MERSEN Boostec: SiC Material Obtained by Pressureless Sintering*

MERSEN Boostec SiC is a polycrystalline technical ceramic obtained by pressureless sintering resulting in a silicon carbide completely free of non-combined silicon. This paper gives a short description of the MERSEN Boostec company. Four of its main current commercial activities concerning laser processes, semiconductor and optomechanics OEMs as well as continuous flow reactors for the chemical industry are overviewed.

Fig. 1
Key numbers

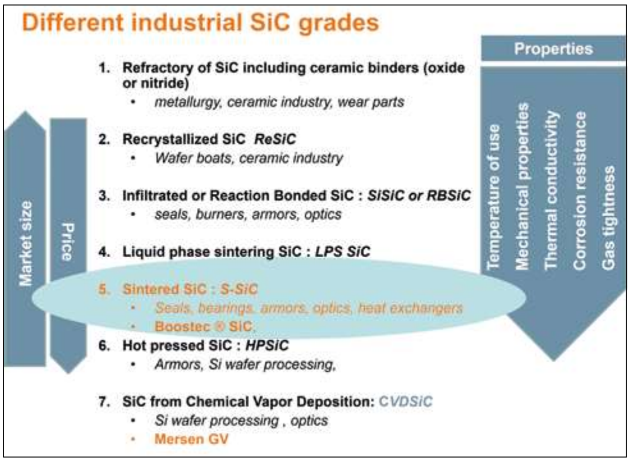

Fig. 2
Main SiC families

1 The company Mersen Boostec

MERSEN Boostec is located in south of France at Bazet and hold by Mersen (95,07 %) and Airbus Defense and Space (4,93 %). Its core business is to design, develop, manufacture and commercialise essentially complex and large SiC hardware for industrial and space applications (Fig. 1).

MERSEN Boostec started its SiC activity in the 90's with bears and seals for high corrosive chemistry and automotive applications. During this period, MERSEN Boostec developed and invested very large equipments to serve industrial applications which request multi-meter class SiC components. Its uses have been enlarged to other industrial sectors with the capacity to produce large and complex full SiC parts and assemblies until 3,5 m-class to offer new solutions for semiconductor and opto-mechanics OEMs.

Today, Boostec® SiC is recognised for its outstanding properties, specifically for harsh environments uses, since more than 30 years. That is the reason, why it is the only SiC material regularly used for space applications within more than 20 missions equipped with all SiC large and complex components (mirrors, structures and focal planes).

Keywords
silicon carbide, pressureless sintering, laser processes, semiconductor industries, optomechanics, continuous flow reactors

2 Boostec® SiC properties

Boostec® SiC is classified in the family of Sintered Silicon Carbide (SSiC) which exhibits full density with no free silicon allowing outstanding properties without weak link effect due to secondary phases.

It has to be distinguished from the other SiC families (Fig. 2) such refractory SiC, liquid phase SiC (LPS SiC), infiltrated SiC (Si–SiC) or reaction bonding SiC (RB–SiC) which typically contain more than 10 % of secondary phases (free silicon, oxide phases) which drastically impact and decrease chemical and physical properties.

