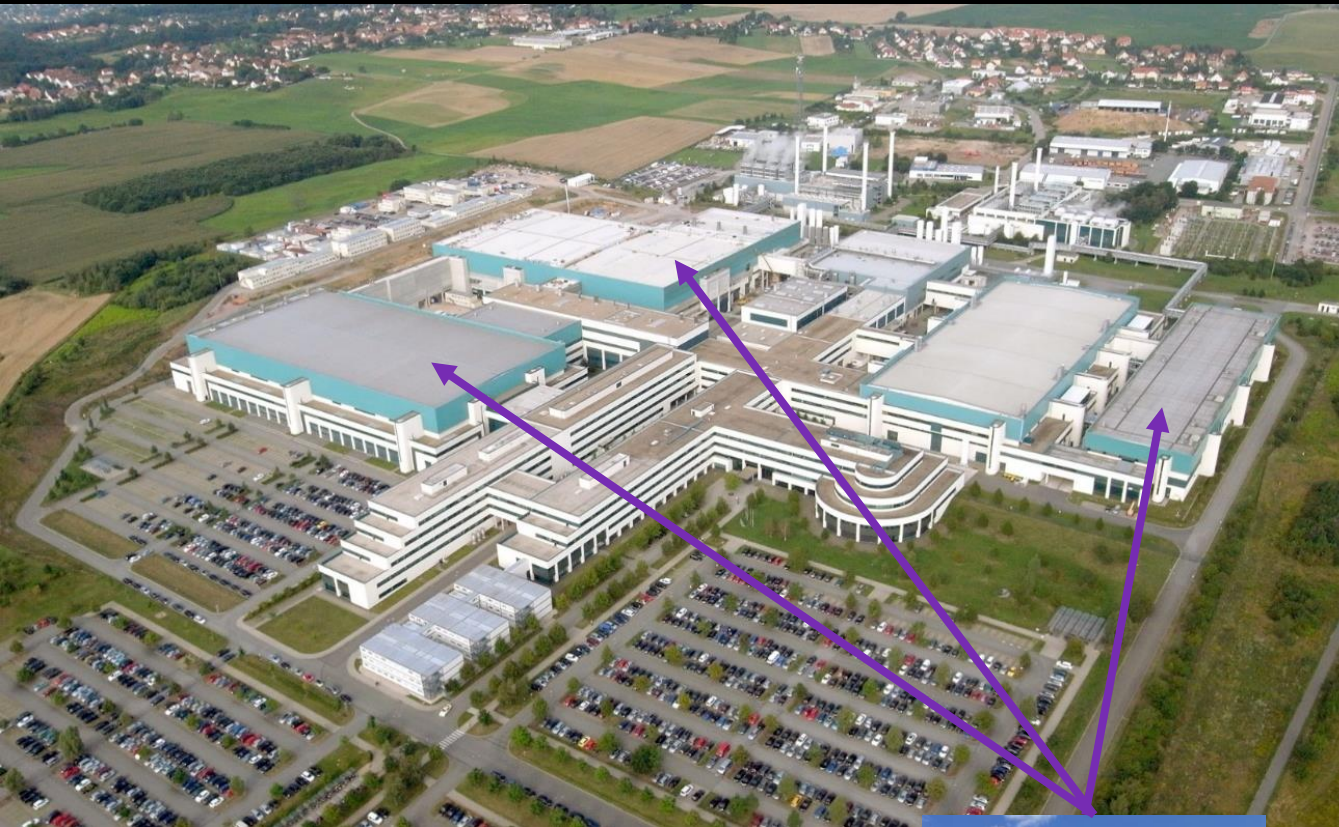


SEMICON Europa 2023

Data Driven Optimization in Semiconductor Fabrication:
How Efficiency Helps Environment as Well

GF Dresden



Market Segments

IC driver for OLED/ μ LED
IC driver for image sensing
Automotive MCUs, GPS/ADAS
ULP/RF/NVM for wireless/IoT

Employees

~3,000 from 50 nations

Differentiated Technologies

22FDX[®]
28SLPe, 28/40HV
28/40ISP
55 BCD and BCDLite[®]
28/40NVM

Operating since

1999

Fabrication Capacity

850k
(300mm wafers/year)

Power & Sustainability

1.2TWh/yr, 2 EVC units,
redundant grid access
hydrogen capable, PV system
on roof tops, water recycling

Why we do AI:ML?



