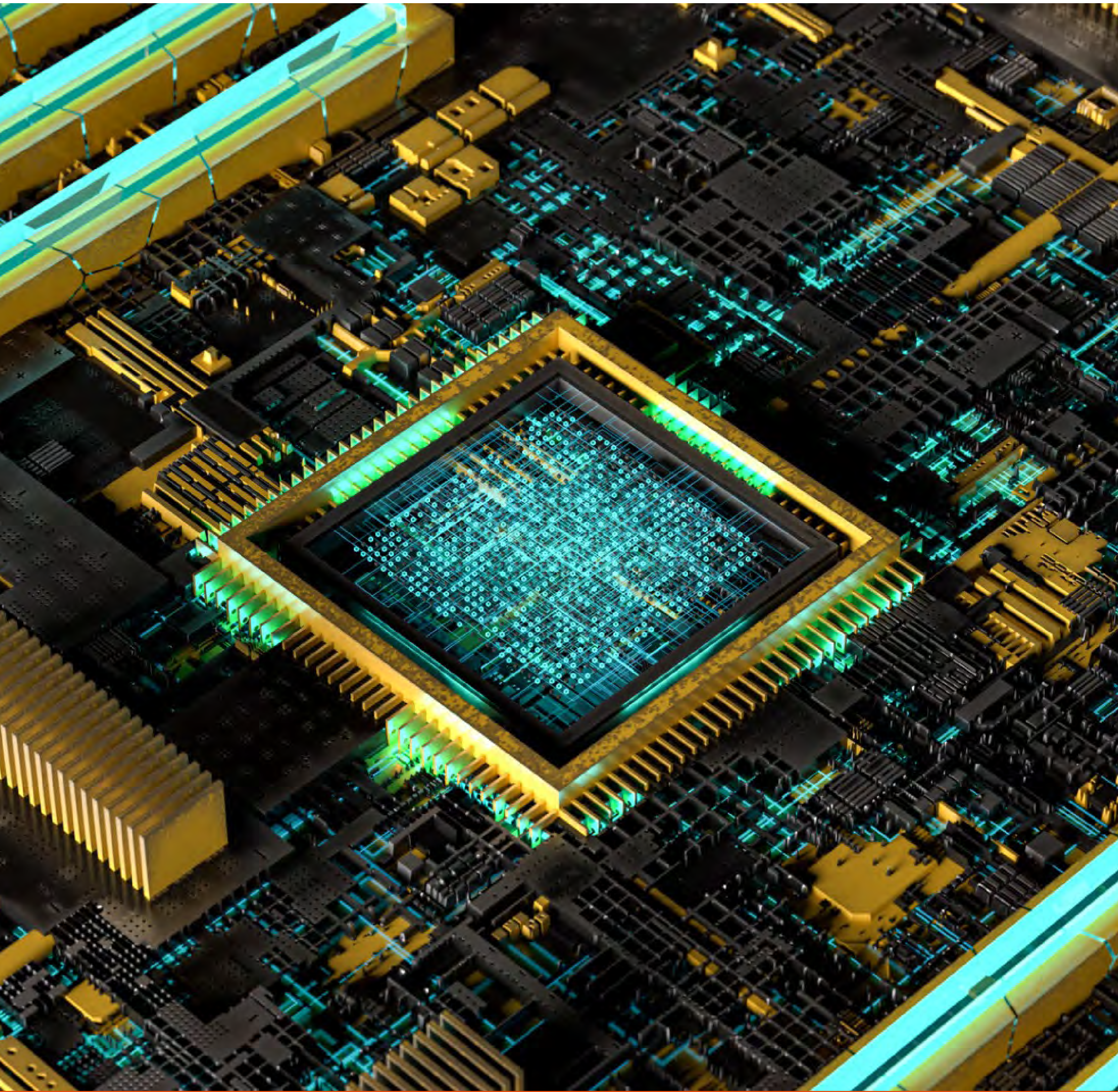
