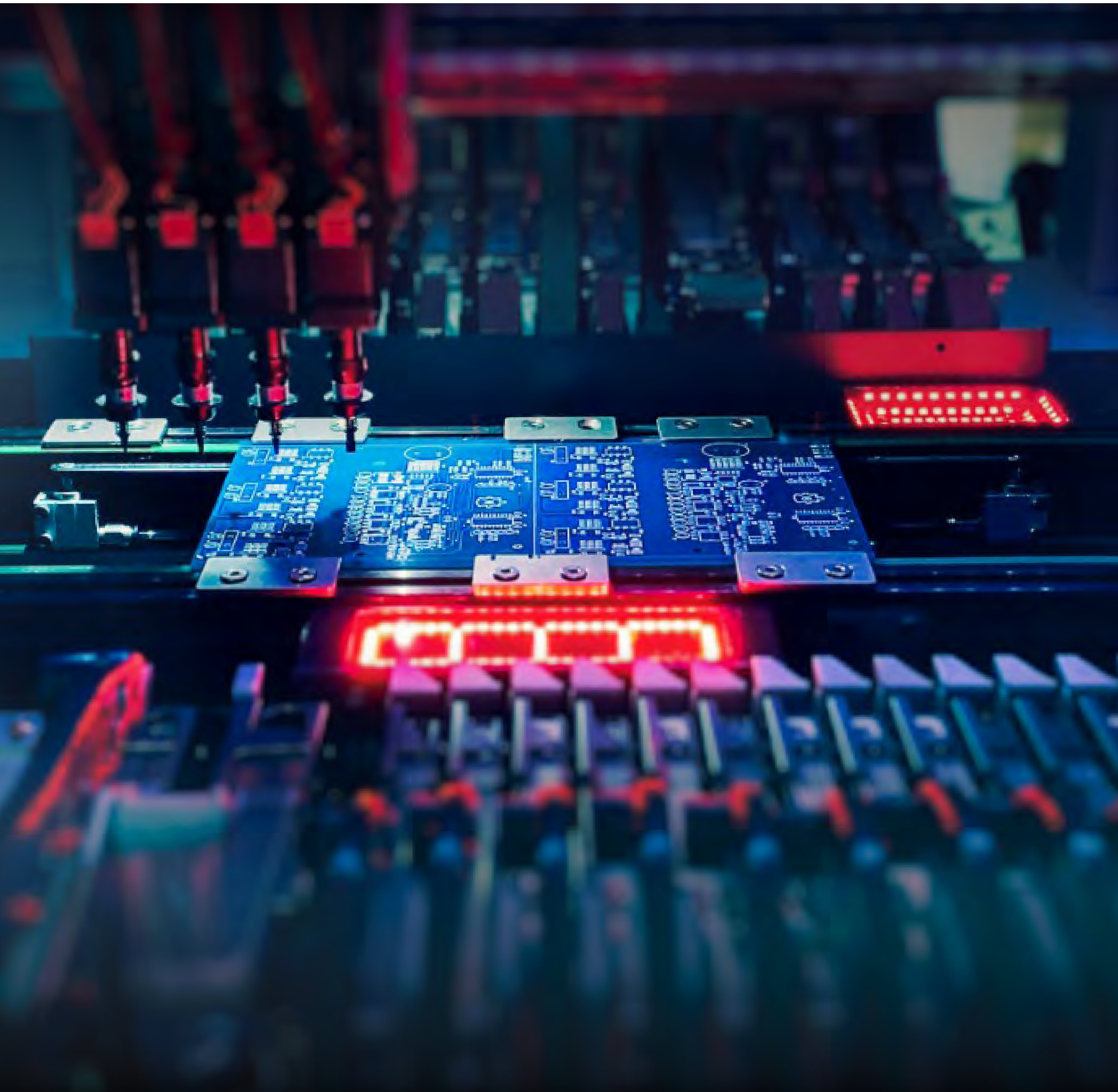
# 3 CHALLENGES SEMICONDUCTORS WILL FACE IN THE NEXT DECADE



## EDITO

All industry sectors are currently undergoing digital and ecological transitions. Both increase the demand for ever more efficient electronic components. And in some key industries, innovative manufacturers are turning to a new technology: silicon carbide, or SiC.

Silicon carbide is a better solution for the specific needs of power electronics, particularly when it comes to electric vehicles. While Tesla may have paved the way, other manufacturers are already catching on to this development.

