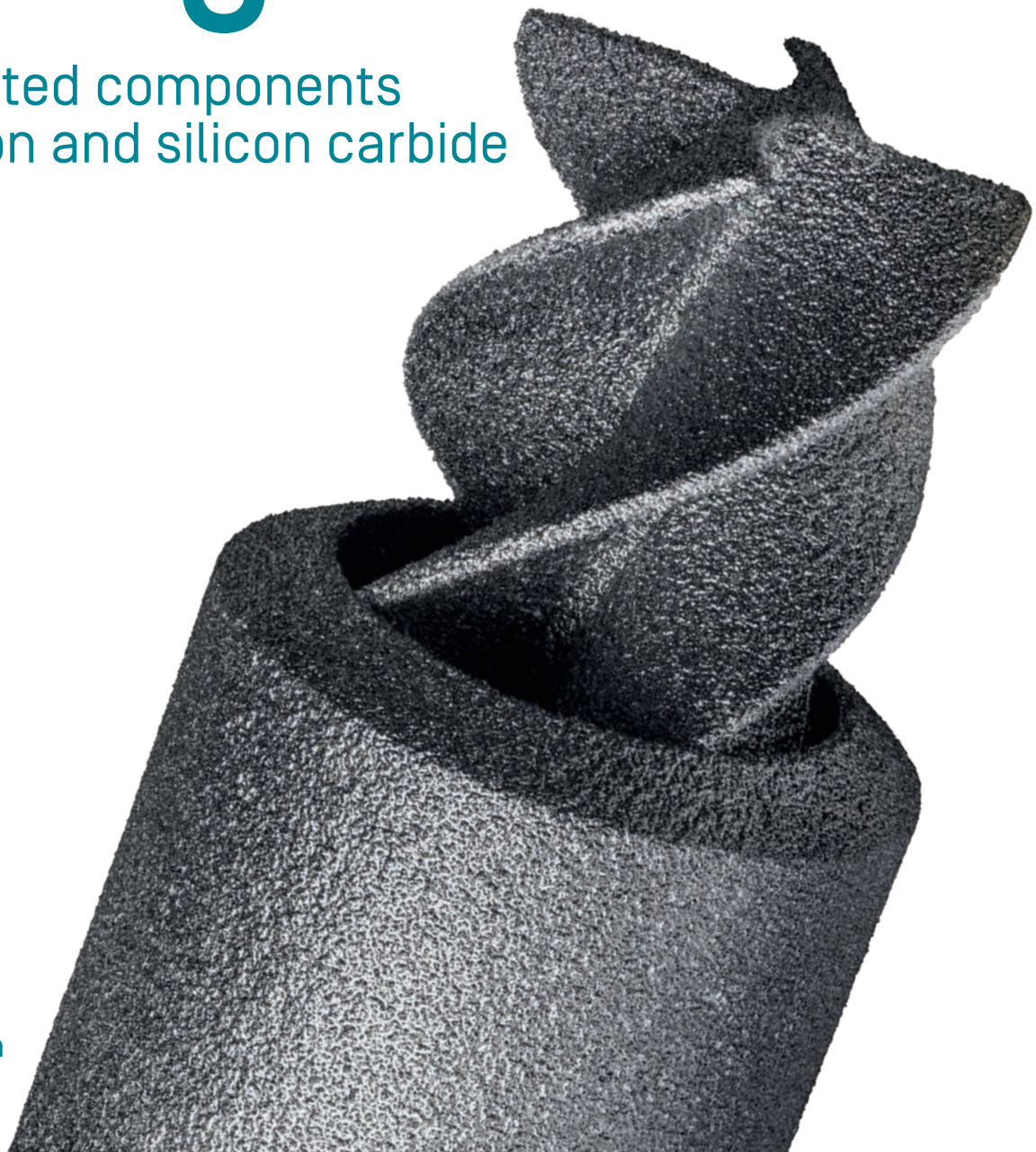
sgl carbon

The 3Designers

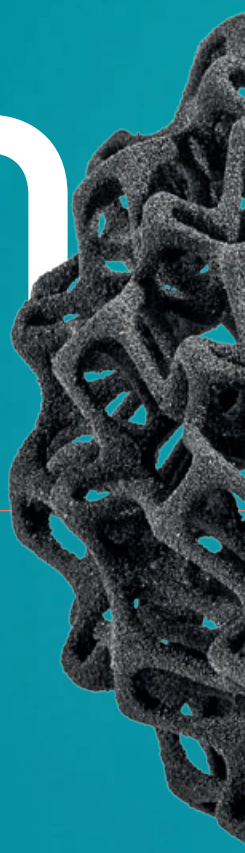
Our 3D printed components from carbon and silicon carbide

CARBOPRINT®
SICAPRINT™



Central Innovation

Freedom Design



CARBOPRINT® and SICAPRINT™

