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2025 Users Conference

Manufacturing Data Analytics

for Fab and Advanced Packaging

Jon Holt

December 4, 2025

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05.

Customer Presentation

Sense the power of light

Scaling Yield Management Intelligence at ams OSRAM

A Journey with Exensio Manufacturing Analytics
Advancing manufacturing efficiency through data-driven insights

Ahmad Abdel Majeed
PUG2025 – December 2025

A trusted advisor for advanced light and sensor solutions

Unique portfolio of key components

Emitters

- LEDs
- microLEDs
- Lasers (EEL/VCSELs)
- Lamps

Sensors

- Light sensors
- Bio-sensors
- Image sensors

Optical micro-modules

- Micro-optical packages
- Optical modules

Integrated circuits & algorithms

- Emitter driver ICs
- Sensor interfaces
- Sensor processors (incl. algorithms)

Powering advanced technologies for:

Visualization

Illumination

Sensing

ams OSRAM’s manufacturing landscape

Overview

Complex Manufacturing Environment

ams OSRAM operates in a highly complex semiconductor environment that demands precision, scalability, and efficiency to meet production goals.

Strategic Operational Goals

Key objectives include improving yield, reducing excursion rates, and accelerating time-to-market for new semiconductor products.

Adoption of Advanced Analytics

Transitioning to Exensio Manufacturing/Yield Analytics enables data-driven decisions to manage increasing data volumes and process complexity effectively.

Driving Operational Excellence

Leveraging advanced analytics supports operational excellence and competitive advantage in semiconductor manufacturing.

Path to AI/ML Integration

Why Exensio Manufacturing/Yield Analytics?

Combining data from multiple disparate sources

Such as data inside the E-MA database, Azure Databricks and MySQL databases, importing stdf4 data files, excel sheets, csv and so forth. Also, the abilities to merge these data sources with activating “Data-On-Demand” option.

Unified Analytics Across Data

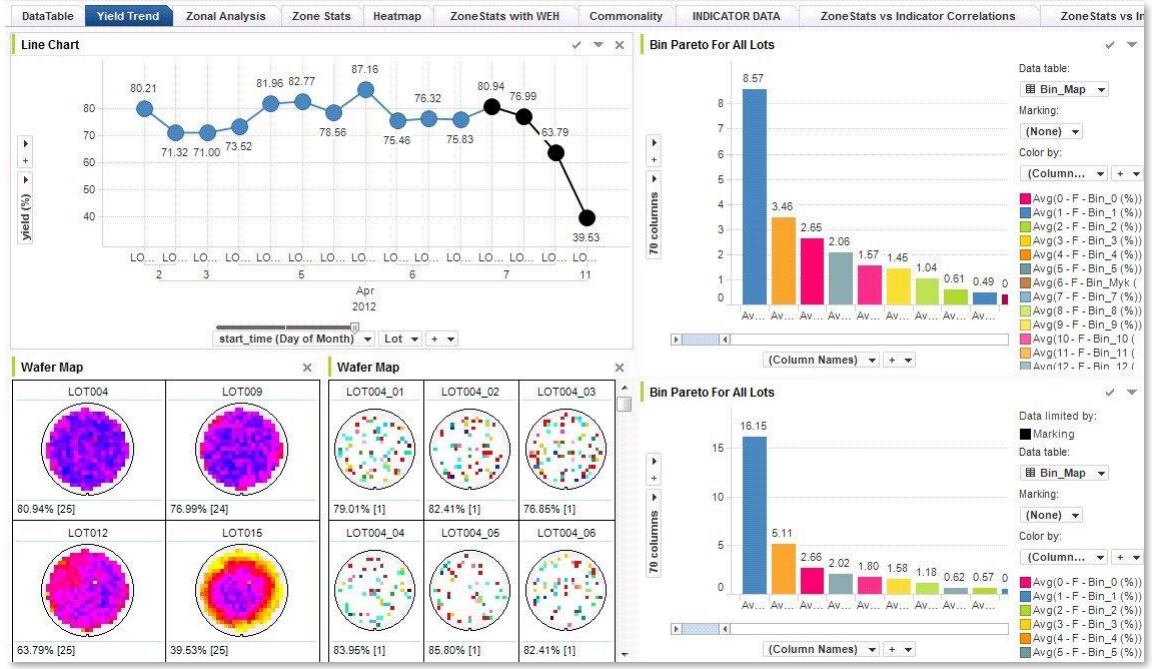
Ability to integrate test, process, and defect data to provide comprehensive yield analytics. Furthermore, it has the capabilities to customize integration non-standard data and load them into E-MA database too.

Scalability and AI Insights

Supports Python and R for AI/ML integration is such a big achievement.

It facilitate to train and use home-grown ML/AI modules directly inside that software using variant manufacturing data to detect the yield-loss.