- What role does SiC play in mainstream electric vehicles, both now and in the future?
- What are its technical strengths and key applications in power electronics?
- How can we build a SiC industry capable of supporting this evolution?

Here, our experts decipher the 3 key challenges facing SiC.

## Electric Vehicles: welcome to the SiC Era

At the heart of ecological and energy transition, electromobility is rapidly becoming a daily essential. But in order to be able to appeal to all users, the electric vehicle must find a way to increase its range and reduce its charging time and cost... In this sustainable revolution, SiC is becoming a strategic tool.

### • Electromobility, a lasting trend

**+ 140%: this represents the increase in electric vehicle global sales** (including plug-in hybrids) **in the first half of 2021, compared to 2019+**. Latest studies shows electric passenger vehicle sales should have jumped by more than 80% in 2021 and reach 5.6 million units. Sales will be mainly made in China (with a fleet now reaching 5.5 million vehicles in circulation), in Europe (4.1 million) and in the United States (2 million).

### • The autonomy issue

This success can be explained by **ecological issues, rising fuel prices and bold political decisions** – such as **the planned end of combustion engine vehicles in Europe by 2035+.**

However, despite considerable progress in recent years, the range of electric vehicles remains a major concern for car manufcaturers, while the network of charging stations remains somewhat lacking.

### • SiC: innovation at the service of electromobility

As manufacturers continue their efforts, particularly to improve autonomy and performance, **SiC semiconductors are emerging as a solution to their technical needs.**

By replacing traditional silicon (Si) with silicon carbide (SiC), manufacturers of power electronics modules **improve the overall energy efficiency of the vehicle and reduce the overall dimensions:** these are key advantages, which make it possible to optimise the design and operation of the electric vehicle battery and reduce the module footprint. We are witnessing **a gradual transition of electric vehicles from Si to SiC amongst manufacturers.** If SiC components are currently more expensive than the traditional solutions in Si, the benefits of the use of SiC and the gain on performance and design are rapidly overtaken.

With a battery of identical size and capacity, SiC allows a gain in autonomy of 10% to 15% compared to Si.

**To date, around thirty countries (including India, Sweden, the United Kingdom, Israel) have committed to banning new thermal vehicles by 2040. And while some other countries have not yet committed (including China, the United States, even if some of these+ have set a deadline for «zero emissions» ...), manufacturers are increasingly likely to start supporting the «all electric" movement. This will be the case for Jaguar from 2025, for Alfa Romeo from 2027, for Opel from 2028, and for Bentley, Mini and Volvo from 2030...**

## SiC innovation: a driving force in energy transition

Nowadays, silicon, for which the production methods and use are perfectly mastered, is the main material used for producing semiconductors. However, these «classic» semiconductors are slowing down the development of innovative technologies, due to their limited switching speed and energy efficiency. By removing these obstacles, silicon carbide (SiC) opens up new perspectives, and fulfill new needs driven by societal changes.

### • SiC, a major evolution in electronic components

SiC has been around for a long time, but its production is complex. Si, a well-mastered and relatively easy-to-access technology, consequently dominated all electronics sectors.

Today, with a better-controlled manufacturing process – accompanied by the materials and components offered by Mersen (isostatic graphite, high performance carbon insulation) – it is possible to produce high-quality SiC with less waste ... and therefore benefit from all the advantages of SiC which, compared to Si, has many benefits:

- Compared to silicon, SiC can withstand higher operating voltages and currents. The design of power electronics circuits is simplified, and opens new potential applications where Si capacity was the limiting factor.

- SiC has better thermal conductivity and temperature resistance, which facilitates and reduces its cooling requirements. By reducing the use of heat sinks or coolant, SiC alleviates design constraints for embedded systems. As a result, **this equipment is more compact+** and lighter.

