Technologies for Smart Industry

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Who We Are

- A global semiconductor leader
- 2017 revenues of **$8.35B** with year-on-year growth of **19.7%**
- Listed: NYSE, Euronext Paris and Borsa Italiana, Milan

- Research & Development
- Main Sales & Marketing
- Front-End
- Back-End

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- Approximately **45,500** employees worldwide
- Approximately **7,400** people working in R&D
- **11** manufacturing sites
- Over **80** sales & marketing offices

As of December 31, 2017

Application Strategic Focus

The leading provider of products and solutions
for Smart Driving and the Internet of Things

Internet of Things

Smart Driving

Smart Industry

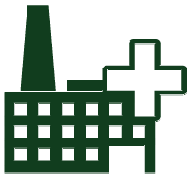
Smart Home & City

Smart Things

Smart Driving

From Industry to Smart Industry

18th century → 20th century → 1970's → Smart Industry



1st Industrial Revolution

Mechanical production equipment driven by water and steam power

All new machines

2nd Industrial Revolution

Mass production achieved by division of labour concept and the use of electrical energy

Change of driving mechanism

3rd Industrial Revolution

Based on the use of electronics and IT to further automate production

Machines largely replaced

4th Industrial Revolution

Use of cyber-physical systems, communications, IoT and decentralized decisions

Machines partially replaced - connected

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The Evolution of Industry to Smart Industry

More efficient operation

Less waste

Producing more **efficiently** and in more **environmentally friendly** manner

Responding to demand more **flexibly** and with more **customization**

Local, mass customized production

Safer working environments

Evolved man-machine cooperation

With a better and safer **human experience**

Collecting and using manufacturing and supply chain **data** better

Big data & Cloud computing

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Smart Industry

Smart Industry
Trends, Dynamics & Applications

Key Trends

- Next levels of automation with distributed control
- Safer working environments & new man-machine interaction models
- Higher energy efficiency for industrial machinery
- Capture & exploitation of manufacturing data
- Artificial Intelligence & machine learning

Industry Dynamics

- Smart Industry initiatives (Industry 4.0, IIoT, …)
- Integrated distributed manufacturing
- Flexible, reconfigurable factories
- Optimization of factory infrastructure life cycle
- Cloud-based condition monitoring & predictive maintenance

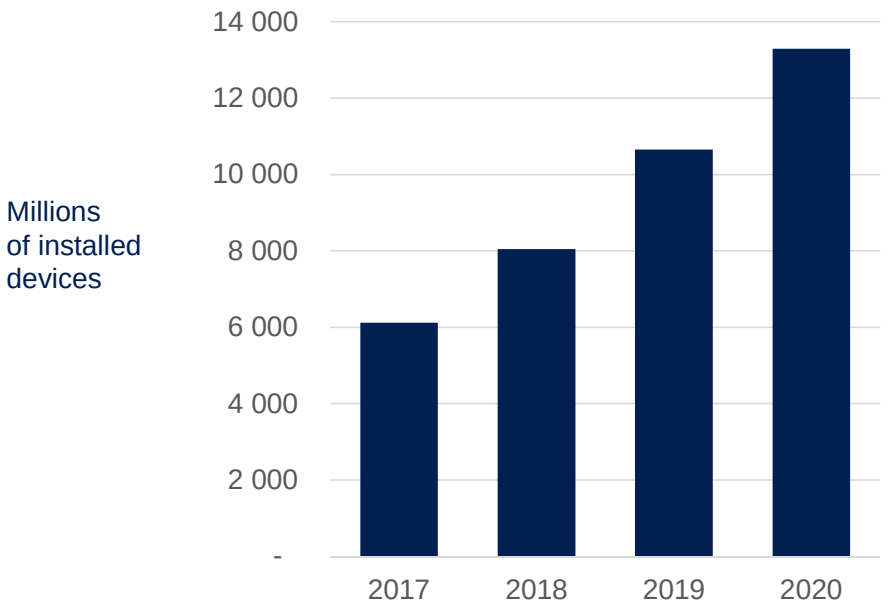
Key Applications

- Smart manufacturing
- Factory automation
- Functional safety and security
- Condition monitoring and predictive maintenance
- Smart motion/motor control
- 3D printing
- Power & energy management
- Industrial robots
- Industrial lighting
- Sensors for industrial, medical, aerospace & defense

