Ceramic Armor Protection Systems

High performance, lightweight materials for composite armor protection applications

SAINT-GOBAIN
CERAMICS

Saint-Gobain Ceramics

The materials of choice for today's armor protection systems

Saint-Gobain Ceramics offers more than 40 years of experience, including Carborundum and Norton technologies, in the development of high performance materials for composite armor systems. Our product lines feature a variety of sintered, reaction-bonded and hot pressed ceramic materials including:

- Hexoloy® Silicon Carbide (SiC)
- CRYSTAR RB® & Silit SKDH® Reaction Bonded SiC
- Norbide® Hot Pressed Boron Carbide
- Alumina
- ZTA
- Reinforcements
- Transparent materials

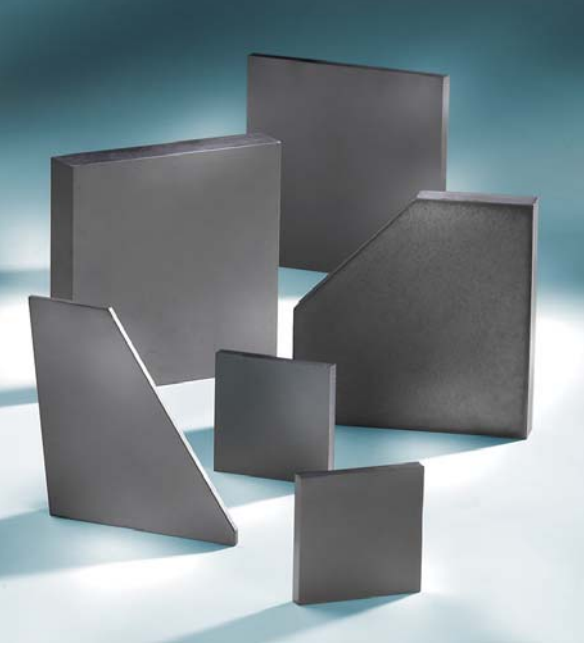
A Choice Of Ceramic Materials To Meet Your Needs

Saint-Gobain Ceramics offers a wide range of ceramic materials to meet your armor application requirements.

Hexoloy® Silicon Carbide (SiC)

Hexoloy SiC is a pressureless, sintered form of alpha silicon carbide with a density greater than 98 percent theoretical. It has a very fine grain structure (less than 10 microns) for excellent wear resistance and contains no free silicon, which makes it highly chemical resistant. No other commercially available material offers the performance advantages of Hexoloy SiC including:

- **High Hardness.** The hardest material commercially available.
- **Light Weight.** Weighs less than half of most metal alloys, 40 percent as much as steel and about the same as aluminum.
- **High Strength.** Extremely high strength and excellent resistance to creep and stress rupture at temperatures up to 1650°C (3000°F)
- **Design Flexibility.** Net shape manufacturing capabilities eliminate costly machining operations.



Proven Performance In Demanding Armor applications

Saint-Gobain Ceramics' armor protection history includes the delivery of more than 46,000 variable armor system vests to US Army soldiers in Vietnam during the late 1960s. Since then, we have developed numerous SiC and B4C armor protection systems with superior ballistic capability for defeating high velocity projectiles for a full range of applications including:

- Transport Aircraft
- Helicopters
- Land Vehicles
- AC-130U Gunships
- Body Armor

Reaction Bonded SiC (CRYSTAR® RB & Silit® SKDH)

These materials offer excellent strength oxidation resistance, high modulus and high sonic velocity. They can be molded to a great variety of shapes and sizes. For example, monolithic plates of up to 30" x 30" are available.

Norbide® Boron Carbide

Norbide® Boron Carbide, the third hardest material known to man, offers light weight, near theoretical density and can be custom engineered to exacting specifications.

Aluminum Oxide

Our aluminum oxide products are the hardest and most rigid of common oxide ceramics.

A Full Complement of Related Armor Materials

Saint-Gobain Ceramics offers a full array of materials for a complete armor system, including transparent armor, reinforcements and composites. Product lines include Technical Fabrics, Vetrotex Twintex® and Saphikon® Sapphire.

Ceramic Material The Way You Need It

We can supply ceramic armor in the following forms:

- Finished components
- Unfinished, machined blanks
- Pressed near net shape components
- High volume pressed net shape components
- Complex, highly machined parts

Saint-Gobain Ceramic Materials For Armor Protection

Your Worldwide Source For Cost-Effective Ceramic Materials

Saint-Gobain Ceramics offers vast resources to meet your needs for silicon carbide armor protection materials. With representation in Asia by Norton KK (a Saint-Gobain company) and locations in Europe, Australia and South America, we can deliver your solution when you need it, where you need it, in virtually every corner of the world.

Physical Properties	Units	Hexoloy® Sintered	CRYSTAR® RB Reaction Bonded	Silit® SKD Reaction Bonded	Norbide® Hot Pressed	T196 Al_2O_3	T198 Al_2O_3	TZ3 Alumina Zirconia	Saphikon® Sapphire
Composition (Phases)		SSiC	SiSiC	SiSiC	B_4C	Al_2O_3	Al_2O_3	Al_2O_3 ZrO_2	Sapphire
Grain Size	µm	4-10	N/A	N/A	8	N/A	N/A	N/A	N/A
Density	g/cm_3	3.13	3.1	3.05	2.51	3.75	3.80	4.00	3.97
Hardness (Knoop 100 gram load)	kg/mm_2	2800	N/A	N/A	2800	2000	N/A	N/A	2200
Flexural Strength 4pt. @ RT Test bar size 3 x 4 x 45mm (0.118" x 0.157" x 1.772")	MPa x 10^6 lb/in^2	380 55	200	250	425	300	320	320	760-1035 110-150
Compressive Strength @ RT	MPa x 10^6 lb/in^2	3900 560	850	850	3900 560	>2000	>2000	>2000	2000
Modulus of Elasticity @ RT	GPa x 10^6 lb/in^2	410 59	300-380	300-380	440	300	380	340	435
Weibull Modulus (2 parameters)		10	~10	~10	N/A	N/A	N/A	N/A	N/A
Poisson Ratio		0.14	0.19	0.19	0.18	0.15	N/A	N/A	0.27-0.30
Fracture Toughness @ RT Double Torsion & SENB	MPa x m$^{1/2}$ x10^3 lb/in^2 /in$^{1/2}$	4.60 4.20	4.0	4.0	3.1	4	3.5	5.8	N/A
Coefficent of Thermal Expansion TR to 700°C	x10^{-6} mm/ mmK x 10^{-6} in/in°F	4.02 2.20	4.3 2.4	4.1	5	7.5	7.5	8	8.8
Max. Service Temp (air)	°C °F	1900 3450	1350 2460	1380 2516	600 1112	1700 3092	1700 3092	1500 2732	2000 3632
Mean Specific Heat @ RT	J/gmK	0.67	0.88 @ 200°C	0.88 @ 200°C	N/A	N/A	N/A	N/A	0.181
Thermal Conductivity @RT @200°C @400°C	W/m°K Btu/ft h°F	125.6 72.6 102.6 59.3 77.5 44.8	160	160	90	25	29	22	40
Electrical Resisitivy @RT @1000°C	ohm-cm	10^2-10^8 0.01-0.2	N/A	N/A	0.3	>10^{12}	>10^{12}	>10^{10}	>10^{16}
Emissivity	N/A	0.9	0.9	0.9	N/A	N/A	N/A	N/A	N/A

**N/A = Not Applicable or Not Available*

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