BOOSTEC® SiC
SINTERED SILICON CARBIDE
AN OUTSTANDING MATERIAL
Boostec® SiC is a polycrystalline technical ceramic of alpha SiC type, obtained by pressureless sintering. This process yields a pure silicon carbide with no traces of free silicon.

Its low residual porosity is fine and completely closed, i.e. the material is perfectly water tight. The very strong covalent Si-C bond gives Boostec® SiC exceptional physical properties that are particularly stable over time: high stiffness and hardness, low thermal expansion, high chemical and thermal stability...

Its fine, homogeneous micro-structure is isotropic and virtually free of secondary phases, leading to perfectly isotropic, homogeneous and reproducible physical properties. In particular, no dispersion or anisotropy of its coefficient of thermal expansion is detectable with an extreme precision of \(0.001 \cdot 10^{-6} \text{K}^{-1}\).

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.

The mechanical properties (bending strength, modulus of elasticity, toughness) of Boostec®SiC hardly change with temperature, from cryogenic environments close to absolute zero up to 1450 °C.

Boostec® SiC is a non-magnetic, semi-conductor material.

### Typical Chemical Composition
- SiC > 98.5 %
- B < 1 %
- free C < 0.2 %
- SiO2 < 500 ppm
- free Si < 500 ppm
- Fe < 500 ppm
- Al < 400 ppm
- Ca < 30 ppm
- K < 1 ppm
- Mg < 1 ppm
- Na < 1 ppm

### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Values (at 20 °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>3.15 g/cm³</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>420 GPa</td>
</tr>
<tr>
<td>Bending strength / Weibull modulus</td>
<td>400 MPa / 11</td>
</tr>
<tr>
<td>(coaxial double ring DIN EN 1288-1 &amp; 5)</td>
<td></td>
</tr>
<tr>
<td>Poisson Coefficient</td>
<td>0.16</td>
</tr>
<tr>
<td>Toughness ((K_{1c}))</td>
<td>3 MN.m³/²</td>
</tr>
<tr>
<td>Coefficient of thermal expansion</td>
<td>2.2 . 10⁻⁶ K⁻¹.</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>180 W.m⁻¹.K⁻¹</td>
</tr>
<tr>
<td>Electrical Resistivity</td>
<td>10⁶ Ω.m</td>
</tr>
</tbody>
</table>
The technology developed by Boostec enables it to serve its markets...

- from prototype to small production runs, with monolithic parts in SiC (coated with CVD SiC if required), SiC/SiC or SiC/metal assemblies that can take very complex shapes and reach very large dimensions.

Fabrication of monolithic ceramics

- Isostatic pressing of large, rough shapes
- Green machining of pressed blocks
- Sintering (T > 2000 °C) under protective atmosphere
- Grinding
- Lapping
- Final inspection
- Cleaning

Maximum overall dimensions
- Cylinders Ø 1.25 m x height 0.60 m
- Blocks 1.70 m x 1.20 m x 0.60 m

Brazed SiC/SiC assemblies

Capacity: up to Ø 3.50 m x 0.8 m

Other assemblies SiC/SiC or SiC/metal

- Epoxy gluing
- Bolting
- Shrink-fitting

CVD SiC coating

Capacity: up to Ø 1.50 m
MIRRORS AND STABLE STRUCTURES
for telescopes (space, ground), scientific instrumentation and high speed lasers

Of the industrial materials that might be considered, Boostec® SiC achieves the best compromise between the key parameters that are common to all these applications:

- **specific stiffness:**
  - Young's modulus / density

- **thermal stability:**
  - thermal conductivity / Coefficient of thermal expansion

**Other key advantages of Boostec® SiC:**

- Monophase material, highly homogeneous
- Micro-structure and thus physical properties perfectly isotropic, in particular the thermal expansion
- Perfect reproducibility of the thermal expansion from one item to another, from one batch to another
- High mechanical strength and absence of mechanical fatigue
- Total absence of outgassing and moisture absorption
- Perfect stability over time
- Insensitivity to radiation in the space environment
- Physical properties retained or even improved at cryogenic temperatures; qualification for space applications down to 30 K
- The optical face of the mirrors can be CVD coated with SiC to mask the fine residual porosities of the sintered SiC

**Space, Science and Laser Industry**

Scientists look for ever larger, lighter, more stable and even colder telescopes to observe the earth or the far universe with extreme precision. Boostec® SiC has shown itself indispensable to meet the mass and thermo-mechanical stability requirements of certain on-board instruments. The excellent mechanical properties of Boostec® SiC permit the production of all SiC optical benches and telescopes: the mirrors, the structure and the focal plane elements (detector support, structure, folding mirrors) are made of SiC. These instruments are insensitive to temperature variations without any temperature control.

