Introduction to MADEin4

Metrology Advances for Digitized ECS Industry 4.0

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SEMICON Europa, EU Digital Future Forum

AGENDA

- MADEin4 Project Essentials
- Objective and Industry 4.0 boosters
- Automotive and Semiconductor domains analogy
- Data is the new oil: design, modeling, metrology and ML Context creation
- Project Highlights
- MADEin4 presentations @ SEMICON Europa

AGENDA

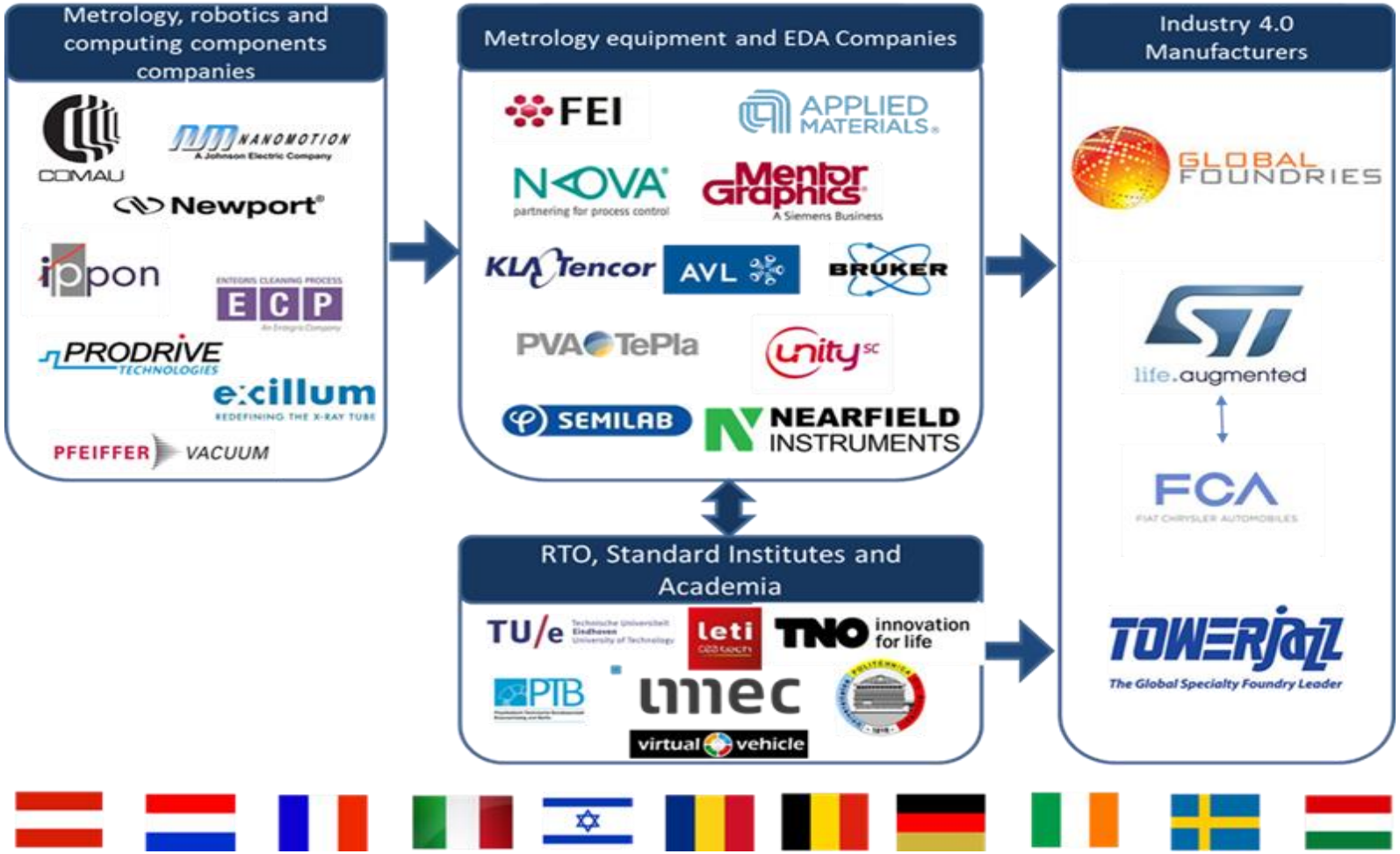
MADEin4 Project Essentials

Objective and Industry 4.0 boosters

MADEIn4 project essentials

- Number of consortium members: 47
- Countries involved: 10
- Start date: April 1, 2019
- Duration: 36 months
- Total effort: person.months: 10,503 (875 person.years)
- Total H2020 eligible costs: € 126,176,472.50

MADEIn4 project essentials



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Objective and Industry 4.0 boosters

Develop and qualify new productivity boosters:

- Booster 1: High-productivity metrology and inspection tools for semiconductor and automotive industry

- Booster 2: Ready for “industry 4.0” Cyber Physical Systems (CPS):
  - Higher data rates and smart acquisition and processing
  - Smart use of data to improve the over-all productivity and predictability

