GlobalWafers Co., Ltd.
環球晶圓股份有限公司

Global Family,
Global Solutions!

Smart Manufacturing in Silicon Wafer fabrication

AI Enabled Innovation Revolution at GlobalWafers

7/10/2024

Highlights

- Significant progress has been made at GlobalWafers on several AI/ML projects in last few years.

- We have successfully leveraged Advanced AI algorithms like Generative AI along with deep neural networks, convolutional neural networks and traditional machine learning algorithms in various projects.

- Will continue to explore the latest developments in AI/ML field to see if they will benefit us in improving our process capability and efficiency.

GlobalWafers: Enabler and User of AI

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

AI Enhanced GlobalWafers' Silicon Products

AI Enhanced Silicon Crystal Growth at GlobalWafers

Silicon Chip Design for AI

AI Algorithms On Chips Fabricated using AI in MFG

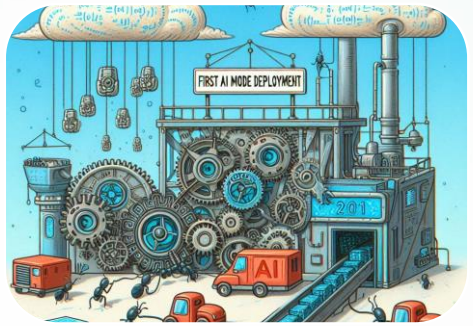
Silicon Chip MFG

AI at GlobalWafers: Key Milestones

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

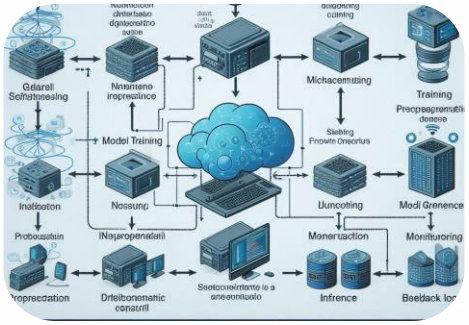
2018: First AI/ML Project Launched

2019: First AI/ML Project Deployed

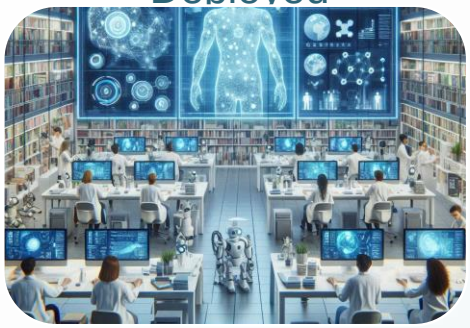


2020: First Generative AI Model Deployed

2021: AI/ML Technical Board Established to Enable Synergistic Development of AI/ML Projects Across all Sites of the Company



2023: A Software Architecture and an API was Developed for Easy Training Data Collection and Model Deployment Across all Sites



2024: Several AI/ML models Implemented at Various Sites are having a Positive Impact on the Company and its Mission.

4 AI Focus Areas

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

Asset And Resource Efficiency

- ARE1: AI Enabled Image Classification
- ARE2: Predictive Maintenance using AI
- ARE3: Large Language Model Based Audit

Product Innovation and R&D

- PIRD1: AI Enabled New Product Development
- PIRD2: AI Enabled Physics Modeling for Faster Product Development

Process Optimization and Control

- POC1: Generative AI Models for Process Control
- POC2: Predictive Deep Neural Networks
- POC3: Image to Image Translation Models

Synergistic Customer Engagement

- SCE1: Customer Yield Improvement
- SCE2: Root Cause Analysis

ML Use and Status Plans

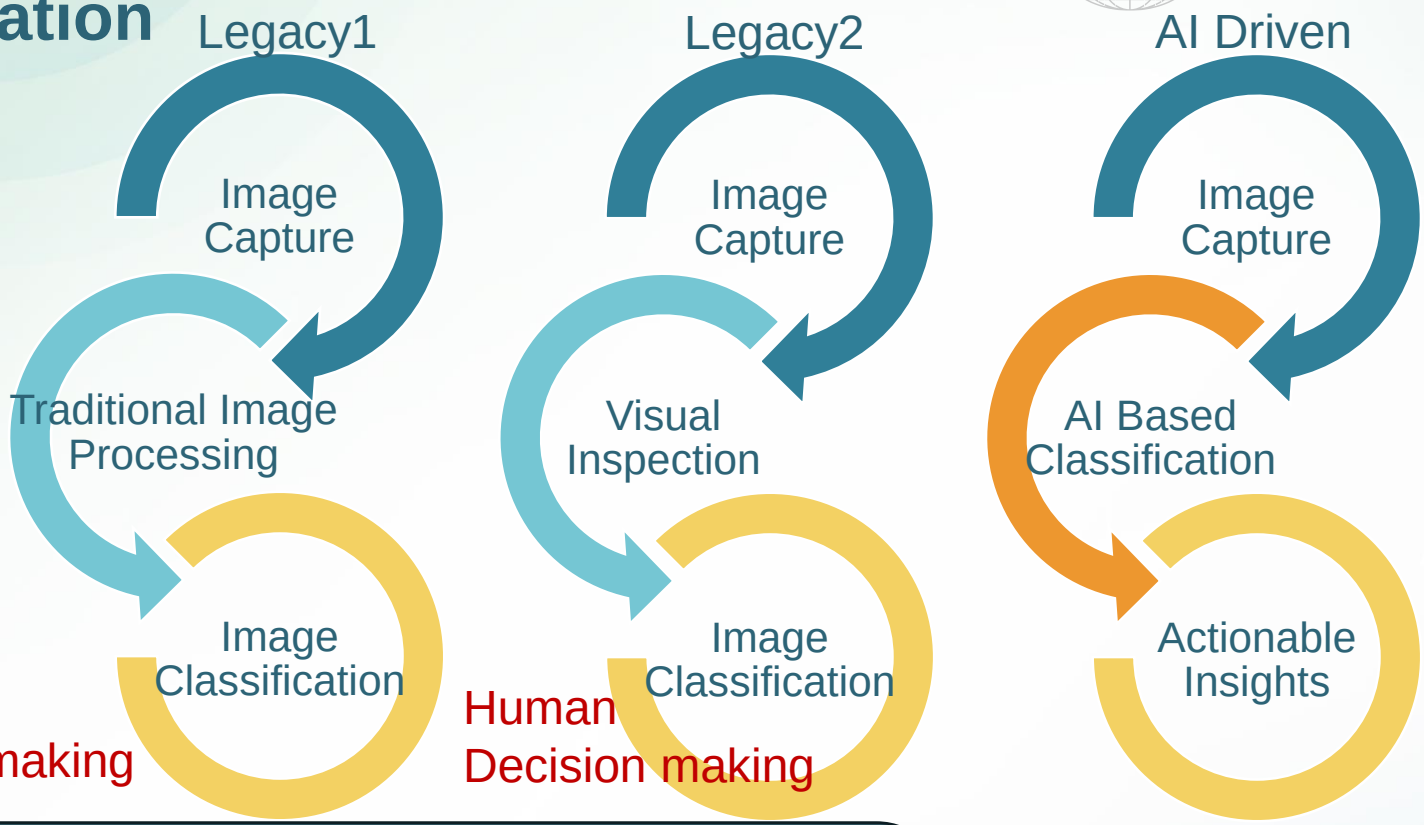
GlobalWafers Co., Ltd.
環球晶圓股份有限公司

- AI/ML Technical Board is installed within GWC.
- Many projects in many fields are on going
- Some areas are under planning.

