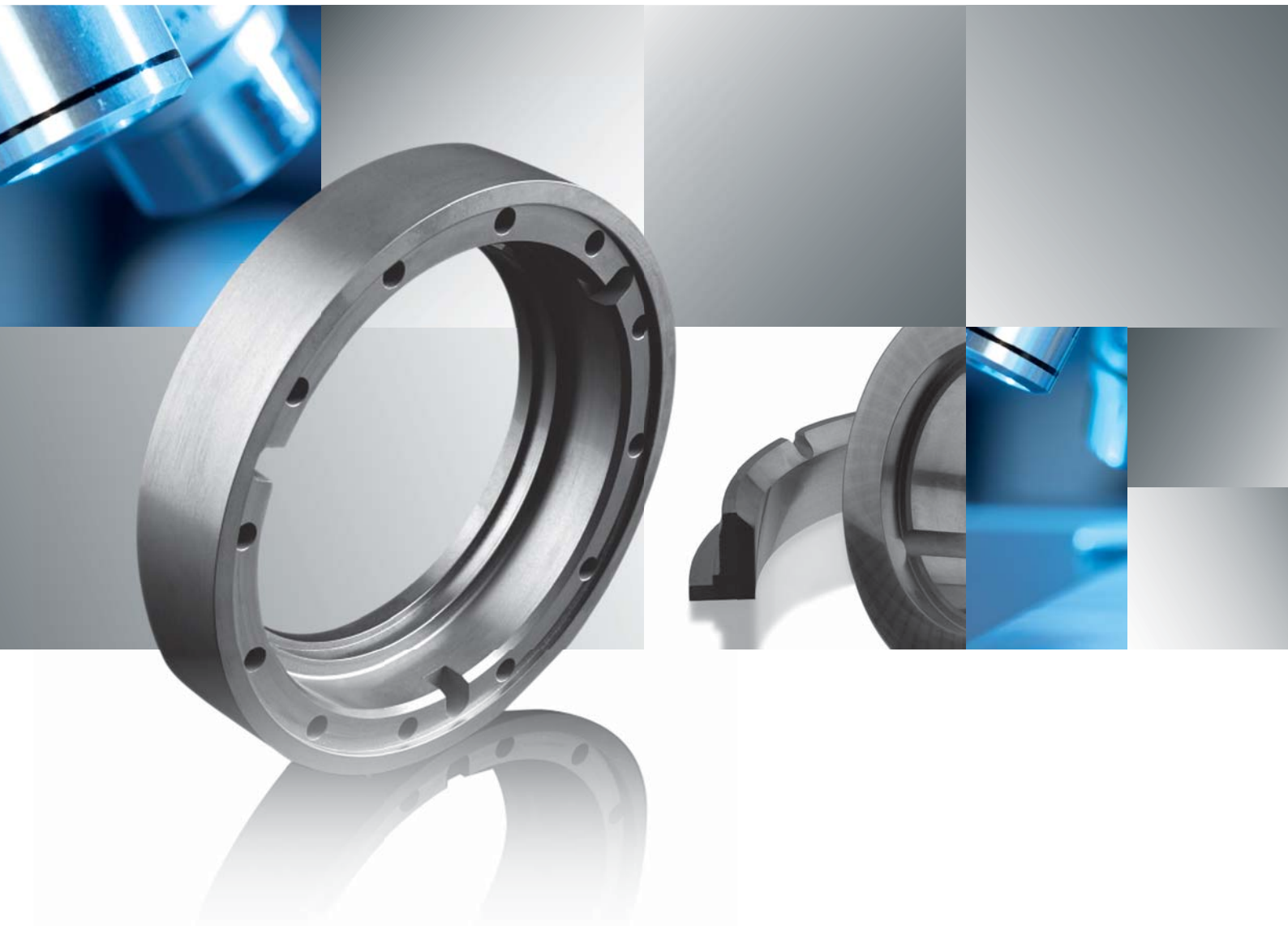
CeramTec Czech Republic, s.r.o



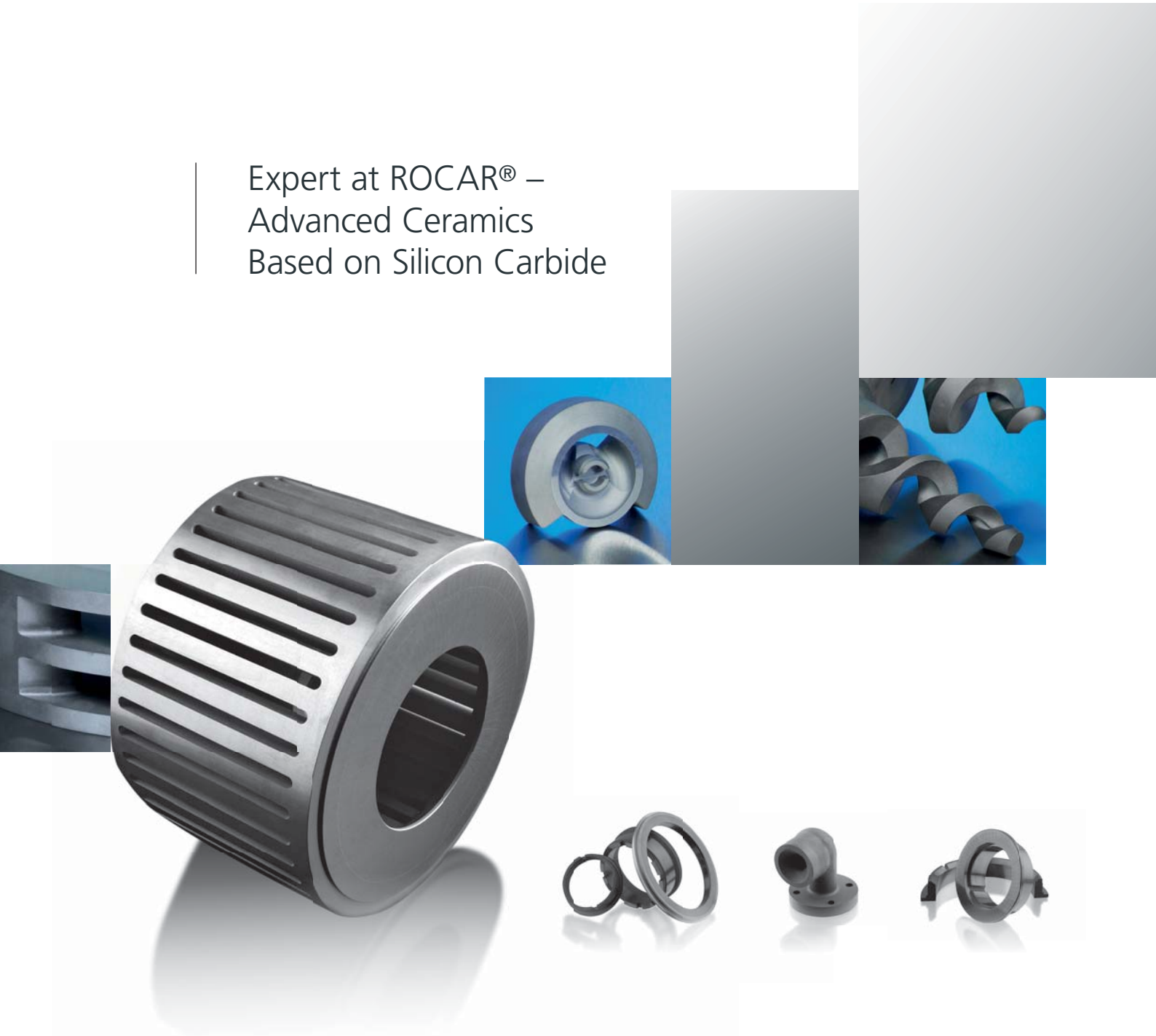
ROCAR®
Silicon Carbide

Special Materials
for Machines and Devices

CeramTec
THE CERAMIC EXPERTS

CeramTec Czech Republic, s.r.o.

Expert at ROCAR® – Advanced Ceramics Based on Silicon Carbide



Production at CeramTec Czech Republic, s.r.o. started in 1994 when the mother company of CeramTec moved the production of technical, SiC-based ceramics from Selb (Germany) to Šumperk (CR).

A few years later, as production expanded, a second production line for sealing discs used in water faucets was built. Currently, it represents one of the largest production capacities in its branch. The core of the production is grinding, polishing, and ofinal inspection of aluminium oxide discs (Al_2O_3).