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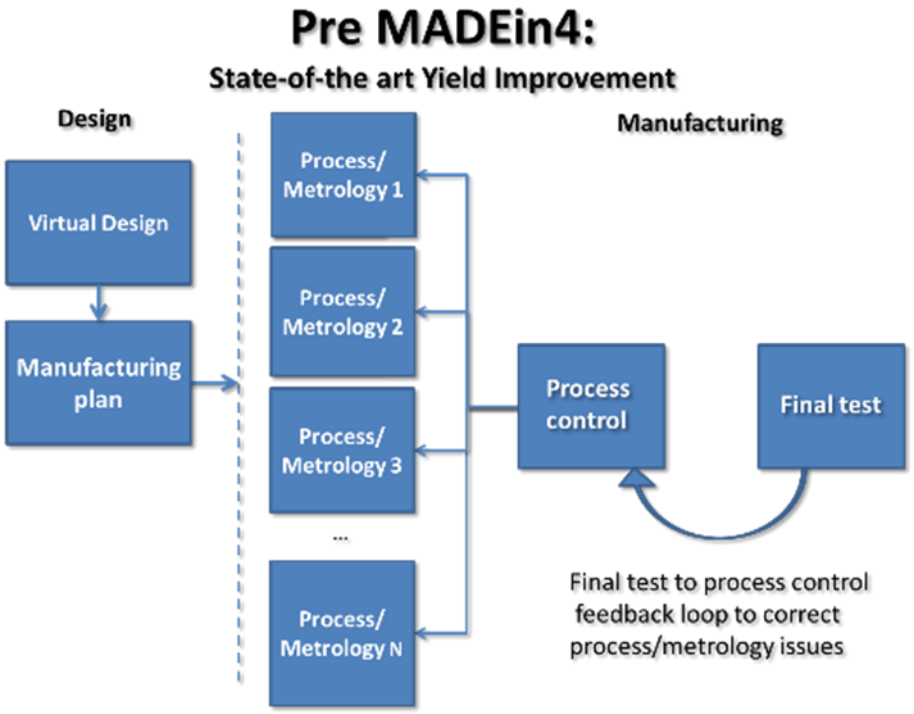
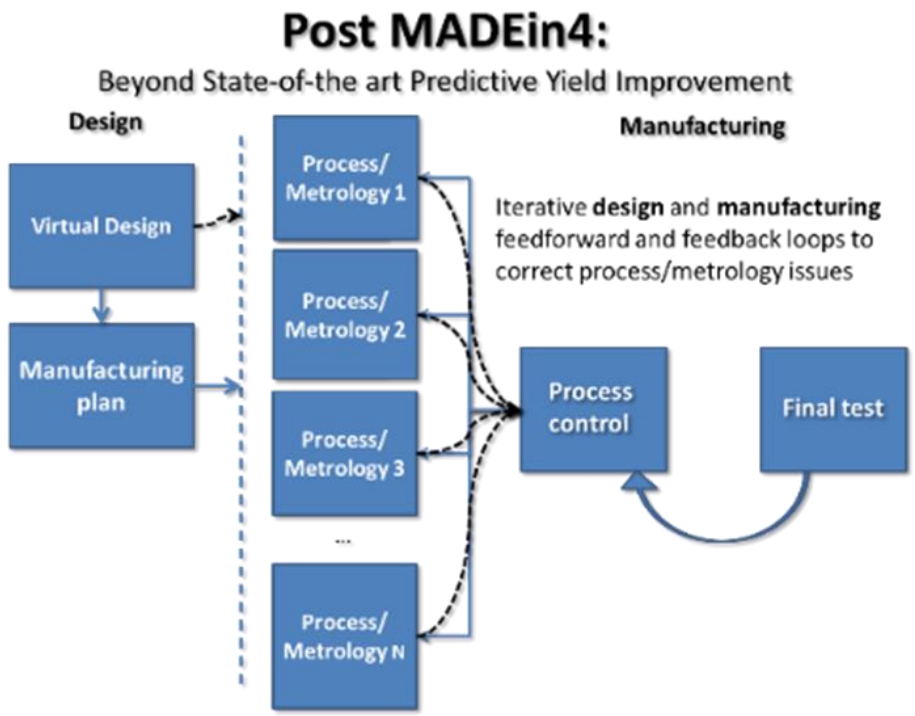
Semiconductor and Automotive domains analogy

Semiconductor and Automotive domains analogy



From: reactive manufacturing



To: predictive manufacturing

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Semiconductor and Automotive domains analogy

Semiconductor		Automotive
Number of measurements per wafer 10^3		Number of measurements per car >>10^3
Wafers per month > 10^7	Litho/ SEM	Doors welding/ Optical inspection
		Cars per month 10^6 - 10^7
Number different products $10^2 < x < 10^3$		Number of different configurations $10^2 < x < 10^4$
Highly automated manufacturing	Etch/ SEM	Painting/ Optical inspection
		Highly automated manufacturing
Number of inputs per unit process (features) 10^2	…	…
		Number of inputs per unit process (features) 10^2
Manufacturing process longevity much less than 10 years	CMP/ Reflectometry	Engines Assembly/ EOL hot test
		Manufacturing process continuously under improvement and changes

* numbers vary in time and between sources

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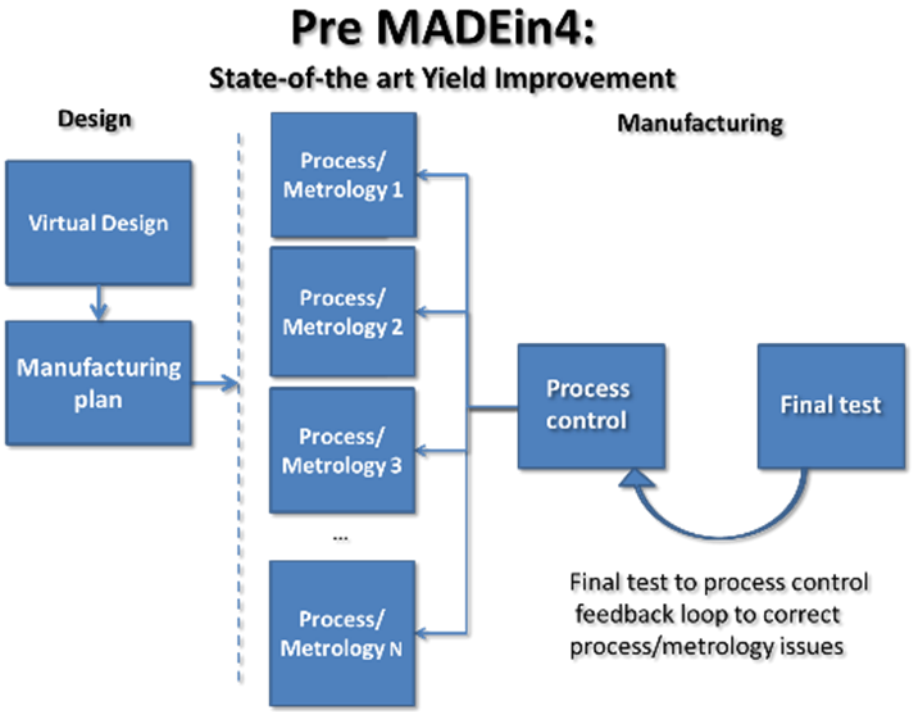
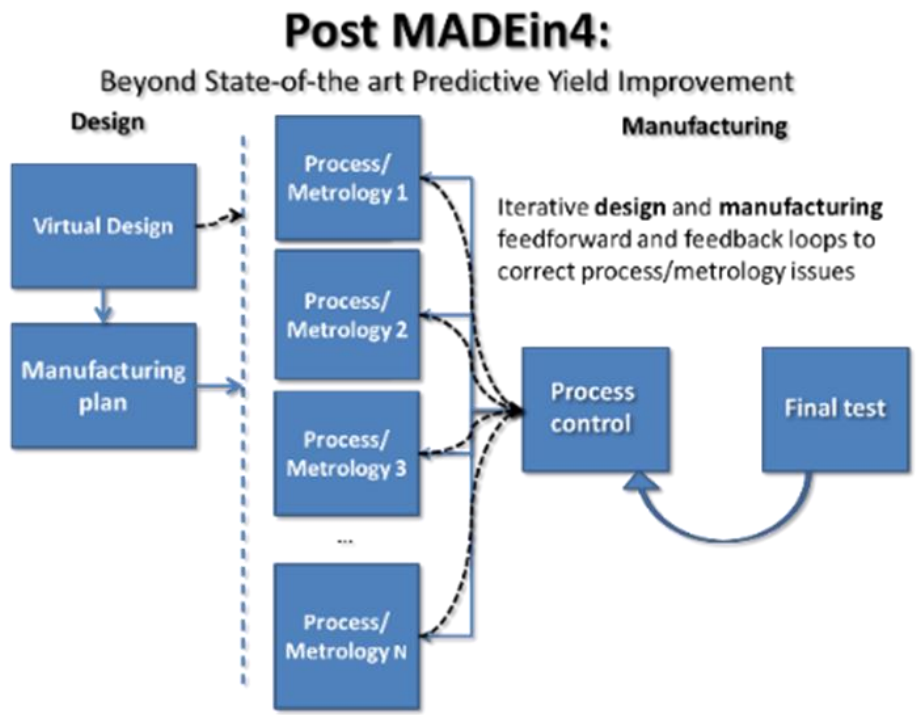
Semiconductor and Automotive domains analogy