- SiC **has a higher switching frequency**, an essential characteristic for electric vehicle power converters,

- Thanks to a lower electrical resistance, and therefore less heat losses, SiC has an improved energy effeiciency with less cooling requirements

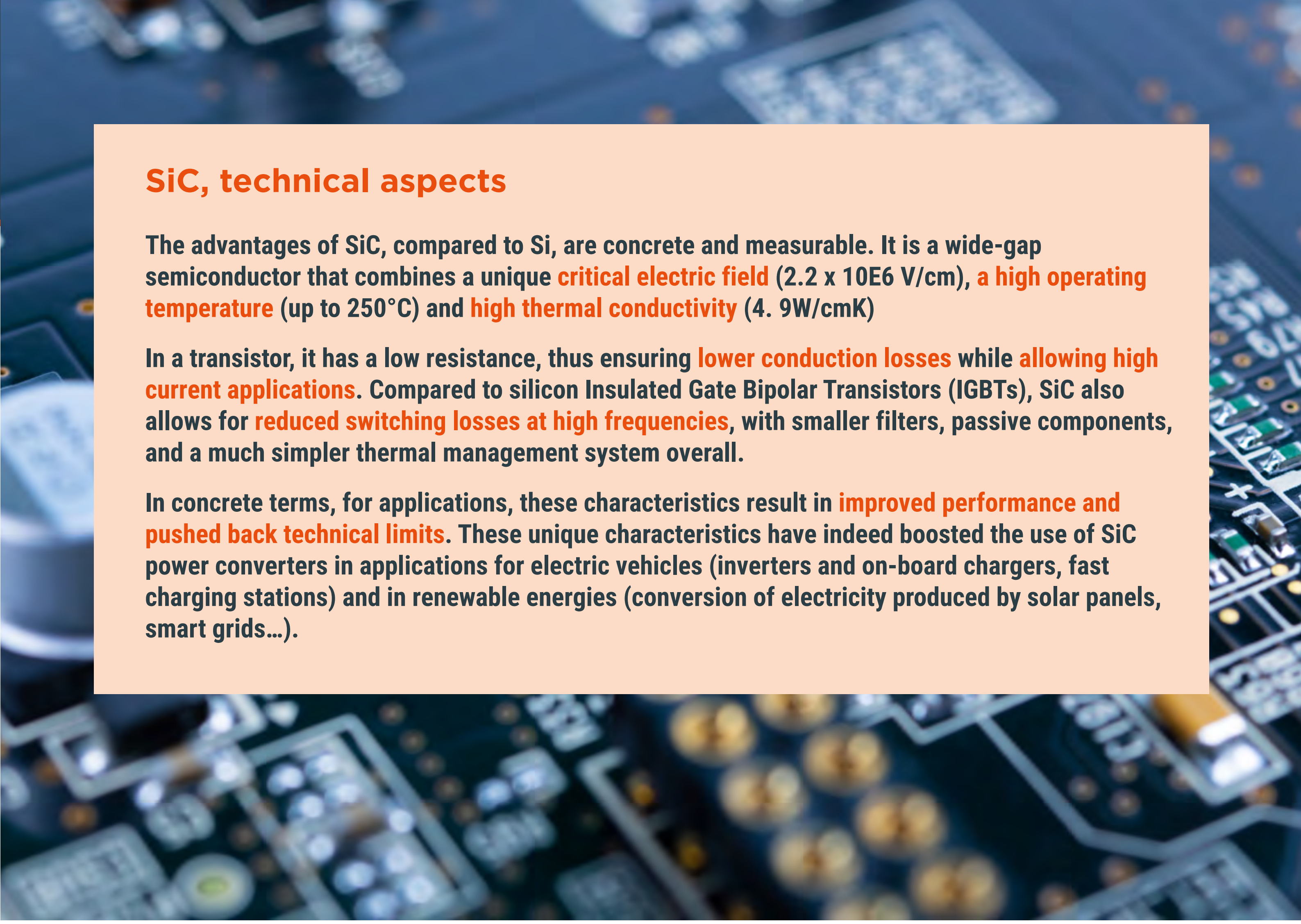
### • New improvements in sight…

SiC benefits from significant R&D efforts, which aim to further improve its production. In recent years, manufacturers have seen:

- **improved manufacturing processes**: the number of defects has been reduced from 12,000 per cm2 10 years ago to less than 1 per cm2 today!

- **increased yield and reduced production costs** due to an increased size of SiC wafers – the first measured 2 inches size, they are now 6 inches and, thanks to better manufacturing methods, should soon measure 8 inches.

