detect & Classify – Die Level

REVIEW

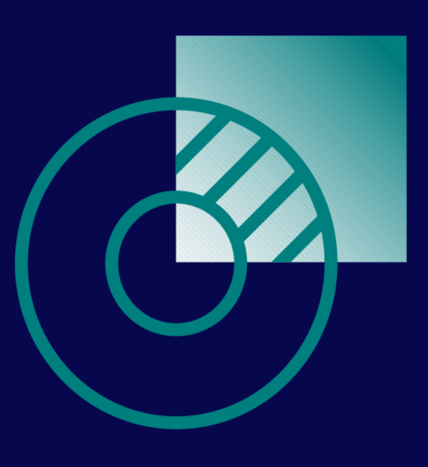
DEFECT

- Rules Based Auto Die Binning
- Auto Bin Potential Reliability Failures (GDBN)
- Trend Hit Rate / Kill Ratios
- Predict Die Bin & Failures
- Integrate, Feedback & Feed Forward
- Enable Industry 4.0 towards Fab Efficiency
- Tools to Monitor Performance both ADC & Manual



Total Solution for Inspection & Metrology

Detect & Classify – Wafer Level



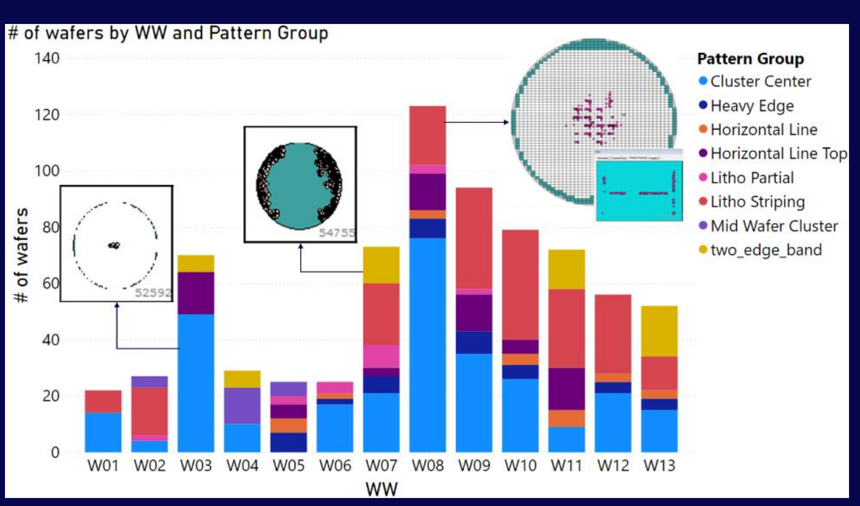
PATTERN

- Auto Discovery for Library Setup
- Detect & Classify Wafer Signatures
- Inline Wafer Monitoring
- Learn from UNKNOWNS
- Search/Link Patterns Across Data Types
- Advanced Scratch Detection
- Integrate, Feedback & Feed Forward

