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SiC at STMicroelectronics: high-volume industrial environment for leading- edge technologies

Luca Riva

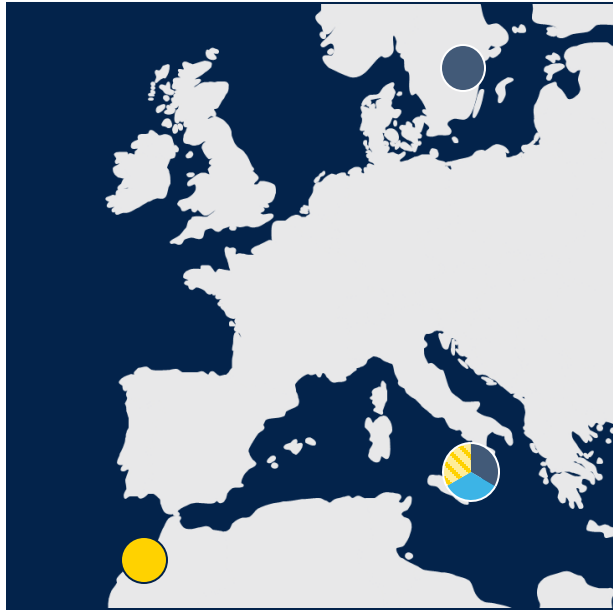
STMicroelectronics

Authors: G. Bruno, E. Carria G. Marchesi, D. Piccolo

Major trends driving the adoption of SiC

	Automotive	Industrial		
What?	 Electric vehicle	 Charging station	 Renewable energy	 Power supplies
Where?	• On-board chargers • DC-DC converters • Traction inverters • Other (PTC heater, e-compressor, etc.)	• Industrial chargers • EV DC fast chargers • EV wireless chargers	• Solar inverters • Energy storage systems • Wind power	• AC-DC server power supplies (AI focus) • Telecom AC-DC rectifiers • UPS
Why?	Small size & weight, high efficiency, longer driving range	High efficiency, low cost, ease of thermal management	High efficiency, low system cost	High efficiency, high power density, lower energy costs

ST SiC vertical integration approach



Norrköping



Substrate manufacturing

- 150 mm volume production
- 200 mm with industrial quality and yields

Singapore



Front-end manufacturing

150 mm SiC diodes and MOSFET production on 150 mm wafers

Shenzhen



Back-end assembly & test

Advanced power packages and modules

Catania



ST Silicon Carbide Campus Vertically integrated silicon carbide facility

- Substrate manufacturing (Operational)
- 200 mm front-end manufacturing (under construction)
- Back-end assembly and test (under construction)

150 mm front-end fab

- Front-end manufacturing of SiC devices on 150 mm wafers

Chongqing*



Front-end manufacturing

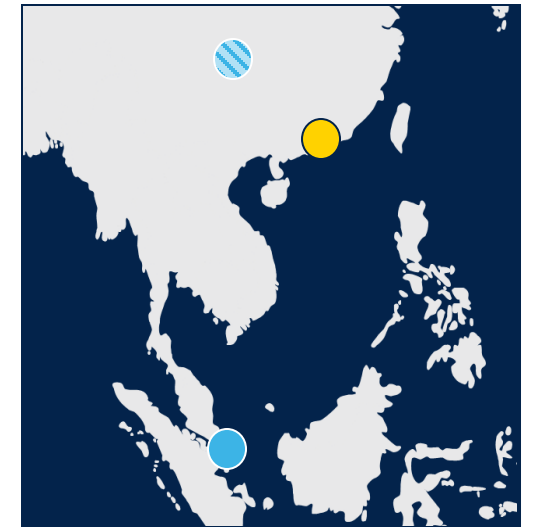
(Under construction. Production start 2025)