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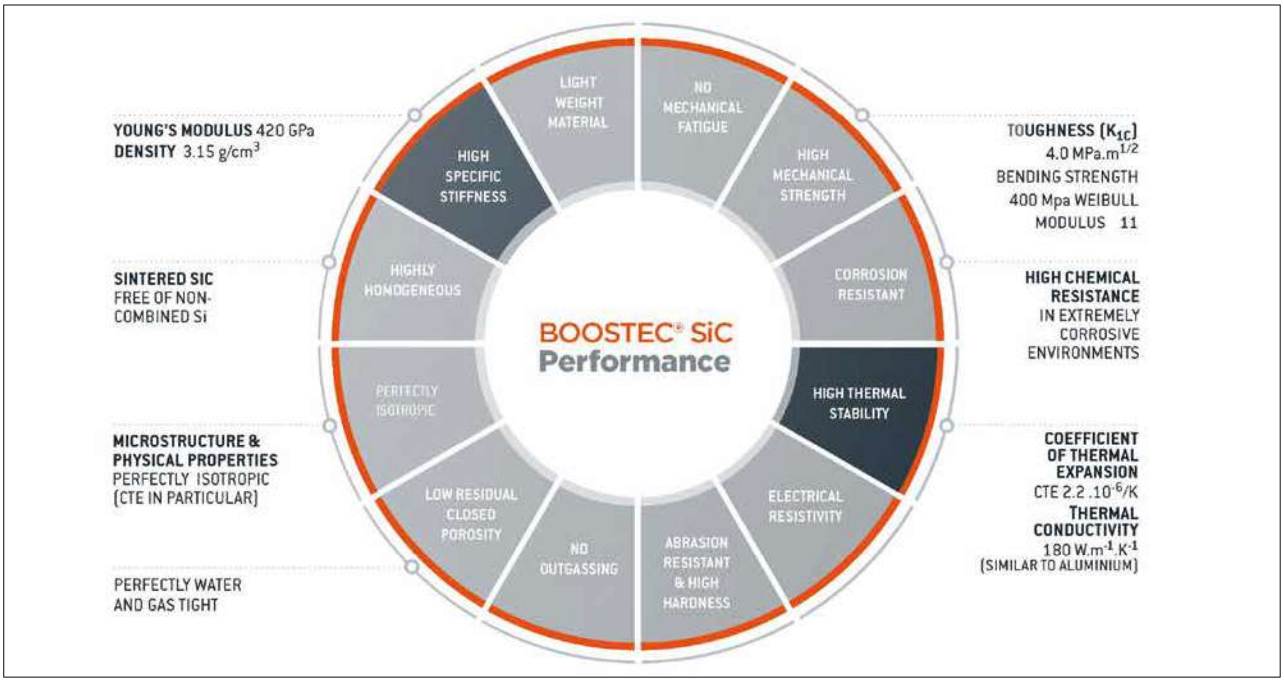