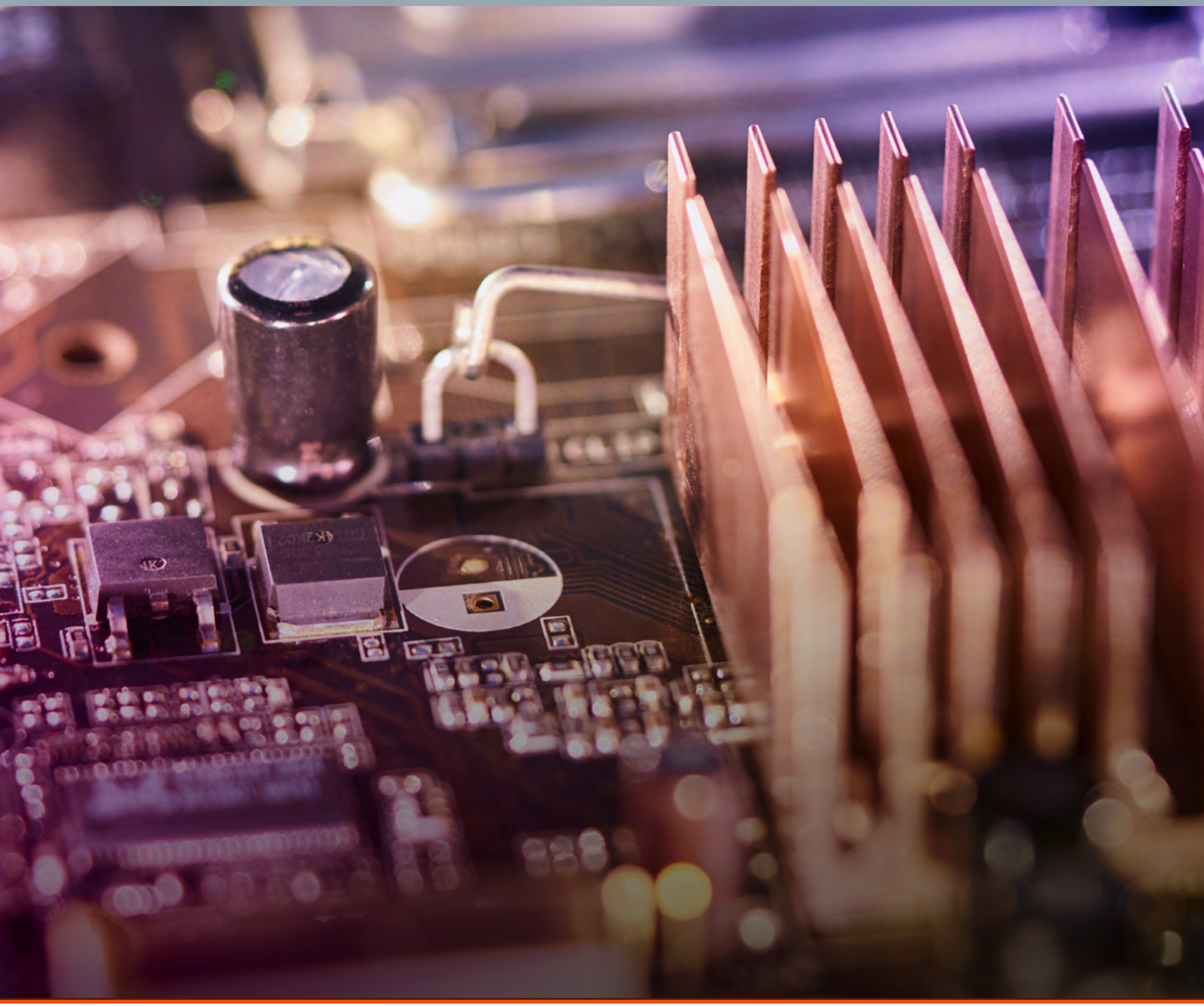
SILICIUM VS SIC:

WHAT'S TO COME FOR INDUSTRIAL ENGINEERING?



EDITO

Silicon Carbide (SiC) has been entering the power electronics market for a few years now, where it competes with silicon thanks to its better performances. Its characteristics make it a semiconductor that is much better suited to power electronics applications, particularly for innovative markets that address major societal challenges: renewable energies, electromobility, telecoms, etc.



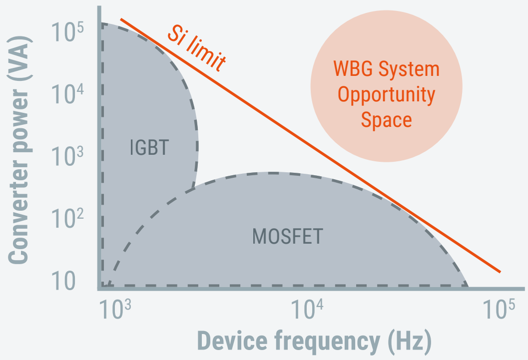
Ideal characteristics for power electronics

Properties that make the difference…

Silicon has gradually become the key semiconductor in all electronic applications. But in the face of the new challenges presented by electromobility and renewable energies, silicon is showing its limits:

- **MOSFET transistors** can work at high frequencies (useful in AC applications) but are limited to voltages up to of 600 V;
- **IGBT transistors** can exceed this limit but at the cost of large losses as the switching frequency increases;
- the switching time and resistance of silicon increase with temperature, which requires cooling to maintain its performance... Wide band gap semiconductors such as Silicon Carbide (SiC) seem to be the ideal solution.

- SiC has a **breakdown voltage 10 times higher than that of silicon alone**: this makes it possible to manufacture MOSFET transistors operating at much higher voltages, while reducing their size.
- Thanks to a lower resistivity, which is less dependent on temperature, SiC will be **more efficient at conducting current**, even at higher temperatures.
- The **thermal conductivity** of SiC is 3 times that of silicon, making it more efficient to cool.



Properties	Si	4H-SiC
Energy Gap: E_G (eV)	1.12	3.26
Breakdown Field: E_B (V/cm) X10^6	0.3	3
Thermal Conductivity (W/cm°C)	1.5	4.9

… for demanding applications

Nowadays, the needs in power electronics are growing, and are accompanied by a demand for increased performance for many applications:

- In **new energies**, with decentralized production and current conversion needs (solar, wind, energy storage, smart grids...);
- For **electric vehicles** and their charging stations, which require high power, efficient, and compact devices;
- In **data centers** where power supply and cooling are critical;
- For **telecommunication infrastructures**, which require powerful high-frequency antennas.

The development of these technologies is largely dependent on the democratization of SiC semiconductors.

A rapid development to support innovative applications

A complex manufacturing process…

Even tough SiC was well known, it was rarely used until now, as its production remains a challenge for manufacturers. Different silicon manufacturing processes exist and are well mastered. **Monocrystalline** silicon is generally obtained by growing crystal from molten silicon at 1500°C.

But SiC (like gallium nitride (GaN), another wide band gap semiconductor) is obtained by **sublimation of pure materials**. This requires mastering temperature gradients around 2400°C. This process, more complex, had not benefited from the same massive investments as silicon, as long as the latter met the needs of industry.