Bouskoura

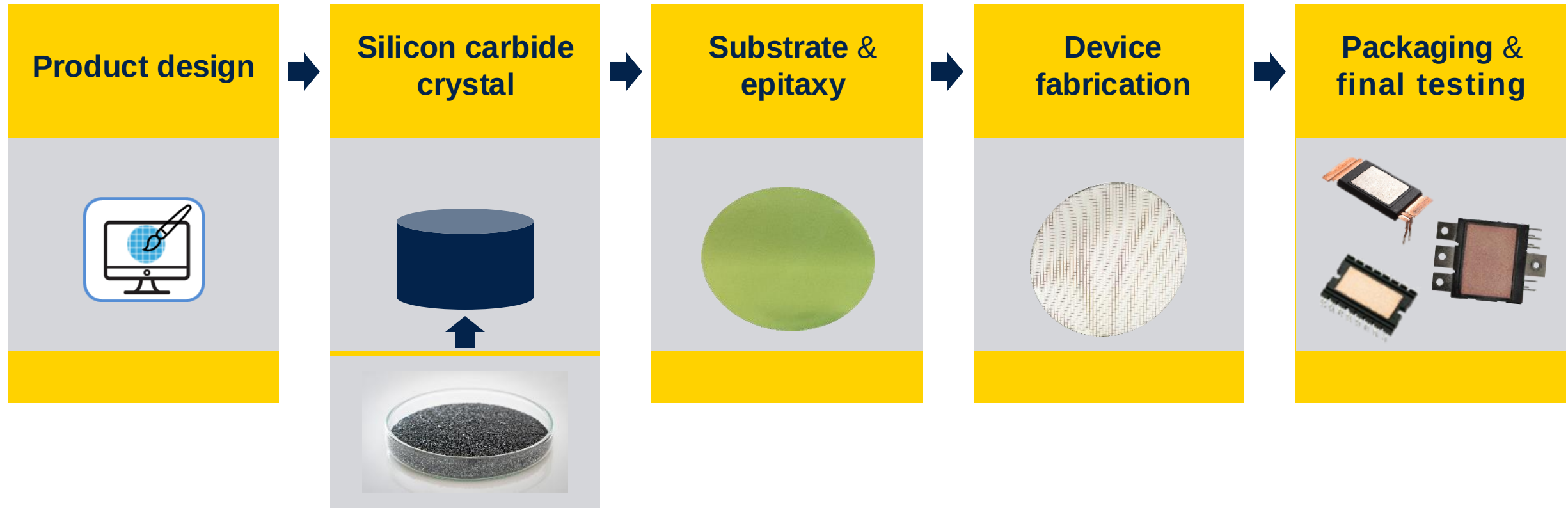


Back-end assembly & test

Advanced power packages and modules

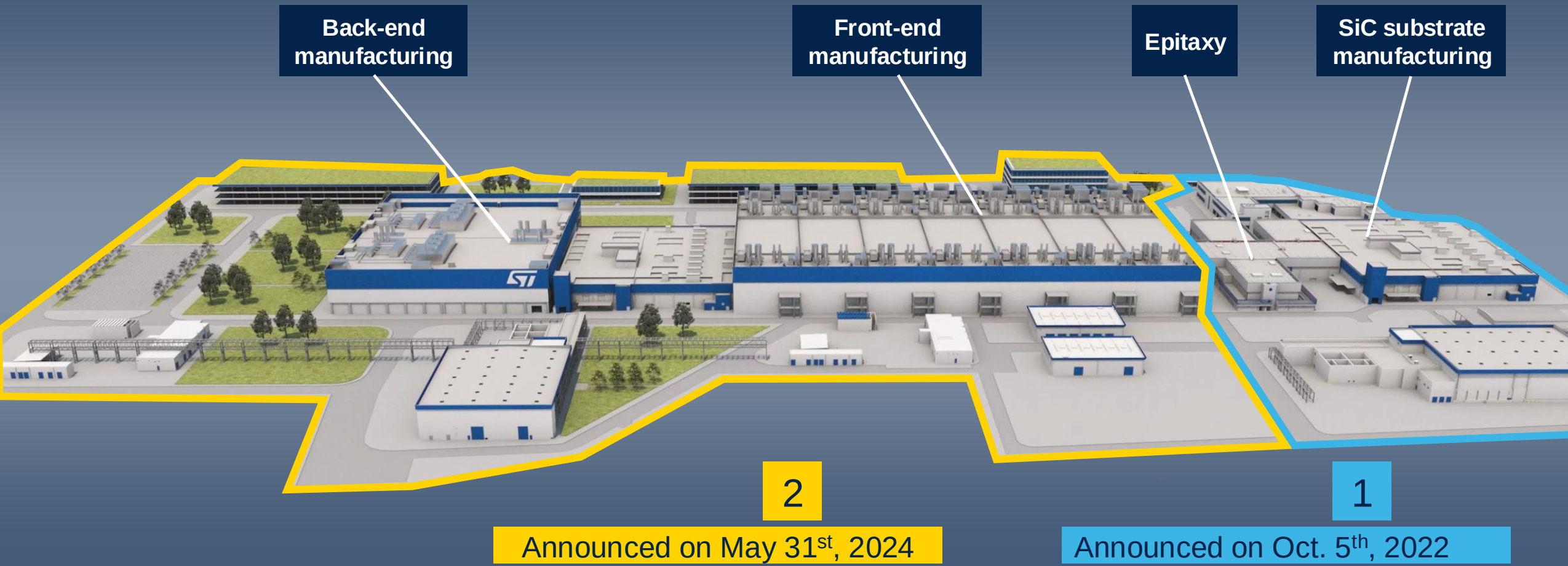


Value chain and fully vertical integration in SiC at ST

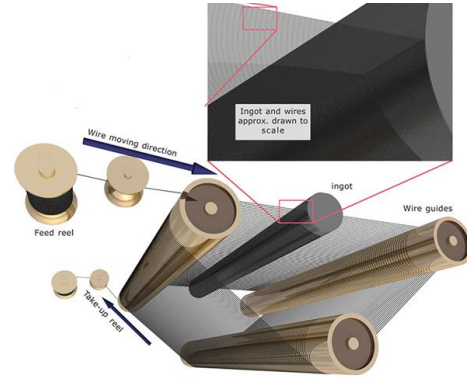


