

# COMBAT®

## Boron Nitride Solids

### Unique Properties for High-Performance Industrial Applications

Combat® hot-pressed hexagonal boron nitride (hBN) ceramics exhibit unique combinations of chemical, electrical, mechanical and thermal properties, making it suitable for a wide range of high-performance industrial applications.

Combat® Boron Nitride's characteristics depend on the type and amount of binder, overall composition and the type of bond between layers. Backed with industry leading, international technical support from Saint-Gobain, Combat® provides a full spectrum of solutions in machinable blanks as well as custom finished shapes.

**COMBAT® A** - Uses boron oxide as a binder to create a hard, dense, yet easily machinable product best used in inert and dry environments. It is ideal for general purpose high-performance applications.

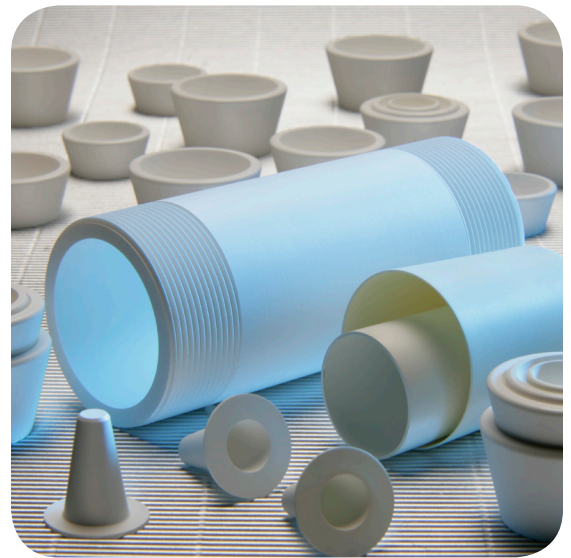
**COMBAT® HP** - Leverages hBN's outstanding thermal shock resistance with calcium borate glass's moisture resistance. HP is ideal for light metal processing application such as aluminum, magnesium and zinc, and excels in electrical insulation applications up to 1000°C.

**COMBAT® AX05** - Does not use any binder and is self bonded, offering the highest purity for high temperature applications. Non-wet by almost all molten metals, AX05 is recommended for applications such as extreme high-temperature insulators and crucibles for high-purity processing.

**COMBAT® M AND M26** - Combine the moisture resistance of silica with unique properties of boron nitride. Differentiated by the amount of SiO<sub>2</sub>, Combat M offers unparalleled resistance to thermal shock while Combat M26 offers higher thermal conductivity. M and M26 are ideal for applications requiring extreme and exacting dielectric properties.

**COMBAT® ZSBN** - Combines the non-wetting properties of boron nitride with extreme refractory and wear resistance of zirconia. ZSBN is widely used in a variety of molten metal contact applications.

## PRODUCT DATA SHEET



### Features/Benefits

- Easily machinable to desired shapes and sizes
- Exceptional heat resistance
- High thermal conductivity
- Low thermal expansion, excellent thermal shock resistance
- Outstanding electrical insulation - even at high temperatures
- High wet resistance to molten metals, slags and glass
- Extreme corrosion and wear resistance

### Key Applications

- MOCVD setters and components
- Insulators for high-temperature furnaces
- Muffles and crucibles for Nitride and Sialon firing
- Nozzles for powder metal atomization
- Side dams for twin-roll casting
- Continuous casting break rings
- High temperature mechanical components such as bearings, valves, spacers
- Crucibles and molds for molten metal processing

### Target Markets

- High temperature furnace construction
- Ceramic manufacturing
- Semiconductor industry
- PVD coating
- Microwave

BORON NITRIDE

SAINT-GOBAIN

### COMBAT® BORON NITRIDE SOLIDS

Typical Properties	Units	A		HP		AX05		M		M26		ZSBN	
Crystalline Phase		hBN > 90%		hBN > 90%		hBN > 99.5%		hBN 40% SiO <sub>2</sub> 60%		hBN 60% SiO <sub>2</sub> 40%		hBN > 45% ZrO <sub>2</sub> < 45% Borosilicate < 10%	
Binder Phase / Binder Type		Boric Oxide		Calcium Borate		Self Bonded		SiO <sub>2</sub>		SiO <sub>2</sub>		Borosilicate glass	
Color		White		White		White		White		White		Grey	
Typical Applications		General purpose		Outstanding Moisture Resistance, Refractory, Dielectric Strength		Extreme Corrosion Resistance, Thermal Conductivity, Purity		Extreme Thermal Shock, Moisture Resistance, Dielectric Strength		Extreme Thermal Conductivity, Moisture Resistance, Dielectric Strength		Extreme Wear Resistance & Corrosion Resistance in molten metals applications	
Directionality			⊥		⊥		⊥		⊥		⊥		⊥
<b>Mechanical Properties</b>													
Flexural Strength (MPa, 25°C)		94	65	59	45	22	21	103	76	62	34	144	107
Youngs Modulus (GPa, 25°C)		47	74	40	60	17	71	94	106			71	71
Compressive Strength (MPa, 25°C)		143	186	96		25		316	289			219	254
Open Porosity (%)		2.8				19.3		6.9		6.7		1.1	
Density (g/cm <sup>3</sup> )		2.0		2.0		1.9		2.3		2.1		2.9	
Hardness - Knoop (kg/mm <sup>2</sup> )		20		16		4						100	
<b>Thermal Properties</b>													
Thermal Conductivity (W/mK, 25°C)		30	34	27	29	78	130	12	14	11	29	24	34
Coeff. of Thermal Expansion (10 <sup>-6</sup> )													
25 - 400° C		3.0	3.0	0.6	0.4	-2.3	-0.7	1.5	0.2	3.0	0.4	4.1	3.4
400 - 800° C		2.0	1.4	1.1	0.8	-2.5	1.1	1.2	0.4	2.5	0.1	5.6	4.3
800 - 1200° C		1.9	1.8	1.5	0.9	1.6	0.4	1.2	0.8	3.0	0.1	7.2	5.2
1200 - 1600° C		5.0	4.8	2.8	2.7	0.9	0.3					4.6	3.4
1600 - 1900° C		7.2	6.1			0.5	0.9						
Specific Heat (J/gK, 25°C)		0.86		0.81		0.81		0.76		0.77		0.64	
Max. Use Temp. - Oxidizing / Inert (°C)		850 / 1,200		850 / 1,150		850 / 2,000		1,000+		1,000+		850 / 1,600	
<b>Electrical Properties</b>													
Dielectric Constant at 1MHz		4.6	4.2	4.3	4.0	4.0	4.0	3.4	3.7	4.5	3.8	18	19
Dissipation factor at 1MHz		1.2E-03	3.4E-03	1.5E-03	2.1E-03	1.2E-03	3.0E-04	3.0E-03	3.1E-03	1.7E-03	6.7E-03	4.5E-02	6.7E-02
Dielectric Strength (KV/mm)		88		>10		79		>10		66		3.5	
Resistivity (Ω cm, 25°C)		>10 <sup>13</sup>	>10 <sup>14</sup>	>10 <sup>13</sup>	>10 <sup>13</sup>	>10 <sup>13</sup>	>10 <sup>14</sup>	>10 <sup>14</sup>	>10 <sup>14</sup>	>10 <sup>13</sup>	>10 <sup>14</sup>	>10 <sup>13</sup>	>10 <sup>12</sup>

Typical properties, not to be used as specification  
Blank cells indicate data is not available



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