

HALSIC R / RX / I / S

Silicon Carbide Special Materials



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HALSIC is the name of four exceptional high-performance ceramics from the silicon carbide (SiC) material group made by W. HALDENWANGER. They share the following characteristics: absolute

dimensional stability despite extreme mechanical strain in high temperature applications – very good thermal shock resistance – excellent high corrosion resistance – low specific weight.

HALSIC-R

- recrystallized silicon carbide (RSiC)
- compact SiC matrix with open porosity
- classic ceramic for high-temperature constructions
- large-sized components possible
- reliable bonding of coatings
- application temperatures: 1600°C (oxidizing) and approx. 2000°C (under protective atmosphere)
- resistant against strong acids and alkalis

HALSIC-I

- silicon-infiltrated reaction-bonded silicon carbide (SiSiC)
- reaction-bonded SiC matrix, free of pores, with residual metallic silicon
- high-temperature ceramic for highest mechanical loads
- excellent good oxidation resistance
- large-sized components possible
- application temperatures: up to 1350°C
- corrosion resistant against strong acids and alkalis

HALSIC-RX

- chemically-doped recrystallized silicon carbide (RSiC_{doped})
- compact SiC matrix with open porosity
- excellent oxidation resistance
- multiply-increased life time compared to HALSIC-R
- ideal material for porcelain fast-firing
- large-sized components possible
- reliable bonding of coatings
- application temperatures: up to 1650°C (oxidizing)

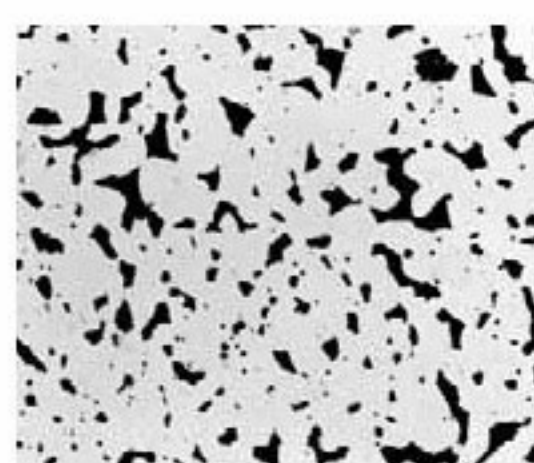
HALSIC-S

- pressureless sintered silicon carbide (SSiC)
- dense sintered SiC matrix with very low percentage of closed pores
- high-temperature ceramic for extreme mechanical loads
- excellent oxidation resistance
- application temperatures: up to 1600°C
- corrosion resistant against strong acids and alkalis

PHYSICAL PROPERTIES * OF W. HALDENWANGER HALSIC MATERIALS

	Units	HALSIC-R RSiC recrystallized	HALSIC-RX RSiC _{doped} chemically doped	HALSIC-I SiSiC reaction bonded silicon infiltrated	HALSIC-S SSiC pressureless sintered
Contents: SiC metallic Si	vol %	≥ 99	≥ 99 ¹⁾	88 – 92 12 – 8	≥ 99
Density 20°C	g/cm ³	2.7	2.7	3.1	3.1
Water absorption capacity	weight %	5	5	≤ 0.1	≤ 0.1
Flexural strength at 20°C ²⁾	MPa	80 – 100	80 – 100	240 – 280	350 – 400
Flexural strength at 1300°C ³⁾	MPa	90 – 110	90 – 110	250 – 300	370 – 420
Thermal expansion 20 – 1000°C, linear	10 ⁻⁶ K ⁻¹	4.5	4.5	4.3	5.0
Thermal conductivity 200°C ⁴⁾	Wm ⁻¹ K ⁻¹	35	35	100	124
Thermal conductivity 1200°C ⁴⁾	Wm ⁻¹ K ⁻¹	26	26	32	33
Young's modulus, static 20°C	GPa	280	280	370	420 _{dyn}
Thermal shock resistance	-	very good	very good	very good	very good
Maximal application temperature ⁵⁾	°C	approx. 1600 ⁶⁾ approx. 2000 ⁷⁾	approx. 1650 ⁶⁾	approx. 1350	approx. 1600