Efficiency

fabricating chips of high quality

- Decrease process variability
- Improve yield
- Enhance detectability of deviations



Environment

Responsible use of resources

- Avoid waste
- Optimize material consumption
- Reduce the industrial footprint



People

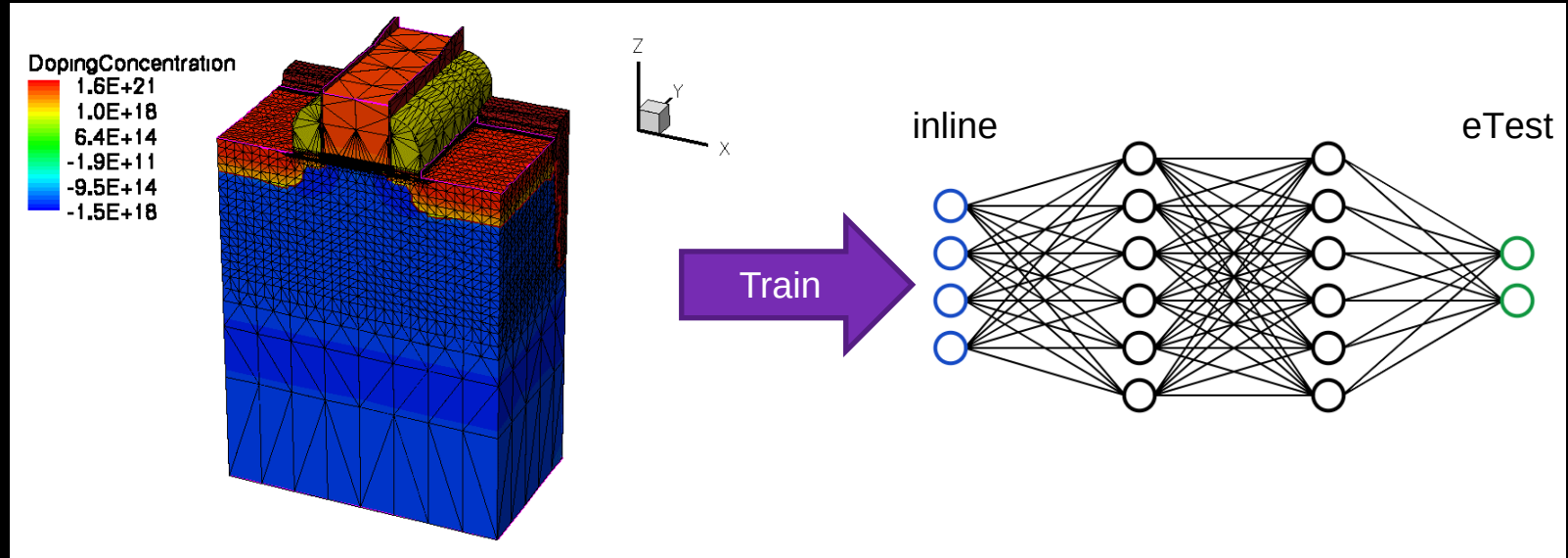
Reduce inefficient and routine work

- Automate data analysis tasks
- Free up resources for Advanced Analytics task or Machine Learning



AI:ML for Efficiency

- TCAD-enabled ML
 - Simulation for FEoL



Simulation

- Slow (1-2 h per planar device)
- Requires infrastructure (HPC)
- Needs TCAD expertise
- Power consumption per device: ~80.000 Ws