REACTIVE TO PROACTIVE

21% of wafer starts have some form of spatial pattern

→ 4% of wafers exhibit new UNKNOWN spatial pattern

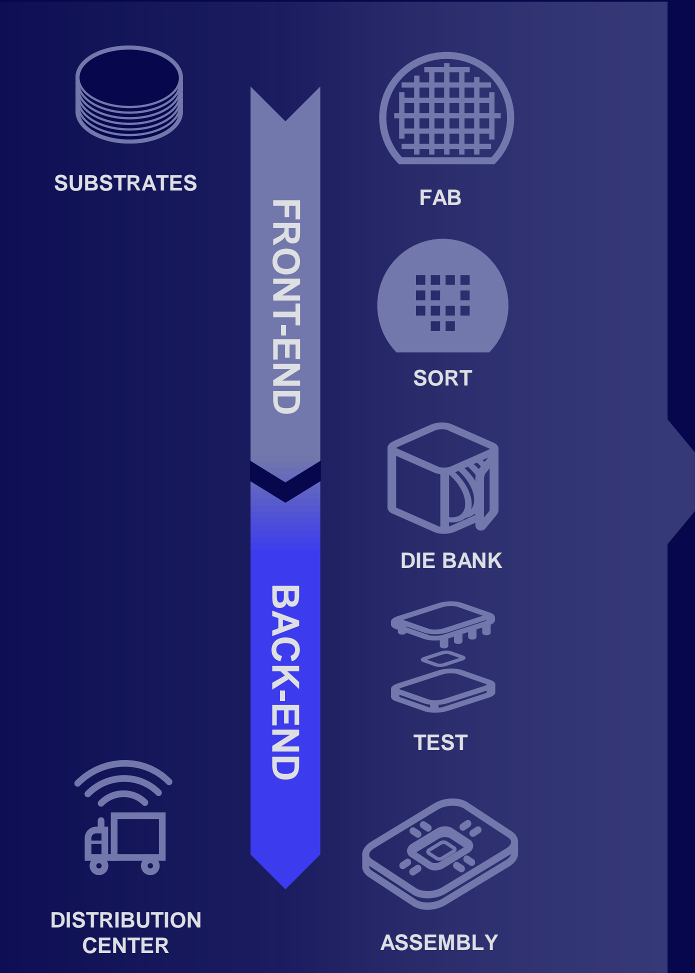


Results of learning from "UNKNOWN" spatial yield limiting events over 3 months

Presented paper in 2021

Root Cause Analytics (RCA)

Faster Understanding of Visual, Non-Visual & Latent Defect Sources



Supply Chain Analytics

- Multi-site Integration
- Enable Feedback – FT to EPI
- On-site & In Cloud Ready

Introducing

- Web Based AI Yield Optimizer
- Test Quality Center

To Improve Quality & Reliability of Automotive Device Manufacturing!

RCA Value Case 1

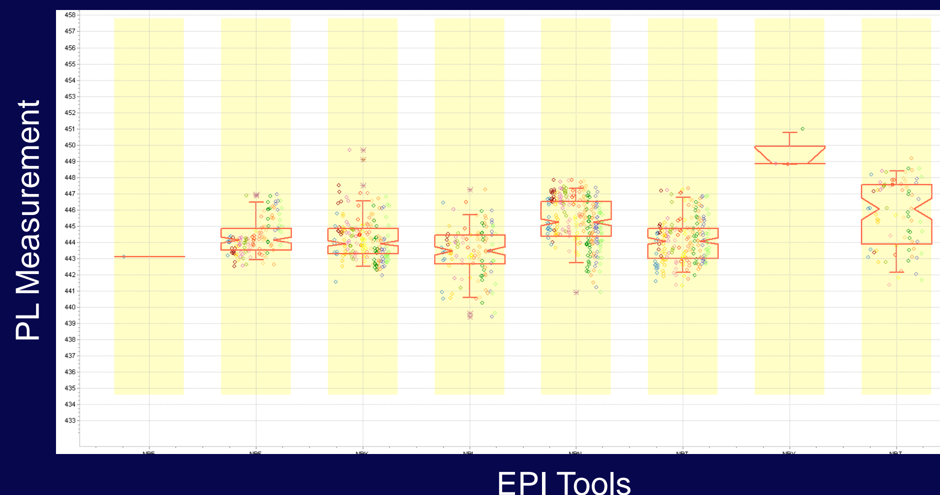
Integrating Wafer Probe, EPI and PL data

Challenges addressed

- Linking wafers pre & post EPI
- Depending on wafer die count, dealing with large volumes of electrical test data
- Normalize and interpolate size level data into die level

Value

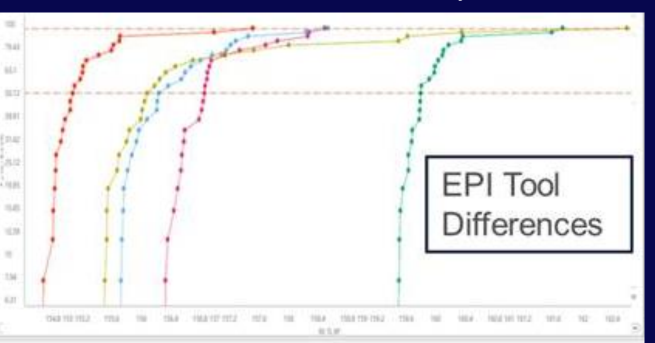
- Reduced time to root cause from days to < 3mins
- Enabled zero defect manufacturing & improved yield by saving 100s of wafers getting processed from problem EPI Tool/Pocket