The Semiconductor and Automotive industries are sharing similar design and manufacturing flows and differ by the content of each of the design and manufacturing modules

This allows to develop innovative shared machine learning based methodologies which will enable the transformation of the manufacturing from reactive to predictive

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Data is the new oil: design, modeling, metrology and ML

Context creation

Data is the new oil

1

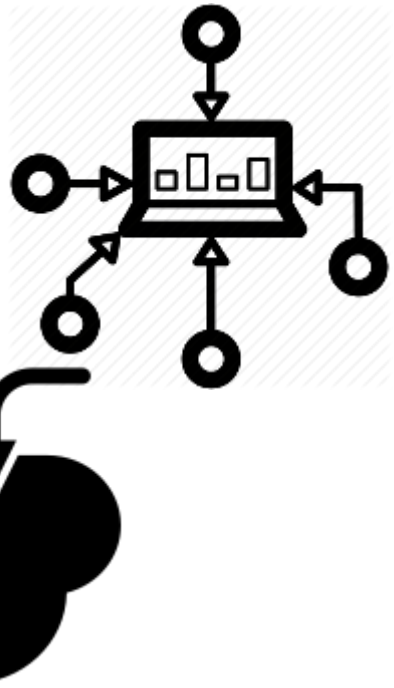
Data collected and pushed to the cloud

2

Sensors are added to industrial computers

3

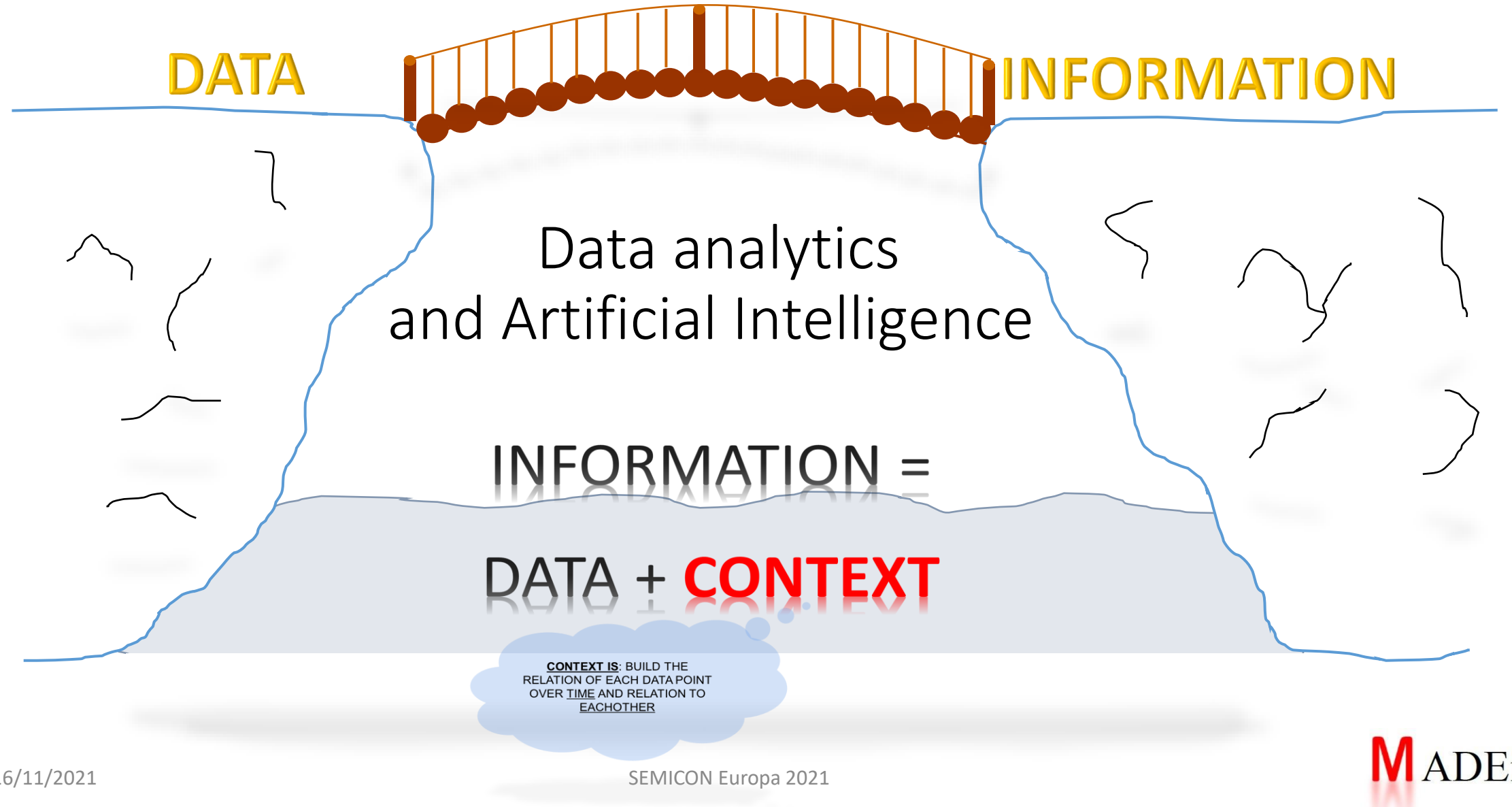
Constant data collection for future possible usage