Flexible range of single-device packages, multidevice modules, and bare dice

ST silicon carbide campus in Catania



SiC substrate manufacturing processes



Crystal growth

- Raw materials
- Simulation

Slicing

- Wire-sawing
- Laser-splitting

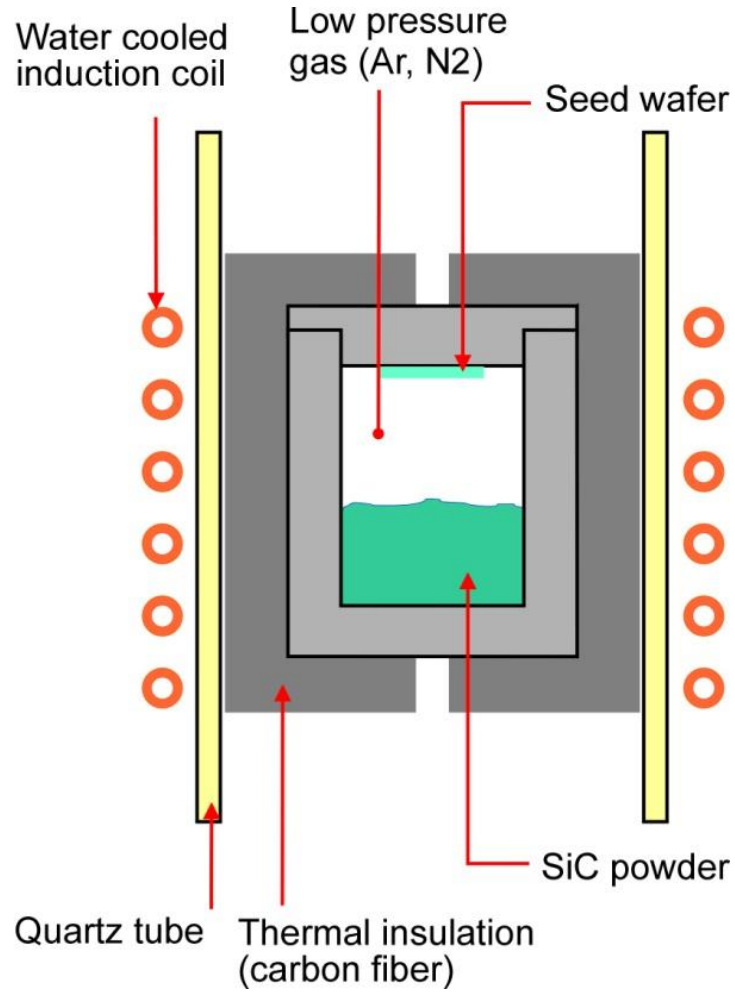
Finishing

- Surface grinding
- Polishing