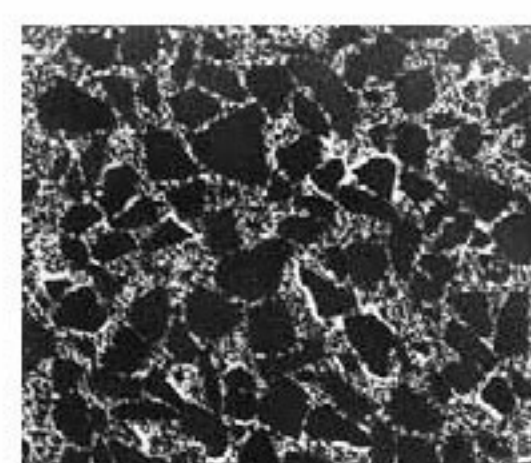
* The physical properties listed above are derived from test specimens. These values can only be used as a reference to technical products and other forms and dimensions.
1) incl. chemical doping agents, 2) 4-point flexural strength, 3) 3-point flexural strength, 4) laser flash method, 5) depending on mechanical load and atmosphere, 6) in oxidizing atmosphere, 7) in protective atmosphere



HALSIC-R

recrystallized SiC
compact SiC matrix with
characteristically open
and comparatively coarse
pore structure

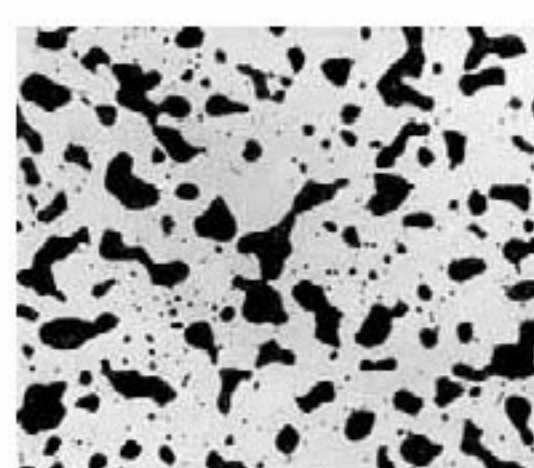
HALSIC-R (RSiC) 200 μm



HALSIC-I

reaction-bonded
silicon-infiltrated SiSiC
SiSiC microstructure of pores devoid
with reaction-bonded SiC matrix (grey)
and infiltrated metallic silicon (white)

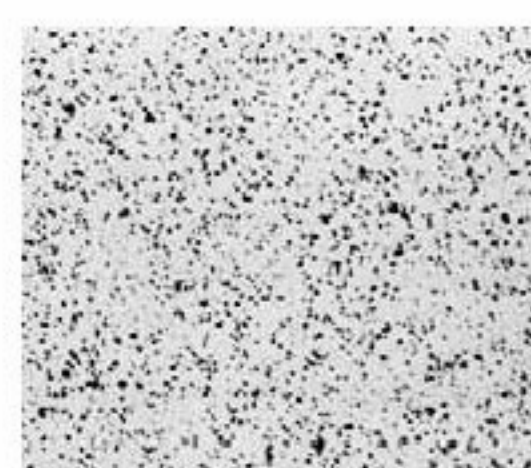
HALSIC-I (SiSiC) 50 μm



HALSIC-RX

recrystallized and doped SiC matrix
of a supporting beam after approx.
2000 cycles in a porcelain fast-firing
application (1420°C, 5 – 7 h cold-
cold): completely intact SiC matrix
with rounded pores