Today, the plant in Šumperk with more than 300 employees is one of the largest subsidiaries of the German group of CeramTec, and it is the only plant that specializes in customizing advanced silicon carbide production under the brand name **ROCAR®**.

CeramTec – worldwide producer and supplier

AMERICA
The USA
Brazil
Mexico

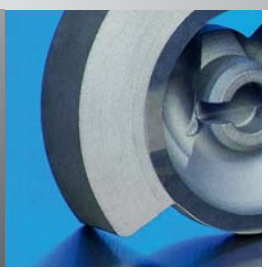
EUROPE
Germany
France
Great Britain
Italy
Poland
Russia
Scandinavia
Spain
The Czech Republic

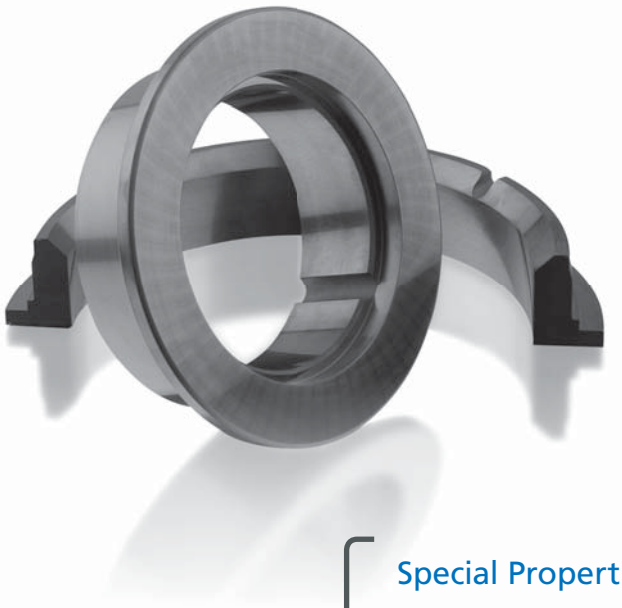
ASIA
China
Korea
Malaysia
India

Silicon Carbide from ROCAR®

Material for Special Applications

Slicon carbide belongs to the group of non-oxide ceramic materials, and is one of the hardest industrially-produced materials.