4

Data analysis by tailor-made algorithms

CONTEXT (crossing) the chasm



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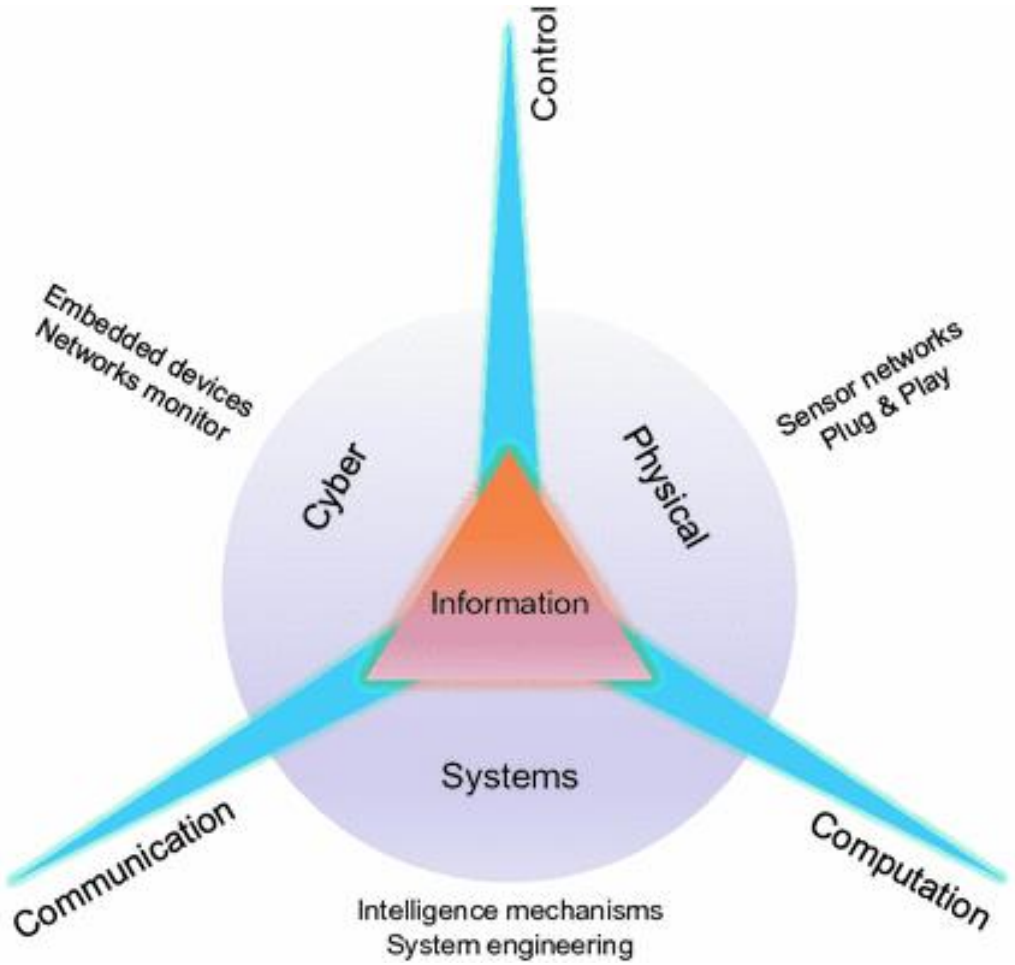
Cyber-physical Systems (CPS) for Information Creation



The interaction of physical and computing, including embedded intelligence at all levels

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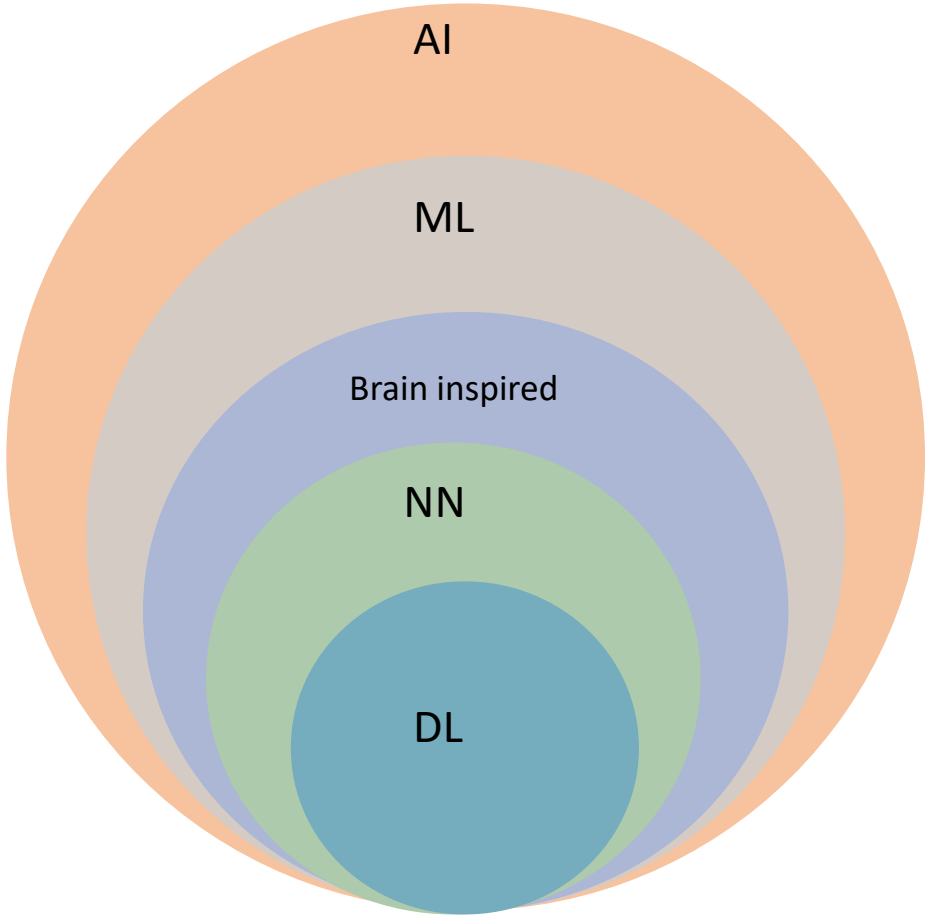
Artificial Intelligence (AI)