Mid 2013, ten “all Boostec® SiC” telescopes were operational in space, including Herschel, the largest space telescope. Boostec is the only company in the world capable of producing SiC parts of 3 meters in diameter.

Ground-based observatories profit from the same remarkable properties of Boostec® SiC, especially for their mirrors or their adaptive optics.

Boostec® SiC technology also offers exceptional opportunities for the extremely stable structures or optical benches used on the ground; it permits the realisation of large dimension optical benches (up to 3.5 m in length) with complex shapes in a single piece, thus reducing the assemblies.

**Better Materials**

<table>
<thead>
<tr>
<th>Material</th>
<th>Thermal Stability (MW/m)</th>
<th>Specific Stiffness (Mm²/S²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>Aluminium</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>various SiSiC</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Glass-ceramics</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>SIC BOOSTEC®</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Better Materials</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Silica</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Beryllium</td>
<td>160</td>
<td></td>
</tr>
</tbody>
</table>

Our SiC technology permits the realisation of lighter mirrors, with high dynamic flatness, low inertia and therefore very agile, for sighting systems, high speed laser scanners and LIDARS. SiC is becoming essential for terrestrial or airborne topographic mapping as well as industrial laser applications such as material processing, marking, metrology or rapid prototyping, where ever greater speed, precision and larger dimensions are sought.
In mechanical seals, silicon carbide is currently used as a counter-face to carbon. SiC/SiC solutions are used for corrosive fluids (strong acids or alkalis) and, above all, for abrasive suspensions.

Boostec® SiC technology enables the use of silicon carbide to be extended to large parts (up to Ø 1 metre) for particularly demanding applications in sectors such as nuclear or marine engineering and certain chemical installations. Pump bearings and thrust bearings use SiC/SiC sliding which is lubricated by the liquid flow.

Key advantages of Boostec® SiC:

- Outstanding corrosion resistance
- Excellent resistance to abrasion
- Low density
- High mechanical strength
- Low coefficient of friction (in liquid medium)
- High Thermal conductivity
- Good resistance to thermal shock.

If necessary, the sintered SiC can be given a sealed coating of CVD SiC of very high purity.
Unlike batch chemical reactors, the intensification of chemical processes enables this industry to be turned towards a decidedly greener chemistry. In the context of an agreement with Corning SAS, Boostec is developing and manufacturing high-technology chemical reactors for continuous flow systems. These new reactors represent a real technological breakthrough and reduce the production steps with improved chemical reactions in more compact and safer factories. This equipment, arising from the Corning SAS / Boostec alliance, permits the production on an industrial scale of specific chemical or pharmaceutical products with competitive costs.

The industrial version marketed by Corning SAS is based on the plate heat exchanger concept, designed as a modular structure in blocks, in which the reaction plates made of Boostec® SiC, are interleaved with metal plates in which the heat-bearing liquid circulates.

Boostec® SiC technology is particularly well-suited for this application; it offers:

- production runs of plates with optimised channel patterns at competitive costs,
- assembly techniques permitting the sealed assembly of the modules.

The “all Boostec® SiC” heat exchangers permit the widening of Mersen’s product range. They offer the following key advantages:

- Absence of leakage
- Can be used at high temperature (>500 °C)
- Resistance to high pressures
- Excellent abrasion resistance, permitting the absence of contamination and greater velocity of the fluids, whence reduced fouling
- Possibility of making more compact equipment
- Possibility of cleaning on site (chemical or thermal process)

Key advantages of Boostec® SiC:

- High thermal conductivity
- Perfect sealing
- Excellent resistance to corrosion, even by hot fluids
- Excellent abrasion resistance
- High mechanical strength
Global expert in materials and solutions for extreme environments as well as in the safety and reliability of electrical equipment, Mersen designs innovative solutions to address its clients’ specific needs to enable them to optimize their manufacturing process in sectors such as energy, transportation, electronics, chemical, pharmaceutical and process industries.