We believe that our customers should experience the freedom of flexible part design and production to solve the greatest challenges in their applications.

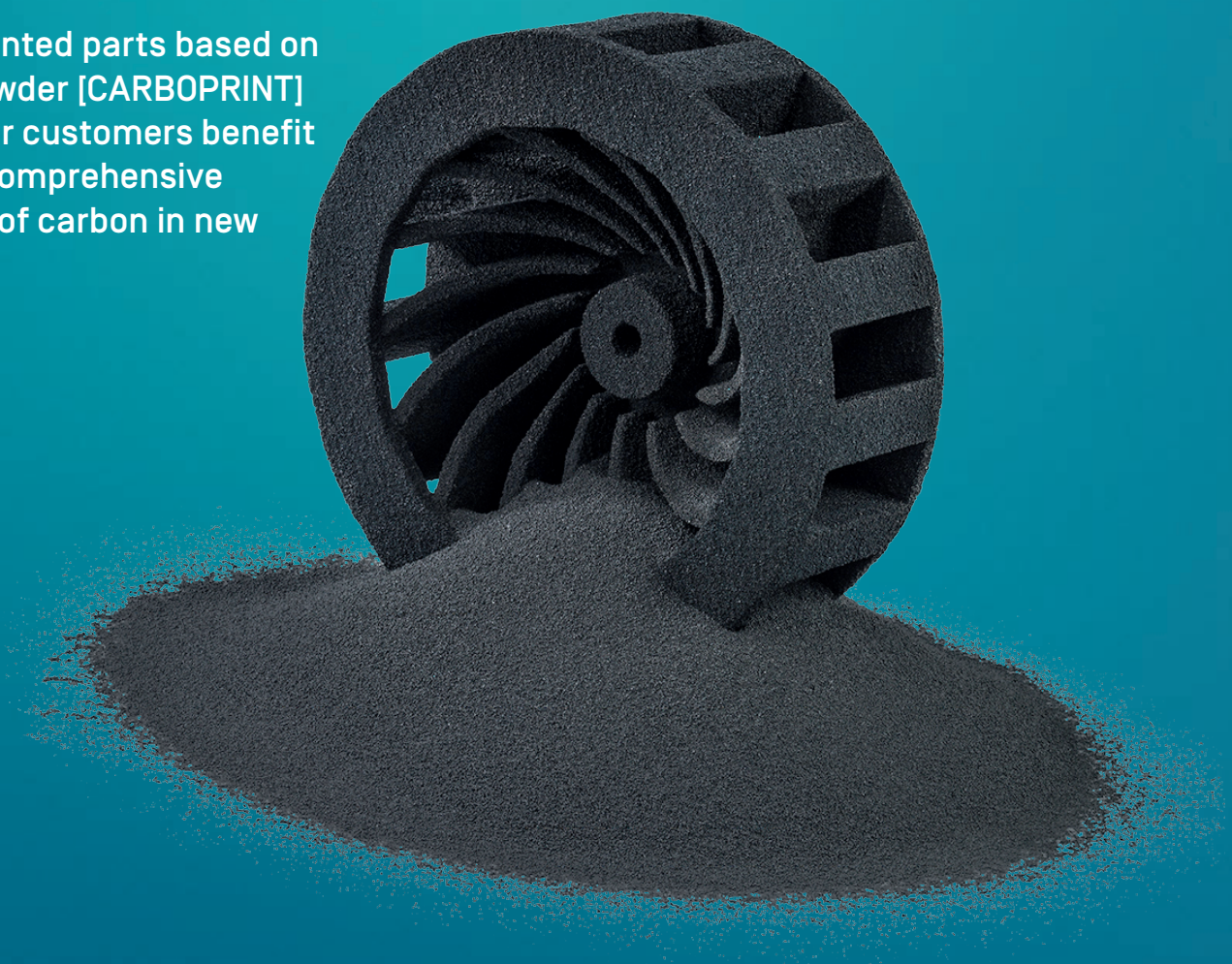
- Adapted 3D printing process
- Two base materials – carbon and silicon carbide
- Realize design possibilities like never before