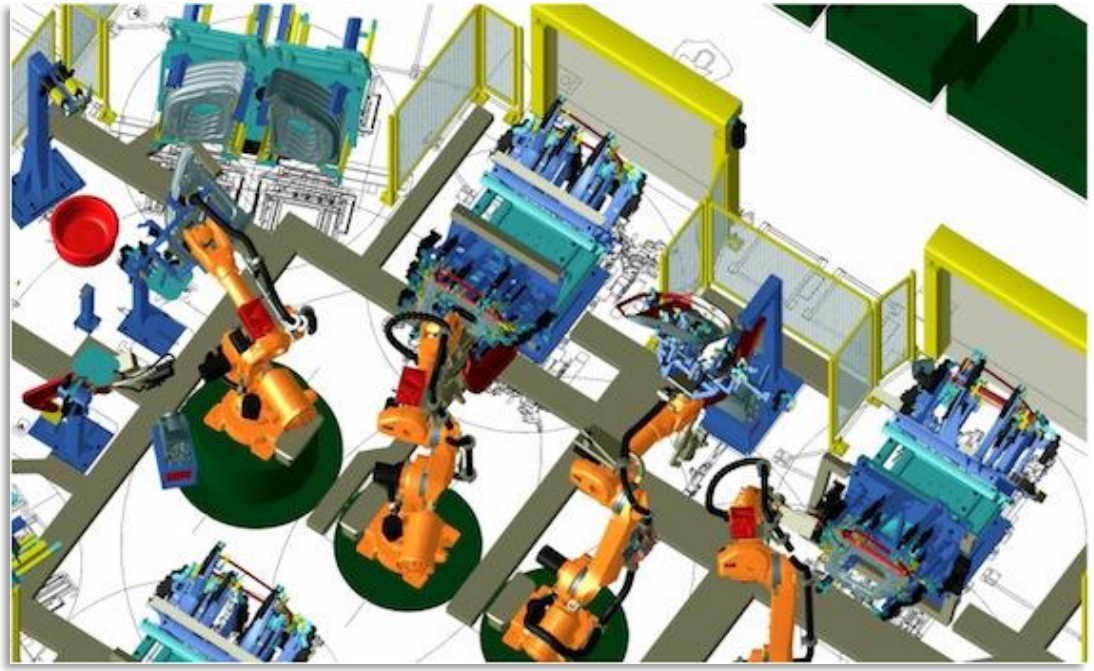


- AI: Artificial intelligence making decisions about a system
- ML: Machine learning modeling the behavior of a system
- NN: Neural networks are one implementation of machine learning
- DL: Deep learning is one implementation of Neural networks

Digital twinning: a virtual Representation of the Production Process

Traditional modeling: Physical models requiring little data but deep understanding of the process.

ML-based modeling: “black box” models requiring feature engineering coupled with sensor data.



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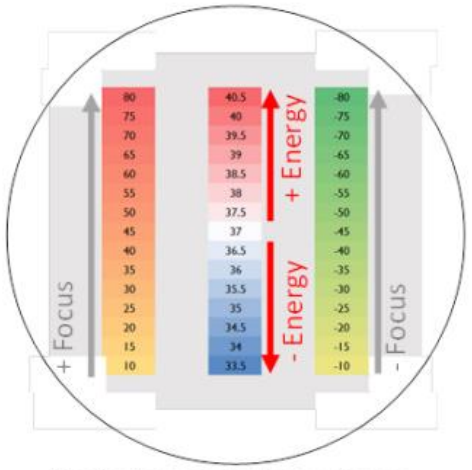
Project Highlights

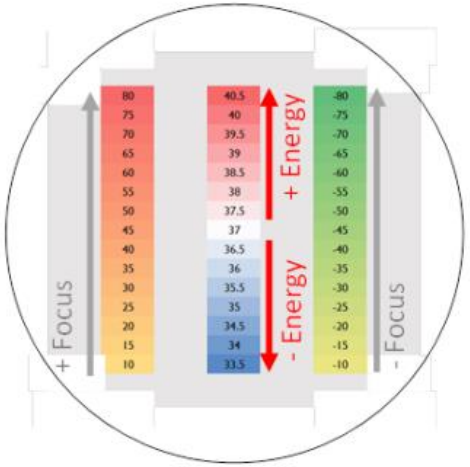
Imec created back end of line samples with special DoE for tools qualifications and predictive analytics activities

PW-**M1**- wafer



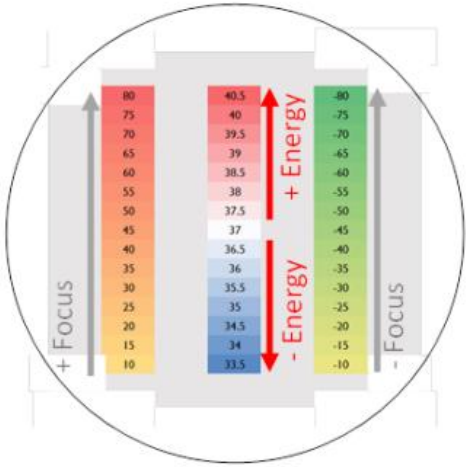
Typical modulations: focus, dose

PW-**M2**- wafer



Typical modulations: focus, dose

PW-**Via**- wafer



Typical modulations: focus, dose

Programmed Overlay

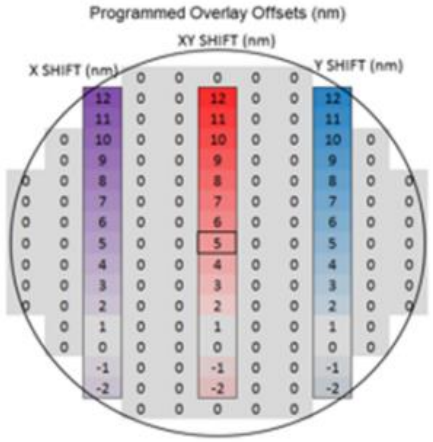
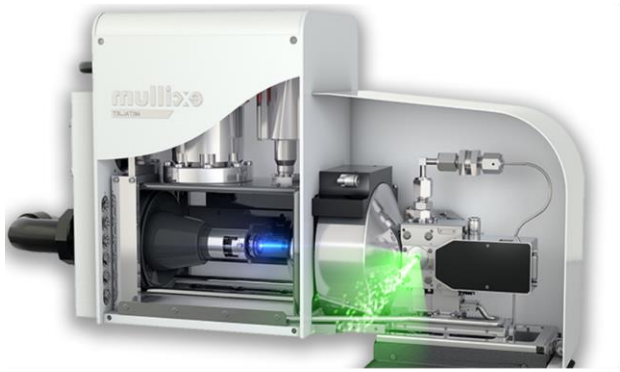


Figure 2

Excillum launched a first in a kind 700W MetalJet X-ray source prototype, increasing metrology tool throughput