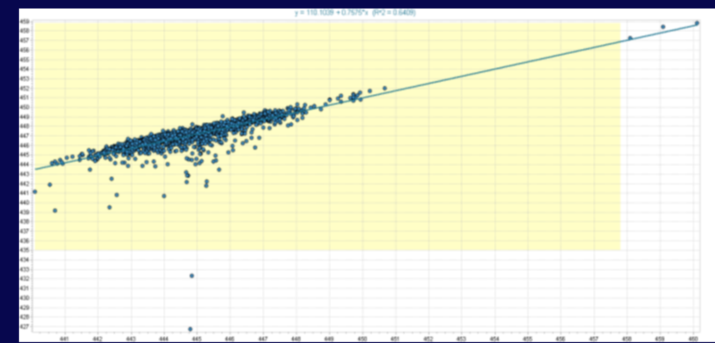
EPI Tools

NOTE: Wafer position within EPI reactor also can be used to understand trends

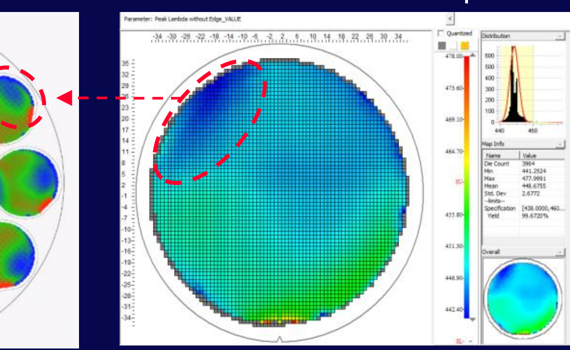
Electrical Test Performance by EPI Tool



WP Parameter vs. PL Statistical Mean

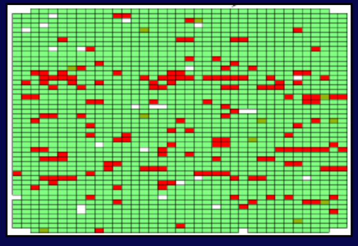


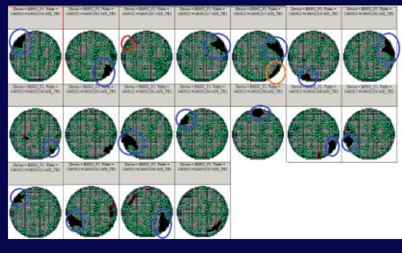
PL Parameter Map

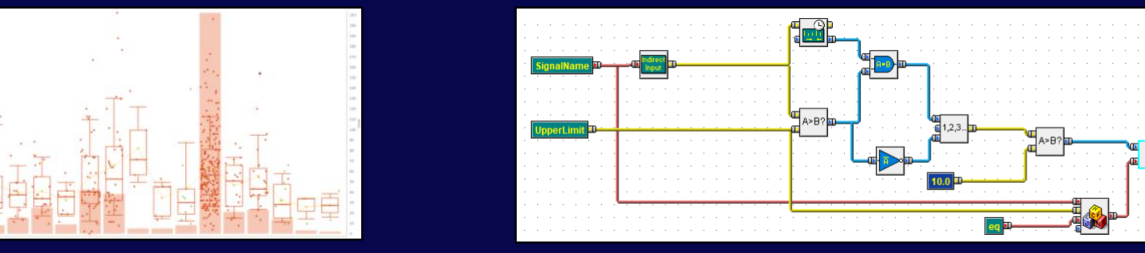


RCA Value Case 2

Problem Solving within the Supply Chain







$375K

Potential loss* due to Final Test on Panel

1,700 wafers

Failed dies come from wafers with edge cluster that are signaled by Spatial Patter Recognition

Issue found to Spinning Step & specific Spin Coater by integrating MES into YMS, Identified the “bad” tool

A proper exhaust flow is crucial for Quality & Yield

Setup monitoring for exhaust flow sensor to notify and clean exhaust when more than 10 consecutive samples are above 95 Pascal

Panel Test → Wafer AOI → MES → FDC

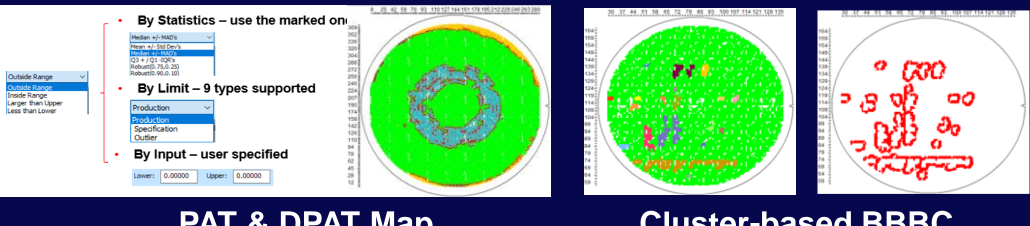
Reactive to Proactive Zero Defect Manufacturing