of

3D printed carbon

To provide our customers with future-oriented technologies which enables them to meet ever increasing challenges in their applications we develop industrial 3D printing materials based on carbon and SiC-ceramics, as well as relevant services.

With 3D printed parts based on carbon powder [CARBOPRINT] we help our customers benefit from the comprehensive propertiesof carbon in new shapes.



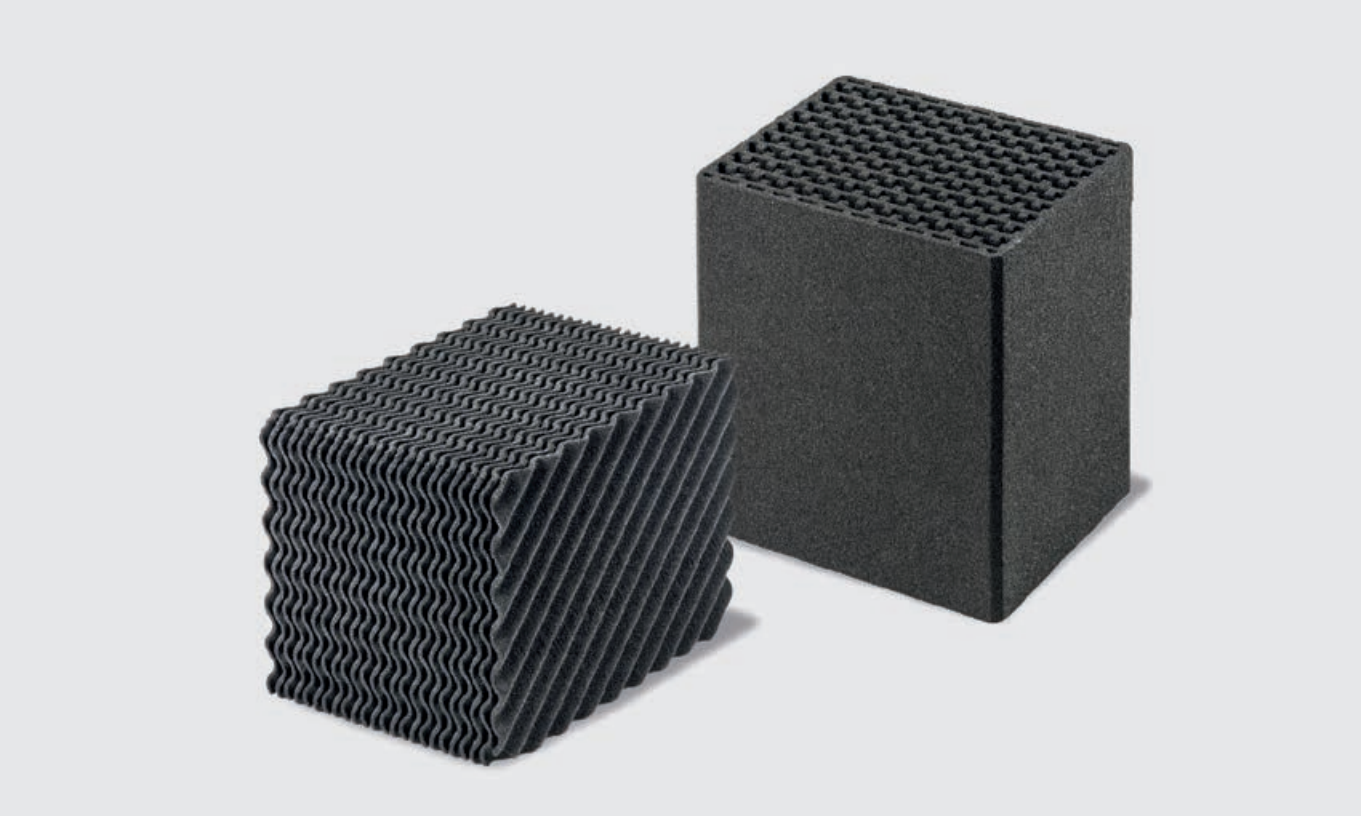
The CARBOPRINT family combines our comprehensive carbon material know-how with additive manufacturing technology. In addition, our broad base of post-processing capabilities, such as resin or silicon infiltration, delivers innovative material solutions for your applications.