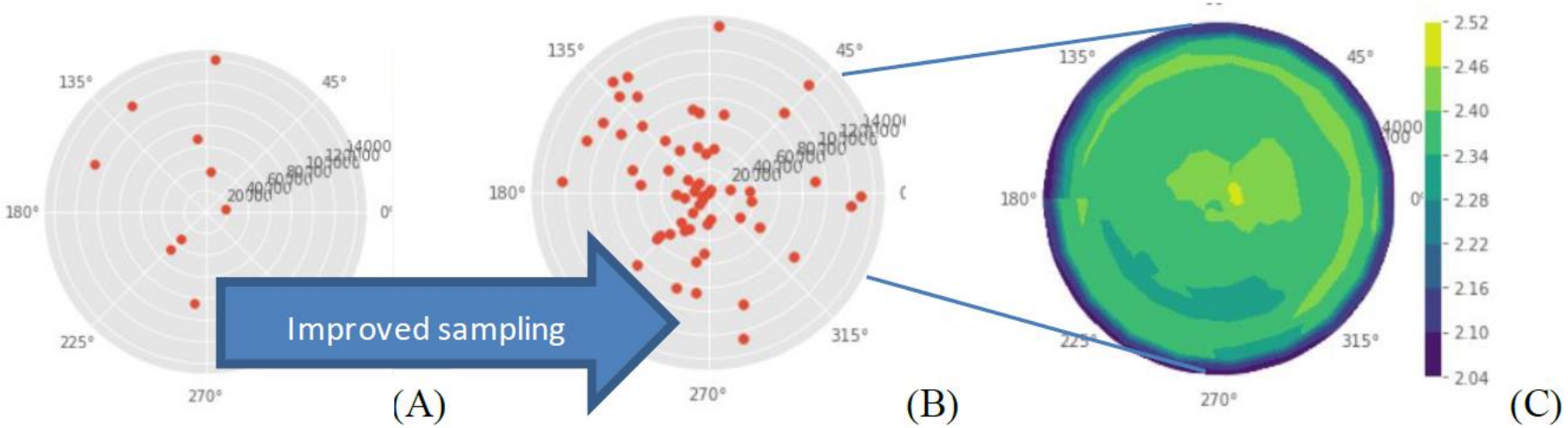
MetalJet D2+ 250 W

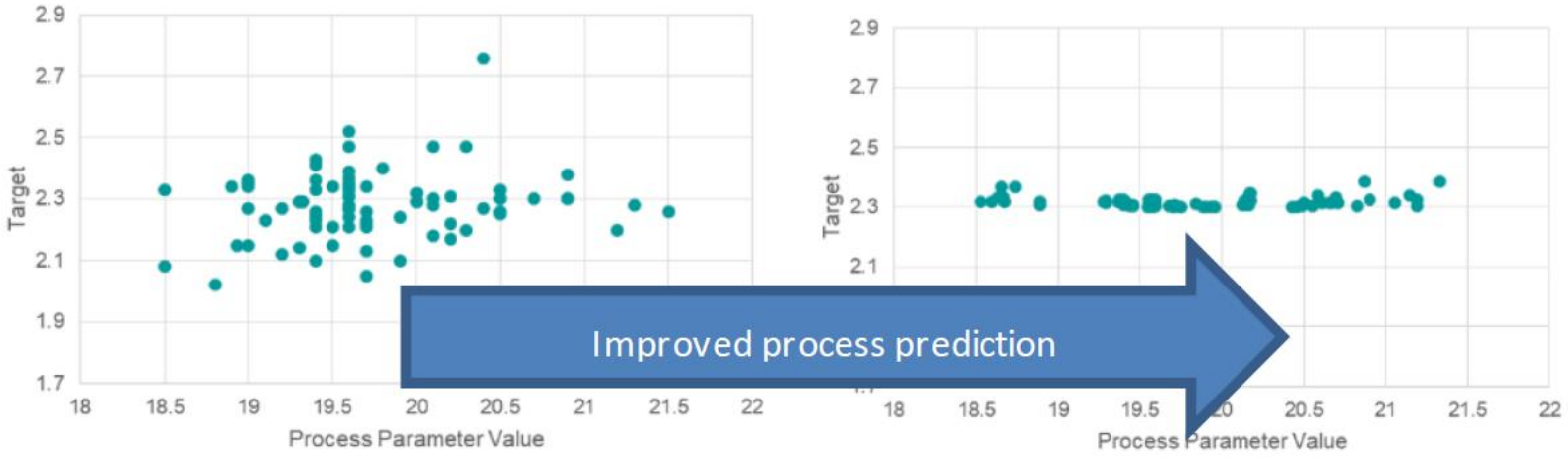


MetalJet E1 700 W

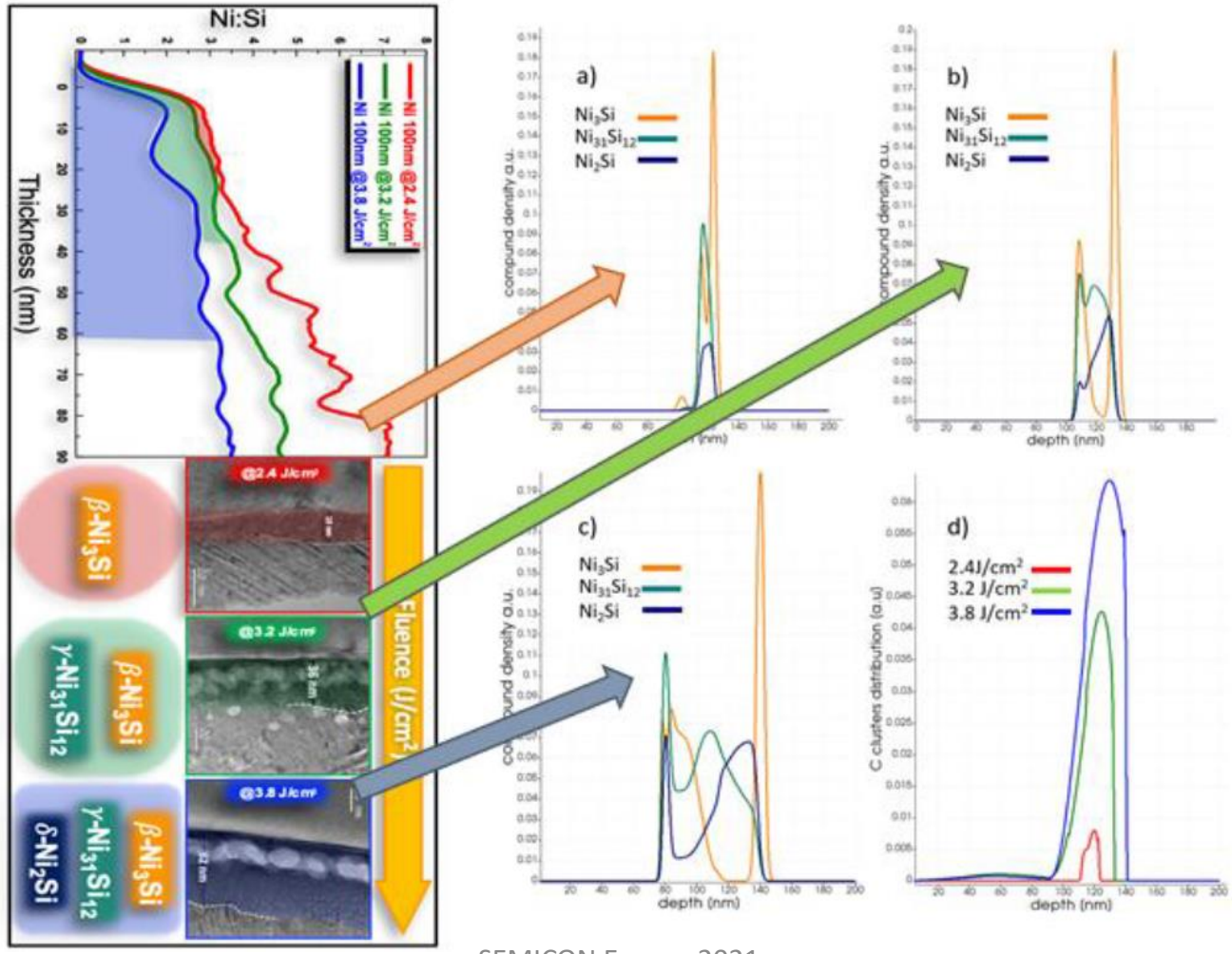
Highly synergetic MetalJet E1 was launched by Excillum in July 2020!

