PHOTOVOLTAICS

Carbon and graphite solutions for a competitive PV industry
Among all renewable energies photovoltaic benefits from many environment and economic advantages:
- Unlimited renewable source of energy
- Increasingly cost competitive
- Decentralized power source
- Peak power at peak time of usage
- Environment friendly

The sun, an energy available for free...
Photovoltaic systems use cells to convert sunlight directly into electricity.
When sunlight strikes a PV cell, electrons are dislodged, creating an electrical current.
The most common semiconductor material used in photovoltaic cell is silicon, an element most commonly found in sand.
The crystalline silicon technology, which distinguishes monocrystalline, multicrystalline and ribbon sheets processes, represents approx. 90% of the market today.

Thanks to its outstanding properties graphite is the unique and only material to withstand high temperature, corrosion and the severe conditions on the silicon production process.

Other photovoltaic processes are now available on the market such as the thin film technology where modules are constructed by depositing extremely thin layers of photosensitive materials onto glass, plastic or stainless steel.

Mersen is a world leader in isostatic graphite production, and proposes proven solutions to each step of the photovoltaic production chain, from polysilicon feedstock to cells antireflective coating via thin film process.
Its range of materials covers graphite, Carbon/Carbon composite as well as insulation materials.

Benefits of Mersen materials:
- Grade consistency (inert and non-wetting to most chemicals)
- Large diameters available up to 1.5 m in graphite and 2.2 m in Carbon/Carbon composites for the whole range of products
- High purity (less than 5 ppm), which avoids contamination and allows high quality products
- Dedicated high performance solutions to increase lifetime and efficiency
- Mersen materials offer strong benefits...

"Photovoltaic" is the combination of two words: "photo" from Greek origin, which means light, and "voltaic", from "volt", the unit used to measure electricity.
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Mersen materials offer strong benefits...

• Dedicated high performance solutions to increase lifetime and efficiency
• High purity (less than 5 ppm), which avoids contamination and wear performance vs. silicon
• Grade consistency (inert and non-wetting to most chemicals)

Benefits of Mersen materials:

• Environment friendly
• Peak power at peak time of usage
• Decentralized power source

Among all renewable energies photovoltaic benefits from high strength & high purity!

Isostatic graphite grade 2191 UHP5
The best combination with high thermal conductivity, high strength & high purity!

Large size rounds up to dia. 1500 mm in isostatic graphite 2020.
Trays or tubes up to dia. 2200 mm in Carbon/Carbon composite AM252.
Rigid carbon thermal insulation CALCARB® and ISOLOR®
Machining capacity and purification capabilities for large dimensions
Dedicated solutions to reduce chemical reaction with molten silicon

Purified graphite grades 2124 UHP5, 2450 UHP5
SiC coating
Rigid carbon thermal insulation CALCARB® and ISOLOR®
Stable properties and excellent wear performance vs. silicon

Isostatic graphite grades
• AM252 carbon/carbon bolts & nuts
• AM252 carbon/carbon carriers
• 2020 graphite carriers
• 2020PT, 2450PT, 2020PT

Polycrystalline

Silica

Metallurgical silicon

TCS Siemens reactor & converter

Silicon refining
Photovoltaic systems use cells to convert sunlight directly into electricity. When sunlight strikes a PV cell, electrons are dislodged, creating an electrical current. Photovoltaic systems use cells to convert sunlight directly into electricity.

Photovoltaic technology allows high quality products. Dedicated high performance solutions to increase lifetime and efficiency allows high quality products. Mersen materials offer strong benefits...

Benefits of Mersen materials:
- High purity (less than 5 ppm), which avoids contamination and contamination
- Large diameters available up to 1.5 m in graphite and 2.2 m in carbon composite as well as insulation materials.
- Grade consistency (inert and non-wetting to most chemicals)
- Machining capacity and purification capabilities for large dimensions
- Rigid carbon thermal insulation CALCARB® and ISOLOR®
- Rigid carbon thermal insulation CALCARB®
- Isostatic graphite grades 2124 UHP5, 2450 UHP5
- Rigid carbon thermal insulation CALCARB® and ISOLOR®
- Ultra high precision machining to ensure process stability
- Non wetting to silicon
- Excellent price to performance