- Cleaning

Characterization

- Defect density
- Resistivity

Crystal growth technology

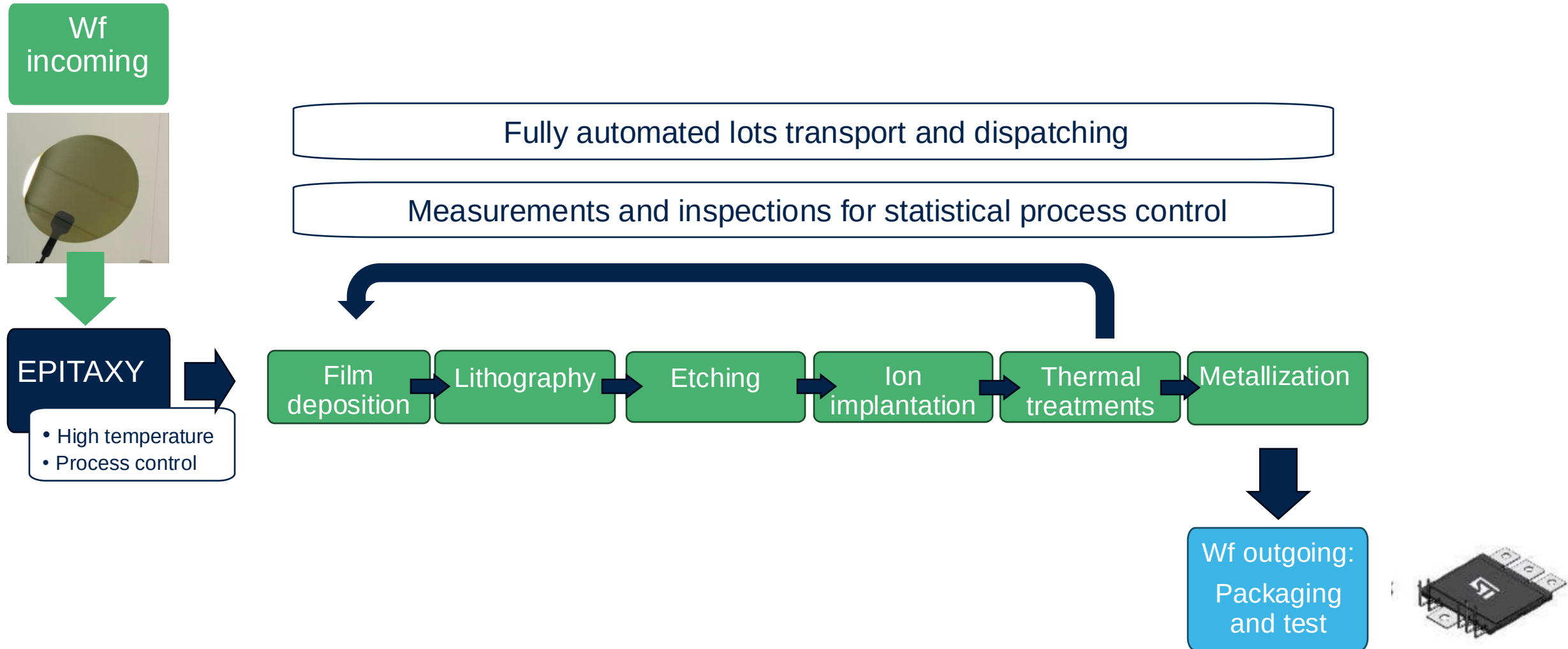


Typical growth conditions

- Inert gas argon
- Doping gas nitrogen
- Pressure 1-100 mbar
- Temperature $>2,000^{\circ}\text{C}$
- Growth rate 0.01-1 mm/h



