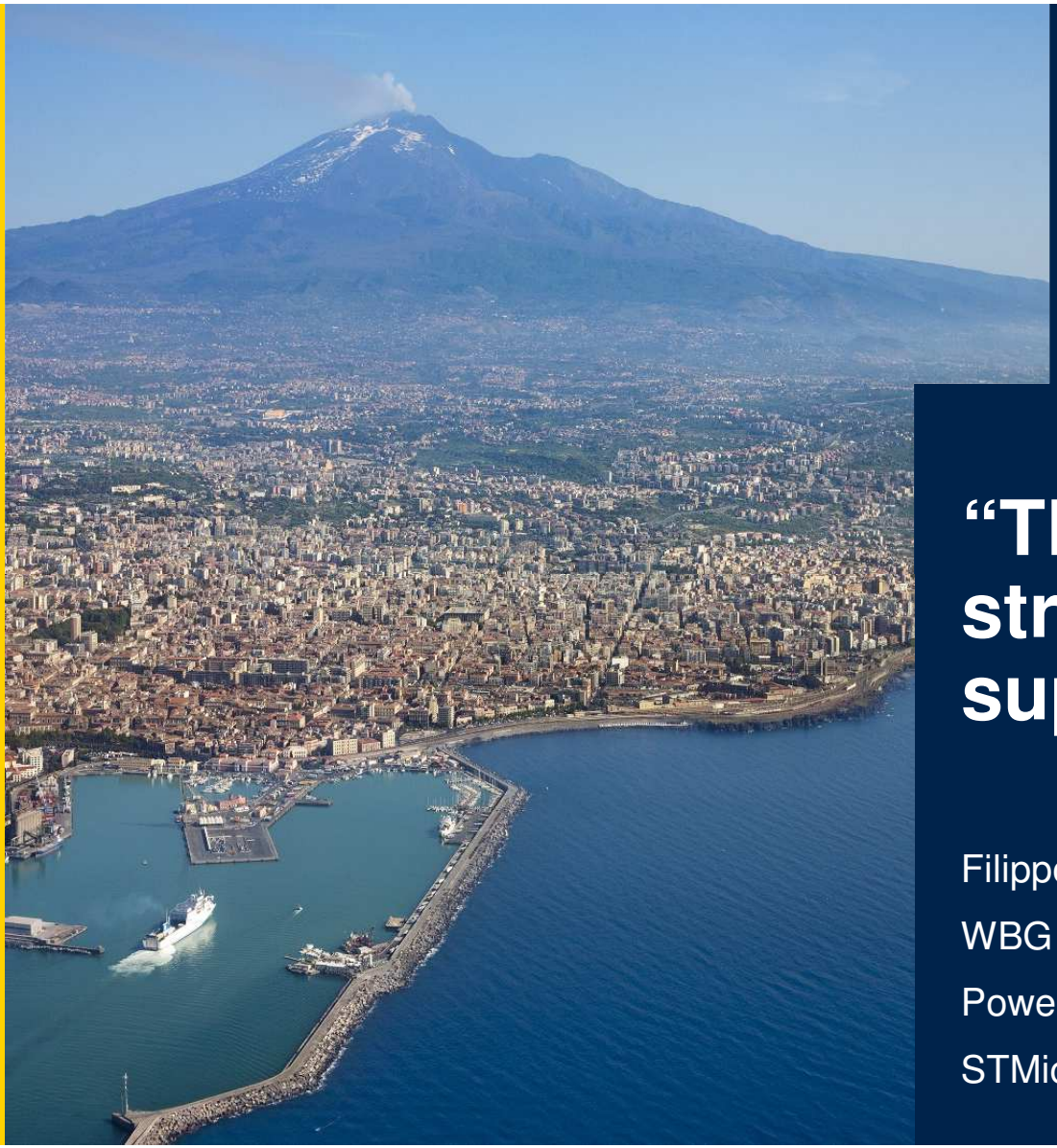

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“TRANSFORM” project strengthens Europe’s SiC supply chain

Filippo Di Giovanni

WBG Strategic Marketing

Power Transistor Macro-Division General Manager

STMicroelectronics

STPOWER

Ambition of TRANSFORM

Trusted European SiC Value Chain for a greener Economy

Horizon 2020 Call: H2020-ECSEL-2020-1-IA-two-stage (H2020-ECSEL-2020-1-IA-two-stage) Topic: ECSEL-2020-1-IA Type of action: ECSEL-IA Proposal number: 101007237-2 Proposal acronym: TRANSFORM