This set of competencies and capabilities is a unique starting point for rapid and economic production of prototypes and small series of carbon based components for various industries such as glass, metal and chemicals, as well as high-temperature and mechanical applications.

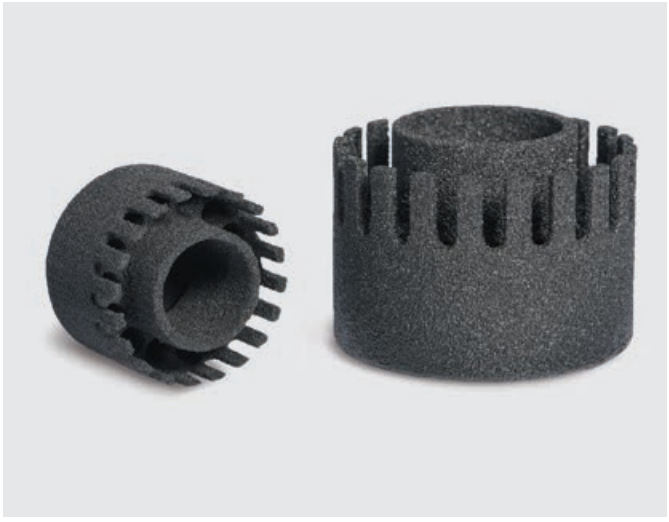
Advantages of using carbon in additive manufacturing

- Carbon and graphite properties (e.g. low weight, electrical and thermal conductivity, mechanical strength, chemical and high-temperature stability, low thermal expansion)
- Porous body structure delivers ideal basis for new material designs via polymer or silicon infiltration
- Intelligent functions are possible (e.g. thermal management)

↓ Catalyst carrier unit in CARBOPRINT P



↑ Casting core made of CARBOPRINT C



↑ Bubble cap infiltrated with polymer

Resin-bonded carbon CARBOPRINT® C

Carbon powders and graphite powders are the basis for cost efficient serial production of carbon and graphite based components.

The porous bodies are bonded with chemically and thermally stable duroplastic binder systems – all with help of SGL Carbon's established processes and know-how.

The highly porous carbon structure of CARBOPRINT C is an ideal basis for post-processing, such as infiltration with silicon or impregnation with polymers.

CARBOPRINT® C advantages:

- Lightweight – low density & open porosity
- Form stable at high temperatures
- Freedom of (material) design
- Further post processing such as thermal treatment and densification possible on demand

Typical Properties	Units	C-1
Density	g/cm³	1
Open porosity	%	40-50
Young's modulus	GPa	2
Flexural strength	MPa	5
Thermal conductivity	W/(mK)	< 1
Spec. electrical resistivity	Ωμm	125000
CTE (RT/200 °C)	μm/(mK)	5.5

Polymer carbon composite CARBOPRINT® P

Applications that require non-metallic materials will profit significantly from polymer carbon composites. This material is temperature resistant up to 200 °C – without creeping effects common among other polymers. Depending on the choice of polymer, properties such as mechanical or chemical stability can be adjusted to customer requirements.