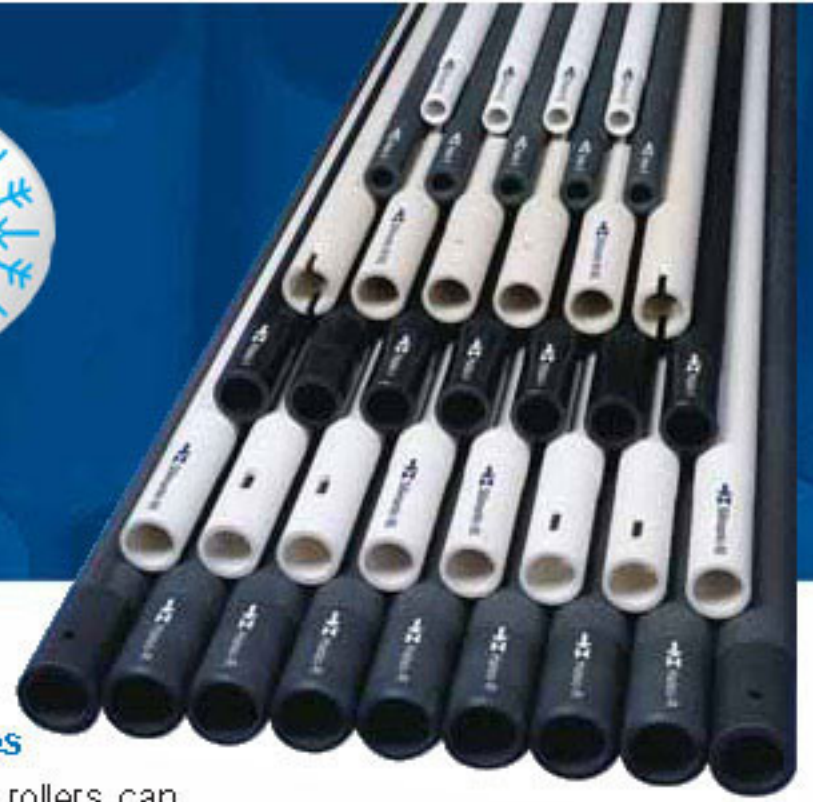
HALSIC-RX (RSiC_{dop}) 200 μm



HALSIC-S

pressureless sintered SSiC
SiC microstructure with closed
porosity and characteristically
fine pore distribution of pores

HALSIC-S (SSiC) 50 μm



Beams and Profiled Supports

Beams and profiled supports in the quality HALSIC-I are used for single- and multilayered firing of larger ceramic components up to a temperature of 1350°C (e.g. sanitary fixtures, high-tension insulators, bricks, larger stone ware or earthenware, etc.). Beams and profiles can be used up to a temperature of approx. 1600°C for HALSIC-R or 1650°C for HALSIC-RX (e.g. porcelain industry, technical ceramics, etc.).



Hollow profiled supports in the above-mentioned qualities can be produced in different cross-sections and up to a length of 3500 mm. They are used as single supports with high load-carrying ability, system-building structures for kiln cars or as load support components for furnace construction and mechanical engineering. The possibility of a long free span of HALSIC beams allows maximization of usable setting space in the kiln.



The combination of different materials for the setups in kilns, such as

- a) cordierite posts, HALSIC-I beams and cordierite batts for the firing of sanitary fixtures –
- b) cordierite posts, HALSIC-I profile beams and Sillimantin tubes for the brick industry –
- c) oxide-bonded SiC pillars and HALSIC-RX beams for the production of insulators, etc., allows sophisticated and economic solutions.

Rollers and Tubes

HALSIC-I rollers can be used up to temperatures of 1350°C, those made of HALSIC-R to 1600°C and HALSIC-RX even up to 1650°C. Due to their high load-bearing ability they can be used in roller kilns for the production of sanitary fixtures, porcelain, heavy clayware and technical ceramics even at very high temperatures and in highly-oxidizing atmospheres.

In applications of heat treatment of metals and sintering of metal powder compacts, in which silicon carbide and metal are in direct contact, precautionary measures are required. At temperatures above 900°C, SiC in contact with various alloys will react chemically and the reaction process will damage or destroy the SiC as well as the metal. This is facilitated by the formation of low-melting eutectics. This process is largely independent of the furnace atmosphere, although extremely low oxygen levels as under strongly reducing conditions and in inert atmospheres can increase the severity of the damage.

In addition, structural SiC-parts carrying a mechanical load can be combined with and protected by oxide ceramics less susceptible to damage than SiC. They complete the roller programme of **W. HALDENWANGER**. With a total of ten different materials, we produce the world's widest range of ceramic rollers. These materials are:

Sillimantin 60, Sillimantin 65, Sillimantin 60 NG, Quarzgut (fused silica), Pythagoras and Korund-Mullit (corundum-mullite), HALSIC-I, HALSIC-R, HALSIC-RX and plasma coated HALSIC.