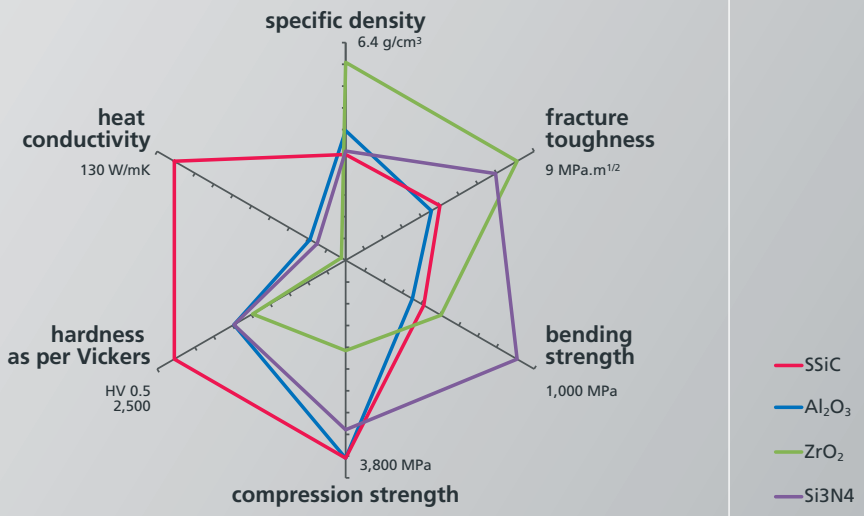
Silicon carbide gained its extraordinary hardness thanks to the homopolar bond between the atoms of silicon and carbon. This strong bond also causes its high elasticity and extremely low thermal expansion.

Silicon carbide also has high thermal conductivity and strength that is almost constant in a wide temperature range.

Regarding its electrical properties, silicon carbide belongs to the group of semiconductive materials.

Special Properties of Silicon Carbide

High heat resistance 1,350/1,800 °C.
Corrosion resistance.
Extremely high hardness.
High strength in all temperature ranges (from – 100 °C to + 1,800 °C).
Excellent thermal conductivity.
Low thermal expansion.
Low specific density.



Reaction Bonded Silicon Carbide **RBSiC/SiSiC**

In this material, the porous cavities of the original matrix structures of SiC are filled with metal silicon during the so-called infiltration firing process. Secondary SiC is created in this phase and the material gains perfect mechanical properties and wear resistance.

Thanks to the minimal firing shrinkage, it can be used even for the production of large, complex components while achieving fine tolerances. The amount of silicon, however, limits the max. operating temperature to 1,350 °C and also the chemical resistance is limited up to pH 10.

Material Grades:
ROCAR® SiG, ROCAR® SiF
ROCAR® Therm G, ROCAR® Therm F

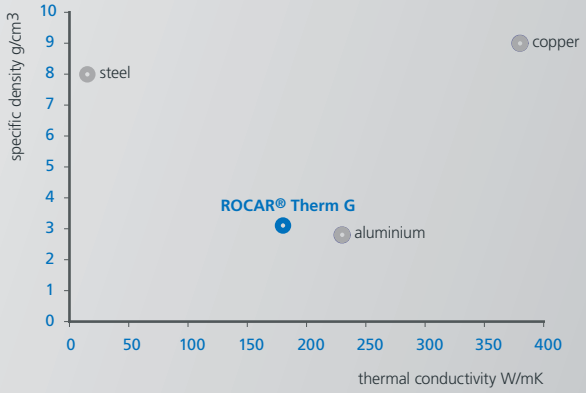
Sintered Silicone Carbide **SSiC**

Sintered silicon carbide is created when pre-pressed and very soft SiC granulate is sintered at a temperature of more than 2,000 °C, when very strong sintering bonds between the material grains are formed.

Firstly, there is lattice densification, then the porosity is lowered, and finally, sintering bonds between the grains of SiC are formed. This firing process has considerable product shrinkage of about 20 %.

The final material is single-phase with higher hardness, heat and chemical resistance than SiSiC.

Material Grades:
ROCAR® S1
ROCAR® G5



material	thermal conductivity W/mK	specific density g/cm³
ROCAR® Therm G	180	3.1
steel	15	8
aluminium-based alloys	230	2.8
copper	380	9

Silicon Carbide from ROCAR®

Material for Advanced Applications

Thanks to its balanced properties, Silicon Carbide ROCAR® finds a wide range of use in many kinds of industries, power engineering, environmental protection, food industry, pharmaceuticals, and ballistic protection of people and vehicles.