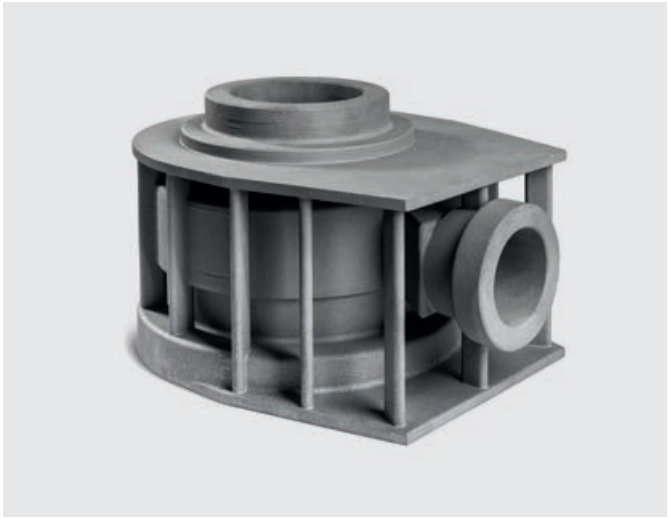
CARBOPRINT P components are made by infiltrating CARBOPRINT C bodies with polymers.

CARBOPRINT® P advantages:

- Temperature stability - heat resistant < 200 °C
- Low weight – porous carbon structure and low density resins
- New material design – infiltration with appropriate resins of choice

Typical Properties	Units	P-1	P-2
Density	g/cm³	1.6	1.4
Young's modulus	GPa	6	6
Flexural strength	MPa	15	45
Thermal conductivity	W/(mK)	40	< 1
Spec. electrical resistivity	Ωμm	35	> 100000
CTE (RT/200 °C)	μm/(mK)	12	40

↑ Pump impeller in CARBOPRINT Si



↑ Pump casing in CARBOPRINT Si

Ceramic carbon composite CARBOPRINT® Si

Ceramic carbon composites provide ideal properties where it comes to reliable function and longevity in harsh environments and at high temperatures.

We bring decades of experience with ceramic composites to additive manufacturing in order to provide our customers the opportunity to realize almost any design with ceramic carbon composites. CARBOPRINT Si components are made by siliconizing CARBOPRINT C bodies.

CARBOPRINT® Si advantages:

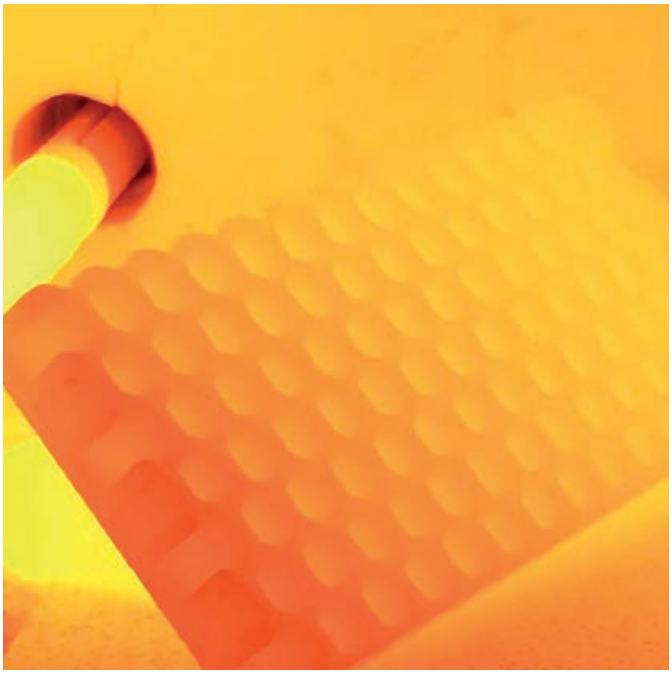
- Low weight due to low density
- High thermal shock resistance
- High bending strength
- High wear resistance