Mentor and GlobalFoundries demonstrated combined across wafer information

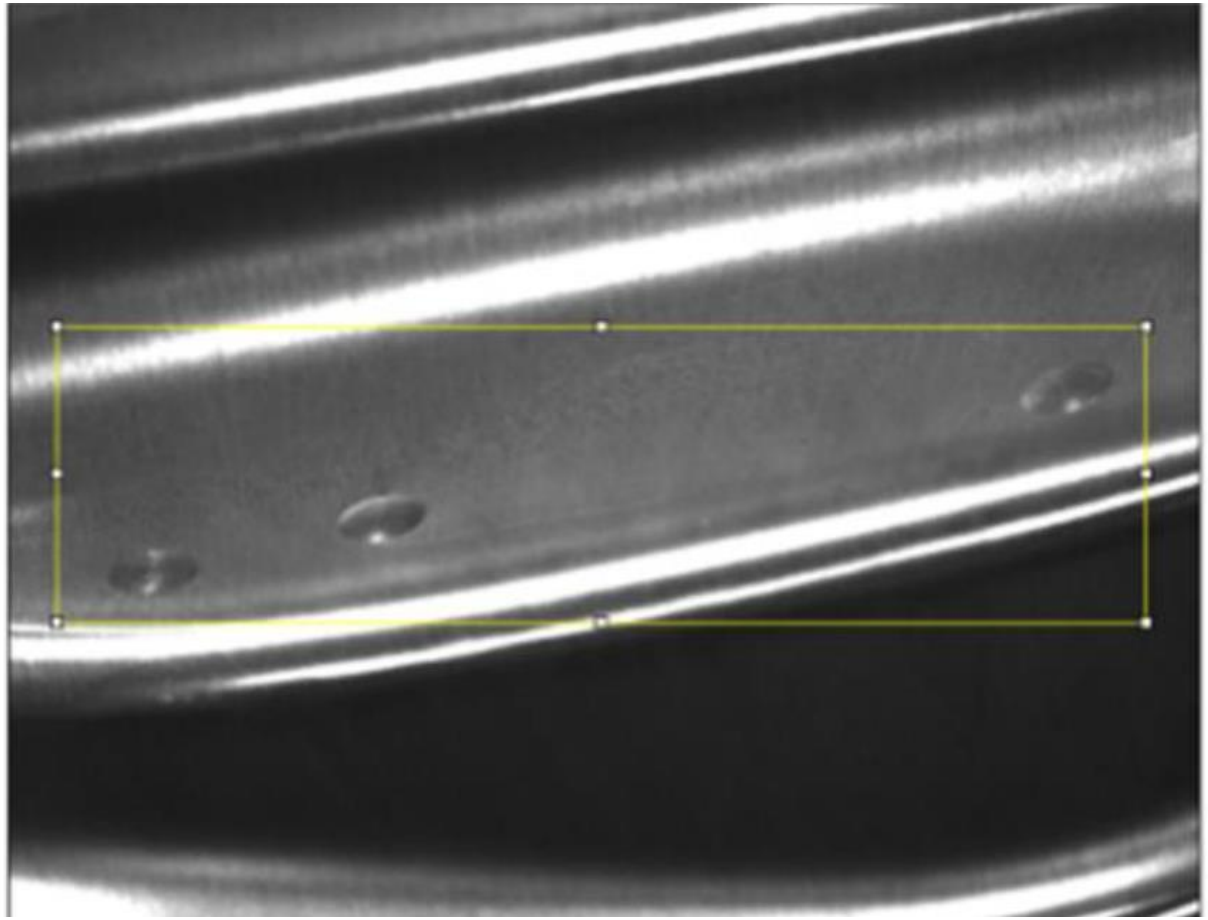




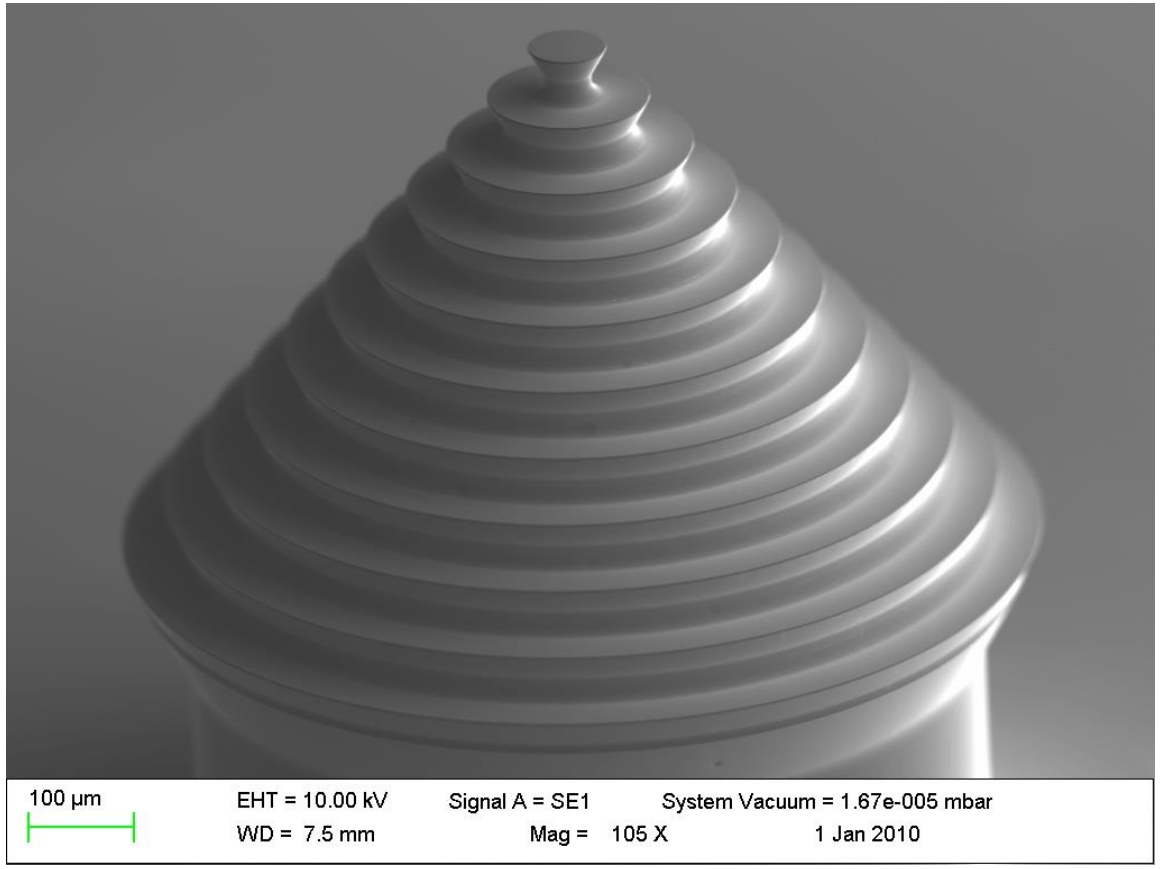
CNR, STMicroelectronics and UPB improved the simulation of laser annealing of Ni-SiC systems for back-junction formation, confirmed by TEM and XRD data