Measuring wheel
for measuring the parameters
of combustion products

Tubes and piping
for aggressive media
or combustion products

Spiral nozzle
with flange
for abrasive liquids

Seal Rings of Mechanical Seals

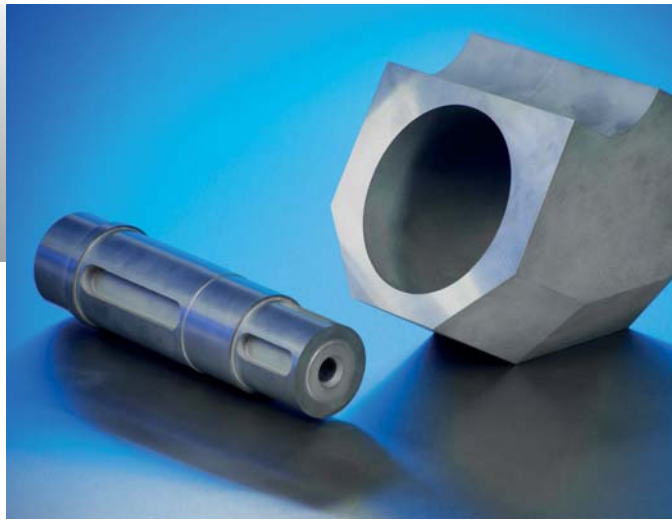
Thanks to its perfect properties, silicon carbide is a good material for tribological applications.
We specialize in the production of sealing rings for advanced application – compressor seals, gas seals, sealings for water turbines and ship propulsion units (normal and jet), and other very specific types of seal rings. Monolithic rings from ROCAR® for ship shaft seals with a diameter of more that 1,000 mm are considered to be unique all over the world.

Journal Bearings

Axial and radial pump sliding bearings made using ROCAR® material are good solutions, and sometimes the only possible solution, for highly abrasive or chemically aggressive media. The material of ROCAR® G5 that contains graphite finds a wide range of uses as graphite improves the friction properties and resistance of the bearings in modes of insufficient lubrication, and substantially decreases the friction forces when starting the pump.

Nozzles

Thanks to its excellent chemical resistance and resistance to abrasion, nozzles made from ROCAR® SiG or ROCAR® S1 material are suitable for demanding operating conditions in the chemical or power engineering industry. High-power spiral or tangential spraying nozzles with a long lifespan are commonly installed in the desulfurization units of coal power plants. The nozzles are supplied in flanged or threaded versions.



Ballistic Protection

Very high hardness, mechanical strength, low specific density, and affordable price make silicon carbide, especially the SSiC version, a modern material used for constructing ballistic protection for people, vehicles, and planes.

Machine Parts, Special Production

Silicon carbide can be widely used in mechanical engineering. In cases when common materials are overloaded and have only a short lifespan, or they cannot be used at all – e.g. chemical corrosion, abrasion, high temperatures, or compression stress – these are typical situations when silicon carbide can outdo the original materials significantly, even during combined load. Materials from ROCAR® are certified by FDA for direct contact with food stuffs.

Optical Devices

It is convenient to use silicon carbide from ROCAR® for supporting structures of very precise optical apparatuses as it has negligible heat expansion, low specific density, and high rigidity.

Thermal Technology

ROCAR® Therm G and F materials, due to their very high heat conductivity, are suitable for the construction of heat exchangers in the chemical industry, or cooling devices and devices used for indirect gas and liquid heating. Burner tips made of silicon carbide are a popular solution in gas ovens.
Our coal burners that are stressed by high temperatures and abrasive coal powder are used in the power engineering industry.

Silicon Carbide from ROCAR®
Production Process

We have optimalized our production processes for different materials and achieved a high standard of reliability over the years.