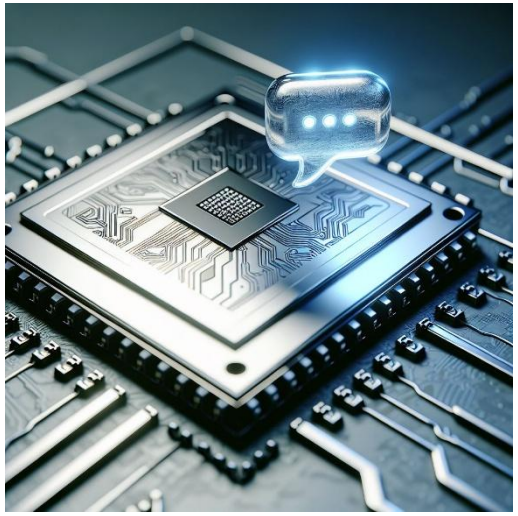
Exensio Yield/Manufacturing is more than an analytic tool *(refer to Benefits of Exensio Yield for AMS presentation – PUG 2019)*



Path to AI/ML Integration

LAVORRO (AI/ML Solutions for Accelerating Performance and Productivity in Semi Manufacturing) - SUMMARY OF EVALUATION

Why are we considering Lavorro?



- Desire to implement “AI Assistant” across the manufacturing community
  - Help new employees increase their effectiveness and navigate the various data sources within the Fab quickly
  - Help to increase speed to root cause analysis and ramp engineering effectiveness
- Provide a framework to capture “fault finding BKM’s” within the Fab maintenance teams
  - Prevent knowledge loss through employee retention/retirements

Evaluation Criteria

- Assessment focused on performance, integration, cost, and security to align AI with organizational needs

Key Findings

- Lavorro AI demonstrated strong natural language processing and easy API integration with moderate cost. It can use big amount of data extracted out of PDF Exensio databases to train AI/ML modules smoothly. No data storage duplication required

Security Considerations

- Further security review needed to ensure data privacy and compliance with industry standards

Recommendation

- Proceed with pilot implementation in selected departments for controlled testing and validation

*Final Decision pending

Path to AI/ML Integration

Migration from Maestria to Exensio Process Control I

Goal of moving to Exensio Process Control

- The first step, will allow yield engineers to perform analytics on aligned FDC data with product metrology data, in a unified data schema, Exensio Manufacturing Analytics
- Enable AI/ML flow… Exensio Manufacturing Analytics will serve as the unified, aligned data source without the need for data wrangling

Expectation

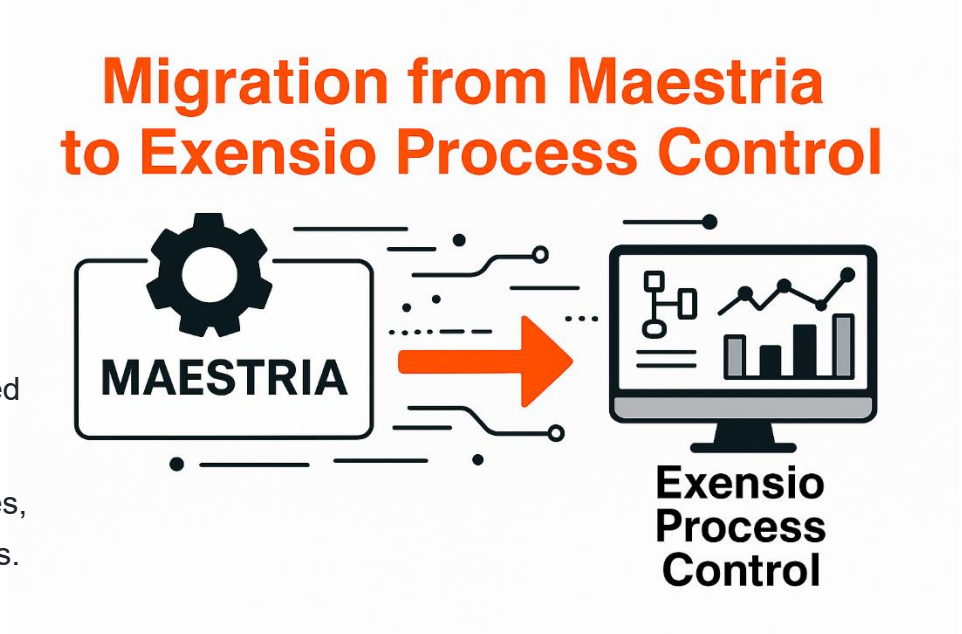
- Engineering manpower optimization
  - FDC engineers will be able to focus on issues that affect **product**, not just signal variance
  - Faster deployment cycle of AI/ML models in HVM (High Volume Manufacturing), with solid aligned data source for pipeline development, testing and execution
- In addition, we will receive advanced new FDC features, guided analytics, strong reporting capabilities, tool matching feature for fast and smooth new tool introduction, and powerful visualization capabilities.