Avoiding Potential Dormant Defects

Test Quality Management

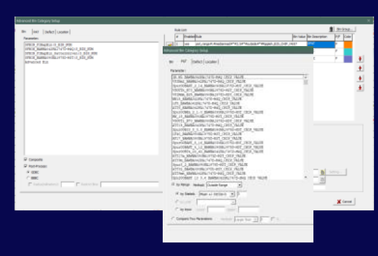
Best practices followed by fabs today

- Dynamic Part Average Testing (DPAT)
- Statistical & engineering rules-based binning per AOI results, WP test values & bin codes
- Good die in bad neighborhood
- Lot level guard banding / die kill
- Reticle field based die kill
- Edge exclusion
- Die score based on different events and data types

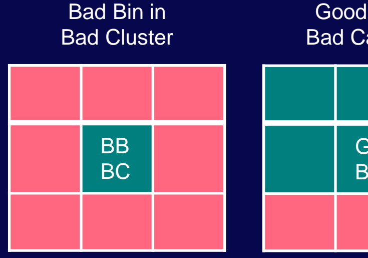


PAT & DPAT Map

Cluster-based BBBC



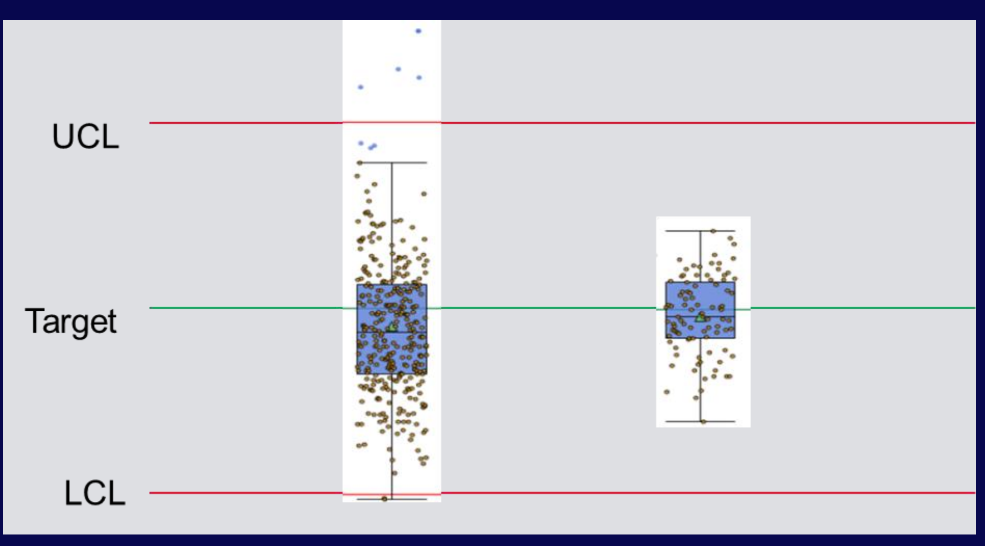
Custom Rule definitions



Prevention of Defects by Process Feedback and Feedforward

Applies to Entire Manufacturing Process Steps

Customer Example: Enabling Dynamic Deposition Rate Control Throughout the Lifetime of the Process Chamber



Without R2R **With R2R**

Zero Defect Initiative

- Implement feedback from Yield Analytics & FDC to empower R2R Controller Design

Process	Equipment
Increased Process Centering	Chamber Lifetime Increased 15%
Dispersion Decreased 32%	Enabled Automated Maintenance Detection
OOC Decreased 40%	Reduced Maintenance Costs

Prevention of Defects by Monitoring Equipment Health

Applies to Entire Manufacturing Process Steps

Monitoring of Tool Sensors prevents defects. Customer Example: Proactive Monitoring exhaust flow sensor in a spin coater resulted in higher Quality & Yield.