ML Regression Model

- Fast (milliseconds per 1000 devices)
- Runs everywhere
- Can be used by everyone
- Power consumption per device: ~0.15 Ws



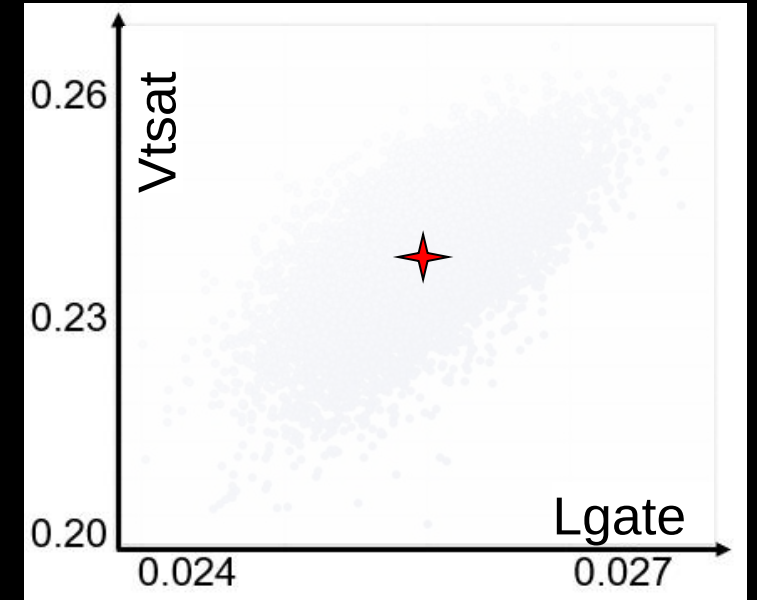
AI:ML for Efficiency

- TCAD-enabled ML
 - Simulation for FEoL
 - Physics informed Digital Twin
- connect TCAD to Yield enhancement and fabrication

	Target	Process Variation
Lgate	0.00000	0.0007
SOI	0.00000	0
ILNIT	0.00000000	0
GPI dose	0.00000000	0
Spc1	0.00000000	0
RTA	0.00000	5
WF	0.00000	0
...	...	...

Input

- Transistor Geometry
- Material Parameters
- Process Settings
- 100k different inputs (process variations)



Output

- Electrical characteristics of device
- Distribution of electrical data



AI:ML for Efficiency

- TCAD enabled ML
 - Simulation for FEoL
 - Physics informed Digital Twin
- Process Tuning Solutions
 - Tighter distribution

IMP4114 50.0 %	IMP4110 52.9 %	IMP4202 53.8 %	IMP4108 54.5 %	IMP1207 66.2 %	IMP1114 66.7 %	IMP4210 66.7 %
IMP4115 71.4 %	IMP4204 72.0 %	IMP4111 75.9 %	IMP4209 75.9 %	IMP4119 78.9 %	IMP1120 80.0 %	IMP4118 80.6 %
IMP1200 81.4 %	IMP4121 83.3 %	IMP1111 86.5 %	IMP1122 88.4 %	IMP1205 88.6 %	IMP1115 89.5 %	IMP4203 89.7 %

before

- Tool to tool difference
→ higher process variation
- Manual analysis of tool performance
→ time consuming, in-efficient