Fig. 3
Typical Boostec® SiC properties

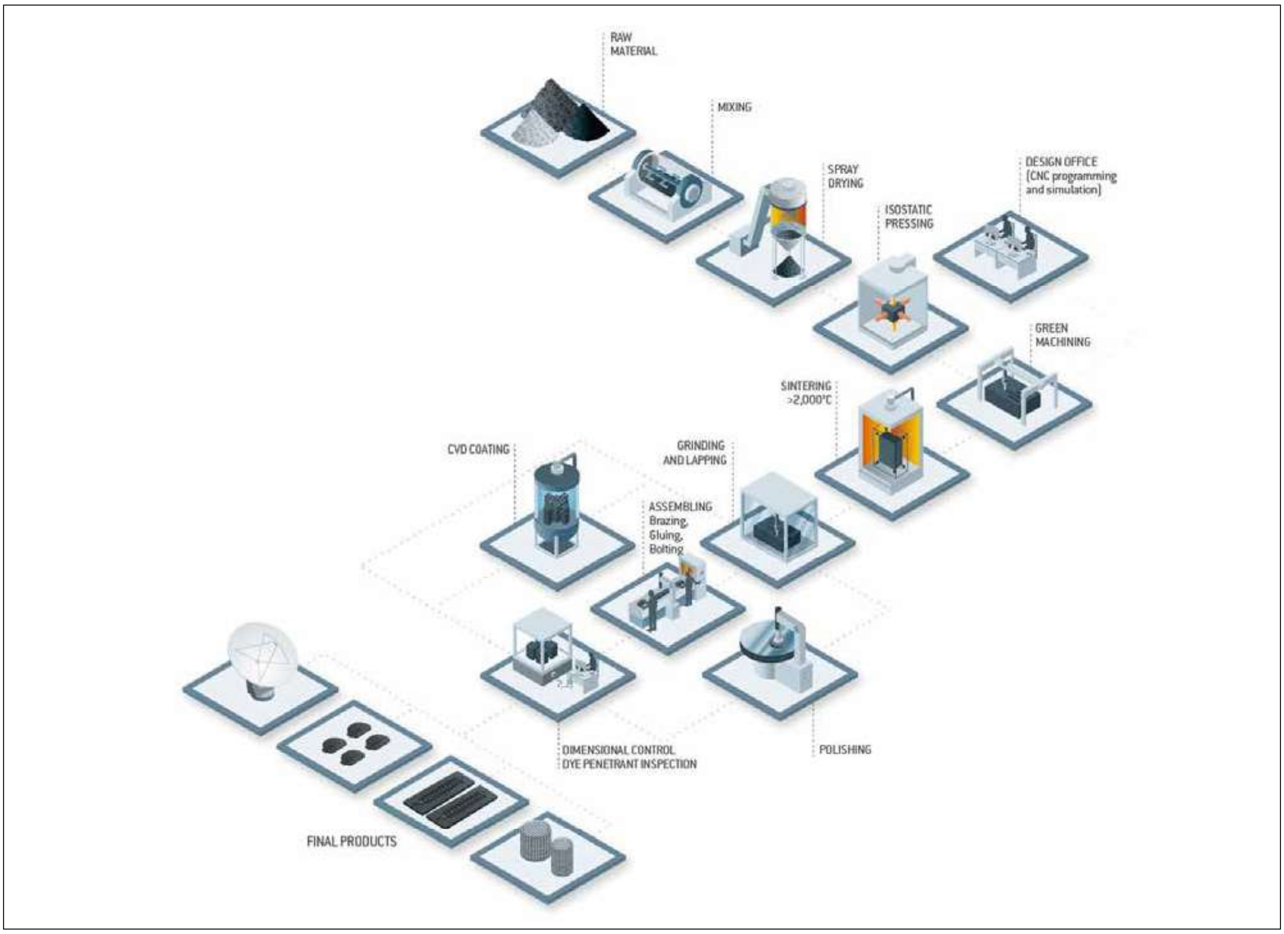

Fig. 4
Boostec® SiC manufacturing process

	CAPACITY
MONOLITHIC CERAMICS	Ø 1.30m x 0.60m 1.65m x 1.30m x0.60m
CVD SIC COATING	up to Ø 1.50 m
BRAZED SIC/SIC	up to Ø 3.50 m
OPTICAL POLISHING	
	AVAILABLE ASSEMBLIES
OTHER SiC/SiC OR SiC/METAL SOLUTIONS	Epoxy gluing Bolting Shrink fitting