Zero Defect Initiatives using FDC data

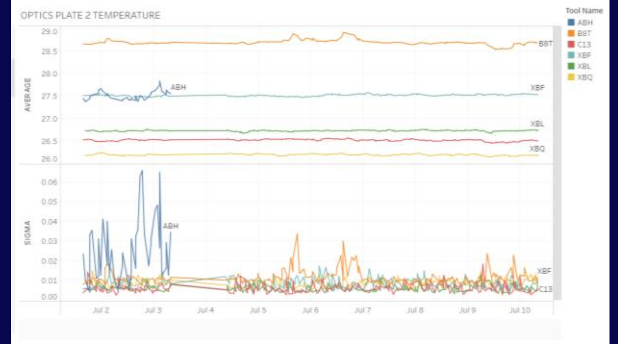
- Utilize FDC Trace and Summary data in Machine Learning based Analytics
- Fleet Management

SignalName
Indirect Input
UpperLimit
A>B?
1,2,3...
10.0
eq

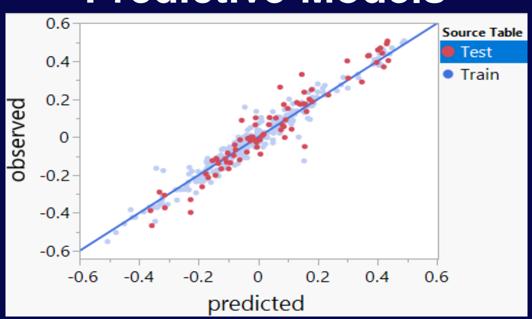
FDC Model

Health Monitor

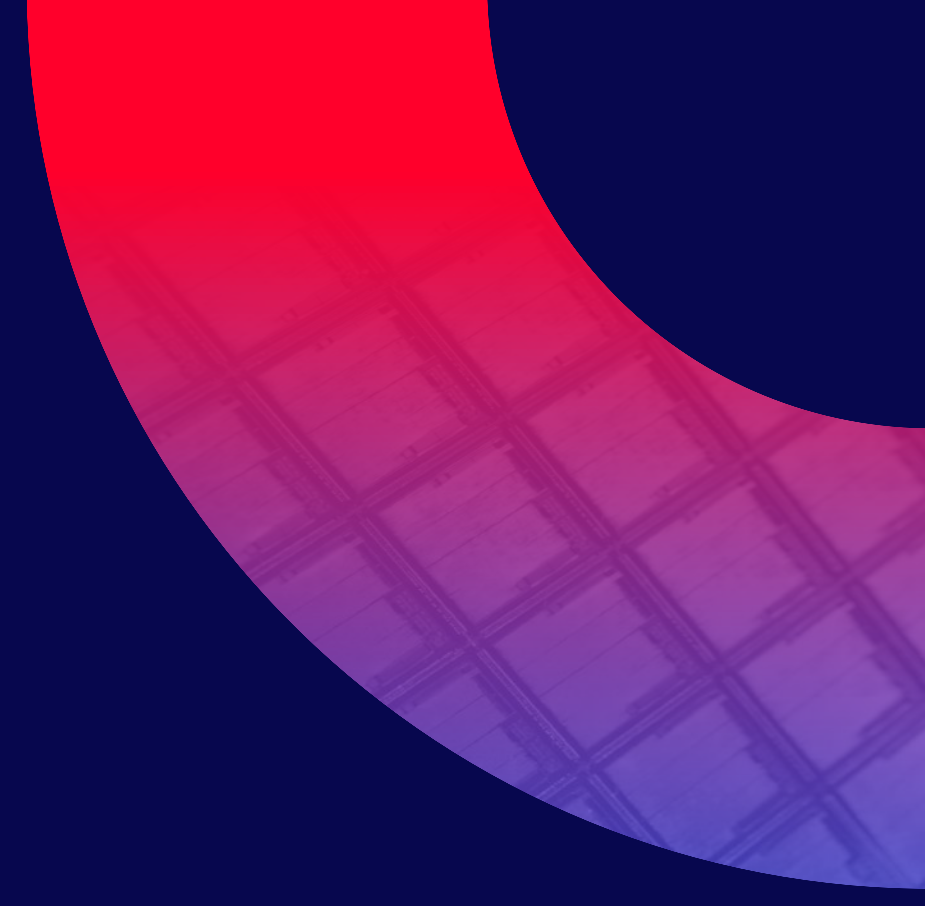
Analysis Toolkit



Predictive Models



Q&A



Thank You

谢谢 | 謝謝

ありがとう

Obrigado

Danke

감사합니다

Merci

info@ontoinnovation.com
www.ontoinnovation.com