Among all renewable energies photovoltaic benefits from many environment and economic advantages:
- Environment friendly
- Unlimited renewable source of energy
- Peak power at peak time of usage
- Decreasing pollution
- High strength & high purity!
- Heat shields AM252, 2450PT, 2020PT
- Non wetting to silicon
- Wear performance vs. silicon
- Stabilization of temperature, corrosion and the severe conditions on the market such as the thin film technology

Monocrystalline silicon pulling

Si - Ribbons process

Wafer slicing

Solar cell

Anti-reflective coating Si₃ N₄

- 2020 graphite carriers
- AM252 carbon/carbon carriers
- Large sizes
- Mechanical stability
- Adapted CTE

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**Graphite grades**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Density (MPa)</th>
<th>FS (MPa)</th>
<th>CTE (10⁻⁶/°C)</th>
<th>Resistivity (µΩcm)</th>
<th>Thermal conductivity (W/m°C)</th>
<th>Permeability (cm²/s)</th>
<th>Standard sizes (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2191</td>
<td>1.75</td>
<td>44</td>
<td>4.2</td>
<td>1,000</td>
<td>116</td>
<td>0.5</td>
<td>540x540x1,830</td>
</tr>
<tr>
<td>2020</td>
<td>1.77</td>
<td>45</td>
<td>4.3</td>
<td>1,550</td>
<td>85</td>
<td>0.4</td>
<td>530x635x1,830</td>
</tr>
<tr>
<td>2123</td>
<td>1.84</td>
<td>58</td>
<td>5.5</td>
<td>1,140</td>
<td>112</td>
<td>0.3</td>
<td>Ø 1,500 on request</td>
</tr>
<tr>
<td>2160</td>
<td>1.86</td>
<td>76</td>
<td>6.0</td>
<td>1,270</td>
<td>102</td>
<td>0.2</td>
<td>305x620x915</td>
</tr>
<tr>
<td>2450</td>
<td>1.86</td>
<td>45</td>
<td>4.5</td>
<td>1,550</td>
<td>85</td>
<td>0.04</td>
<td>305x305x915</td>
</tr>
<tr>
<td>6503</td>
<td>1.74</td>
<td>23</td>
<td>3.3</td>
<td>800</td>
<td>200</td>
<td>1</td>
<td>550x550x1,830</td>
</tr>
</tbody>
</table>

**Purity**

<table>
<thead>
<tr>
<th></th>
<th>Unpurified</th>
<th>PT : &lt; 20 ppm</th>
<th>Purified</th>
<th>UHP : &lt; 5 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiC coating</td>
<td>290 ppm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T max</th>
<th>Density (MPa)</th>
<th>Open porosity</th>
<th>RF (MPa)</th>
<th>CTE (10⁻⁶/°C)</th>
<th>Coating thickness</th>
<th>Hardness</th>
<th>Young modulus (GPa)</th>
<th>Permeability (cm²/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700°C</td>
<td>3.2</td>
<td>Impervious to most gases (H₂) and liquids</td>
<td>350</td>
<td>4.8</td>
<td>50-250 µm</td>
<td>2280</td>
<td>2950</td>
<td>&lt; 10⁻⁴</td>
</tr>
</tbody>
</table>

**Rigid carbon insulation**

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>Thermal conductivity at 400°C (W/m°C)</th>
<th>Thermal conductivity at 2,200°C (W/m°C)</th>
<th>Standard Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISOLOR® S10</td>
<td>0.1</td>
<td>2.4</td>
<td>2.2</td>
<td>1,500x1000x40 Rounds &amp; special sizes on request</td>
</tr>
<tr>
<td>CALCARB® CBCF 18-2000</td>
<td>0.18</td>
<td>0.1</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

**CALCBAR® CBCF 18-2000**

**Thermal Conductivity vs Temperature**

- Laser Flash Diffusivity ASTM E-1461
- Hot Plate ASTM C-177

**Carbon / Carbon composite**

<table>
<thead>
<tr>
<th>Material</th>
<th>Density</th>
<th>FS (MPa)</th>
<th>Flexural modulus (GPa)</th>
<th>Max sizes (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM252</td>
<td>1.70</td>
<td>100</td>
<td>10</td>
<td>Ring Ø 2,200 Tube length 3,000</td>
</tr>
</tbody>
</table>
A WORLD EXPERT
in materials and solutions for high temperature processes

A GLOBAL PLAYER
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.

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