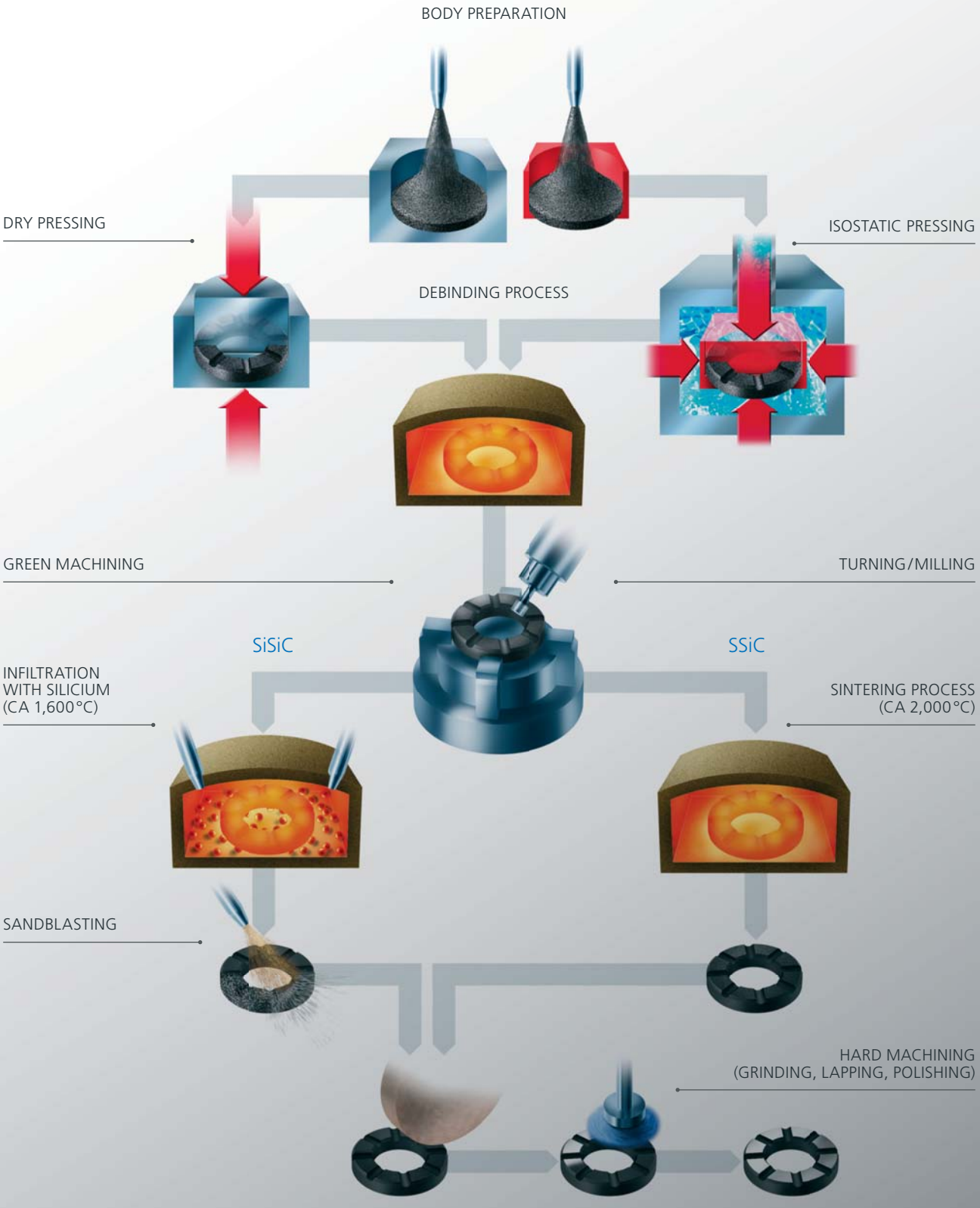
Thanks to perfect mastery of our production technologies, we are able to produce components made of SiSiC up to a diameter of 1,000 mm and with a length of 950 mm. SSiC components are limited to a diameter of 700 mm and a length of 700 mm.

We achieve optimal results in designing products and systems because of our experience and close cooperation with our customers. That is why we can minimalise production costs from the beginning.

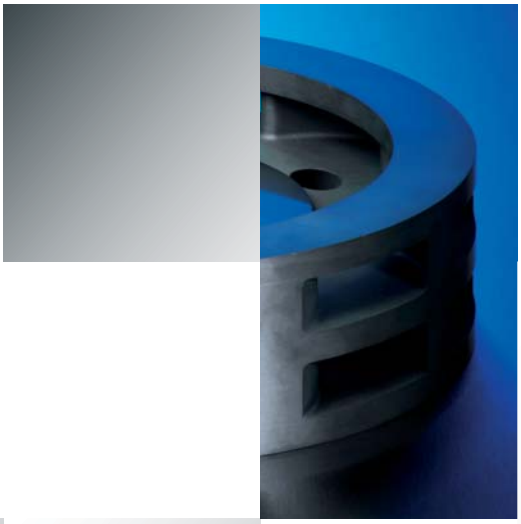
Testing samples and prototypes are produced, tested, and developed for mass production in our development department.

Serial Production

Small Series Production
(Single-Part Production)