Smart Industry

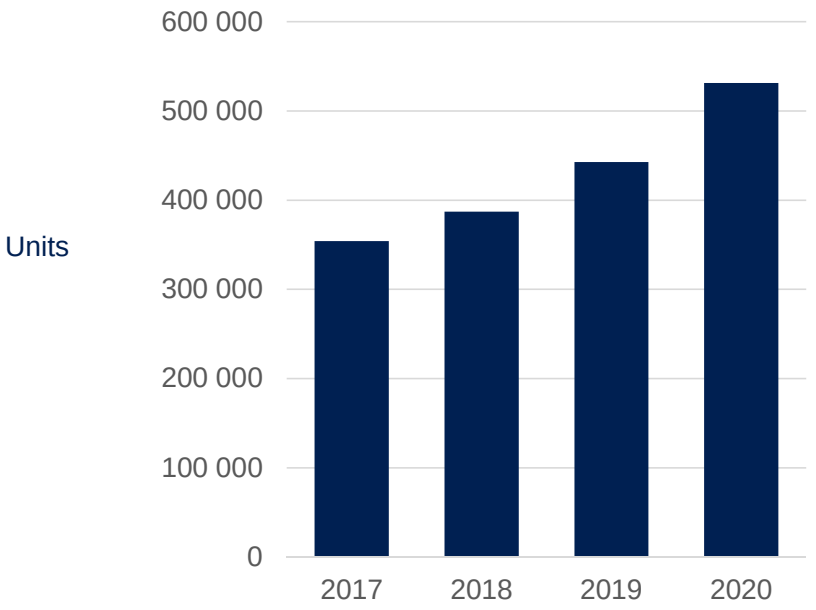
Smart Industry Opportunities

Internet Connectable Industrial devices



Source: ABI Research 2017

Annual Supply of Industrial Robots



Source: World Robotics 2017

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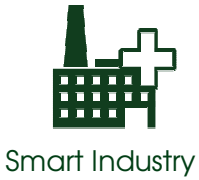

Technology Enablers for Smart Industry

Safer More Efficient

Higher efficiency at all power usage points
- Power conversion & energy harvesting
- Power Management
- Power storage
- Motor Control

Components are more robust providing better safety for machines and operators

More Intelligent & Aware

Sensors collect information about every machine and distributed local processing allows data to be turned into information

Safe & Secure real-time processing

Products contain the instructions for their manufacturing

Machines are aware of the people and provide easier and safer interactions

More Connected

Machines are connected inside the factory, to the larger supply chain and to the cloud

Real-time communication down to the lowest level (sensor & actuator)

All communications must be secure

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Smart Industry

Technology Enablers

Safer & More Efficient

Analog & Digital inputs	MCU	Secure MCU
Motor Drivers	Gate Drivers	Intelligent Power Switches
Galvanically Isolated ICs	Safety Integrity Level (SIL) ICs	ASICs with Embedded Diagnostics
Power Management	AC-DC Conversion	Digital Power
Power Modules & Discrete	MOSFET IGBT SiC	

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Smart Industry

Technology Enablers

More Intelligent and Aware

More Intelligent & Aware

Controlling and information sharing down to the last node

	MCU	Secure MCU
Signal Conditioning	Acoustic MEMS	Ranging & Proximity sensors
	Motion MEMS	Environmental sensors
	Industrial Sensors	
Gate Drivers with SPI and Diagnostics	ASICs with Embedded Diagnostics	Motor Drivers SiP with MCU

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Smart Industry

Technology Enablers

More Connected

Wired	Power line modem	IO link	USB Type-C	RS485 RS232
Wireless	Wi-Fi module	Bluetooth	Sub-GHz	
Contactless	NFC			
	Secure MCU	MCU	ESD & EMI Protection	

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Securing Industrial Devices Against Attack

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Use the embedded security features of an MCU