Typical Properties	Units	Si-1	Si-2	Si-3
Density	g/cm³	2.2	2.4	2.3
Open porosity	%	< 0.1	< 0.1	< 0.1
Young's modulus	GPa	70	95	100
Flexural strength	MPa	65	75	110
Universal hardness	MPa	2500	3000	2000
Spec. electrical resistivity	Ωμm	30	100	40
Thermal conductivity	W/(mK)	40	60	80
CTE (RT/200 °C)	μm/(mK)	3	3	3

3D printed silicon carbide

Our 3D printed silicon carbide parts [SICAPRINT] enhance the portfolio of high-performance parts for application in various industries such as chemical processing, semiconductors, automotive and aerospace just to name a few. Our range of material types and the freedom of design allow our customers to meet new challenges and manage complexity of part designs easier.

The additive manufacturing of ceramic materials enables us to create complex geometrical structures such as undercuts, hollow spaces or variable wall thicknesses, which is very hard and costly when using traditional production processes of ceramics. The SICAPRINT family together with the CARBOPRINT family allows a high degree of freedom of design, helping our customers to realize their needs in corrosive, high-temperature or ballistic protection applications, to name a few. Additive manufacturing of ceramic parts is faster than the traditional production processes, helping our customers to accelerate their product development and achieve faster time to market.



↑ Honeycomb structure in SICAPRINT Si stable during heat treatment [here at 1200 °C in air]. SICAPRINT Si parts can provide better mechanical strength at high temperatures compared to most metals.

Advantages of using silicon carbide in additive manufacturing

- Striking material properties such as high thermal conductivity, temperature stability in air, very high hardness, as well as abrasion and corrosion resistance
- Economically high-performance parts for small series
- Broad spectrum of material properties combined with freedom of design

Polymer silicon carbide composite SICAPRINT™ P

Pragmatic solution for functional parts that are exposed to abrasive and corrosive fluids and constant temperatures up to 200 °C. The simple refinement process allows for economical solutions.

Depending on the technical requirements a variety of resins is being held on demand to realize the desired result.

SICAPRINT™ P advantages:

- Abrasion resistance
- Corrosion resistance
- Economically advantageous

Typical Properties	Units	P-100	P-200	P-210
Density	g/cm³	2.0	2.0	2.0
Young's modulus	GPa	19	13	17
Flexural strength	MPa	55	95	120
Compressive strength	MPa	130	120	140
Thermal conductivity	W/(mK)	2.6	2.4	2.4
Shore D hardness		90	90	90

↑ Static mixer infiltrated with polymer in SICAPRINT P

Ceramic silicon carbide composite SICAPRINT™ Si

Here we bring the excellent physical properties of silicon carbide into complex shapes.

The material base and the broad range of refinement processes allow us to produce tough industrial components with high heat resistance, high thermal conductivity and hardness. The different types of SICAPRINT Si give our customers the opportunity to choose the most economical type for their application.

SICAPRINT™ Si advantages:

- Temperature stability up to 1400 °C
- Excellent thermal conductivity
- High hardness

Typical Properties	Units	Si-10	Si-100	Si-200
Density	g/cm³	2.8	2.9	3.0
Open porosity	%	< 0.1	< 0.1	< 0.1
Young's modulus	GPa	270	320	360
Flexural strength	MPa	110	150	180
Thermal conductivity	W/(mK)	120	150	170
Electrical resistivity	Ωμm	75	80	80
Universal hardness	MPa	7500	9000	10500

↑ Electric heater element made from SICAPRINT Si material

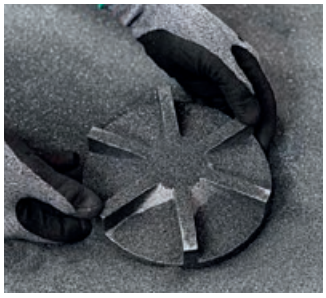
Our 3D Printing technology and postprocessing capabilities