Silicon Carbide from ROCAR®
Quality Management

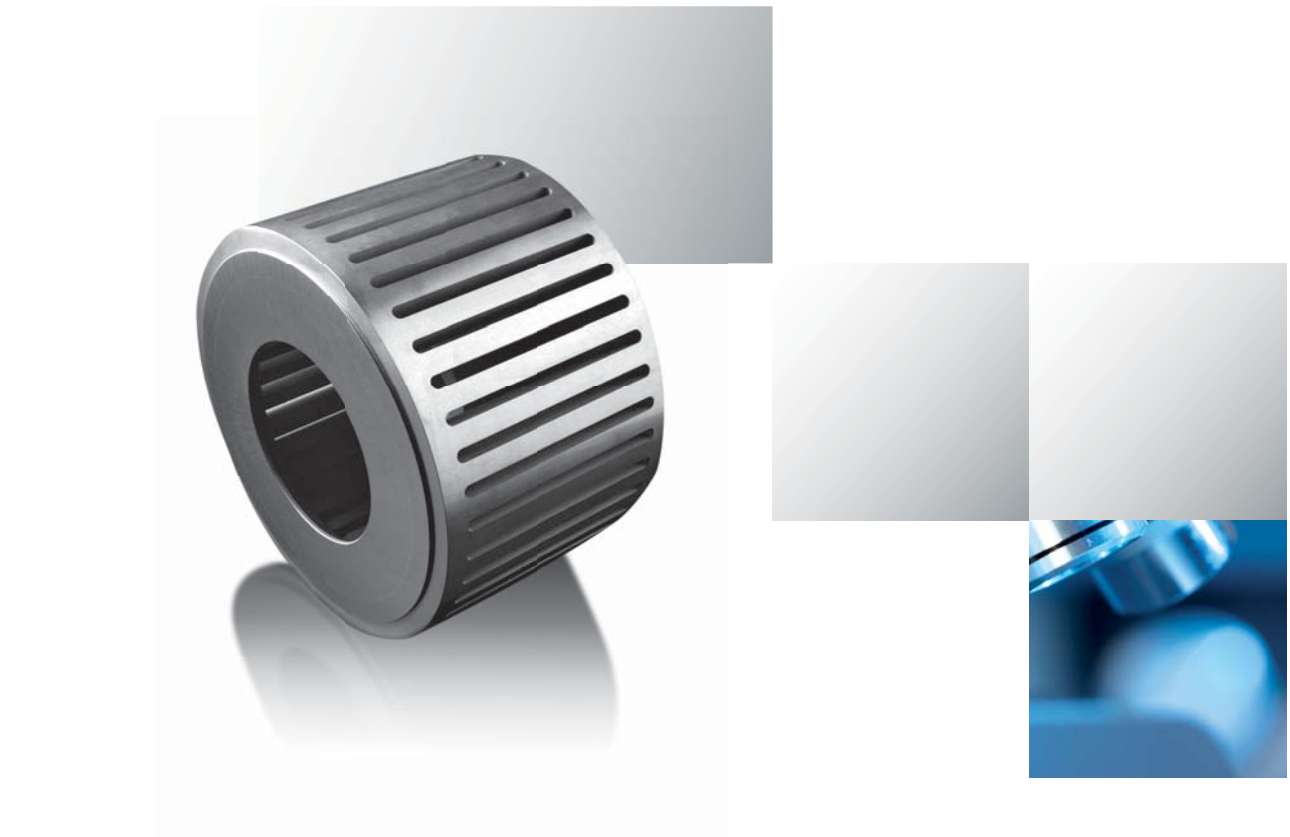


The excellent characteristics of our materials and their applications are constantly optimalized in our laboratories, which enhances our technological advancement.

Nowadays we have advanced, cost-effective, development, and production technologies.

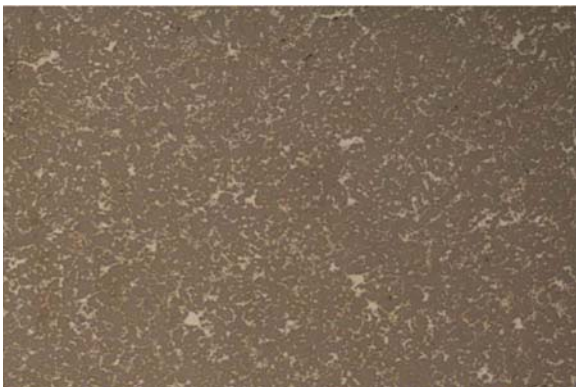
Based on the ISO 9001 quality system and ISO 14001 environmental protection, we use the latest techniques of company management.

Thanks to our advanced processes and monitored procedures, we produce customized mass production with the same accuracy as small series production and sample parts.



Microstructures

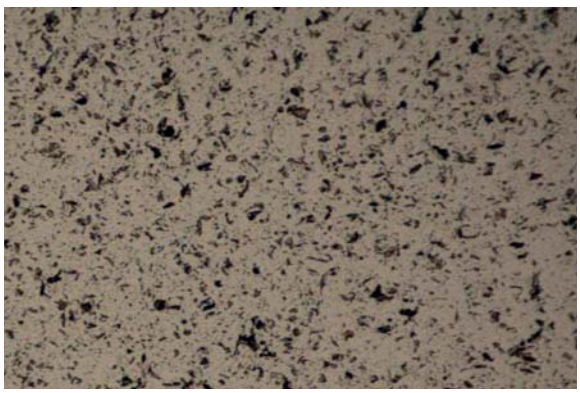
ROCAR® SIG



ROCAR® SIF

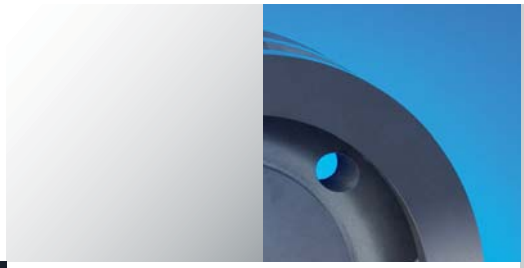
ROCAR® S1

ROCAR® G5



Silicon Carbide from ROCAR®

Excellent Properties



Silicon carbide is extremely hard and shows excellent corrosion and heat resistance.