STM32 General Purpose MCU

Application

Key

Key

Add a Secure Element for state-of-the-art security protection

STM32 General Purpose MCU

Application

STSAFE Secure Element

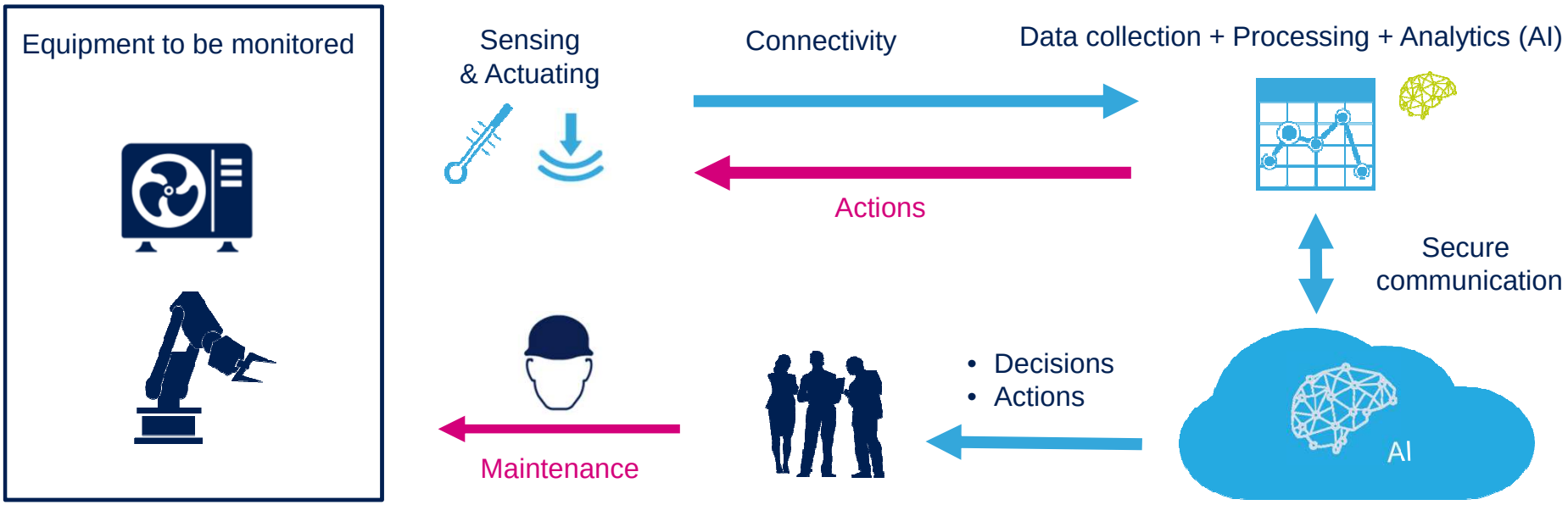
Key

Key

Smart Industry

Predictive Maintenance

Predictive maintenance can reduce downtime by up to 50%
with up to 40% cost savings on equipment & maintenance*



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ST Crolles – Smart Industry in Action

60 000 m² of buildings - 40 hectares site area

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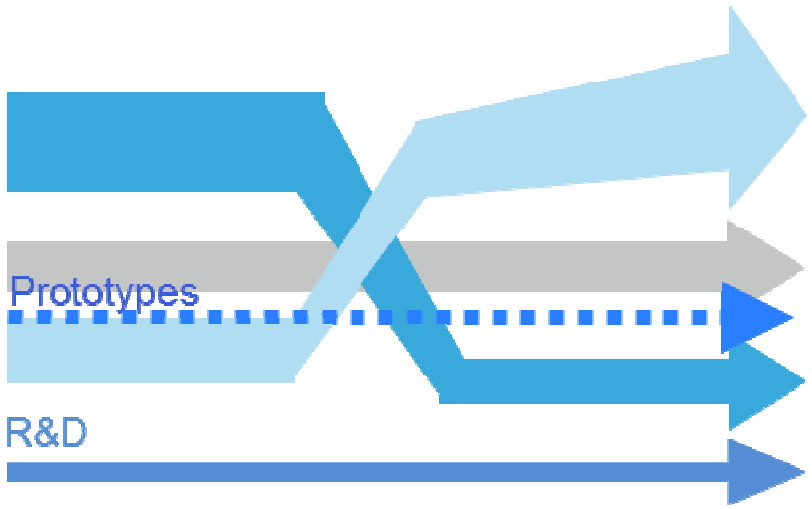
ST Crolles
Demand Management

- Product Mix & Volume
- Technology development
- Prototyping
- Priorities

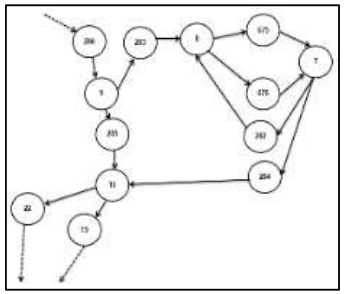


ST Crolles
Fab Modelling & Simulation

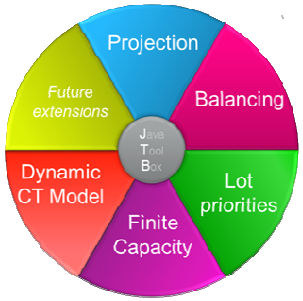
- Production flows & capacity
- Equipment layout
- Automated Material Handling System