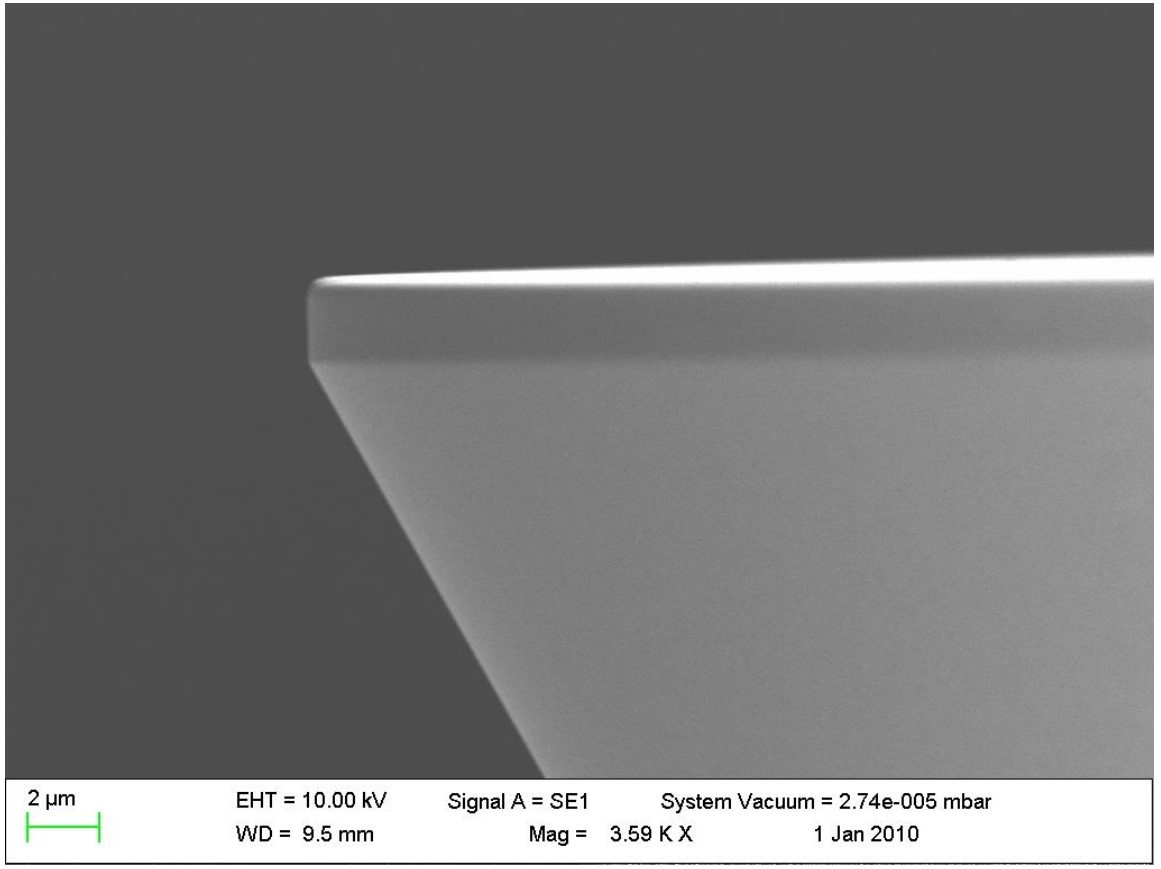


FCA, TOWER and TUD optimized the imaging conditioning for spot defects classification analysis in car doors welding



PTB created a prototype 3D metrology physical target to standardize probe-based microscope calibration





AGENDA

MADEin4 presentations @ SEMICON Europa

MADEin4 presentations @ SEMICON Europa

MADEin4 Session 16. November 2021 / 10:00 – 11:30
From reactive to predictive: Smart Manufacturing in the Semiconductor Industry – The MADEin4 Initiative

- Simona Laza (Excillum) – MetalJet - a New Key Module for Enhanced Metrology Capabilities
- Juliette van der Meer (Bruker) – Advances in X-ray Metrology under MADEin4
- Thomas Ashby (imec) – Privacy Preserving Amalgamated Machine Learning (PAML) in the Fab, and machine learning workflow in the MADEin4 project

SMART X Session 17. November 2021 / 10:00 – 10:30

- Ovadia Ilgayev (NOVA) – Recent Innovations in Integrated Metrology

MADEin4 presentations @ SEMICON Europa

MADEin4 Session 19. November 2021 / 10:00 – 11:30
Artificial Intelligence and Robotics in the Semiconductor Industry: Manufacturing the Smart Way – The MADEin4 Initiative

- Jean Hervé Tortai (LTM) – Go Faster for Process Deviation: Fast Errors Detections on Large Surfaces Using Ellipsometry
- Giulio Vivo (CRF) – Digital Twin methodology for energy modelling and management of body and assembly shop floors
- Meirav Hadad-Segev (Brillianetor) / Alfio Minissale (COMAU) – Giving robots and machines human-like skills to collaborate
- Lior Yehieli (Applied Materials) – Next Generation Defect Inspection Computing Challenges

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Thank You For Your Attention

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