Area	Current	Plan
Product Quality	X	
Manufacturing Cost	X	
Product TPT	X	
Technology Development	X	
Safety		X
Sustainability		X
Tool Availability	X	
Supply Chain/Logistics		X

Asset Efficiency: AI Enabled Image Classification

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

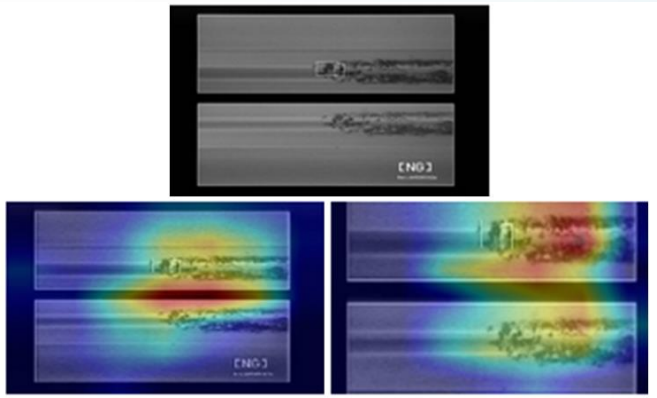


Advantages:

- More accurate, faster, and repeatable Image classification
- Significant human resources reduction.

Examples:

- Wafer Edge Bevel Defect Classification Using Convolutional Neural Networks.
- Crystal Point Defects Quality Classification.
- Wafer Defect Classification.

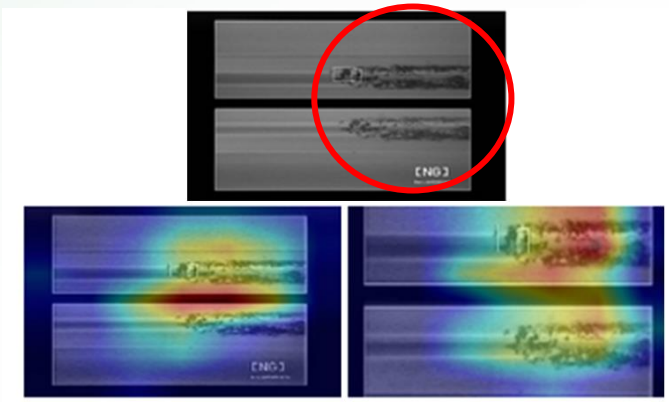


Edge Damage Defect Classification

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

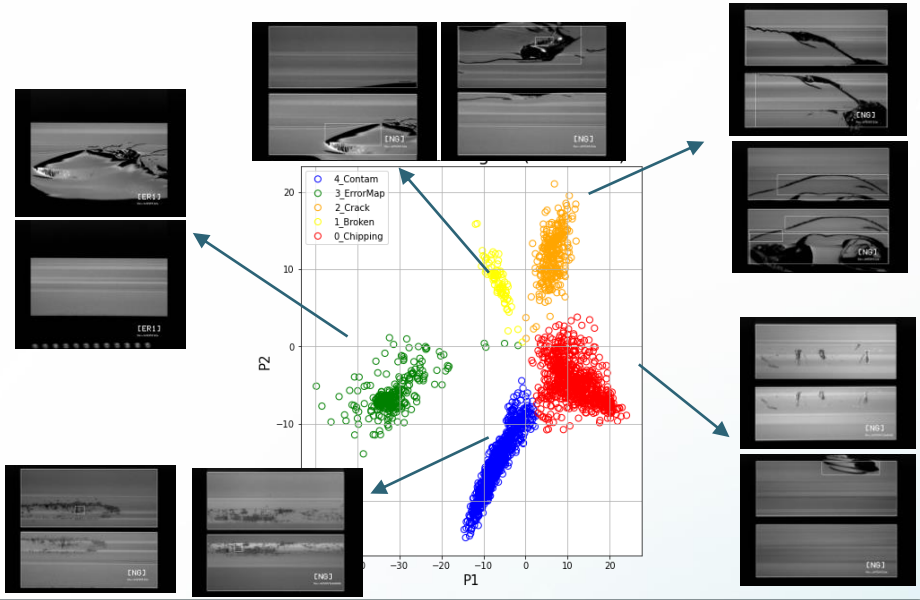
Goal: Deploy a robust AI image classification model for Edge Damage Classification.
Benefit: Lower yield loss and better quality.
Background: Current method results in significant misclassification
Result: Significant mis-classification reduction! Better understanding of type of each defect and actions taken.

AI vision



Example of attention map of AI algorithm for an image.

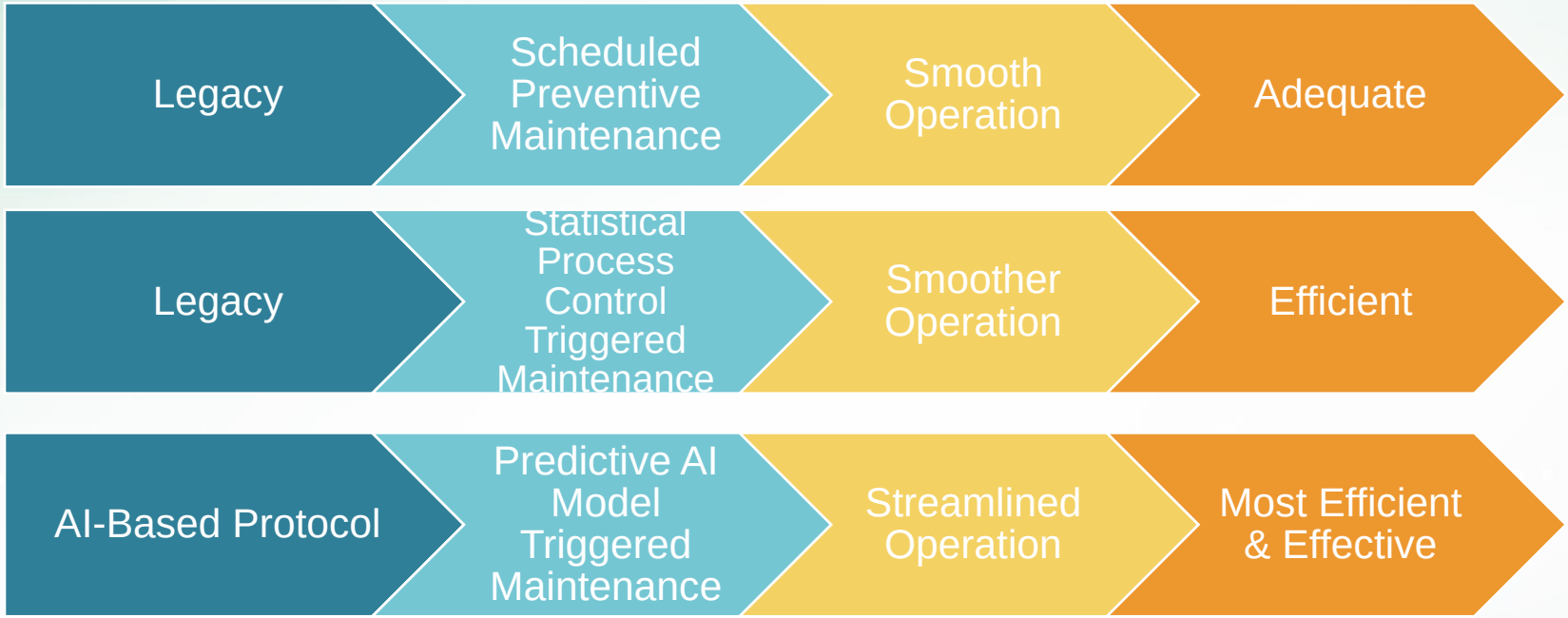
Image samples for 5 kinds of defects



Above illustrates power of dimensionally reduced image components P1 and P2 using an AI algorithm to separate various types of defects.

