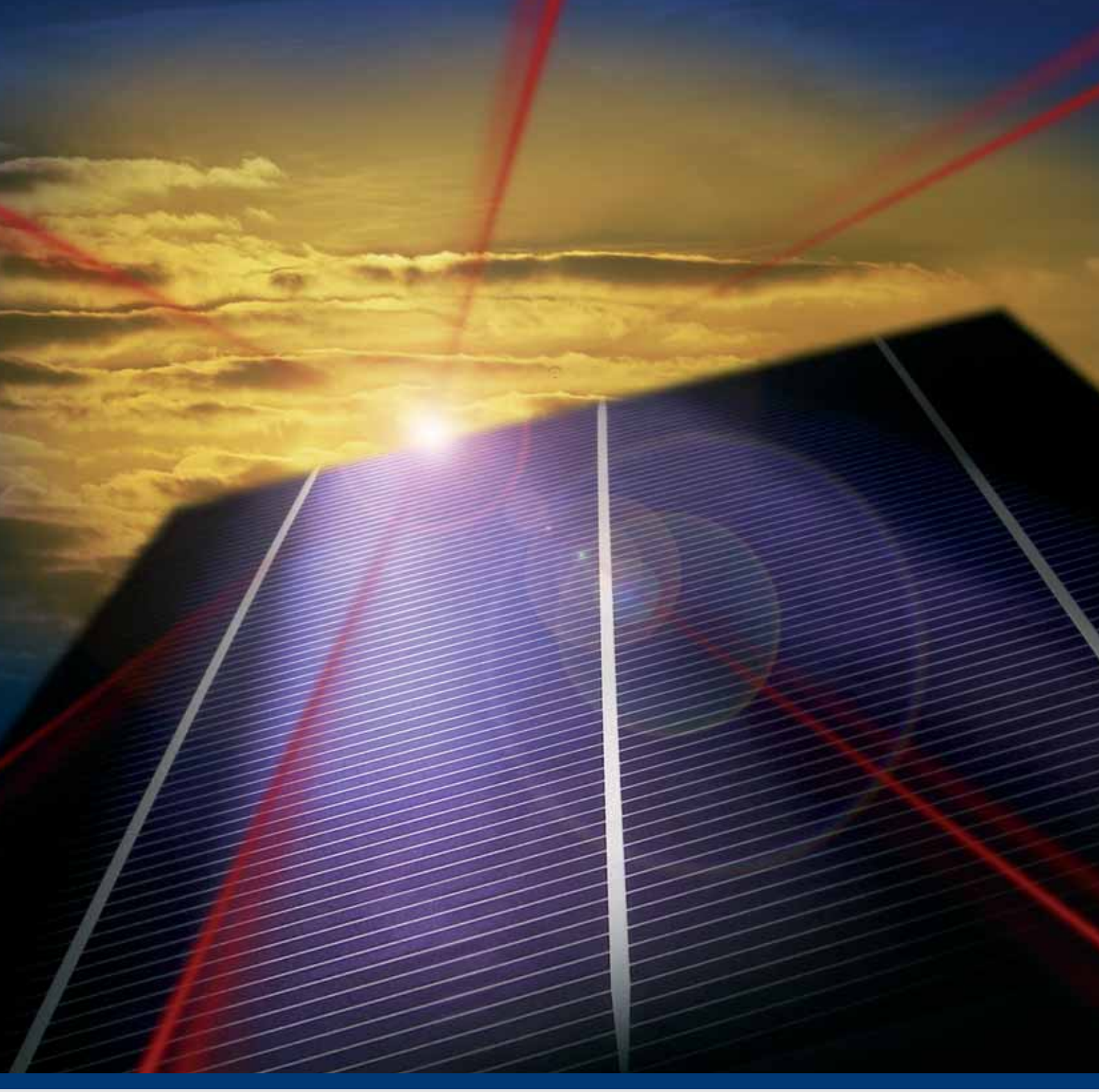


Schunk – Preserving our Future with Solar Energy Today

schunk Group

Schunk Kohlenstofftechnik GmbH schunk

Solar Energy – Technology of the Future

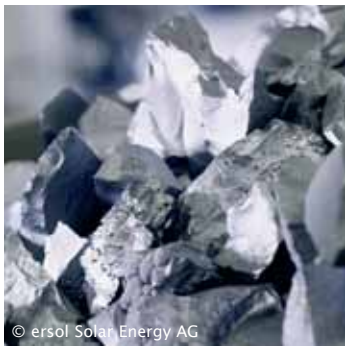
Schunk – Global Player

Schunk Kohlenstofftechnik is part of the Schunk Group, a group of global technology companies which operate independently in the world's markets. It takes a long time and many processes to transform raw materials into solar panels used as energy collectors. Schunk Kohlenstofftechnik, as a manufacturer of different components for today's crystal growing systems, is directly involved in this production process.