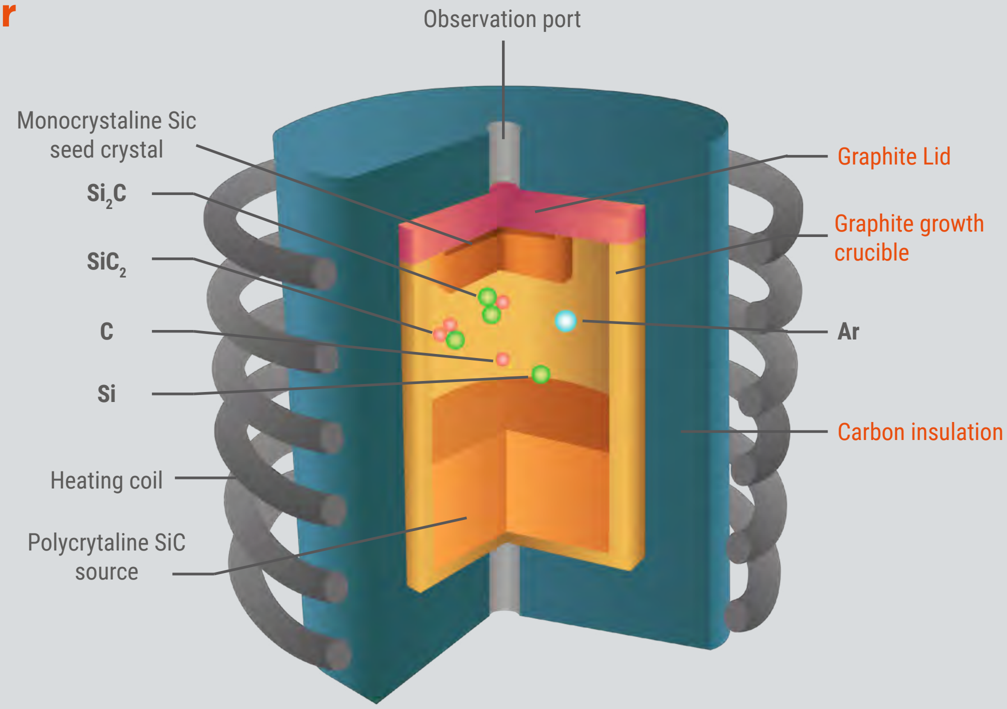
…with better control

However, given the irreplaceable properties of wide band gap semiconductors, investments are now multiplying to take advantage of a promising market. As a result, the size of SiC wafers has increased from 1 inch in the early 1990s to soon 8 inches. That is to say a surface multiplied by 60. In the meantime, the quality of these wafers increased and the level of impurity has decreased. With both an increasing production yield and quality, the costs of SiC gradually decreased.

Annual sales of SiC power semiconductors are expected to grow by an average of 38% per year, and reach $ 3.39 billions by 2025[1].

Mersen, the SiC partner

Mersen supports manufacturers in the production of silicon carbide by offering them insulation and graphite products adapted to their needs. Mersen's insulators and graphite enable manufacturers to achieve and control temperature in production units. Thanks to the quality and stability of Mersen products, reliable and repeatable SiC manufacturing processes have been developed over the decades and have contributed to the democratization of SiC.



Simplified design, increased autonomy

Components are getting smaller

Power modules manufacturers are progressively integrating SiC components in their products. This choice brings them 2 main advantages during the design process:

- **SiC components require less cooling**, while maintaining stable efficiency as temperature rises. This means that the modules can do without space-consuming heat sinks and cooling systems
- **Other peripheral components can also be reduced**, due to the higher input frequencies SiC components can accept.