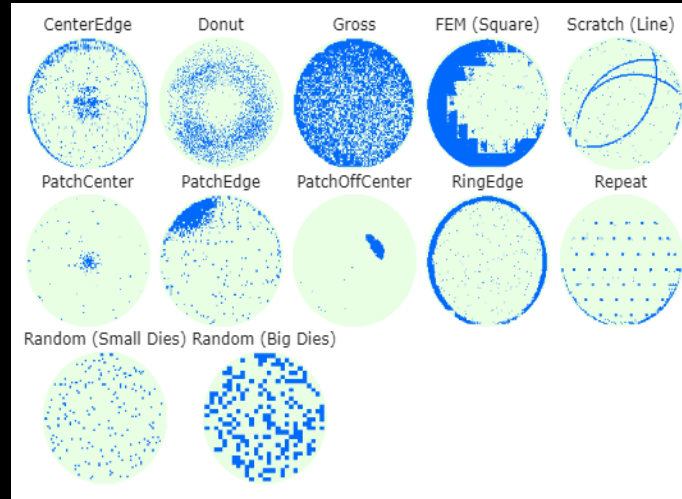
after

- Automatic analysis of tool performance for each implanter → more accurate tool matching
- Tighter electrical variation
- Increase in tool availability



AI:ML for People

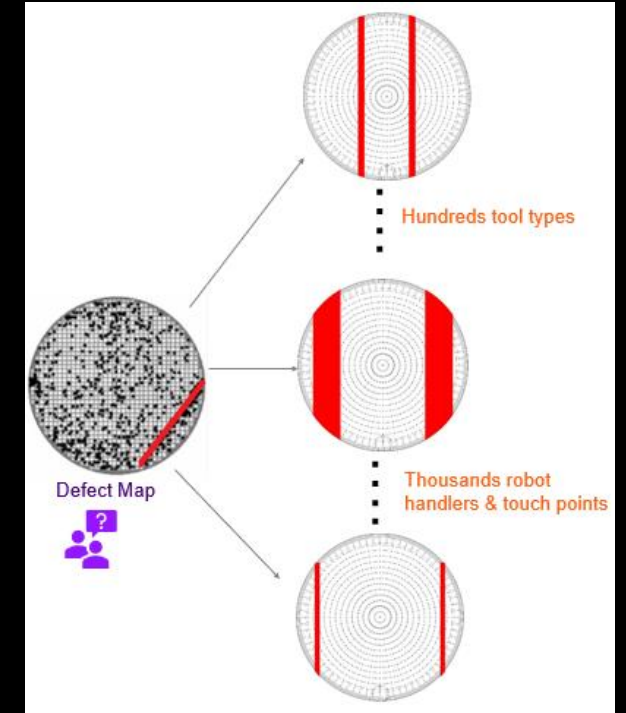
- Automated Pattern Recognition
 - Faster Anomaly detection of different SORT signatures
 - Automated detection of wafer backside signatures caused by tool handlers



Examples for Yield loss signatures

Signature Classification

- Reduced human effort
- Faster and more accurate detection of signatures
- Faster containment



Examples for wafer backside signature

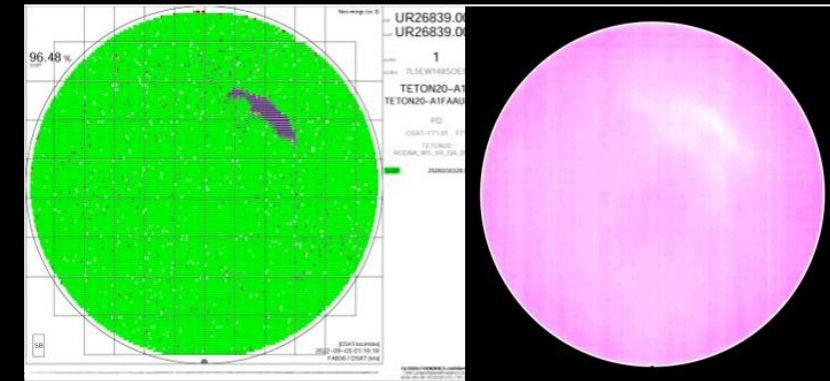
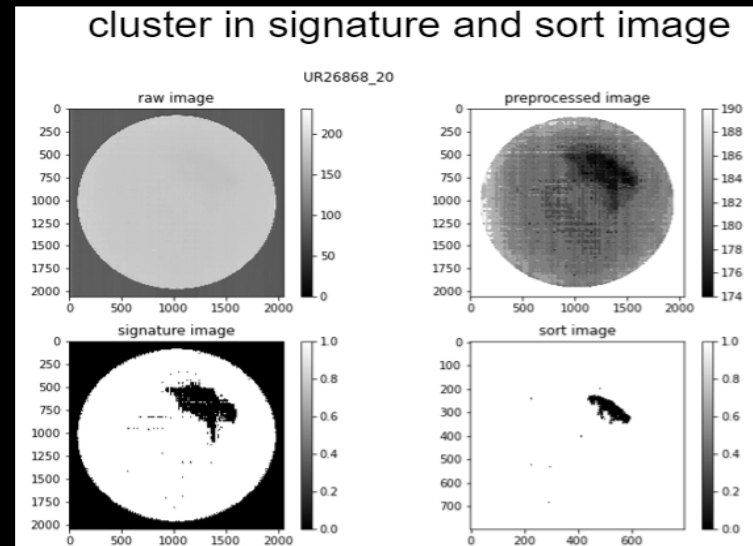
Tool Fingerprint Identification