Digitized factory for traffic simulation

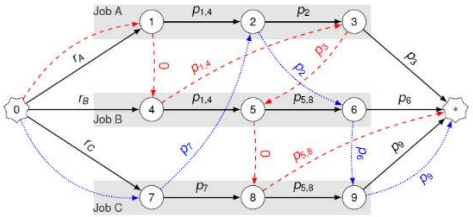
Topological representation of vehicle routing



Production flow projection at finite capacity



Modelling of complex flows



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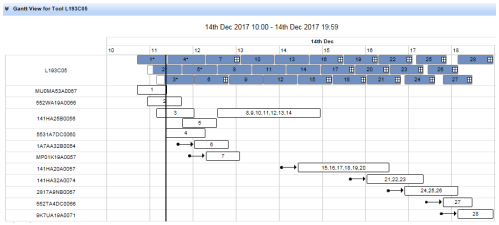
ST Crolles

Fab Optimization & Execution

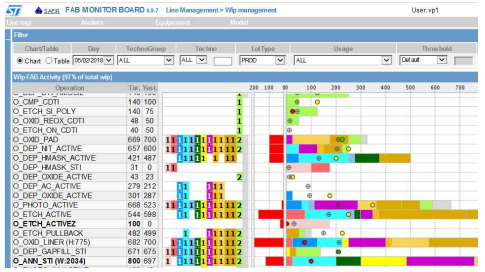
- Equipment configuration
- Scheduling & Dispatching & Routing
- Human Machine Interface (cockpit)

100 vehicles
45,000 transports/day
350T/day moved

Real-time optimization
over millions of
combinations



Real-time GUI for
factory supervision



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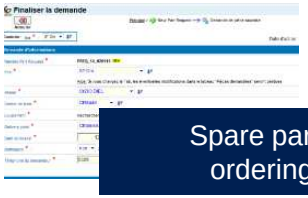
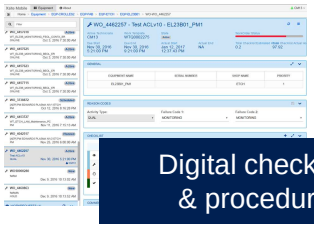
ST Crolles
Tools & Enablers