- **increase the lifetime of SiC components.**



## SiC, technical aspects

**The advantages of SiC, compared to Si, are concrete and measurable. It is a wide-gap semiconductor that combines a unique critical electric field (2.2 x 10E6 V/cm), a high operating temperature (up to 250°C) and high thermal conductivity (4. 9W/cmK)**

**In a transistor, it has a low resistance, thus ensuring lower conduction losses while allowing high current applications. Compared to silicon Insulated Gate Bipolar Transistors (IGBTs), SiC also allows for reduced switching losses at high frequencies, with smaller filters, passive components, and a much simpler thermal management system overall.**

**In concrete terms, for applications, these characteristics result in improved performance and pushed back technical limits. These unique characteristics have indeed boosted the use of SiC power converters in applications for electric vehicles (inverters and on-board chargers, fast charging stations) and in renewable energies (conversion of electricity produced by solar panels, smart grids…).**

### • Key SiC markets

SiC markets thus correspond to fast-growing sectors and provide a real solution to important societal challenges:

- renewable energies such as solar power and wind energy,
- supplying industrial equipment and data centres,
- electromobility such as electric vehicles and trains.

According to IDTechEx, SiC MOSFET (Metal Oxide Semiconductor Field Effect Transistor) inverters powered nearly **30% of the global electric vehicle market in 2020+**. A trend largely driven by the success of Tesla, fowlloed today by other manufacturers. The arrival of **800 V high-voltage charging stations** (at Porsche, Audi, Hyundai, Renault, etc.) **promotes the adoption of SiC power devices+**.

### • How strong is the growth of SiC?

**According to Industry Arc+**, the **SiC power semiconductor market** will be worth $2.6 billion in 2026. This represents a growth of 27.1% from 2021 to 2026.

In its report, the research firm highlights the **«increasing number of modern applications requiring SiC power»**, and the usefulness of SiC “for use in the electric vehicle industry», which is also used in research (in optoelectronics, and in high-power, high-temperature and high-frequency power supply devices).

Other studies predict even stronger growth: according to Fortune Business Insights, the global market for SiC-based power electronics and inverters could show **a growth rate of up to 36.4% between 2021 and 2028+**.

## Securing the SiC supply chain: How to succeed?

For several months, a shortage of electronic chips has negatively impacted many manufacturers. A problem specific to Si components which nevertheless provides some answers in terms of how to structure the SiC sector and assess the reliability of a supplier.

### • Why is there a shortage of electronic components?

The global **health crisis** has disrupted the semiconductor market. On the one hand, demand was increasing (due to the demand for computers for remote working, in addition to the growing number of uses for the Internet of Things, the digital transition, etc.).

On the other hand, **manufacturers were held back** by the lockdowns and, as a result, production struggled, and the **supply chains were disorganised**... A phenomenon aggravated by an **extreme market concentration**: Eighty percent of semiconductor production is now located in Asia, and in particular in Taiwan.

### • Ripple effects

This shortage has impacted many sectors, from consumer electronics to the automotive industry. The shortfall in the automotive industry, linked to the shortage of electronic chips, **should have reach 210 billion dollars in 2021, studies shows+**.

This situation has highlighted the fragility of strategic sourcing for many companies. A gap specific to Si components: while the demand for SiC components may be witnessing a strong surge, this development is known and anticipated, and the SiC sector has not suffered from the risks associated with the Covid pandemic.

### • An industrial and political challenge

However, it is essential to build a robust semiconductor industry, both for Si and SiC. States as well as the whole industry are working on it: stakeholders are working towards securing and diversifying supplies, multiplying production zones and reinforcing production capacities.

### • How to choose a reliable partner?

The shortage also highlights **new criteria for selecting suppliers**: beyond product quality, innovation, and production capacity, it is important to look at their supply policy, production localisation... In short, **their ability to secure their activity and to honour orders and deliveries!**

Fully aware of the challenges ahead, Mersen is acting on all fronts to support the growth of electric vehicles – and therefore of SiC semiconductors. Mersen does this by:

- structuring their international supply chain,
- maintaining their high standards in the production quality of its materials,
- developing new product lines,
- pursuing the IATF 16949 certification process for their sites…

**In addition, Mersen has joined the Transform initiative+**, led by Bosch at European level, aimed at advancing SiC technologies and building a complete and competitive value chain in Europe. An international project supported by the European Union, which brings together industrials and academic stakeholders.

Read more :

- Silicium vs SIC: what's next for industrial engineering?
- How & why is SiC transforming the semiconductor industry?
- Will SiC be the game changer in the electric vehicle industry?

MERSEN
Expertise, our source of energy

MERSEN IS A GLOBAL EXPERT
IN ELECTRICAL SPECIALITIES
& GRAPHITE BASE MATERIALS

**Contact us**
semicon@mersen.com

www.mersen.com