AI Predictive Maintenance

GlobalWafers Co., Ltd.
環球晶圓股份有限公司



Advantages:

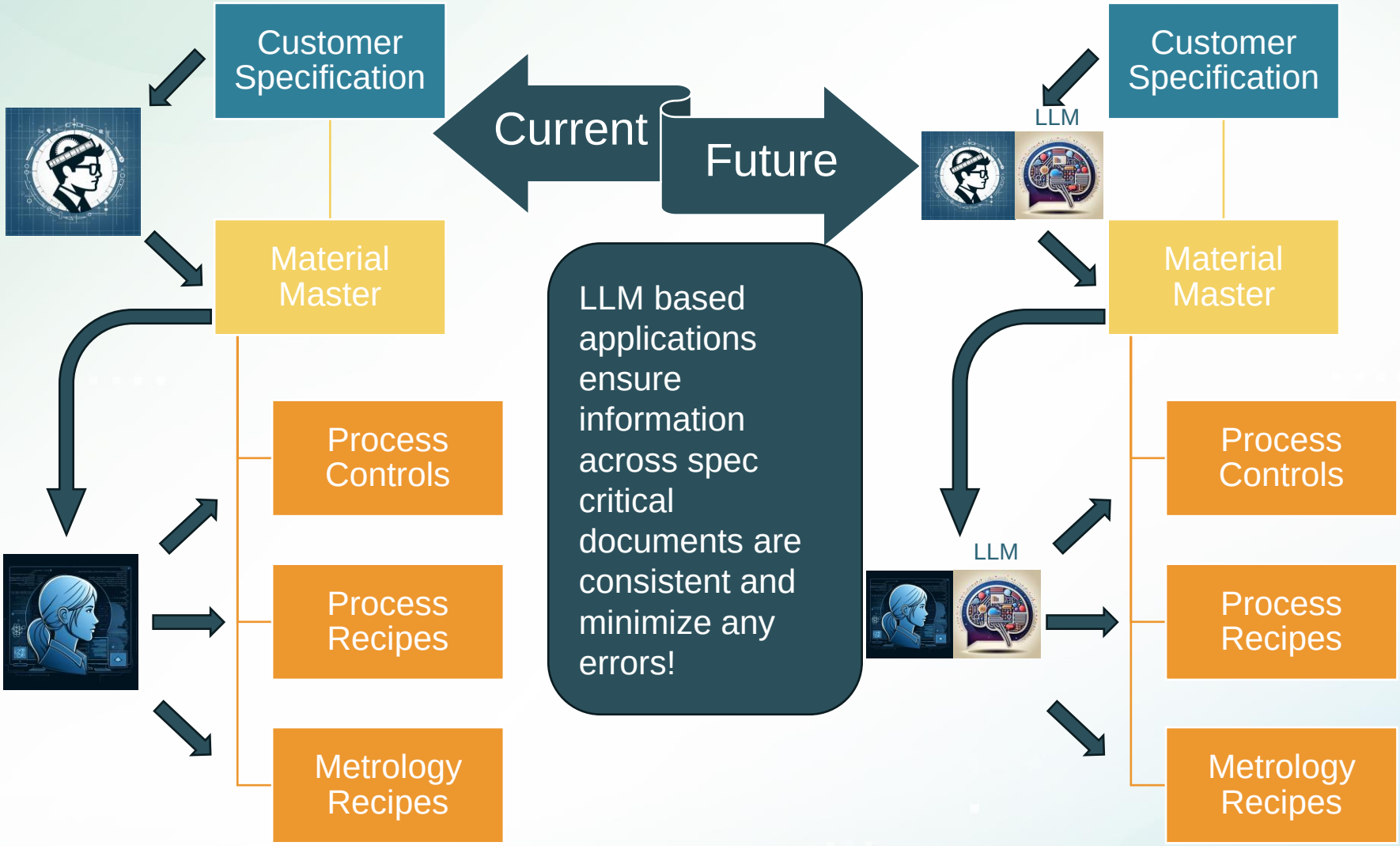
- Most efficient.
- Less downtime.
- Less catastrophic failures.

Examples:

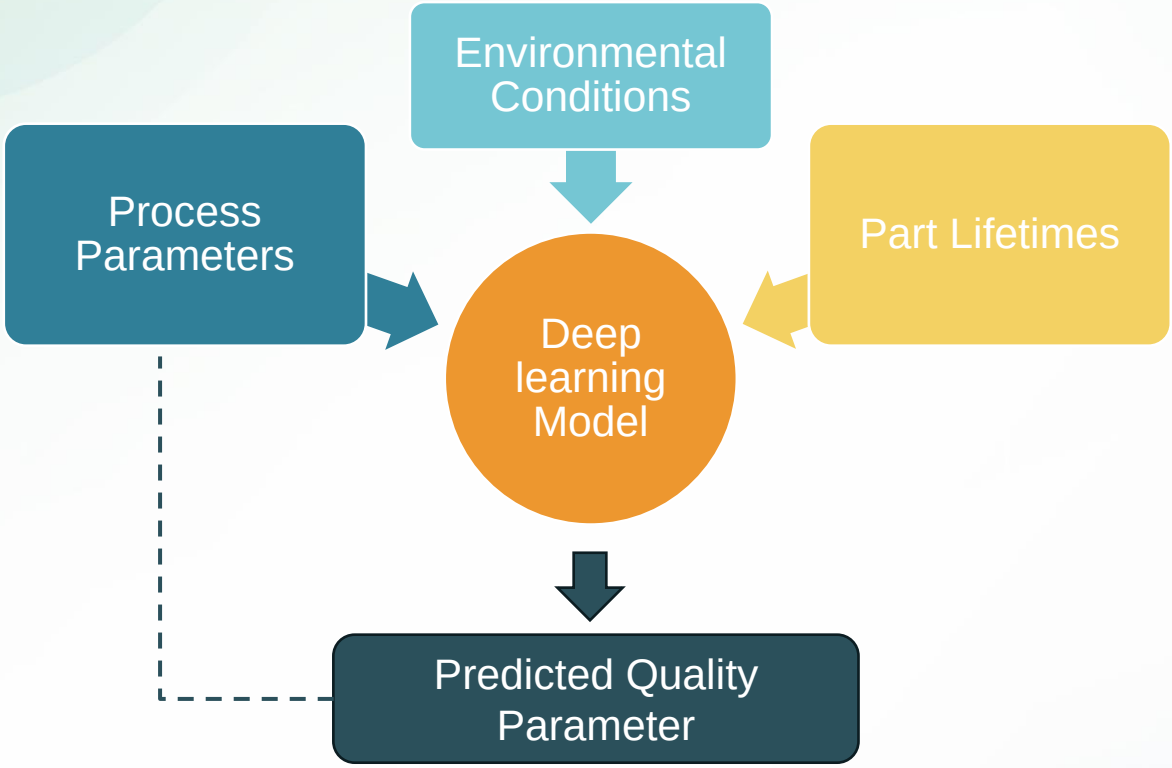
- Electric Motor Current Monitoring Model.
- Water Quality Monitoring Model.
- Machine Acoustics Monitoring Model.
- Machine Vibration Monitoring Model.