"TRANSFORM will provide European downstream market players with a reliable source of these important electronic components and systems, based on an entirely European silicon carbide value chain, ranging from substrate wafers to energy converters…. will significantly strengthen the competitive position of European technology in the global market. The project TRANSFORM will strongly improve current SiC technologies beyond the state-of-the-art to serve the large emerging markets for electric power conversion in renewable energies, mobility and industry…"

ECSEL Joint Undertaking
Electronic Components and Systems for European Leadership

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Consortium structure and TRL

E-Power train

Smart bi-directional charger (link V2GSmart Grid)

		1	2	3	4	5	6	7	8	9
WP3	Smart Cut 150mm									
	Smart Cut 150->200mm scale-up									
	High-quality bulk									
	Substrate 150->200mm scale-up									
	Epitaxy 150 -> 200mm scale-up									
WP4	Trench MOS									
	Planar MOS									
	Copper backend									
WP5	Ultrasonic copper bonding									
	Copper sintering									
	Power modules									
	SiC specific gate driver									
	Robustness/Reliability (Tests + Modeling)									
WP6	Reversible AC charging									
	SiC traction inverter									
	Machinery for precision farming									
	Industrial power converter									
	High-voltage DC/DC power converter									

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Demonstration of the technology

BOSCH 1

Traction Inverter

- 800V
- 50kW/l
- 98,5% efficiency @10%Pnom

Valeo SIEMENS eAutomotive 2

On Board charger

- 800V batteries
- Bidirectionnal
- 22kW 1/3 phases
- 2kW/l

HPECOXA 3

Precision farming DCDC converter

- 700V
- 25-30kW
- For actuator supply in heavy tractors farming application

BRNO UNIVERSITY OF TECHNOLOGY 4

Industrial machine battery charger

- 20kW
- 96V batteries
- 3phase 400VAC
- Cloud connected

5

DCDC converter for PV string optimization

- 20kW
- 1500V input/output
- Multillevel converter

SiC component benefits and smartcut technology will be demonstrated through 5 different converters for 4 different application domains

TRANSFORM press release

> “The aim of the Transform project is to secure a leading role for Europe in new technologies based on silicon carbide,”

says Jens Fabrowsky, who holds the position of executive vice-president in the Bosch Automotive Electronics division.

https://www.bosch-presse.de/pressportal/de/en/from-wafers-to-power-electronic-applications-new-consortium-to-create-european-supply-chain-for-silicon-carbide-semiconductors-234624.html

From SiC wafers to hyperefficient power electronic applications

Power electronic applications are at the heart of numerous electronic systems. They control the switching processes in these systems and keep any power losses to a minimum. The power semiconductor devices in these applications ensure that they operate as efficiently as possible. Conventionally, the chips in these devices are made of ultra-pure silicon. In the future, however, this will increasingly be replaced by silicon carbide, which offers numerous advantages over pure silicon. For example, silicon carbide semiconductors display better electrical conductivity and enables higher switching frequencies while also ensuring that much less energy is dissipated in the form of heat. In addition, power electronic applications with SiC chips can be operated at much higher temperatures, with the result that a simpler cooling system is required, which also saves energy. And finally, silicon carbide has a higher electric field strength, meaning that components made of this material can be smaller in design while nonetheless delivering a higher power conversion efficiency. Compared with conventional silicon chips, experts believe this will result in an energy saving of as much as 30 percent, depending on where the components are used.

The objectives of Transform

The objective of the Transform project is to establish a resilient European supply chain for the production of power electronic applications based on innovative SiC power semiconductor devices. The demand for such technology is set to grow rapidly, especially with respect to energy-intensive applications such as electrical vehicle powertrains, EV charge spots, and power supply infrastructure. A forecast by the market research and consulting company Yole indicates that, between now and 2025, the SiC market as a whole will grow on average by 30 percent a year to over 2.5 billion dollars. The Transform project will therefore also cover the development of new SiC technology along with the requisite production processes and methods. In addition, it will endeavor to secure the availability of machinery and equipment for the production of this technology by European suppliers, ranging from wafers to finished power

ST pioneering Silicon Carbide
more than 25 years of R&D commitment

Catania: Power Electronics Competence Center

Ecosystem made of Academic, **Research Centers** and ST as a semiconductor leader, created a true "incubator"

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Consiglio Nazionale Ricerche

Everything started from **1" wafer**

More than **70 patents and 580 technical documents** on SiC

Leveraging on **CNR Facilities** at early stage

> 30 years experience in power semiconductor

ST major milestones

June 1996: Collaboration with Physics Dept.