SiC devices manufacturing processes



SiC devices manufacturing processes

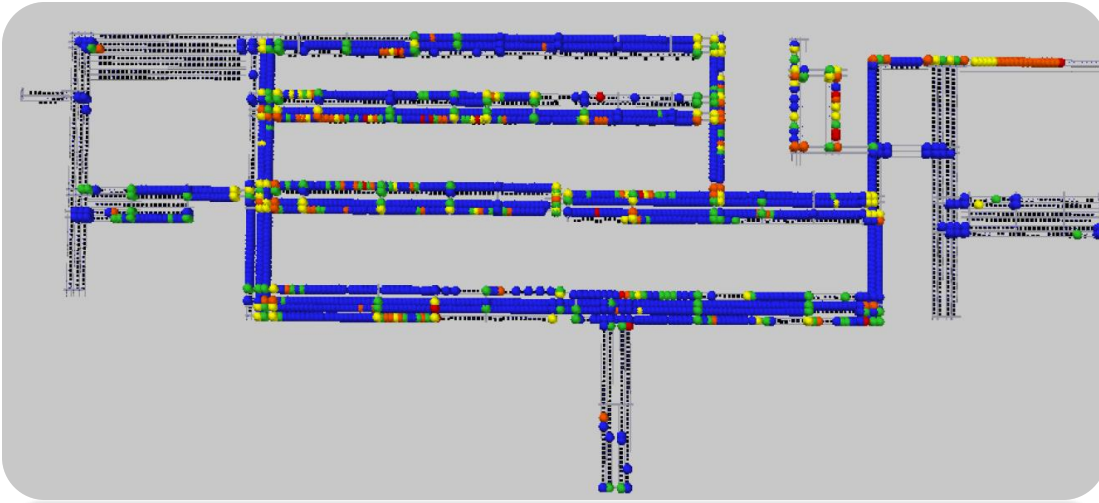
POWER DISCRETE Techno features

- Large layout rules
- Thick layers
- High topography
- Specific implant steps
- Activation/ salicidation by laser
- Backside processing

Challenges

- Defectivity control
- High bow and warpage management
- Long and high temperature thermal processes
- Implant control
- Thin wafers management

Multi-method Simulation at WSiC



Multi-method simulation is a powerful framework used to optimize layout and capacity of a Fab identifying the possible bottleneck and to display heatmap and process flow in 3D.

Anylogic is the software solution chosen that include:

- Work easily with the three different simulation methods:
 - **System dynamics** (Jay Forrester '50s)
 - **Discrete event modeling** (G. Gordon '60s)
 - **Agent-based modeling**
- Easy to choose and adjust the abstraction level:
 - From tool to factory
- Modern and flexible software platform