Advantages of additive manufacturing with binder jetting technology

- Complex design at no additional cost (e.g. realization of undercuts and / or cavities)
- Acceleration of development and production of small series
- Use of material suitable for industrial applications
- Capability to produce large industrial components

Additional post processing steps beyond resin and liquid silicon infiltration

- Heat treatment (carbonization, graphitization)
- CVI with carbon
- Metal impregnation
- Coating
- Finishing



As printed

Resin impregnation

Liquid silicon infiltration

Carbon powder

CARBOPRINT C
resin bonded carbon

CARBOPRINT P
Polymer carbon composites

CARBOPRINT SI
Ceramic carbon composites

Silicon carbide powder

SICAPRINT
Resin bonded silicon carbide

SICAPRINT P
Polymer silicon carbide composites

SICAPRINT Si
Ceramic silicon carbide composite

Our digital services for 3D printing designs

- 3D CAD/CAM Drawing
- Design for additive manufacturing
- Outstanding numerical simulations know-how in:
    - Geometry and topology optimization
    - Structural mechanics [FEM]
    - Fluid dynamics and heat transfer [CFD]
    - AM process optimization
    - Microstructure and complex material models
    - Phase transition and reaction kinetics [e.g. for post processing steps]

If you want to combine the unique properties of carbon and SiC with the advantage of additive manufacturing technology, SGL Carbon will be your development partner of trust.

We encourage industrial partners with “pioneer” spirit to develop innovative carbon and ceramic based components with us to gain a significant competitive advantage.

↑ 3D printed optimized cantilever with highest specific stiffness achieved with topology optimization

Potential applications

3D printing

CARBOPRINT C	Polymer carbon composite **CARBOPRINT P**	Polymer SiC composite **SICAPRINT P**	Ceramic carbon composite **CARBOPRINT Si**	Ceramic SiC composite **SICAPRINT Si**
• Casting cores • Casting molds • Preforms	• Gliding elements • Pump parts • Electrodes • Sealings • Chemical packings & internals • Spray nozzles		• Pump impellers and casings • Burner nozzles • Heat exchangers • Ballistic protection • Abrasive protection • Electric heaters	

Smart Solutions

Be it materials, components or production processes, we keep an eye on the big picture and focus our thinking and actions on the customer. We work on solutions that already anticipate the future today.

The following examples show just a selection of our unique product range.

Mobility

- Lightweight components and structural parts based on fiber-reinforced composites for automotive and aerospace manufacture
- Graphite anode material for lithium-ion batteries in electric vehicles
- Carbon-ceramic brake disks for sports cars and luxury sedans

Energy

- High-temperature solutions based on specialty graphites and fiber materials for the photovoltaic industry
- Carbon fiber materials for rotor blades
- Gas diffusion layers for fuel cells
- Systems for more efficient heat exchange and heat recovery
- Carbon fibers for pressurized gas containers

Digitization

- Carbon, graphite, and CFC components for polysilicon and monocrystal pulling in the semiconductor industry
- High precision, coated graphite carriers for the production of LEDs

→ State-of-the-art additive manufacturing with carbon

SGL Carbon

We are leaders in the development and manufacture of products based on carbon, graphite, carbon fibers, and fiber-reinforced composites. In partnership with our customers, we develop intelligent, trendsetting, and sustainable solutions that deliver a clear benefit.

With our in-depth material, engineering, and application know-how, we make a substantial contribution to the major future topics mobility, energy, and digitization.

Contact

SGL CARBON GmbH
Central Innovation
Werner-von-Siemens-Straße 18
86405 Meitingen / Germany
additive.manufacturing@sglcarbon.com

05 2018 / 0.5E Printed in Germany

SGL CARBON GmbH
Central Innovation
Werner-von-Siemens-Straße 18
86405 Meitingen / Germany
www.sglcarbon.com