Large Language Model Based Critical Documentation Audit

GlobalWafers Co., Ltd.
環球晶圓股份有限公司



Deep Learning Predictive Models



Advantages:

- Better Process Control
- Can be implemented in real-time
- Lower yield loss and better capability

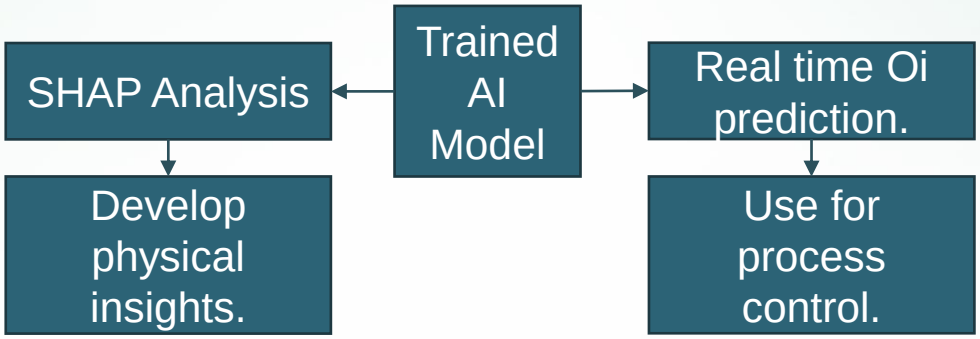
Examples:

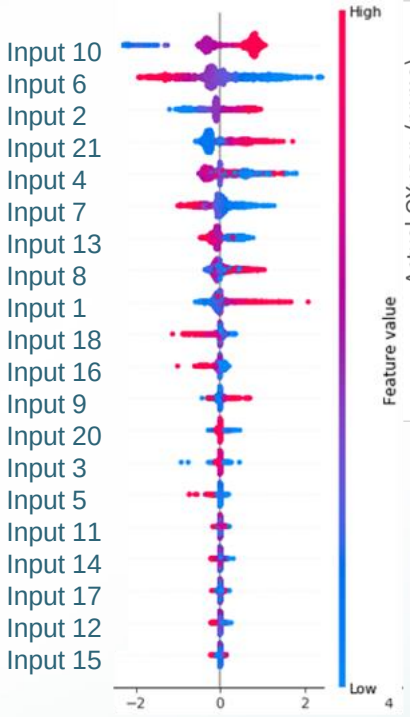
- Oxygen Prediction and Control During Crystal Growth
- Crystal Quality Prediction and Control.

Deep Learning Predictive Model for Oxygen

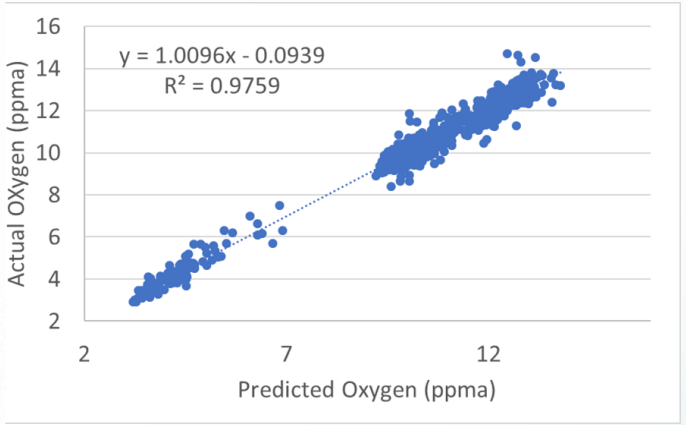
GlobalWafers Co., Ltd.
環球晶圓股份有限公司

- **Goal:** Build an AI model to predict and control oxygen and ORG in real time.
- **Benefit:** Better oxygen control and lower yield losses due to oxygen.
- **Result:** Preliminary model trained for oxygen and ORG prediction. Correlation between predicted value and actual value is good.