In order to insert the rollers into the mechanical drive systems, their ends can be ground and/or drilled (round or elongated holes, slots, etc.). Standard rollers in the described materials can be manufactured in diameters from 20 to 60 mm and lengths of over 3300 mm.

Tubes with a closed end in the qualities HALSIC-I/HALSIC-S (impermeable) and HALSIC-R/HALSIC-RX (porous) can be used e.g. as thermocouple protection sheaths or radiant heater tubes. These tubes can also be supplied with a flange. Tubes with aligned bores are used as burner or cooling tubes.



Batts and Plate Setters

Kiln furniture made of HALSIC-R and HALSIC-RX possesses excellent dimensional stability and is especially suitable for fast-firing cycles due to its high thermal conductivity. In general, batts are rectangular, but setting rings and plate setters are increasingly being used in porcelain production.

Batts can be manufactured in dimensions of over 3000 cm² and have a thickness of 5 to 8 mm, depending on their size. HALSIC-R and HALSIC-RX kiln furniture is completely free of any grain fall. If required they can be supplied with a coating on one or on both sides. With the development of HALSIC-RX, we have succeeded in developing a material with which has a life several times longer than the standard RSIC.

For special applications we supply HALSIC batts with reinforced corners and with holes for the mechanical connection of batts in a roller kiln (porcelain fast-firing). In addition, we manufacture batts with a rim on one or all sides.

For applications requiring extremely level surfaces and high-quality finishes, we can also supply ground batts.



Special Parts

In addition to the described standard product geometries, our materials can be manufactured in a large variety of different shapes and sizes.



According to the application and temperature, the impermeable materials HALSIC-I (1350°C) and HALSIC-S (1600°C) or the porous materials HALSIC-R (1600°C) and HALSIC-RX (1650°C) are available.

Typical applications for HALSIC special parts in industrial engineering are parts for burners, heat exchangers and high-temperature construction components, not to forget the use in mechanical engineering when operating conditions require a material with resistance against temperature, oxidation, corrosion or abrasion.

Furthermore, HALSIC materials possess excellent mechanical strength and thermal conductivity, as well as extreme hardness and outstanding thermal shock resistance.





Mechanical Treatment

Products made of HALSIC special materials are used as construction components for furnace construction and mechanical engineering, as kiln furniture for automated kilns, or as mechanical components. In order to meet the required tight tolerances of the finished products, HALSIC products often have to undergo mechanical machining. This can be done either before firing in the green stage or after firing, using diamond tools.

The most common machining methods are cutting into lengths, grinding, drilling and slotting. In addition, we perform cylindrical and surface grinding, as well as finishing of surfaces.



Machining: grinding

Quality Management System

The consistently high standard of our HALSIC products is guaranteed by comprehensive quality management. It corresponds to the international standard ISO EN 9001 and has been certified accordingly.