Advanced maintenance

Spare parts identification

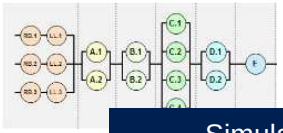


Spare parts ordering

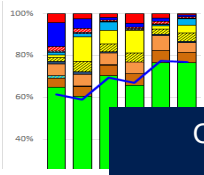


Digital checklists & procedures

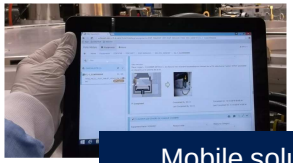
Robotics



Simulation



Optimization

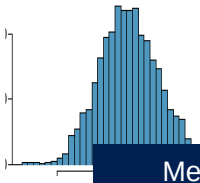


Mobile solutions for human intervention

Sensors & embedded metrology

Automatic process regulation loops

Real-time fault detection



Measurements on wafers

Connectivity

Real-time lot traceability

Private cloud Cyber security

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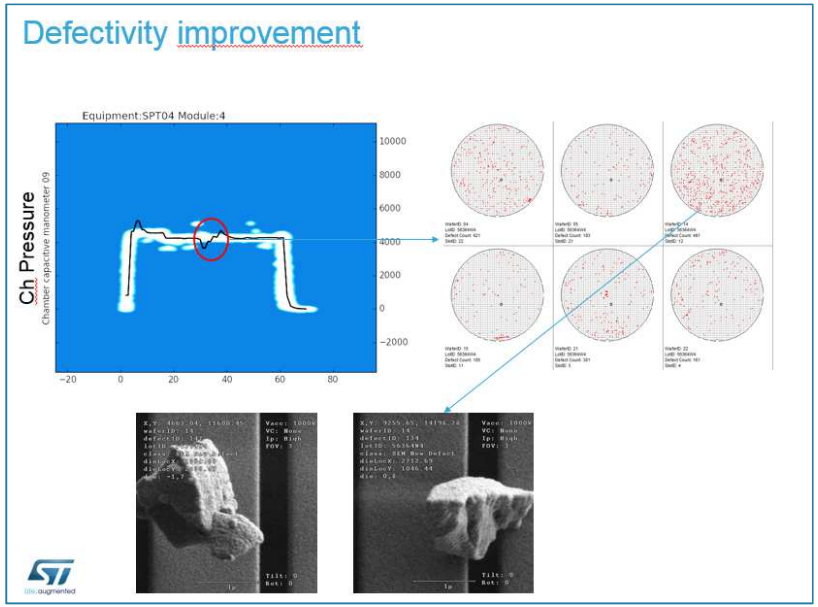
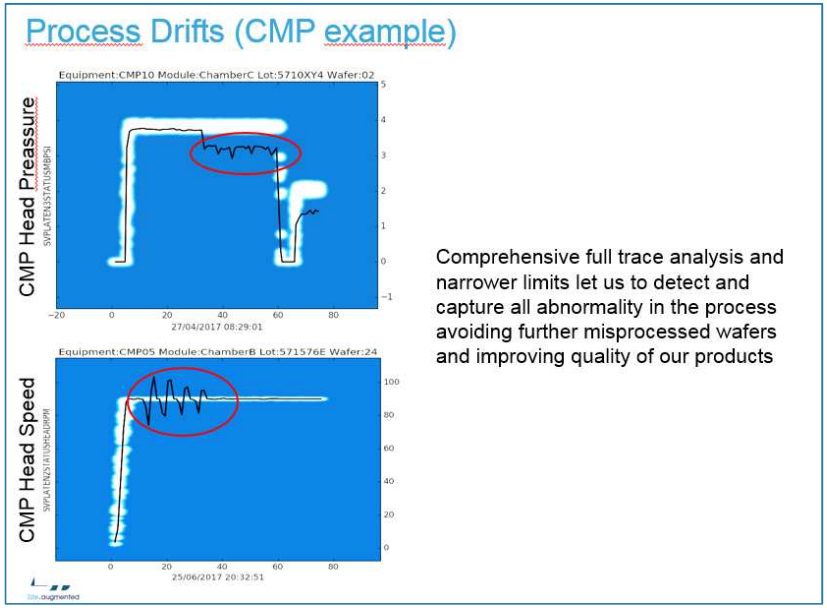
Fault Detection & Classification Principle

- Detecting equipment faults at the “moment” they occur based on equipment parameters to take appropriate corrective action

Equipment Sensor Data for Real-time Drift Detection





Comprehensive full trace analysis and narrower limits let us to detect and capture all abnormality in the process avoiding further misprocessed wafers and improving quality of our products

- Machine Learning algorithm (SVM)
- Wafer scrap reduction already seen in production
- Automatic control chart optimization and detect of new type of excursions