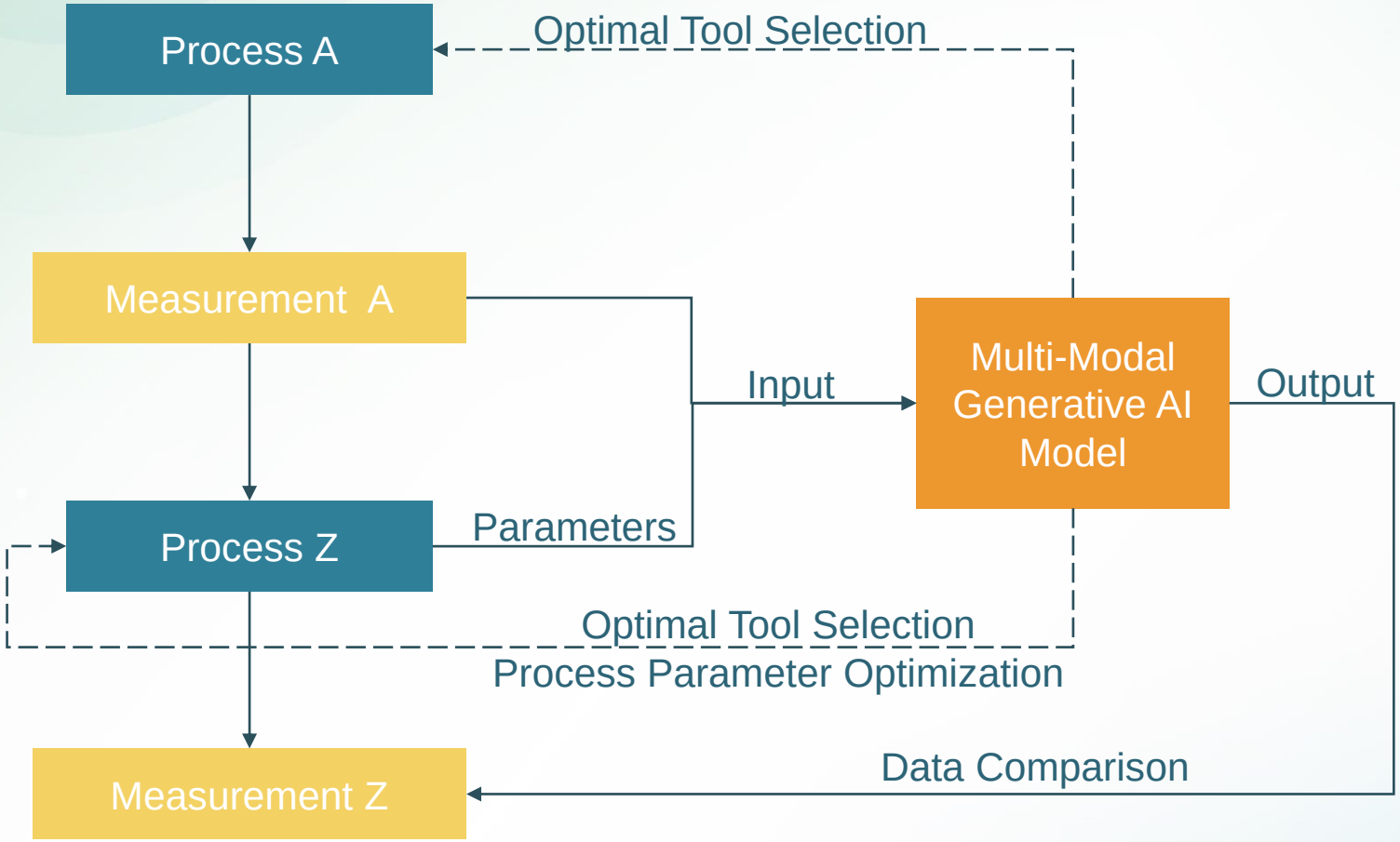
SHAP Result



Correlation Plot

Process Control by Generative AI

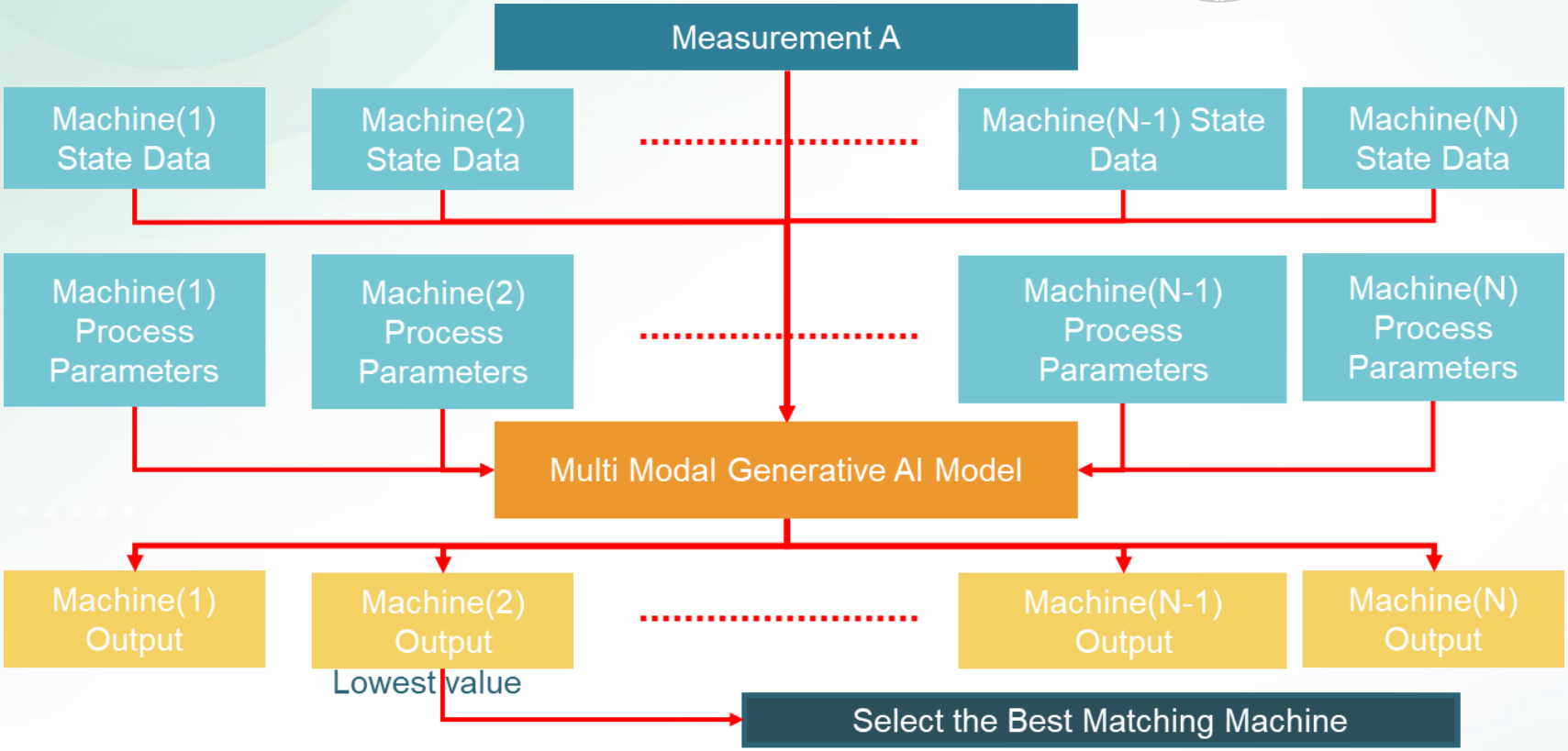
GlobalWafers Co., Ltd.
環球晶圓股份有限公司



Generative AI Models can be trained with multimodal (images, process parameters, audio files etc) inputs to predict performance of each wafer on each tool. Such a model can then be used to select the best matching tool for each wafer or to tune the process parameters for each wafer.

Generative AI for Tool Selection

GlobalWafers Co., Ltd.
環球晶圓股份有限公司



Advantages:

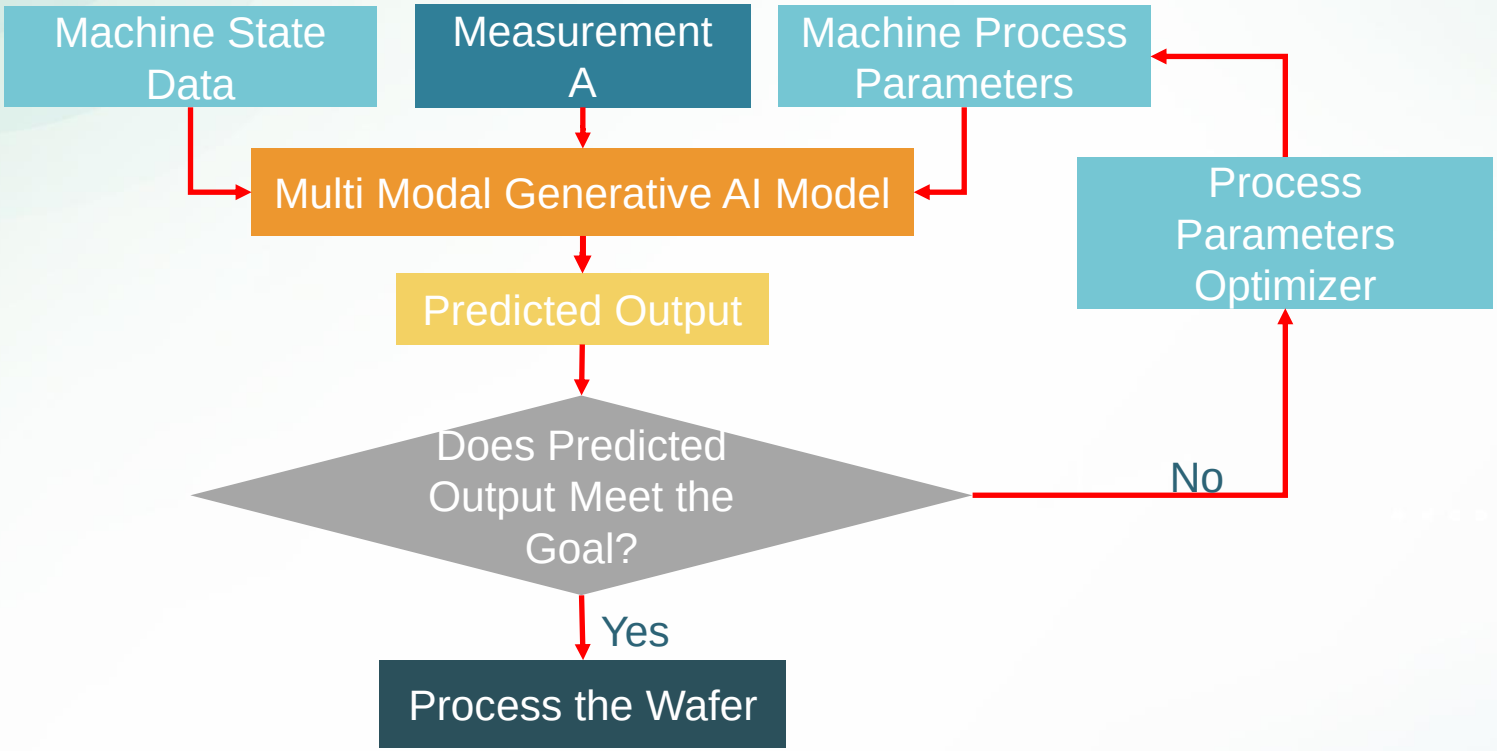
- More efficient tool utilization.
- Less downtime for tool adjustment.
- Better product capability and quality.