April 1998: 1st contract on SiC with CNR-IMETEM

May 2002: Schottky Diode Demonstrator (CNR line)

February 2003: ETC Epitaxial reactor prototype installed in ST

May 2004: Schottky Diode Demonstrator (ST)

October 2007: 1st Gen **DIODE Start Production**

March 2009: Power MOSFET 3" Demonstrator

May 2012: 2nd Gen **DIODE Start Production**

June 2014: 3rd Gen **DIODE Start Production**

September 2014: 1st Gen **MOSFET Start Production**

June 2017: 2nd **Gen MOSFET Start Production**

Jan 2020: First ST 6"substrate (*)

Dec 2019 Vertical integrated

Dec 2020: 3nd **Gen MOSFET Qualification**

July 2021: First ST 8"substrate (**)

1996 — 2003: 2" ST line — 2006: 3" ST line — 2011: 4" ST line — 2016: 6" ST line — 2021

(*) start production (**) prototype

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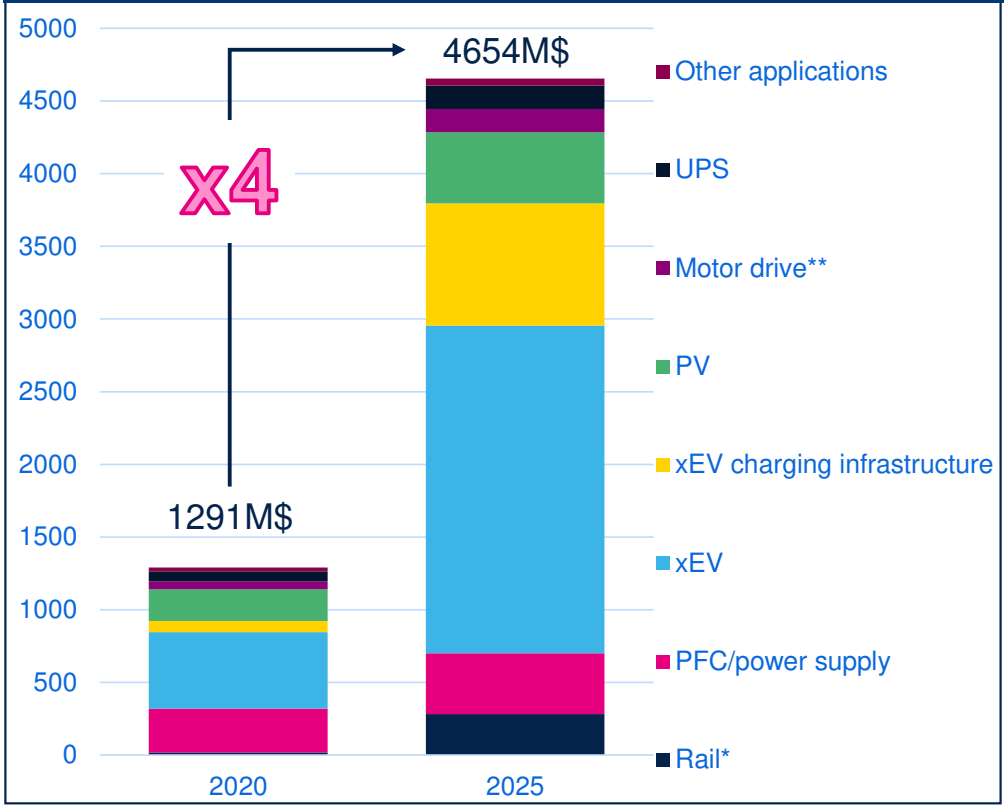
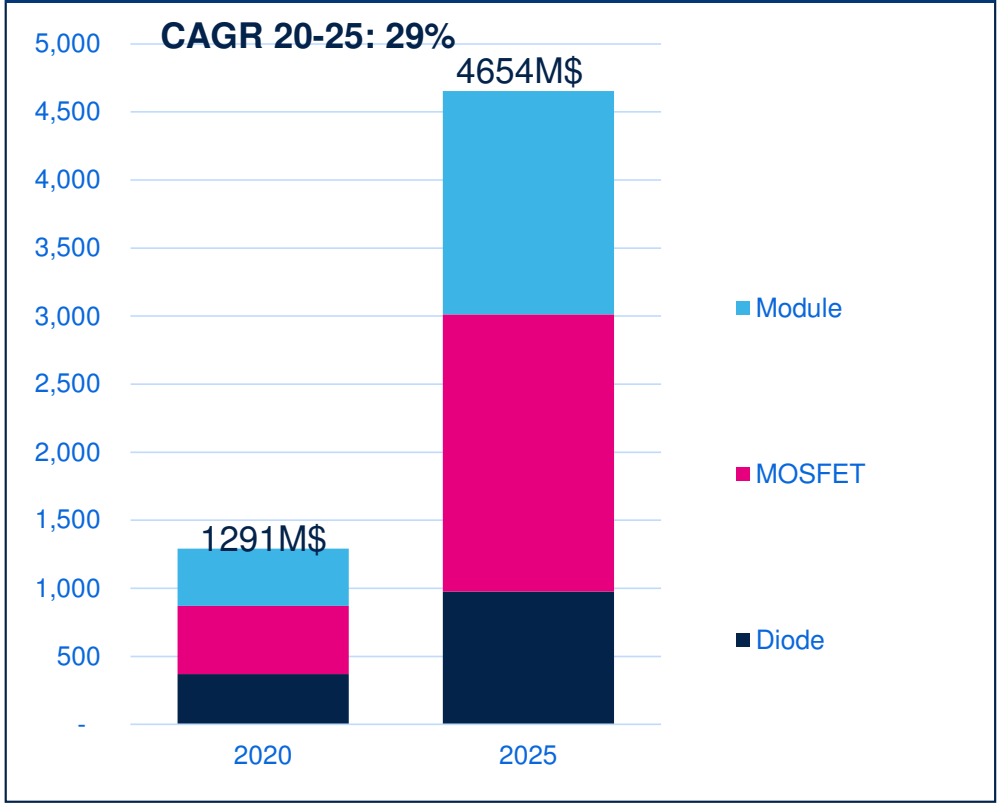
Silicon Carbide market outlook