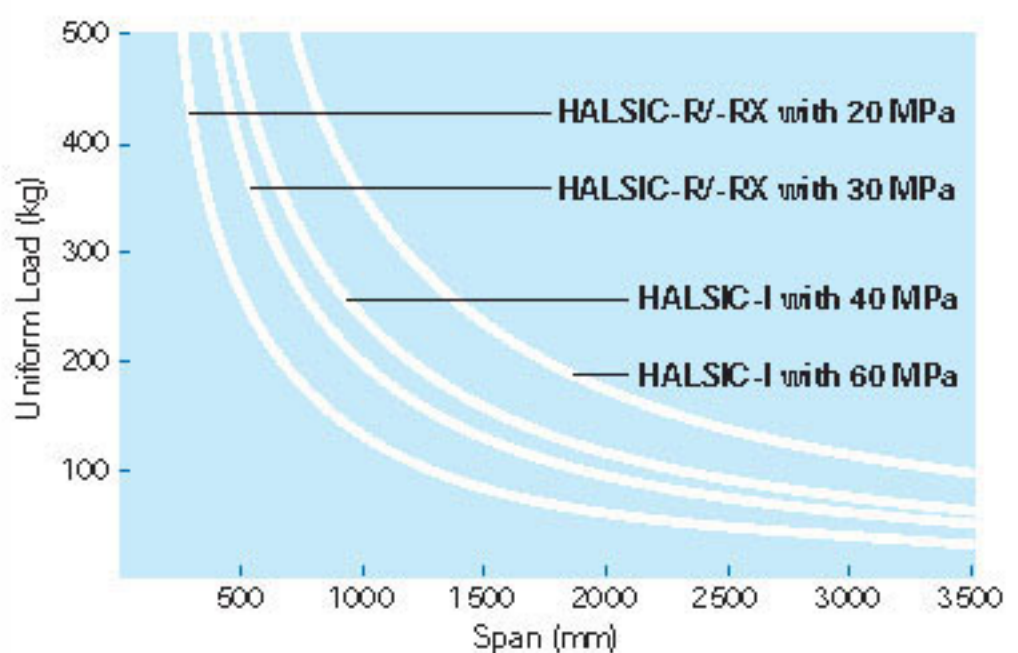


Calculation of Kiln Furniture Constructions

The use of HALSIC kiln furniture requires careful calculation for all supporting components. We carry out these static calculations for our customers, and together with them, we determine the required cross-sectional dimensions of the components for their specific application.

Compared to metals, ceramic materials have a wider range of physical properties. Thus an increased factor of safety is necessary. Depending on the application, a multiple factor of safety is used for the dimensioning of beams and rollers, which will be shown by an example.

The load diagram shows the interdependence of the loaded length to the span, based on a maximum flexural strength of 20 and 30 MPa for HALSIC-R/RX and 40 and 60 MPa for HALSIC-I. The lower flexural strength values provide an increased safety factor for the component.



Load diagram (beam cross section 40 x 40 mm)



Thermocouple Protective Sheaths

The increased requirements in the field of temperature measurement at elevated temperatures under extreme conditions have led to the development of protective sheaths made of high-purity SiC materials. They are the porous materials HALSIC-R and HALSIC-RX and the impermeable materials HALSIC-I and HALSIC-S. Due to their excellent properties, thermocouple protective sheaths in these qualities allow a long service life even for demanding applications.

Common Material Properties

- excellent resistance against erosion and corrosion
- high mechanical strength
- extreme high thermal resistance

HALSIC-I:		1350°C
HALSIC-R:	(oxidizing atmosphere)	1600°C
HALSIC-R:	(protective atmosphere)	> 2000°C
HALSIC-RX:	(oxidizing atmosphere)	1650°C
HALSIC-S:		1600°C

- excellent thermal conductivity
- outstanding thermal shock resistance
- excellent oxidation resistance
- outstanding resistance against acids
- good resistance against alkalis



Application Examples

Thermocouple protective sheaths for temperature measurement under extensive dust pollution, corrosive surroundings and high temperatures:

- boilers and furnaces of all kinds
- flue gas channels
- firing chambers
- flue gas desulphurizing and free from NOx plants

Thermocouple protective sheaths for temperature measurement in molten metals:

- tin
- lead
- zinc
- aluminium (only applicable with a plasma coating)

TABLE WITH STANDARD DIMENSIONS

HALSIC-R/-RX Outer sheath O x l Ø mm	HALSIC-R/-RX Maximum lengths mm	HALSIC-I Outer sheath O x l Ø mm	HALSIC-I Maximum lengths mm
20 x 10	1350	20 x 13	2000
25 x 15	1800	25 x 18	2000
30 x 20	1850	30 x 20	2000
34 x 24	2100	34 x 24	2250
40 x 28	2250	40 x 30	2500
55 x 41	2250	55 x 42	2500
60 x 46	2250	60 x 46	2500

Different diameters and lengths can be made on request.

Електролукс
Битола



Variety
TUBES

Excellent Surface Finish
FUSED SILICA ROLLERS

Tradition
LABORATORY PORCELAIN



Long Service Life
ROLLERS

High Performance
HALSIC

Flexibility
SPECIALITIES



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