Examples:

- Post Double Side Grinding Shape Prediction
- Post Epitaxial Flatness Prediction

Generative AI for Process Optimization

GlobalWafers Co., Ltd.
環球晶圓股份有限公司



Advantages:

- Less downtime for tool adjustment.
- Better product capability and quality.

Examples:

- Post Double Side Grinding Shape Prediction.
- Post Epitaxial Flatness Prediction.

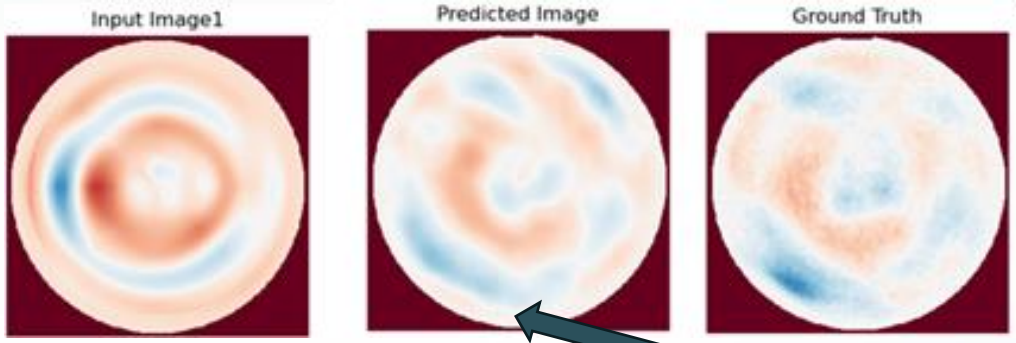
Process Control: Image to Image Translation Models

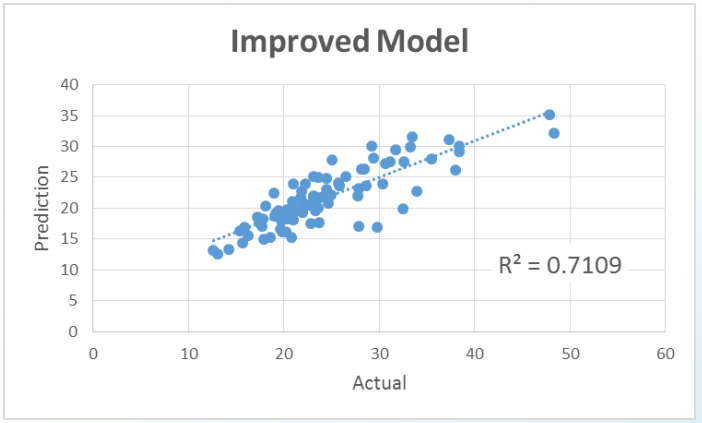
GlobalWafers Co., Ltd.
環球晶圓股份有限公司

Process A → Measurement A → Many Process Steps → Measurement Z

- Main Contributor to features in Measurement B
- Fast low-resolution noisy measurement of the same signal as in measurement B
- High resolution low noise end of line measurement.

Advantages:
- Quicker feedback for process adjustments.
- Better product capability and quality.
- Lower yield loss.



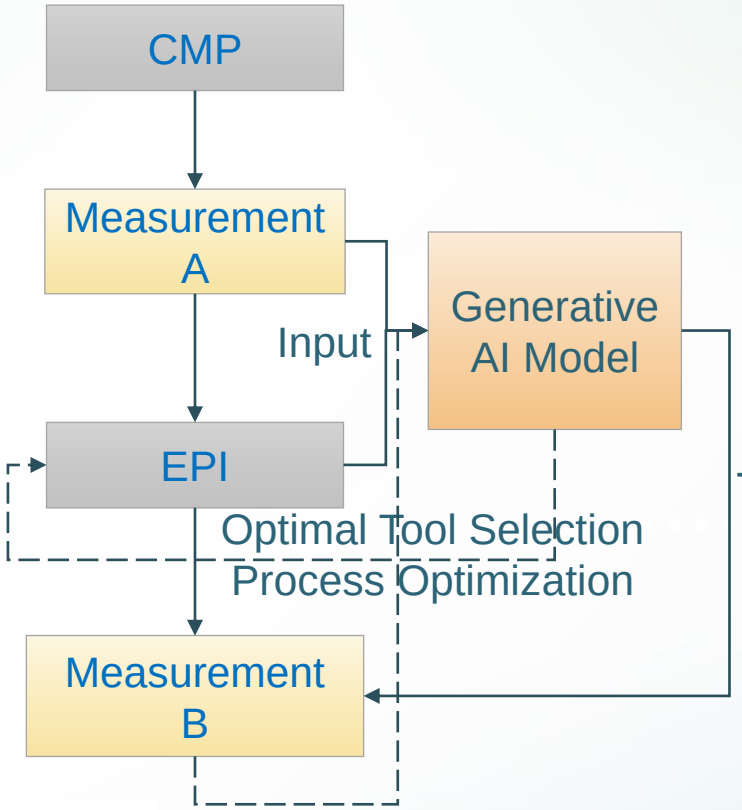


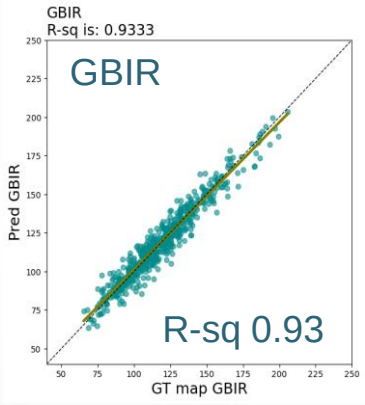
Process A → Measurement A → Image to Image Translation Model → Predicted Measurement Z

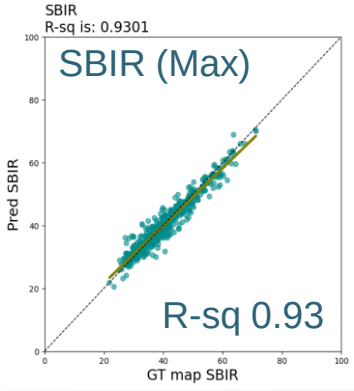
Post Epitaxial Flatness Prediction using Generative AI

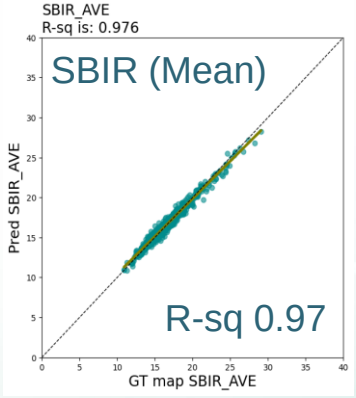
GlobalWafers Co., Ltd.
環球晶圓股份有限公司

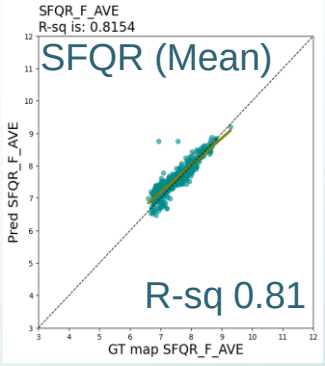
- **Goal:** Generative AI models predict post-epitaxy thickness map and flatness metrics.
- **Benefit:** AI prediction program select tools or inform engineer to adjust process recipe based on incoming material status. AI model automated control of process parameters is under development.