Evaluation Criteria

- This migration will be focused on selected functionalities *(four tools from two equipment types)*.. This includes the system performance, smooth integration, and security. And that evaluation includes pros and cons features too.

Recommendation

- Proceed with pilot implementation in selected departments for controlled testing and validation after the successful evaluation.



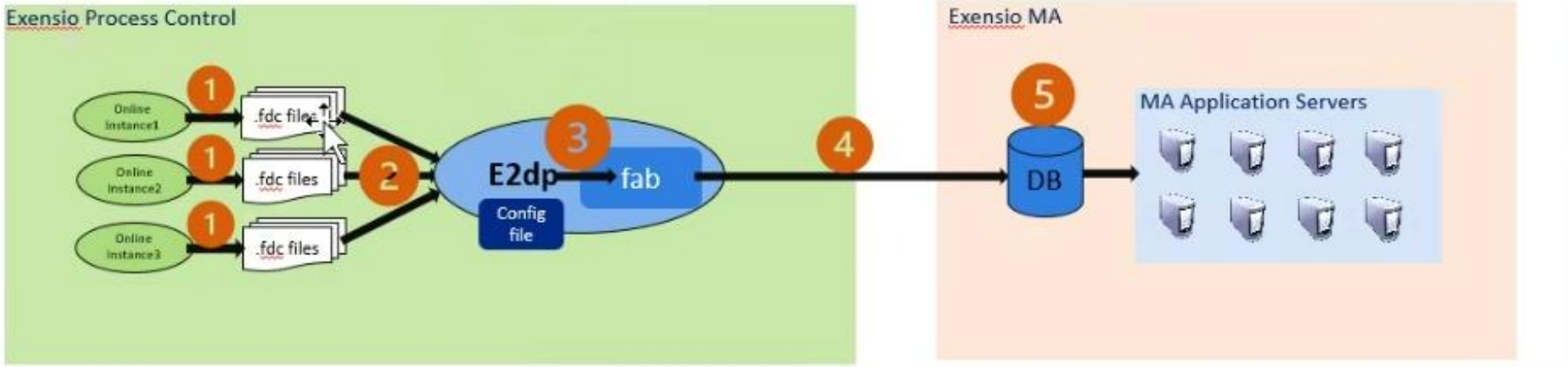
- * PCE (data collection part) will be kept in Masteria, and that is not used for online control.

Path to AI/ML Integration

Migration from Maestria to Exensio Process Control II

E2dp Introduction

- E2DP loads E-PC indicator data into E-MA
- Typically, it is covered in E-PC project



1. Online service generate .fdc files, containing all indicators data (standard E-PC feature)
2. E2dp loads those .fdc files, with a config file (standard E-PC feature)
3. E2dp calls fab loader (fab loader is a E-MA component)
4. Fab inserts indicator data into E-MA DB schema
5. E-MA DB schema already supports E-PC indicator data storage (standard E-MA feature)

MH131024-2.fdc

- Config files contains below key parameters
  - . Fdc data file path
  - Fab loader path
  - E-MA DB schema alias
  - Format file path
  - others

```
/home/exnadmin/pdf/logs/dpReader/03/Wd:/home/exnadmin/pdf/E2dP/
fab:fdc:-db TEST_YMS_01 -rework_action 2 -start_time -bigcond -nolotstats -
dynamic -fmt /home/exnadmin/pdf/E2dP/FDC_API.fmt -arg single_file:
```

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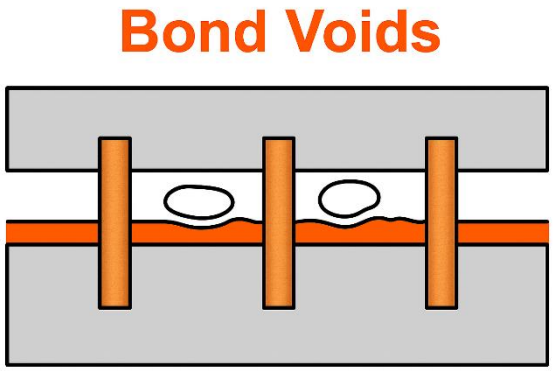
Innovative AI/ML Use Cases

Bond Voids

Problem:

In the context of **TSV (Through-Silicon Via) technology**, **bond voids** refer to **gaps or empty spaces that occur in the bonding interface between two materials**—typically during wafer-to-wafer or die-to-wafer bonding processes. These voids can form due to:

- Insufficient bonding pressure or temperature
- Surface contamination or oxidation
- Non-uniform adhesive or bonding layer
- Trapped gases during bonding



Solution:

- 3,285 wafers were used for modeling, and data extracted through ***Information Link in E-MA***.
- WEH data was manually retrieved, with Defective_die_% set as the target column.
- A **CatBoost** model was trained in this dataset.
- **noEBR_Count** was identified as the most influential factor contributing to a higher percentage of defective dies.
  - If there were Stages without **EBR** then it was correlated with increased **Defective_die_%.**
- Findings were validated and confirmed by the engineering team.

