

### The **ADEin4** project

### Combining manufacturing data with Design for improved process performance

**Dr. Andres Torres** 

**Siemens EDA** 

February 16<sup>th</sup> 2021 Technology Unites Global Summit

**Technology Unites Global Summit** 



### Agenda

SIEMENS EDA Approach and previous results State-of-the-art in manufacturing Semiconductor and automotive

**Going beyond state-of-the-art** 

**Progress highlights** 

Conclusions



### **SIEMENS**

#### Specific solutions for your industry

Process Industries			Hybrid Industries			Discrete Industries
Chemicals	Marine	Glass	Food and Beverage	Electronics	Aerospace	Automotive
		S OF S				
Water and Wastewater	Minerals	Pharmaceuticals	Batteries	Wind	Machine Building	Intralogistics
Oil and Gas	Power and Utilities	Paper	Tire	Additive Manufacturing	Cranes	Robotics



### Mentor is now **SIEMENS EDA**

# SIEMENS



A Siemens Business

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### **SIEMENS EDA** competence areas



### Approach

#### Current semiconductor fab environment

Segregated metrology clusters associated to production tools providing means of process control in a perprocess basis.

Production data exists in silos, and it is underutilized

Post MADEin4 vision Metrology and Inspection Modeling Without data, there is no model: MADEin4 allows **CVD: Chemical Vap** for this exchange of data. ASML TwinScan **CNP: Chemical Meta** Data Analysis **Data Analysis Data Analysis Data Analysis Data Analysis Data Analysis** and Software development MADEin4 task and Software and Software and Software and Software and Software development MADEin4 task development MADEin4 task development MADEin4 tasi development MADEin4 tasi development MADEin4 tasi Partners Partners Partners Partners Partners Partners ECD: Electro Chemical Anonymize data Lithography Anonymize data Anonymize data Anonymize data Anonymize data Anonymize data SEMECON EUROPE 2019 depending on depending on depending on depending on depending on depending on sions/task nermissions/task permissions/task permissions/task permissions/task ocess/Metrolo FCA ocess/Met rocess/Metrolog cess/Metrolog TOWER vocess/Metro LETI On site On site On site On site On site On site Metrology SEMICON EUROPE 2019 Metrology Metrology Metrology Metrology Metrology ADEin4 Partn ADEin4 Partn ADEin4 Partn ADEin4 Partne ADEin4 Partn MADEin4 Partne **Off site Off site Off site** Off site **Off site** Off site Metrology Metrology Metrology Metrology ADEin4 Parts Metrology Metrology ADEin4 Part ADEin4 Partn ADEin4 Part ADEin4 Part ADEin4 Partn Data Exchange Logistics: Dissemination of process and tool () 2010 Mentor Graphics Case, Company Confidential GMERIZ

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information to Data Analysis partners

1.2

#### MADEin4 helps bring relevant data together

#### Across multiple partners and applications



### **Previous Results**

**Design Incorporation Example** 





Different designs impose their own process response

Including design information improved model quality

Feature engineering is necessary to apply machine learning

Feature engineering is extremely sensitive to domain knowledge (Knowing what to extract, or how to extract it). Machine logs (numerical or categorical), image processing.



### **Cross Industries Manufacturing Commonalities**



Semiconductor

#### Highly automated

- Similar production volumes
- Similar amount of data generated
- Similar process lifetime
- Similar amount of variability on the products



Automotive



### **Semiconductor Manufacturing**

Design considering process tolerances

imited process adjustments

Product performs within specifications



Design



#### Manufacture

Dynamic process adjustments

Virtualizing process / design interactions



Test

Increased coverage by virtualization

Improve maintenance, tool matching and productivity



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### **Automotive Manufacturing**

Design considering process tolerances

imited process adjustments

Product performs within specifications



Design



#### Manufacture

Dynamic process adjustments

Virtualizing process / design interactions



Test

Increased coverage by virtualization

Improve maintenance, tool matching and productivity



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### **Optimizing Manufacturing Process Flow**



### **Semiconductor Process Flow**



### **Automotive Process Flow**







### Semiconductor: Design-specific process optimization



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P1 P1 P2 P2 P2 P3

Processes can be optimized in a per-product basis.

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P10 P10 P10 P10 P10

### Semiconductor: Process impact detection



### Semiconductor: Detecting metrology abnormalities





### Semiconductor: Tool matching



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### Semiconductor: Multivariate SPC



Process interactions are complex, and univariate statistical process control is not longer sufficient.

Considering multivariate process interactions it is possible to detect actual process drifts.



### Semiconductor: Defect reduction







### Automotive: Virtual testing



Post-MADEin4

Reduction in the number of expensive tests by modeling larger portions of the process and improving model quality.





### Automotive: Robot operation modeling



Understanding machine operation permits modeling of effects that if not properly corrected can be a source of defects.







### Automotive: Weld defect detection



Identifying locations in the process where more information needs to be collected.

Using image processing techniques to virtualize process characterization.









### Conclusions

- Manufacturing of semiconductors and automobiles are highly automated processes with many opportunities for optimization.
- Analysis methods are applicable across a wide range of problems
  - Selecting Hot/Cold engine test, Tool matching, Tool operation, Process optimization
- Feature engineering is critical in the effective use of industry 4.0 techniques
  - Without proper understanding of the interplay between the different data sources, it is not possible to use "out of the box" analytics tool, making feature engineering (Transformation of the input) critical for successful modeling.







# ADEIN4

## THANK YOU FOR YOUR ATTENTION

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826589. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Netherlands, Belgium, Germany, France, Italy, Austria, Hungary, Romania, Sweden and Israel Technology Unites Global Summit