Manufacturing Process

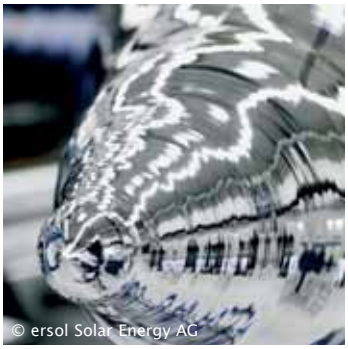
Our core specialties include purification and coating of graphite and C/C components for high-temperature applications.

We manufacture high precision components from graphite and carbon fiber reinforced carbon (C/C) which are used in conventional crystal growing furnaces to produce mono- and polycrystaline silicon.

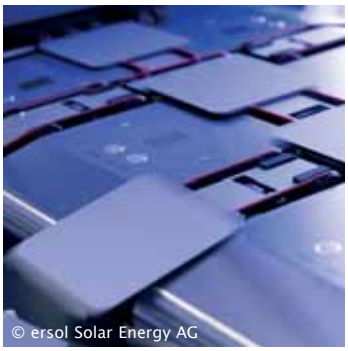


raw material → **purifying**

pulling



grinding, sawing, lapping, polishing and sizing



doping

With continuing development and progress of both technology and process we can assist our customers in achieving their production goals.

soldering/laminating

Schunk – Your Partner

As an international technology company, Schunk Kohlenstofftechnik offers an entire range of components for crystal growing systems.

- Assistance with material selection
- Expertise in custom designs
- Full support after the sale
- Advice from concept to completion
- Experience and flexibility

Application Fields

Schunk heaters and crucibles made of graphite or C/C are used in conventional crystal growth.

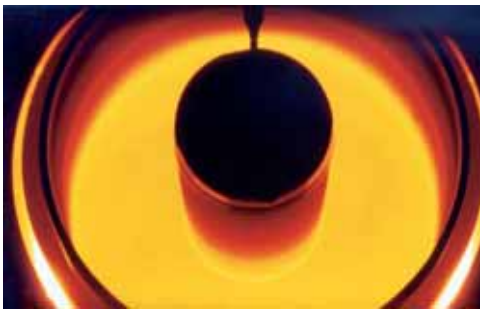
- Czochralski technique (CZ)
- Vertical gradient freeze technique (VGF)

During the crystal growing process our graphite and C/C components are used for melting and holding the material charge.

C/C heaters available in different sizes

Large Components to Improve your Efficiency

Through extensive experience together with constant development in high-temperature technology and custom furnace design we are able to manufacture almost all components in the largest sizes possible.



CZ melt

C/C crucibles, 20 – 36 inch

- Large melt reservoir
- Excellent accuracy to size
- High mechanical strength

Transport Systems

Wafer Carrier Systems for PECVD Processes

An anti-reflection layer of silicon nitride with a thickness of approximately 70 nm is deposited onto today's solar cells using the PECVD process.

Schunk components are manufactured in various designs to meet your general requirements or your most specific needs. We will help you optimize purity levels for each of your applications.

The wafers are placed in so-called graphite boats and then transferred to the PECVD furnace where the coating process is performed.

C/C carriers are also used for wafer transportation. Compared to conventional graphite, C/C has a lower thermal mass, a higher strength and significantly lower thermal conductivity which results in a reduced energy consumption during heating.

Graphite boat

All common carrier types are available in both standard or custum sizes.