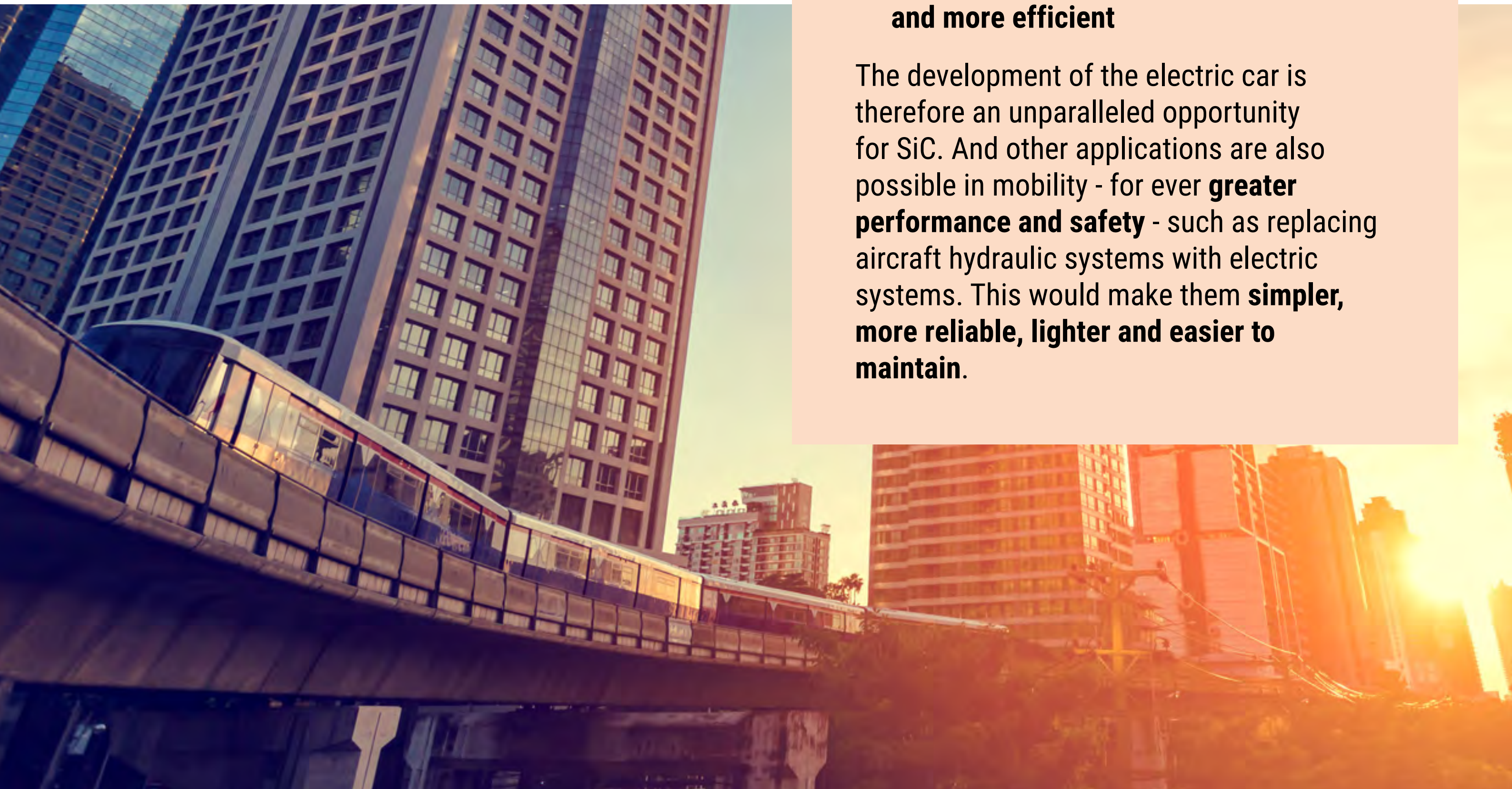
The dimensions of SiC-based circuits are therefore considerably more compact and lighter. The design constraints, especially in terms of routing placement, are therefore reduced. And if the price of SiC components remains higher, the gains in terms of performance, as well as the reduction of constraints, make the final products competitive.

SiC is a game-changer for electromobility

SiC is thus increasingly used in industrial applications to power energy-intensive systems, in renewable energies to condition the electricity produced, and soon in heat pumps... But SiC clearly makes a difference is in electric mobility:

- With lighter and smaller components, as well as reduced electrical losses, SiC allows the optimization of the size and usage of batteries. **This results in a 10 to 15% increase in range in current electric vehicles.**
- The reduction in the size of the components makes it **possible to integrate elements that could not be on board**, in particular high-power chargers that **reduce the charging time**.
- **Charging stations** also benefit from SiC: they will eventually **become smaller and more efficient**

The development of the electric car is therefore an unparalleled opportunity for SiC. And other applications are also possible in mobility - for ever **greater performance and safety** - such as replacing aircraft hydraulic systems with electric systems. This would make them **simpler, more reliable, lighter and easier to maintain**.



Read more :

- 3 challenges semiconductors will face in the next decade
- 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