SiC by major applications



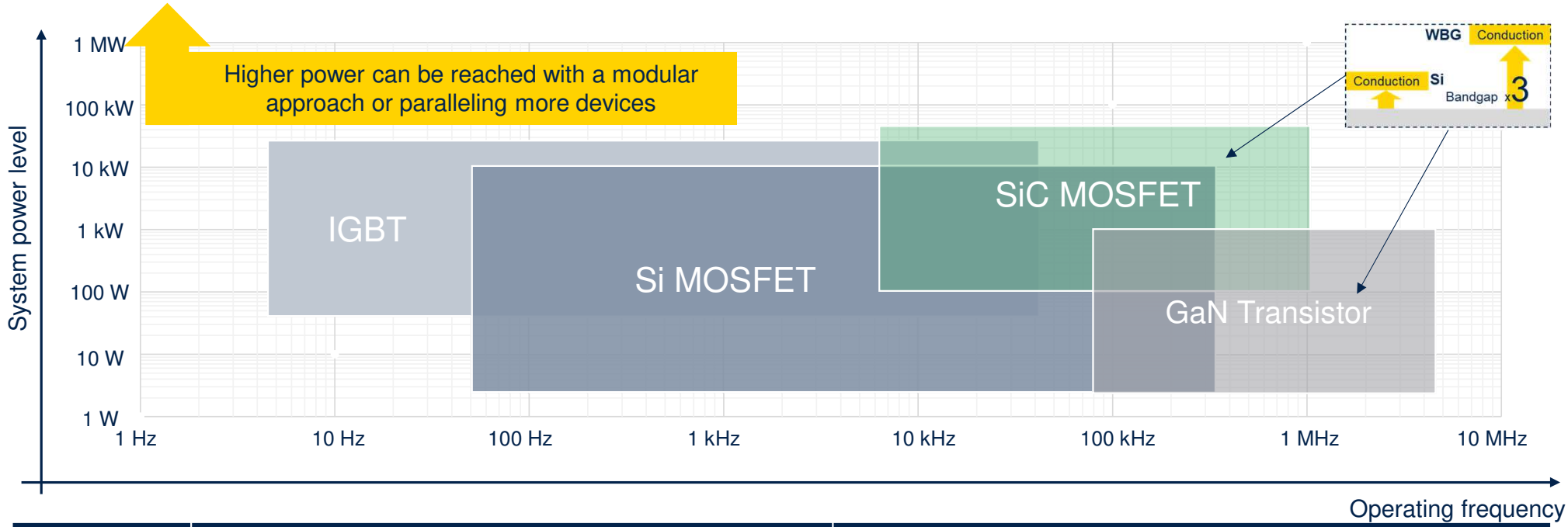
SiC by products



Other applications = Others, Wind, Oil and Gas, Military, Medical, R&D
* including auxiliary power
** including air conditioning

Source: Power SiC Market July 2019 Report (2025 projected by CAGR) – YOLE

Si and Wide Band Gap technologies mapping



Technology	Features	Applications
SiC MOSFET	**Very high power, high voltage, high frequency, high temperature ratings**	**High power DC/DC, UPS, charging stations, main traction inverters, OBC**, etc.