C/C carrier

C/C Material Properties

Material Properties *		CF 226	CF 226/2
Reinforcement pattern	Type	cloth	cloth
Heat treatment temperature	[°C/°F]	2000/3630	2000/3630
Fiber volume fraction	[% by volume]	60	60
Bulk density	[g/cm³]	1.50	1.35
Porosity	[%]	8	20
Flexural strength	[MPa]	120	100
Young's modulus (dyn.)	[GPa]	60	50
Elongation at rupture	[%]	0.23	0.18
Interlaminar shear strength	[MPa]	8	6
Coefficient of thermal expansion	[10^{-6}/K]	∥ to the lamination 0.8 ⊥ to the lamination 7.3	∥ to the lamination 1.1 ⊥ to the lamination 7.0
Specific electrical resistance	[µΩm]	at ambient temperature 25	at ambient temperature 28 at 2000 °C/3630 °F 14
Thermal conductivity	[W/mK]	∥ to the plane of reinforcement 40 ⊥ to the plane of reinforcement 5	∥ to the plane of reinforcement 20 ⊥ to the plane of reinforcement 2
Fracture behavior	Type	pseudoplastic	pseudoplastic

Graphite and C/C are outstanding high-temperature materials due to their properties and versatility.

Graphite Material Properties

Material Properties *		FU 2584	FU 2590	FU 4501	FU 8957
Bulk density	[g/cm³]	1.94	1.88	1.78	1.75
Porosity	[%]	6	10	13	16
Flexural strength	[MPa]	60	50	37	55
Tensile strength	[MPa]	40	30	23	32
Compressive strength	[MPa]	140	110	90	100
Young's modulus (dyn.)	[GPa]	13	10	10	9.8
Rockwell hardness HR5/40		115	105	90	100
Coefficient of thermal expansion	[10^{-6}/K]	5.8	5.2	5	4.6
Thermal conductivity	[W/mK]	120	110	90	90
Specific electrical resistance	[µΩm]	11	11	12	14
Ash	[µg/g]	300	300	500	70
Forming method	Type	isostatic molding	isostatic molding	isostatic molding	isostatic molding
Grain size	[µm]	10	10	12	15

* *The given data are not binding but are typcial values based on our experiences.*
It should be taken into consideration that a spread of results can arise due to material and production variations.

Optional Processes

The Route to a Clean Black Material – High-Temperature Purification

Graphite and C/C materials can be purified in a high-temperature purification to remove almost all impurities. The purification is carried out under vacuum conditions and by using special gases. At temperatures exceeding 2000 °C / 3630 °F the impurities are converted into volatile compounds and removed by the gas flow.

This process allows us to meet your requirements regarding the highest possible purity.

Constant development in the field of high-temperature purification enables us to remove almost all metallic impurities to a level of less than 1 ppm.

Element Concentration*	Unpurified	Purified
Cu	0,2	< 0,04
Cr	0,6	< 0,04
Mn	0,3	< 0,02
Zr	0,5	< 0,04
Co	0,2	< 0,02
Ni	0,6	< 0,04
V	0,4	< 0,04
Mo	0,5	< 0,04
Mg	0,7	< 0,04
Ti	7	< 0,04
W	1	< 0,04
Al	3	< 0,05
Fe	15	< 0,07
Ca	10	< 0,07
Ash	< 300 ppm	<10 ppm

* *The given data are not binding but are typcial values based on our experiences. It should be taken into consideration that a spread of results can arise due to material and production variations.*

Plate coated with pyrolytic carbon (PyC)

Coating Processes

Constant development of new applications is our focus. A variety of coatings can be applied onto our basic materials, thereby offering a wide range of new possibilities to our customers.

Space mirror with oriented SiC coating by Schunk

SiC Deposition

Silicon carbide (SiC) coatings are applied by chemical vapor deposition (CVD). The coating is produced by thermal decomposition of special gases and subsequent chemical interlocking onto the substrate surface. By closely controlling the process parameters the coating thickness can be adjusted over a wide range.

The outstanding properties of SiC are:

- High decomposition temperature of up to 1600 °C / 2910 °F in vacuum
- High mechanical strength
- Excellent oxidation resistance
- High chemical resistance
- High thermal conductivity

Pyrolytic Carbon (PyC) Coating

Pyrolytic carbon (PyC) coatings are applied by chemical vapor deposition (CVD). Graphite and C/C components may be coated or infiltrated with pyrocarbon. The pyrocarbon layer enables very long lifetimes of highly pure graphite components, even in an aggressive environment.

Characteristics of pyrolytic carbon:

- Flawless microstructure
- No open porosity
- Highly anisotropic structure

Crucibles coated with pyrolytic carbon (PyC)

We will be pleased to help you!

We are happy to share information with you about any of our:

- Crucible systems
- Heater systems
- C/C carriers
- Graphite boats

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