Terms:

- **CatBoost:** It is one of gradient boosting algorithms used in machine learning to build highly accurate predictive models by combining multiple decision trees for tasks like classification and regression. It is Excellent for handling categorical features without heavy preprocessing; robust and easy to use.
- **noEBR:** in the context of **TRK tools** refers to a recipe type where Edge Bead Removal (EBR) is disabled during wafer processing.

Innovative AI/ML Use Cases

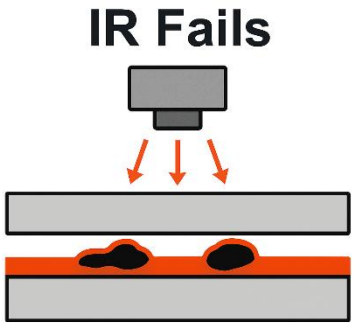
IR Fails

Problem:

Failure occurring during the Infrared (IR) testing phase of our products.
These failure are typically related to the optical and electrical parameters of the devices being tested.

Solution:

- WEH data collected from 2,424 wafers for failure rate analysis.
- Data extracted through ***Information Link in E-MA***.
- **Fail_rate_%** of the dices per wafer was taken as a target value.
- Applied tree-based models: **CatBoost**, **XGBoost**, and **LightGBM** for feature importance analysis.
- FDC data merged with WEH data because WEH alone was not conclusive.
- **TotalTargetEnergy** identified as a major factor contributing to higher **IR fail** rates at specific stages.
- Findings were Validated and confirmed by engineering teams.



Terms:

- **CatBoost, XGBoost,** and **LightGBM:** are gradient boosting algorithms used in machine learning to build highly accurate predictive models by combining multiple decision trees for tasks like classification and regression.
- **TotalTargetEnergy:** in a **PVD (Physical Vapor Deposition) tool** refers to the cumulative energy delivered to the sputtering target during the deposition process.

Future Vision

Leveraging AI for fault detection and predictive analytics

Exensio-MA Expansion

Expanding Exensio-MA usage across all fabs will enhance data integration and manufacturing insights.

Generative AI for Automation

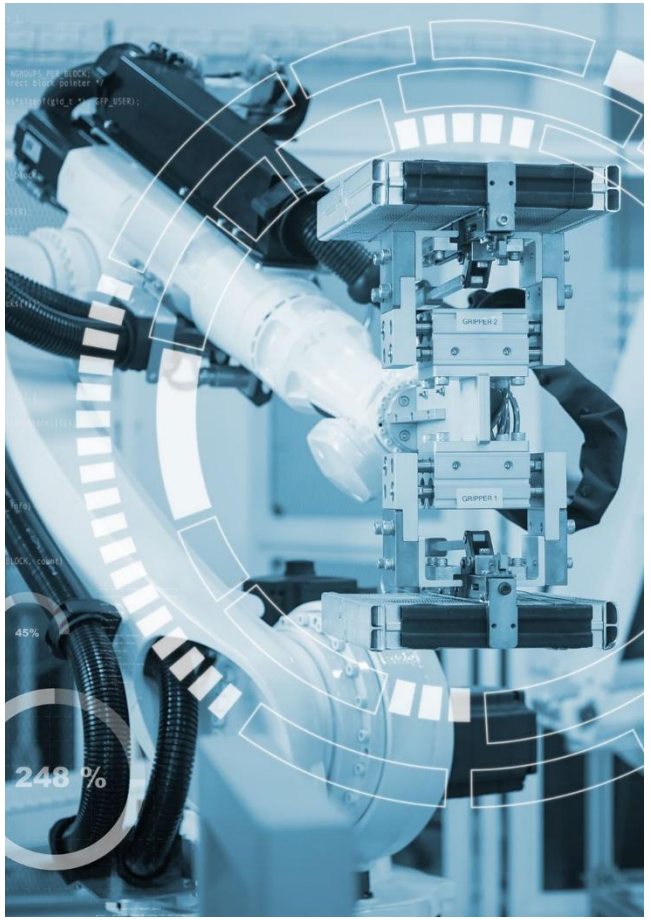
Integrating generative AI enables autonomous decision-making and automates engineering workflows.

Predictive Maintenance & Digital Twins

Using digital twin models and real-time analytics supports predictive maintenance and process optimization.

Smart Manufacturing Vision

Advancements support factory efficiency and reduce MTTR (Mean Time to Repair).



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