PHOTOVOLTAICS

Carbon
and graphite
solutions for
a competitive
PV industry

MERSEN

MERSEN

all along the photovoltaic production chain

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.

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

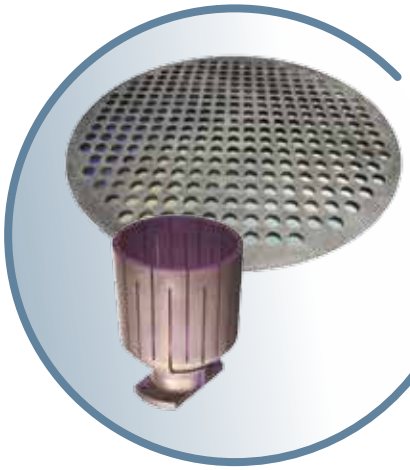
Benefits of Mersen materials:

- 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...

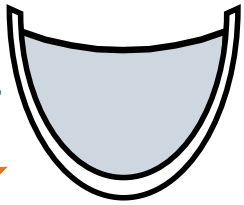




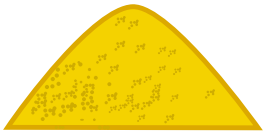
MERSEN ALL ALONG THE PHOTOVO



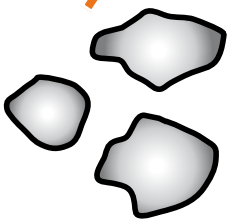
- Large size rounds up to dia. 1500 mm in isostatic graphite 2020.
- Trays or tubes up to dia. 2200 mm in Carbon/Carbon composite AM25
- Rigid carbon thermal insulation CALCARB® and ISOLOR®
- Machining capacity and purification capabilities for large dimensions
- Dedicated solutions to reduce chemical reaction with molten silicon



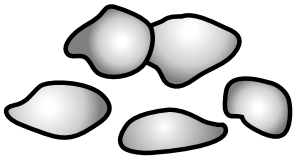
Silicon refining



Silica

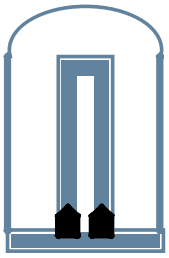


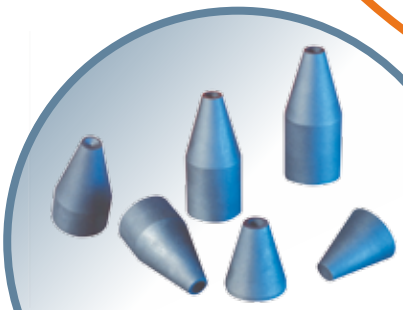
Metallurgical silicon



Polysilicon

TCS Siemens reactor & converter





Isostatic graphite grade 2191 UHP5

The best combination with high thermal conductivity, high strength & high purity!

- Purified graphite grades 212 2450PT, 2020PT
- SiC coating
- Rigid carbon thermal insulati CALCARB® and ISOLOR®
- Heat shields AM252
- Stable properties and excelle wear performance vs. silicon environment

LTAIC PRODUCTION CHAIN

- 2020 graphite crucibles, holders, heaters
- Rigid carbon thermal insulation CALCARB® and ISOLOR®
- AM252 carbon/carbon bolts & nuts
- Large sizes
- Excellent price to performance

Multicrystalline silicon melting

Monocrystalline silicon pulling

Wafer slicing

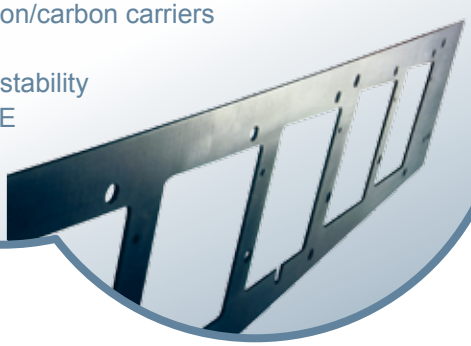
Solar cell

Si - Ribbons process

- 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

Anti-reflective coating
$Si_3 N_4$

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



MATERIALS

Graphite grades

Grade	Density	FS (MPa)	CTE (10^{-6}/°C)	Resistivity (µΩcm)	Thermal conductivity (W/m°C)	Permeability (cm^2/s)	Standard sizes (mm)
2191	1.75	44	4.2	1,000	116	0.5	540x540x1,830
2020	1.77	45	4.3	1,550	85	0.4	530x635x1,830 1,030x1080x325 Ø 610 x1,830 Ø 915x760 Ø 1,500 on request
2123	1.84	58	5.5	1,140	112	0.3	305x620x915
2160	1.86	76	6.0	1,270	102	0.2	305x305x915
2450	1.86	45	4.5	1,550	85	0.04	On request
6503	1.74	23	3.3	800	200	1	550x550x1,830

Purity

Unpurified	Purified	
290 ppm	**PT : < 20 ppm**	**UHP : < 5 ppm**

SiC coating

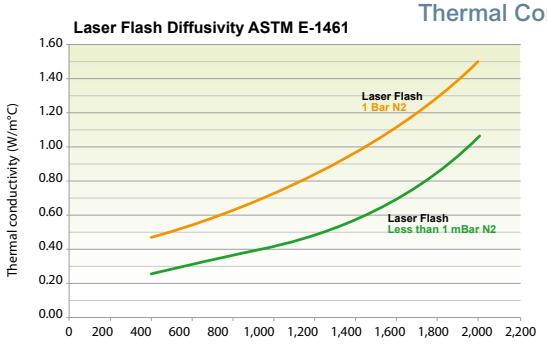
T max	Density	Open porosity	RF (MPa)	CTE (10^{-6}/°C)	Coating thickness	Hardness	Young modulus (GPa)	Permeability (cm^2/s)
1700°C	3.2	Impervious to most gases (H2) and liquids	350	4.8	50-250 µm	2280 2950 Knoop	63	< 10^{-4}

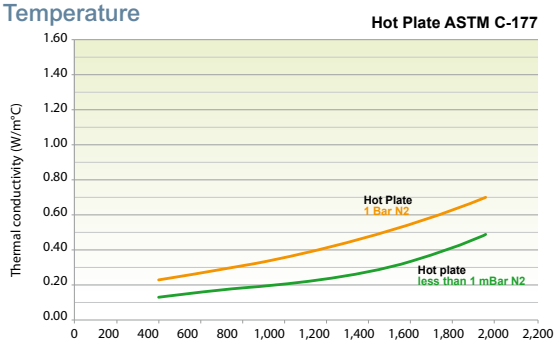
Rigid carbon insulation

	Density	Thermal conductivity at 400°C (W/m°C)	Thermal conductivity at 2,200°C (W/m°C)	Standard Dimensions (mm)
ISOLOR® S10	0.1	2.4	2.2	**1,500x1000x40 Rounds & special sizes on request**
CALCARB® CBCF 18-2000	0.18	0.1	1.0	

CALCARB® CBCF 18-2000

Thermal Conductivity *vs* Temperature





Carbon / Carbon composite

	Density	FS (MPa)	Flexural modulus (GPa)	Max sizes (mm)
AM252	1.70	100	10	Ring Ø 2,200 Tube length 3,000

Main production sites

Industrial or commercial branch

MERSEN

Expertise, our source of energy

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.

Pictures with courtesy of EPA, Dupont, RWE, Schott Solar, Shell Solar B.V., Photovatt international, PV Crystalox, Isofoton, ANXO S.A.

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