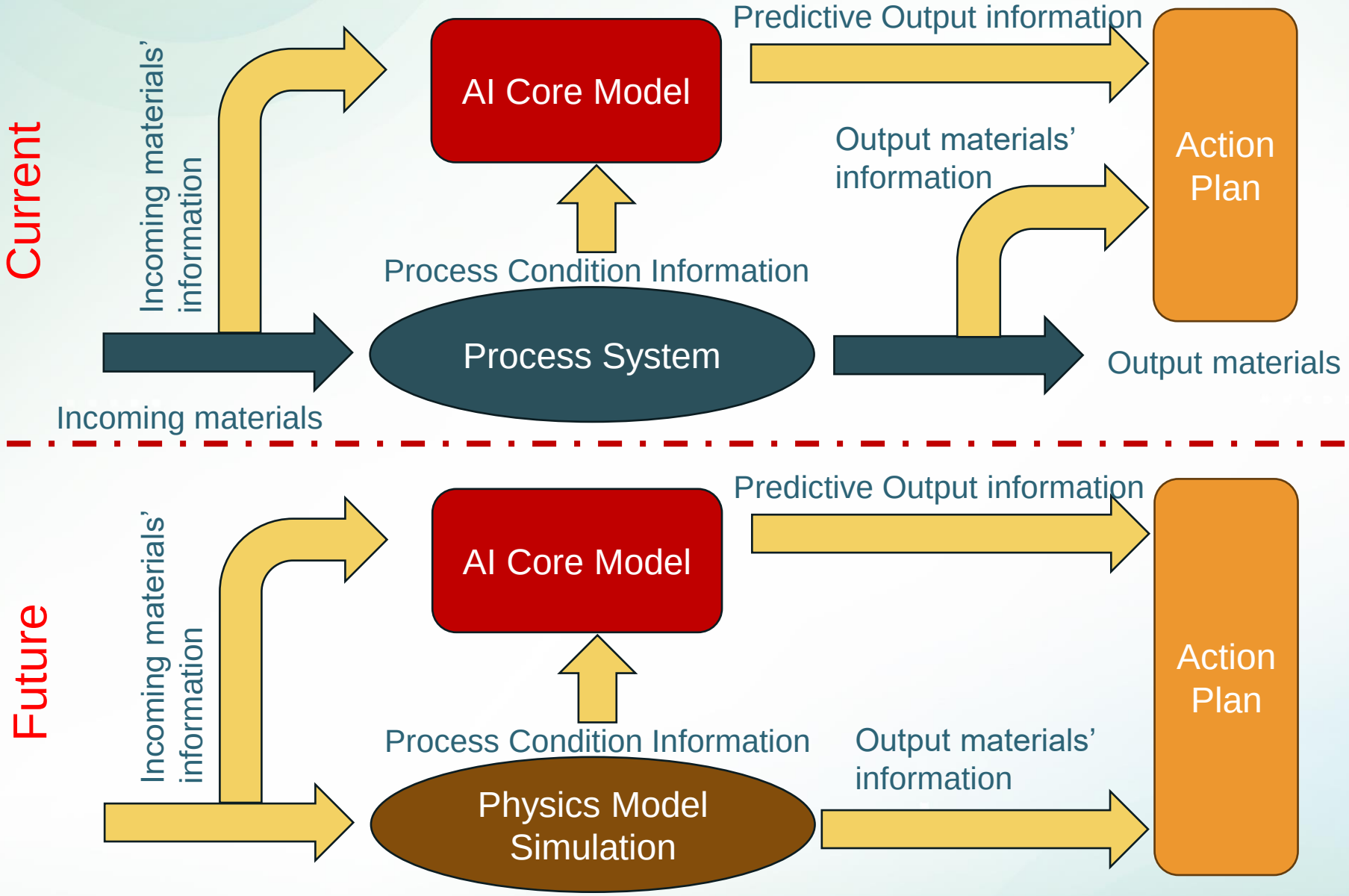




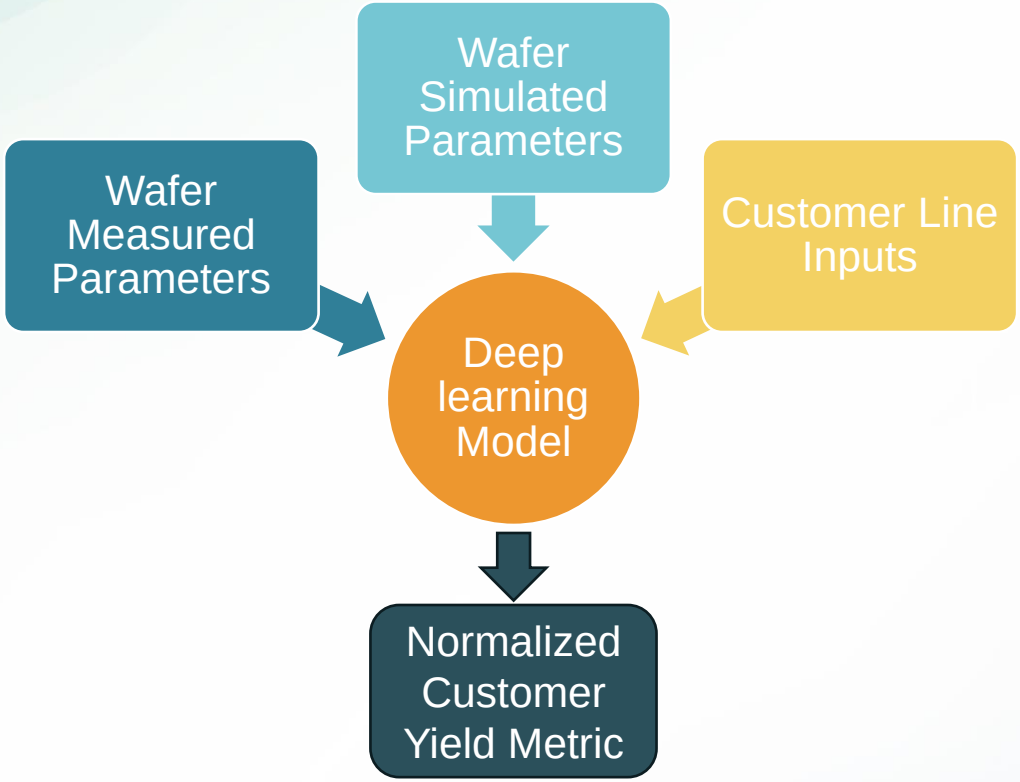


AI Enabled Development

GlobalWafers Co., Ltd.
環球晶圓股份有限公司



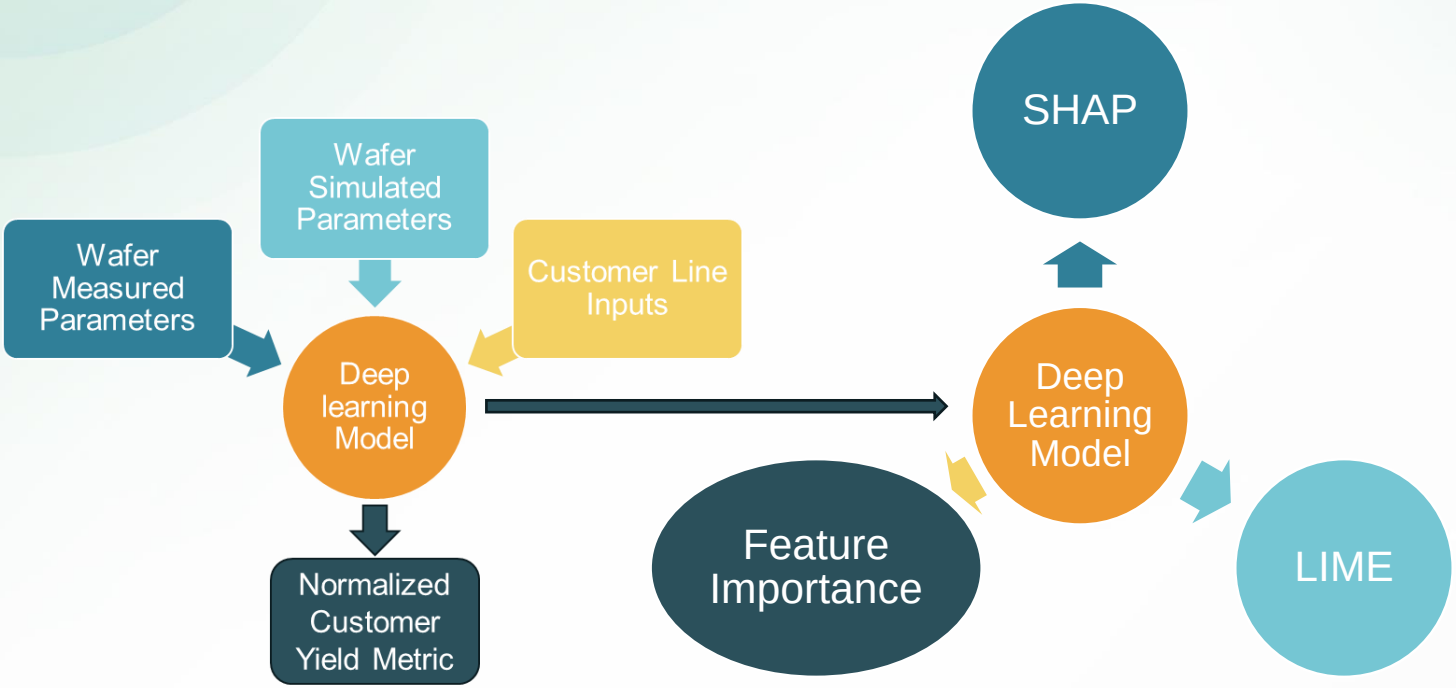
Customer Yield Enhancement



Advantages:
- Predictability for Yield for each batch.

Examples:
- Normalized Yield Metric Analysis Exercises with Several Customers.

Root Cause Analysis



Advantages:

- Algorithms like SHAP and Feature Importance can be applied to well trained models to understand the main contributors to the predicted output.
- In case of image-based models, algorithms like LIME can applied to understand important areas of image that affect the output.

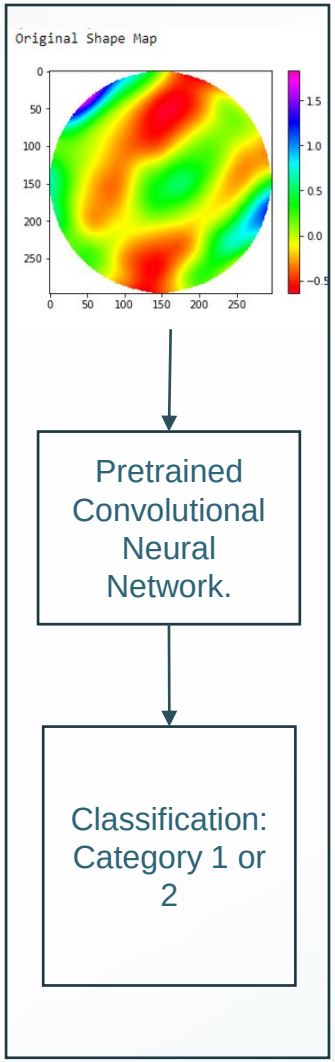
Examples:

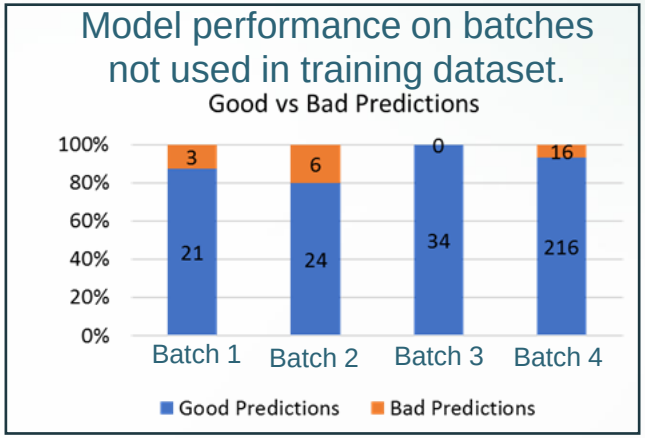
- Applied to identify wafer parameters affecting customer yields in case of several customers.

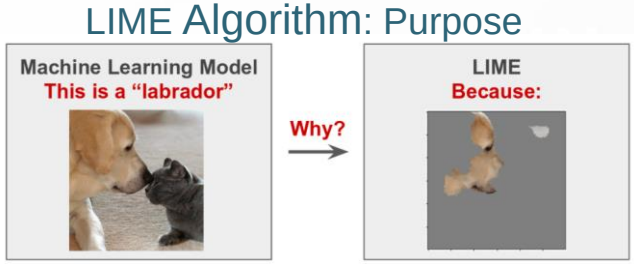
Customer Yield Enhancement and Root Cause Analysis

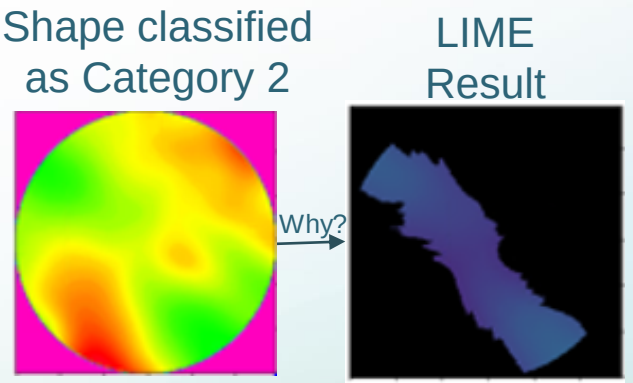
GlobalWafers Co., Ltd.
環球晶圓股份有限公司

- **Goal:** Build a convolutional neural network model to classify the wafer topography into customer classification category. Analyze the trained model using AI explainer algorithms like LIME or SHAP to understand features in topography that may be affecting customer yield.
- **Background:** Wafer shape may play a role in the yield metric. Customer classifies good yield and poor yield due to suspected shape effects.
- **Result:** This project successfully allowed us to classify and sort out wafers with bad potential yield wafers at customer.









Summary

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

- Significant progress has been made at GlobalWafers on several AI/ML projects in last few years.
- We have successfully leveraged Advanced AI algorithms like Generative AI along with deep neural networks, convolutional neural networks and traditional machine learning algorithms in various projects.
- GWC has benefits from AI in improving wafer quality, improving yield, enhancing productivity, shortening development cycle time, and having better process control.
- Many projects are on going…..
- GWC is the enabler of AI and the user of AI

GlobalWafers Co., Ltd.
環球晶圓股份有限公司

Thank You

Learn More on
Our Website