- Automated signature comparison with fingerprint data base
- Identifies corresponding tool handlers
- Speed up root cause finding



AI:ML for People

- Automated Pattern Recognition
 - Faster Anomaly detection
- Incoming Quality
 - Automatic detection of SOI thickness variation



Incoming SOI thickness variation

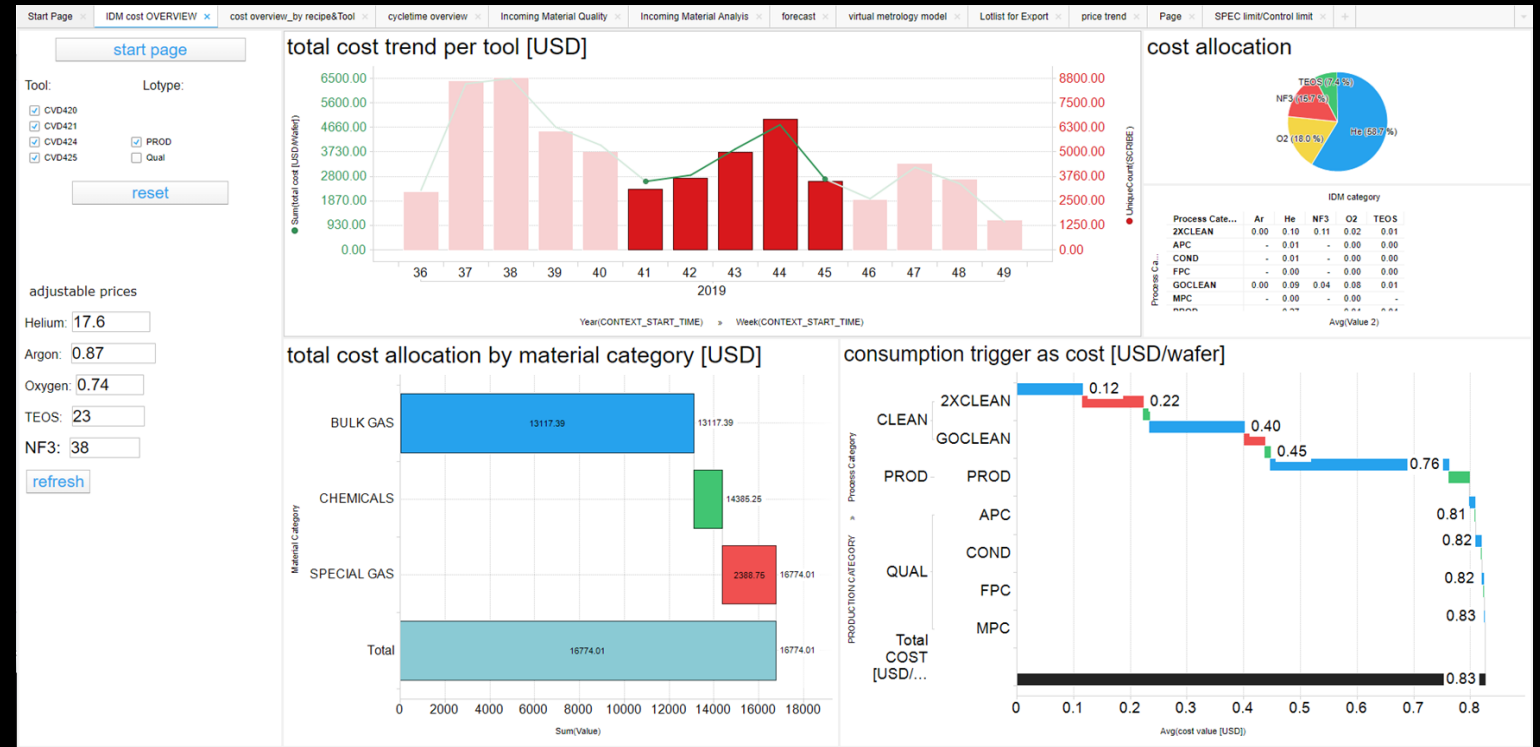
- May cause higher electrical variability, in worse case yield loss
- Small thickness variation difficult to detect on standard inspection tools monitoring incoming quality