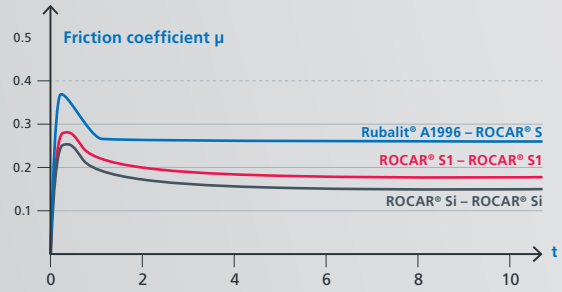
Its perfect friction properties and high heat conductivity make it an ideal tribological material, especially for mechanical seals.

	Brand	Material	Specific density	Closed porosity (approximately)[2]	Bending strength at 20 °C	Compression strengt	Young's modulus of elasticity	Vickers hardness HV 0.5	Fracture toughness K_{IC}	Weibull modulus	Poisson's ratio
	Material characteristics		General properties		Mechanical properties						
	Units		g/cm³	Vol. [%]	MPa	MPa	GPa		MPa m$^{1/2}$		
	Test values		DIN EN 623-2		DIN EN 843-1	DIN 51067T1	DINV ENV 843-2	DINV ENV 843-4	DIN 51109	DINV ENV 843-5	DINV ENV 843-2
Silicon carbide	**ROCAR® S1**	SSiC	3.15	2	410	3,500	430	2,300	4.1	> 10	0.17
Silicon carbide	**ROCAR® G5** with 5% graphite	SSiC	3.00	2	240	2,000	360	2,100	2.6	> 10	
Silicon carbide	**ROCAR® SiG**	SiSiC/RBSiC	3.07	0	340	3,500	380	two-phase mat.[1]	4	> 14	0.17
Silicon carbide	**ROCAR® SiF**	SiSiC/RBSiC	3.07	0	350	3,500	395	two-phase mat.[1]	4	> 14	0.17
Silicon carbide	**ROCAR® Therm G**	SiSiC/RBSiC	3.07	0	340	3,500	380	two-phase mat.[1]	4	> 14	0.17
Silicon carbide	**ROCAR® Therm F**	SiSiC/RBSiC	3.07	0	350	3,500	395	two-phase mat.[1]	4	> 14	0.17

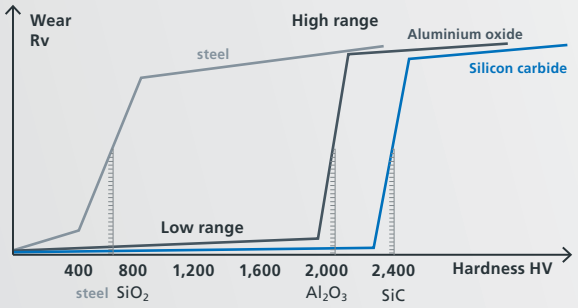
[1] HV 0.2 1200 (Si)/2700 (SiC)

[2] None of the materials has open porosity (water absorption 0 %)

Tribological conditions in a disc/disc system: comparison of pairs made of different materials



Wear – relation of low/high range: comparison of different materials



SSiC

SSiC is resistant to most chemical media. As no metal silicon is present in the structure, it can be used at temperatures up to 1,800 °C without any impact on its mechanical properties. Our new ROCAR® S1 is optimalized for mass production using the dry-pressing process, which enables high process reliability at lower production costs.

SiSiC

For SiSiC material, the originally porous cavities are filled during the firing process with metal silicon. Because of the negligible shrinkage in the firing process, complex components with small tolerances can be produced. Its maximum operating temperature is 1,350 °C. Nevertheless, it is not suitable for strong alkali media due to the content of metal silicon.