Fig. 5
Boostec® SiC capacity up to 3,5 m by brazing technology

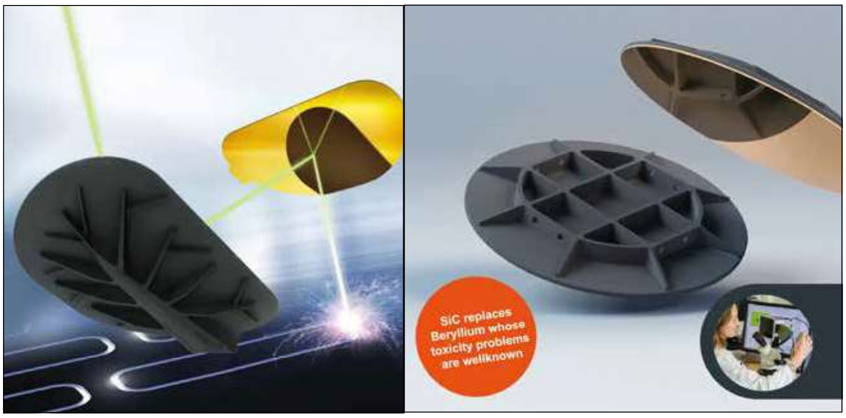

Fig. 6
SiC mirrors to guide laser beam

On the other hand, recrystallized SiC (ReSiC) is not suitable for high technical applications due to its porosity which strongly decreases mechanical properties.
Sintered SiC is widely used for long time for industrial cost effective and high-performance applications. The very strong covalent Si–C bond gives Boostec® SiC exceptional physical properties that are particularly reproducible and stable over time.
Unlike glasses, glass-ceramics and oxide ceramics, Boostec® SiC does not present a phenomenon of sub-critical cracking. Unlike toughened ceramics (silicon nitride, stabilised zirconia), Boostec® SiC shows no sensitivity to mechanical fatigue.
Boostec® SiC mechanical properties (bending strength, modulus of elasticity, toughness) hardly change with temperature, from cryogenic environments close to absolute zero (–273,15 °C) up to 1450 °C. Some order of magnitude of typical properties are given in Fig. 3. Boostec® SiC is a non-magnetic material and an excellent radio-frequency (RF) absorber.
Thanks to its very high mechanical strength, Boostec® SiC is used not only for making functional parts (mirrors, heat exchangers) but also for the thermomechanical structures of ultra high precision equipments for micro-electronic applications for example.

3 Boostec® SiC manufacturing process

MERSEN Boostec offers assistance to its customers for the design of their SiC parts to ensure better feasibility, mitigate risks and also reduce costs and lead times. The technology is based on isostatic pressing process from powder to grinding steps (Fig. 4).

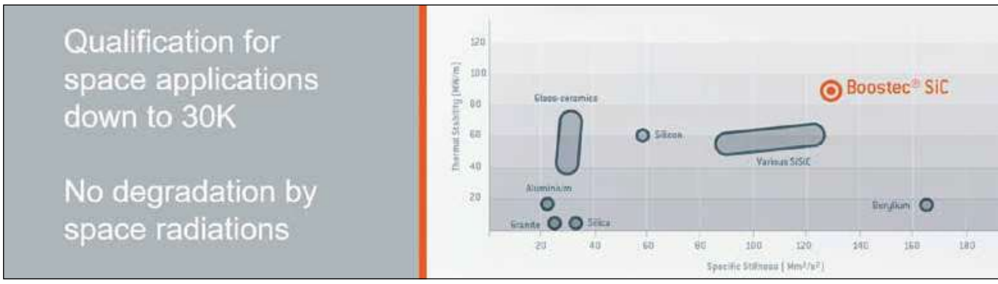

Fig. 7
Diagram of merit for typical materials used for optics

From the manufacturing of monolithic ceramics to the production of complex solutions, MERSEN Boostec has developed over the years a unique expertise which leads to complex and large SiC parts which can be assembled by brazing. Size limit is unique for this kind of material with 3,5 m by brazing technology (Fig. 5).

4 Boostec® SiC solutions

4.1 Laser processes

MERSEN Boostec provides standard and custom active mirrors from 500 mm apertures, with a range of high reflective coatings. In particular, standard generic XY laser galvo-scanning mirrors from 10–100 mm aperture are provided in pairs. Glued mounts are also proposed for all standard shaft sizes. These products are distributed under the trademark optoSiC®.SiC mirrors allow to guide laser beams for industrial applications (Fig. 6).
Thanks to its high stiffness, high thermal conductivity, low expansion and low volumetric mass, Boostec® SiC exhibits outstanding properties compare to its competitor materials (Fig. 8).