ML Approach for detection

- automated image processing to identify cluster (thickness variation)
- Usage of images prior first litho step
- Containment of affected material in early stage of fabrication process

AI:ML for Environment

- Material and Energy consumption
 - Identify waste
 - Optimize consumption



Identify waste

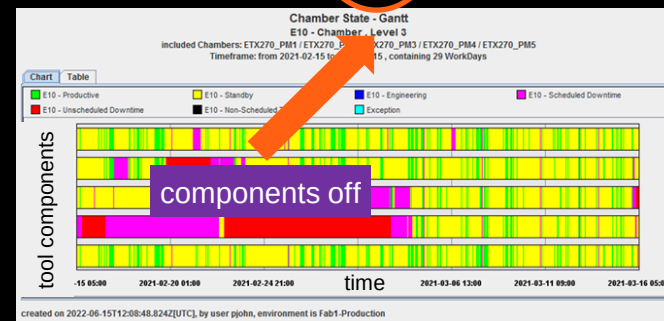
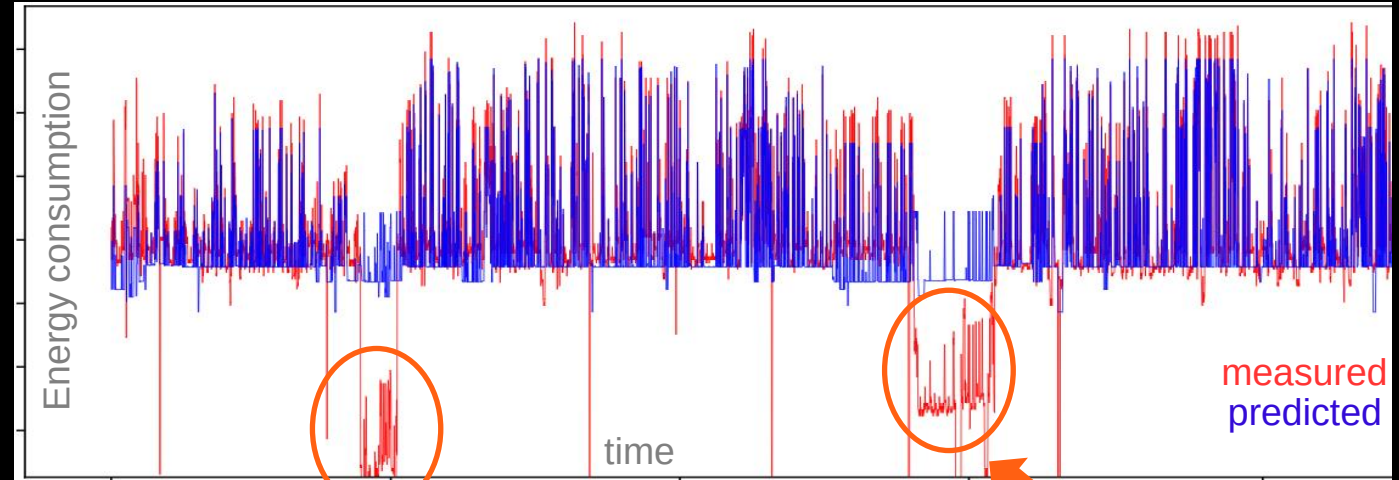
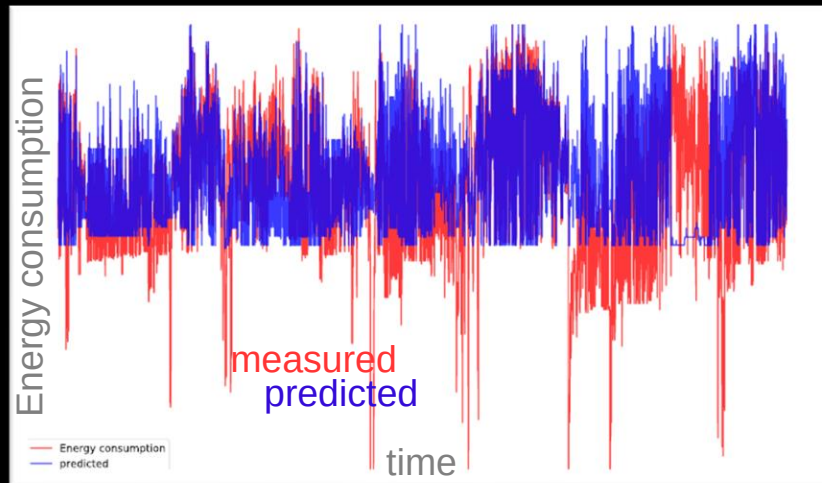
- Usage of FDC sensor data to calculate real material consumption

Optimize Consumption

- Visualize consumption in every recipe step to identify projects for waste reduction

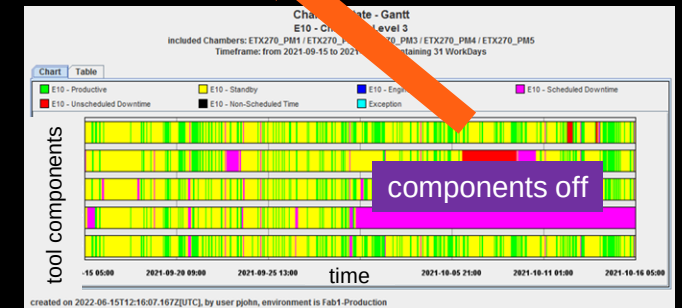
AI:ML for Environment

- Material and Energy consumption
 - Identify waste
 - Optimize consumption



Identify opportunities

- Using tool specific prediction models for understand impact on total power consumption



Optimize Consumption

- Visualize consumption over time and by tool state to identify projects for energy reduction and track actions for energy savings

Summary

Data Driven Optimization in Semiconductor Fabrication: efficiency helps environment as well

- Data driven optimization and digital fabrication enable a new area to harvest savings related to energy consumption, material spending and efficiency regarding human capital.
- These points equally improve cost efficiency of the supply and fabrication chain, which also helps to spare the environment.
- The presented examples show that there are opportunities in every area within semiconductor fabrication in which digital fabrication can be used to harvest/enable savings that also protect our environment.



↑
AI=ML



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Thank you

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