

Advances in SiC refractories are leading to cost-effective solutions for a wide range of high temperature applications in the ceramic industry.

SINTERED ALPHA SiC REFRACTORIES

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From kiln support beams and batts/tiles to rollers, nozzles and custom components, silicon carbide (SiC) has been used for decades in very high temperature and severe environment applications in the ceramic industry. Within the past several years, new forms of SiC have been engineered to provide even greater performance characteristics.

Perhaps one of the most notable of these advancements has been the development of alpha sintered SiC*. This new material has proven to be an excellent alternative to conventional, refractory grade, recrystallized silicon carbide, actually increasing in strength at elevated temperatures where other ceramics quickly drop off. In fact, sintered alpha SiC performs well in air up to 1650°C and to 2000°C in inert atmospheres (see Figure 1). It exhibits high temperature strength two to three times that of nitride bonded, recrystallized and siliconized SiC refractory materials. It also offers a low coefficient of thermal expansion and high thermal conductivity, giving the material desirable thermal shock resistance and enabling it to survive rapid thermal cycling far better than aluminum oxide and some conventional SiC materials.

Material Characteristics

Sintered alpha SiC is produced by pressureless sintering submicron silicon carbide powder. The sintering process results in a self-bonded, fine-grained (less than 10 µm) SiC material that is 98% dense, giving it high durability. It is a single-phase material with no secondary bond phase that can weaken at high temperatures and cause component failure. Additionally, it has outstanding high

temperature properties, including oxidation resistance, superior creep resistance and excellent strength.

The oxidation resistance of sintered alpha SiC translates into long component life, as oxidation is often the cause of failure for SiC kiln furniture because it loses strength. In extended duration testing in steam (1100°C), sintered alpha SiC exhibited outstanding oxidation resistance as evidenced by its extremely low weight gain compared to traditional SiC refractory materials (see Figure 2). In tests performed at 1600°C, sintered alpha SiC showed improvement in creep resistance of greater than 400% compared to recrystallized, siliconized and nitride-bonded SiC materials (see Figure 3).

The material also offers virtually universal corrosion resistance and is proven against chemical attack even at elevated temperatures. Tests have shown that sintered alpha SiC outperforms siliconized, aluminum oxide and metals in all chemical corrosion categories (see Figure 4). In addition, it is impervious to gases up to 1093°C even at 4000 psi, making it suitable for corrosive environments. And with emissivity of 0.9, it is an excellent black body.

Application Advantages

There are numerous applications for sintered alpha SiC in the ceramic industry, from ceramic belts for sintering furnaces (ceramic and metal) to rolls for roller hearth furnaces to kiln furniture for high temperature firing of products, such as alumina components. Other examples include nozzles, wear tile/liners, thin pins and assemblies for hang firing long tubes, thermocouple protection tubes and heat exchanger tubing, among others.

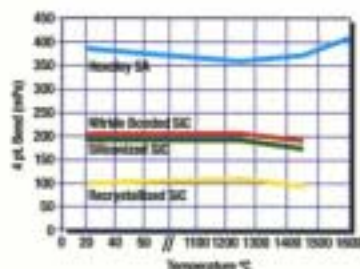


Figure 1. Temperature range in degrees C. (In testing, the sintered alpha silicon carbide was the only material to reach 1600°C.)

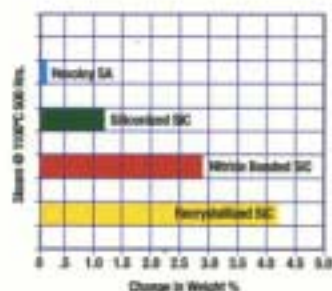


Figure 2. Effects of steam on weight change (no weight change is optimal).

In these and other applications, sintered alpha SiC provides numerous advantages over other types of refractories. For example, sintered alpha SiC kiln support beams offer low mass design potential and excellent strength, allowing for reduction of beam cross section by 50%. At the same time, the sintered alpha SiC beams offer a 40% reduction in mass (weight) versus traditional refractory SiC materials—without compromising load carrying capacity. This reduced beam volume and weight mean more product per kiln run to maximize furnace productivity and reduce total firing costs. Documented kiln car retrofits with sintered alpha SiC beams have

*Hexoloy® SiC, a registered trademark of Saint-Gobain Advanced Ceramics, Structural Ceramics Group—formerly Carborundum Corp.

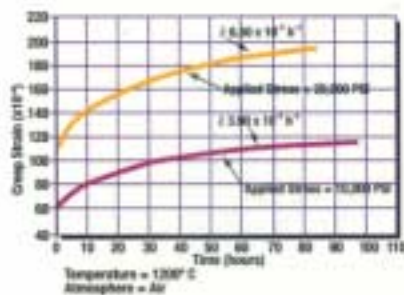


Figure 3. The creep response of sintered alpha SiC.

increased productivity over 20% and have shown paybacks of two years and less.*

As another example, similar results can be obtained with sintered alpha SiC ultra-thin, lightweight kiln tiles. The thinner tiles/batts are extremely strong, yet are as thin as 2 mm in smaller sizes, allowing for more useable kiln space and the ability to efficiently load and fire more shippable product with less kiln furniture. Very fast thermal cycling is also possible given the tile's resistance to thermal shocking and its low mass.

Test Environment ¹ Conc. Reagent (wt%)	Temp. (°C)	Corrosive Weight Loss (mg/cm ² yr)**			
		SA SiC (No Free Si)	SiSiC (12% Si)	Tungsten Carbide (8% Co)	Aluminum Oxide (99%)
30% H ₂ SO ₄	100	1.8	35.3	>1000	68.3
50% NaOH	100	2.8	>1000	1.3	75.3
50% HF	75	<-0.2	7.8	8.3	26.3
50% H ₂ PO ₄	100	<-0.2	8.3	35.3	>1000
70% HNO ₃	100	<-0.2	0.3	>1000	7.8
40% KOH	100	<-0.2	>1000	3.8	95.3
20% HCl	75	<-0.2	6.8	95.3	72.3
10% HF plus 50% HNO ₃	75	<-0.2	>1000	>1000	16.3

¹Test time: 125 to 200 hours of submersive testing, continuously stirred.

**Corrosion weight loss guide:

- >1000 mg/cm² yr - Completely destroyed within days.
 - 50 to 100 mg/cm² yr - Not recommended for service greater than a month.
 - 30 to 50 mg/cm² yr - Not recommended for service greater than one year.
 - 10 to 40 mg/cm² yr - Caution recommended based on the specific application.
 - 0.3 to 0.8 mg/cm² yr - Recommended for long-term service.
 - <0.2 mg/cm² yr - Recommended for long-term service.
- No corrosion, other than as a result of surface cleaning, was witnessed.

Figure 4. Corrosion test results in liquid.

Custom Components and Special Shapes

The as-fired surface finish of sintered alpha SiC components is smooth, about 1 μm, reflecting its fine grain nature and high density. Using sintered alpha SiC, even the most intricate components can be manufactured to the most exacting specifications. The components can also be ground to tight tolerances.

With exceptional properties such as high temperature strength, oxidation

resistance, creep resistance, thermal shock resistance and high thermal conductivity, sintered alpha SiC has been proven as an excellent alternative material to other ceramics, refractories and superalloys. It can provide a cost-effective solution for a wide range of high temperature applications in the ceramic industry. ☺

**"Kiln Support Beams Increase Capacity," Ceramic Industry, May 2000, pp. 16-18.

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