Heat conductivity at 20–100 °C	Factor of linear heat expansion of 20–200 °C	Factor of linear heat expansion of 20–400 °C	Factor of linear heat expansion of 20–600 °C	Factor of linear heat expansion of 20–1,000 °C	Heat capacity Cp 20–100 °C	Heat capacity Cp 1,000 °C	Resistivity at 20 °C	Resistivity at 400 °C	Resistivity at 800 °C	Maximum temperature for use in oxidizing environment	Maximum temperature for use in reducing or inert environment	CeramTec material No.
Thermal and electrical properties												
W/mK	10^{-6} K^{-1}	10^{-6} K^{-1}	10^{-6} K^{-1}	10^{-6} K^{-1}	KJ/kgK	KJ/kgK	Ω cm	Ω cm	Ω cm	°C	°C	
DIN EN 821-2	DIN EN 821-1	DIN EN 821-1	DIN EN 821-1	DIN EN 821-1	DINV ENV 821-3	DINV ENV 821-3	IEC 672-1	IEC 672-1	IEC 672-1			
115	3	3.6	4.1	4.6	0.6		1.10^3	< 10		1,500	1,800	333
104	4.1	4.4	4.5	4.9	0.7					1,500	1,800	350
115	3.4	4.1	4.4	4.9	0.7	1.3	< 1	0.024	0.034	1,350	1,350	678
120	3.8	4.3	4.5	4.9	0.7	1.3	< 1	0.035	0.055	1,350	1,350	780
180	3.9	4.2	4.3	4.7	0.8		0.018	0.027	0.037	1,350	1,350	685
190	4.1	4.3	4.4	4.8	0.8		0.055	0.062	0.053	1,350	1,350	785

Values and properties of ceramic materials:
Typical values were used to present the individual materials. The crystal structure of these materials, statistical deviations in composition, and the influence of production processes can cause changes in parameters, so the values mentioned above are only informative, common values, and they cannot be guaranteed.

Corrosion Resistance
SiSiC and SSiC

Medium	Solution concentration in %	SiSiC		SSiC	
		20 °C	50 °C	20 °C	50 °C
Acetone	Concentrated	+	+	+	+
Aluminium chloride	10	+	+	+	+
Formic acid	Concentrated	+	+	+	+
Ammonia	Concentrated	+	(+)	+	+
Ammonium chloride	25	+	+	+	+
Ammonium fluoride	20	(+)	0	+	+
Ammonium nitrate	50	+	+	+	+
Benzene	Concentrated	+	+	+	+
Boric acid	Cold saturated solution	+	+	+	+
Calcium oxide	Cold saturated solution	+	+	+	+
Citric acid	50	+	+	+	+
Chromosulfuric acid	Concentrated	+	+	+	+
Iron (III) chloride	45	+	+	+	+
Iron (II) sulfate	25	+	+	+	+
Glacial acetic acid	Concentrated	+	+	+	+
Ethanol	Concentrated	+	+	+	+
Ethyl acetate	Concentrated	+	+	+	+
Fluorhydric acid	Concentrated, 40	(+)	0	+	+
Fluorhydric acid + nitric acid	Concentrated, 3:1	0	0	+	(+)
Urea	Cold saturated solution	+	+	+	+
Potassium hydroxide	30	0	0	+	(+)
Potassium hydroxide	20	(+)	0	+	0
Potassium chloride	Cold saturated solution	+	+	+	+
Potassium chromate	35	+	+	+	+
Potassium nitrate	20	+	+	+	+
Potassium permanganate	5	+	+	+	+
Aqua regia	Concentrated, 3:1	+	+	+	+
Copper (II) chloride	40	+	+	+	+
Copper (II) sulfate	20	+	+	+	+
Lithium hydroxide	10	+	(+)	+	+
Magnesium sulfate	4	+	+	+	+
Methanol	Concentrated	+	+	+	+

Medium	Solution concentration in %	SiSiC		SSiC	
		20 °C	50 °C	20 °C	50 °C
Mixed acid	Concentrated, 1:1	+	+	+	+
Sodium carbonate	15	+	+	+	+
Sodium chloride	Cold saturated solution	+	+	+	+
Sodium fluoride	4	+	(+)	+	+
Sodium hypochlorite	12,5 % of free Cl	+	+	+	+
Sodium tetraborate	20	+	+	+	+
Sodium peroxide	10	+	+	+	+
Trisodium phosphate	10	+	+	+	+
Sodium sulfide	50	+	+	+	+
Sodium thiosulfate	40	+	+	+	+
Sodium hydroxide	10	(+)	0	+	(+)
Sodium hydroxide	30	0	0	+	0
Oleic acid	Concentrated	+	+	+	+
Oxalic acid	Cold saturated solution	+	+	+	+
Phosphoric acid	Concentrated, 85	+	+	+	+
Phthalic acid	Alcohol solution	+	+	+	+
Propionic acid	Concentrated	+	+	+	+
Mercury (II) nitrate	10	+	+	+	+
Nitric acid	Concentrated, 65	+	+	+	+
Salt acid	Concentrated, 36	+	+	+	+
Fuming sulfuric acid	30 of free SO_3	+	+	+	+
Sulfuric acid	Concentrated, 98	+	+	+	+
Sulfuric acid	50	+	+	+	+
Sulfurous acid	5–6 of free SO_2	+	+	+	+
Silver nitrate	10	+	+	+	+
Tetrachloroethylene	Concentrated	+	+	+	+
Carbon tetrachloride	Concentrated	+	+	+	+
Hydrogen tetrafluoroborate	Concentrated	(+)	(+)	+	+
Hydrogen peroxide	30	+	+	+	+
Tartaric acid	10	+	+	+	+
Zinc chloride	60	+	+	+	+

+ = no corrosion (+) = corrosion possible 0 = corrosion occurs

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