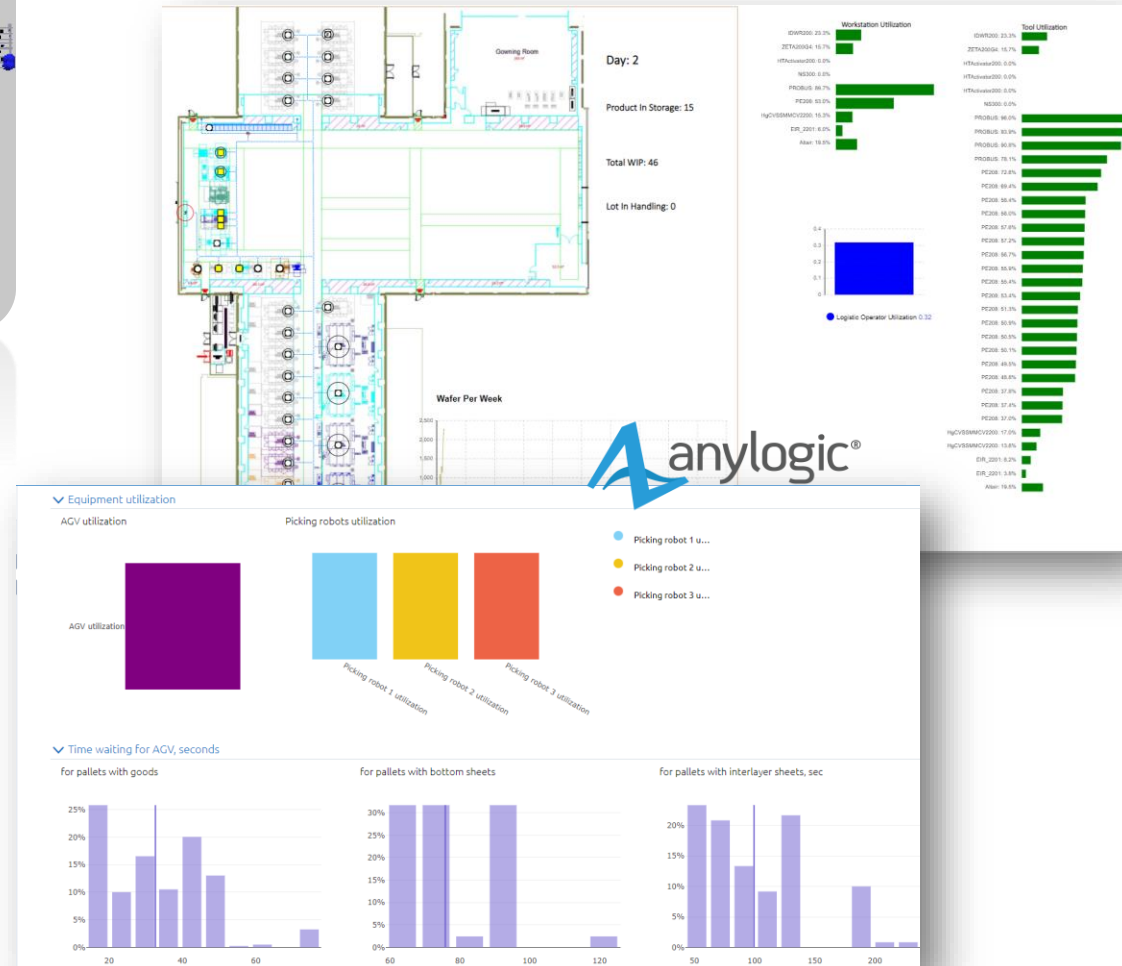
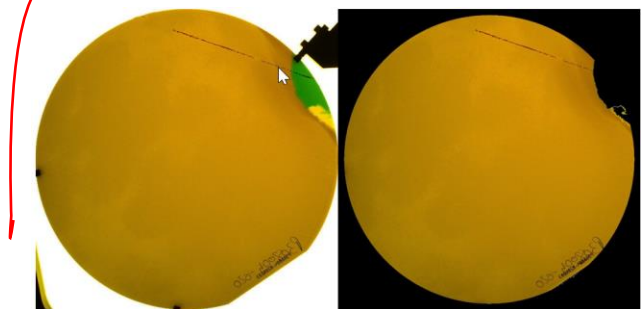


Image polytype recognition

2024 Substrate scraps reason

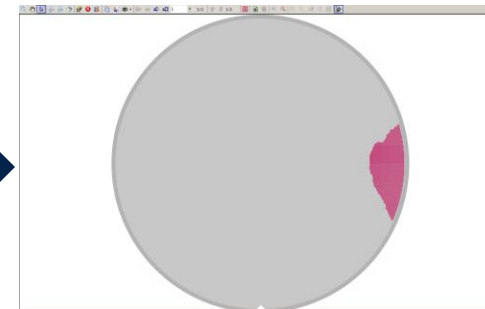
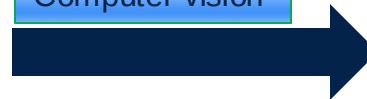