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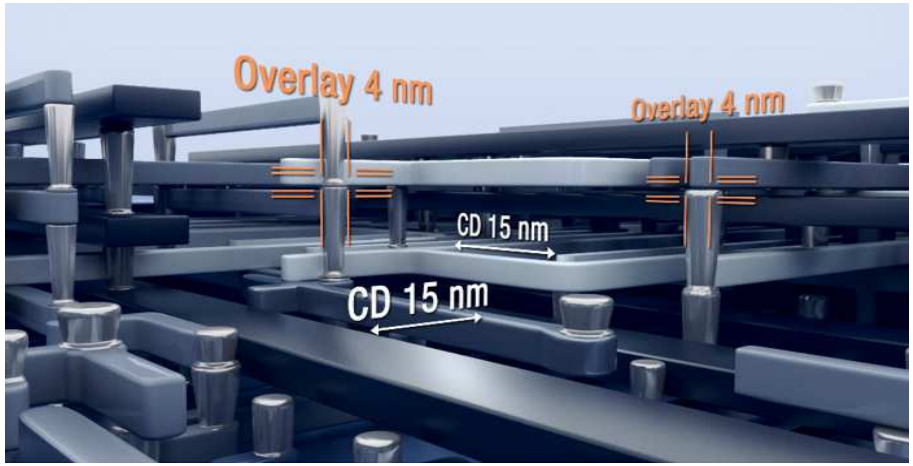
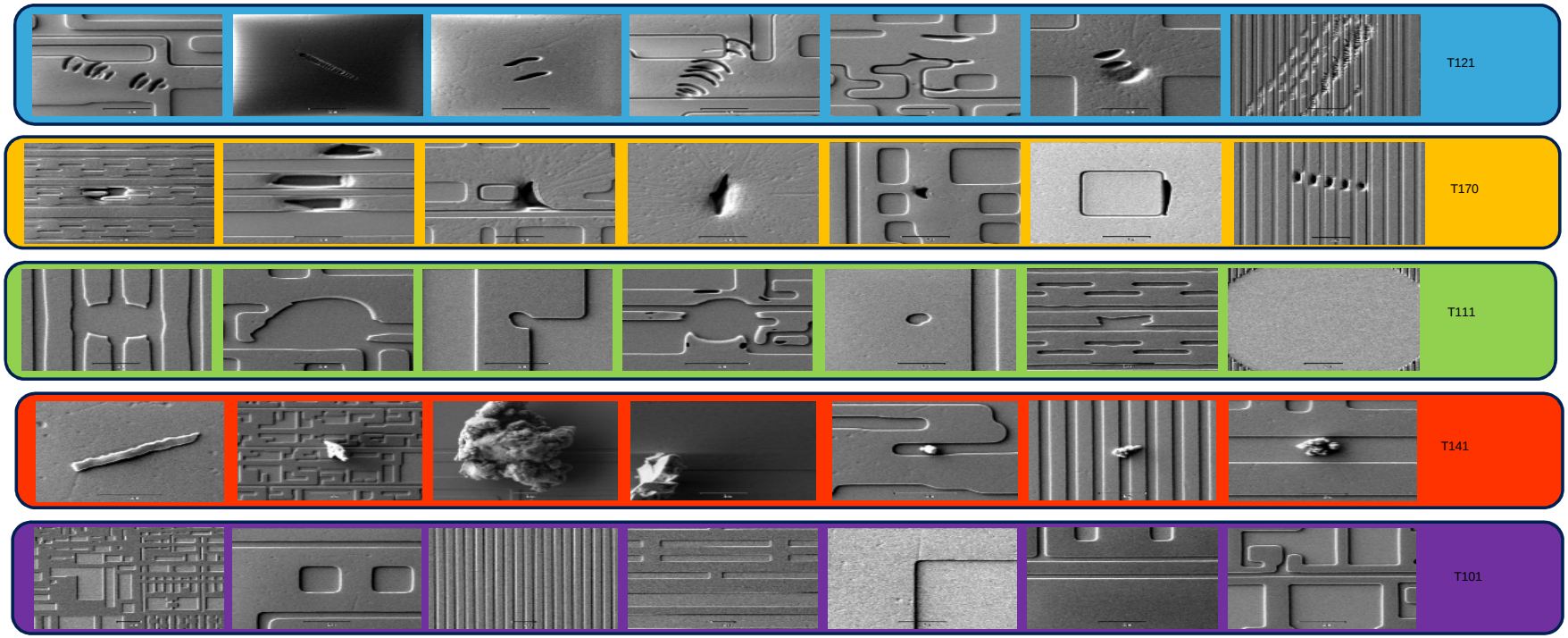
Virtual Metrology

- Bayesian networks
- Overlay is a key process parameter for Yield
- High number of overlay measurements (>1000 points) required during Front-End lot lifetime
- Statistical sampling solution is too limited
  - minimum measurements required to feed APC
  - need to keep wafer at risk to acceptable level
- Typical conflict between productivity and quality control



Source : https://medium.com/@ASMLcompany/data-mining-uncovers-hidden-interactions-ea5c49e74318

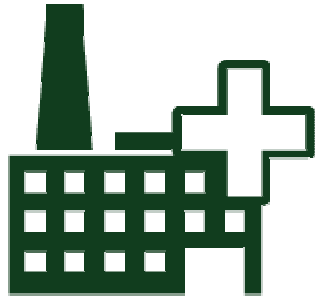
Automatic Defect Classification



- Algorithm based on neural networks
- Able to detect and classify defects into 13 independent classes
- Very high classification success (96% above the 92% of manual classification)

Takeaways

- Smart Industry is the next evolution of the industrial world and it is happening now
- All of the enabling technologies for Smart industry are available today with new capabilities being added as each of the technologies evolves
- ST is implementing Smart industry methodologies in its factories today



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