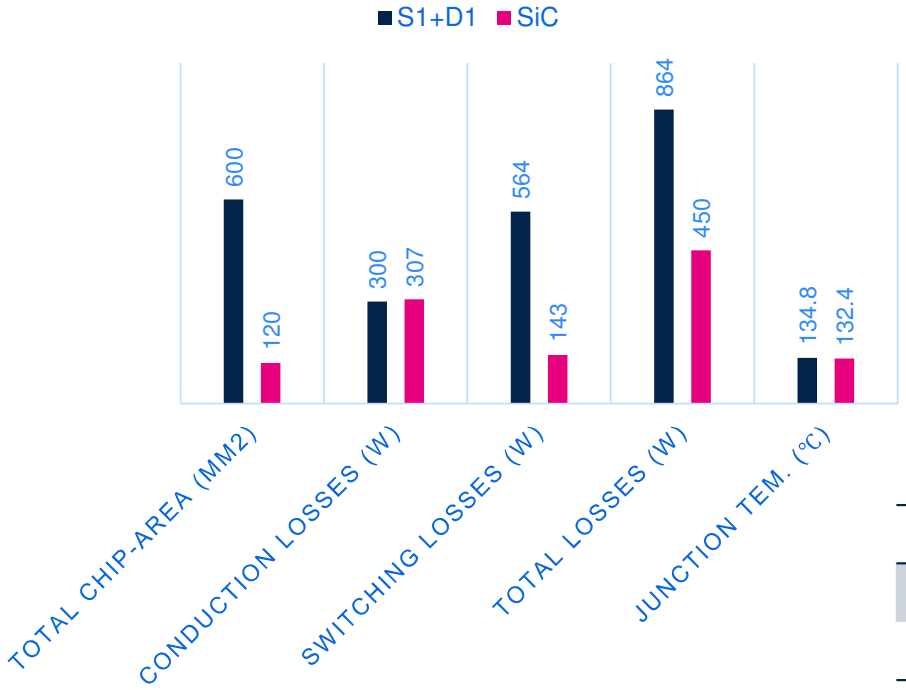
Mobility e-revolution

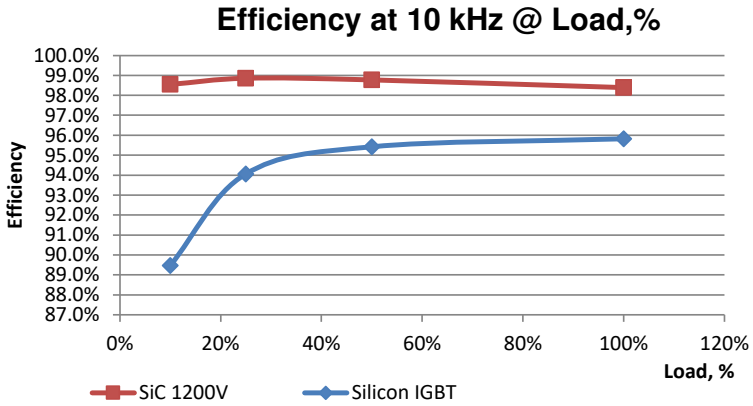
weight: ~ 100 - 250kg
working temperature up to 250 °C
efficiency ~ 30 - 45%
CO_2 emission > 100g/km

weight: 75kg
working temperature 65 °C
efficiency > 90%
CO_2 emission = 0 g/km

SiC advantages in a EV's inverter

1200V SiC MOSFET vs. IGBT: 210 kW traction inverter @ 10 kHz





Mission profile of a typical EV traction inverter

Modes	City	Highway	Top speed	Accelerating	Regeneration
Percentage of time	45%	40%	10%	5%	Braking
Load	10%	20%	7%	100%	30%

Typical power losses per switch at peak power: 350 A_{rms}

Our technology starts with You

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

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