Laser for material processing
- Welding
- Cutting, Drilling
- Marking, Microlithography
- Additive manufacturing

Laser for instrumentation
- Tracker systems
- Scanner systems, Lidars
- Military application
- Imaging, Laser show

Laser for medical application
- Biomedical (ophtalmology)

Fig. 8
Market segment for optoSiC® high-end scanning mirrors

SiC replaces beryllium whose toxicity problems are well known. Scan mirrors are largely used for processes like welding, cutting, drilling, marking (microlithography) and additive manufacturing processes.
Scan mirrors are also used for instrumentation like laser tracker system (inspection, alignment, reverse engineering, robot tracking, calibration, ship building, aircraft

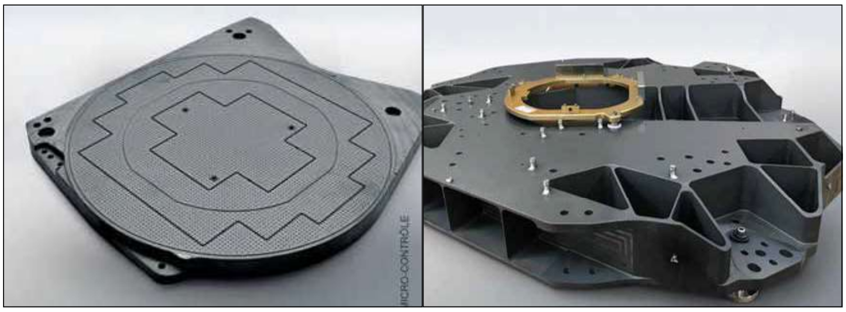

Fig. 9
Ultra-stable structures and components for optomechanics and semiconductor industries (wafer rotating systems)

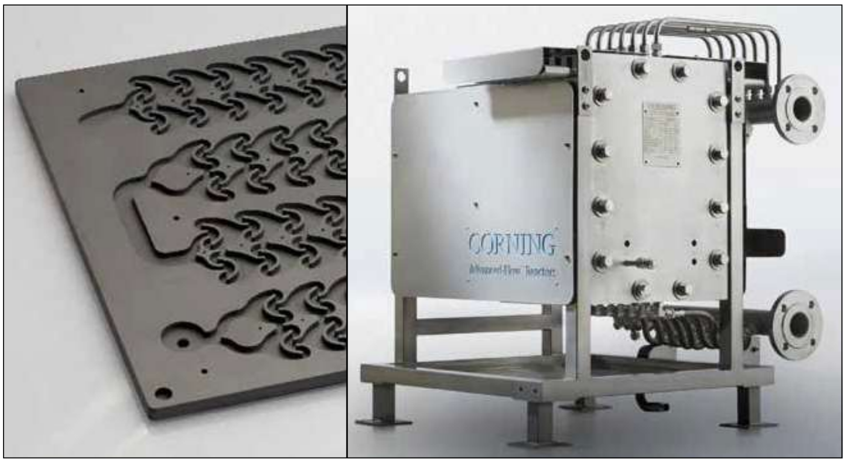

Fig. 10
Boostec® SiC/Corning AFR module (l.) and reactor (r.)

Fig. 11
Technical specifications and key benefit

manufacturing, etc.), laser scanner system (terrestrial stationary, terrestrial mobile, airborne, space, etc.), laser for military applications, for biomedical and for imaging (Fig. 9).

4.2 Semiconductor and optomechanics OEMs

As shown on the diagram of merit (Fig. 8), Boostec® SiC material is perfectly stable to provide ultra-high accurate structures that are now required by the semiconductor and optomechanical equipments.

4.3 Continuous flow reactors for the chemical industry

Due to outstanding chemical resistance associated with high thermal conductivity Boostec® SiC modules for continuous flow reactors represent an outstanding technological breakthrough in the chemical industry. This product has been developed in strong partnership with Corning AFR.

Technical specifications and key benefit of this green technology (Fig. 11) give Boostec/Corning partnership a strong world wide position in the field of green chemistry.

5 Conclusion

These 30 years old background allows the company to develop new innovative applications based on collaborative programs with end users. From the manufacturing of monolith ceramics to the production of complex solutions, MERSEN Boostec has developed over the years a unique expertise.