Computer vision algorithm to automatize defects in the flow



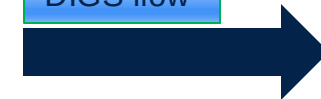
Kocos image

Computer vision



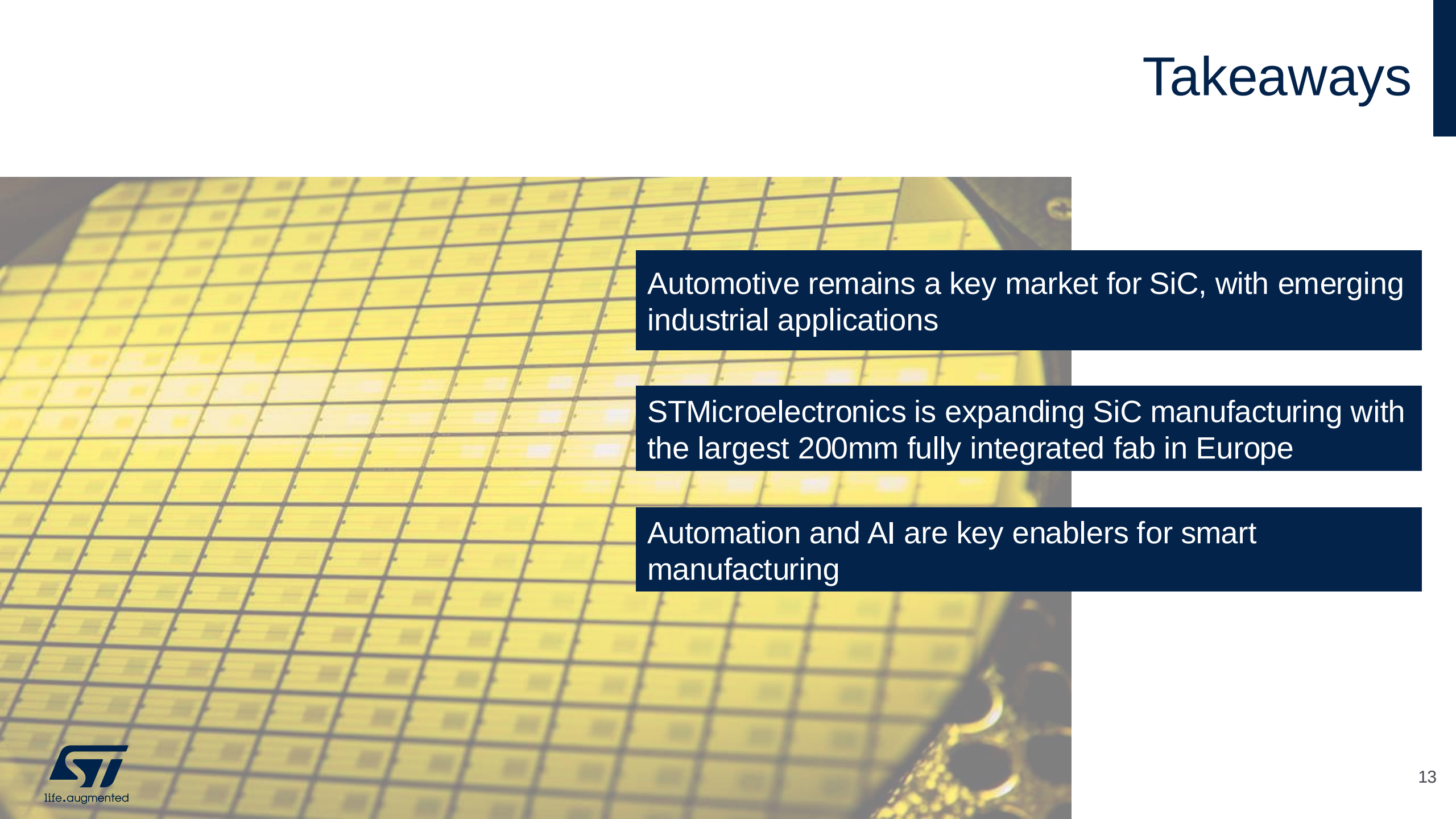
Klarf file

DIGS flow



DIGS Database

Takeaways



Automotive remains a key market for SiC, with emerging industrial applications

STMicroelectronics is expanding SiC manufacturing with the largest 200mm fully integrated fab in Europe

Automation and AI are key enablers for smart manufacturing

Our technology starts with You



Find out more at <http://www.st.com/stpower>

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