Advanced Ceramics: Silicon Carbide Abrasives, a complete guide

Advanced Ceramics

Advanced ceramic materials find diverse uses in electronics, communication, aviation, military, and high-tech industries. They are highly beneficial in information technology systems like chip manufacturing, piezoelectric ceramics, capacitor ceramics, and ferrite magnetic applications.

Advanced ceramics sales in the US is a 30 billion dollar industry. It is registering a growth of 105 annually. Advanced ceramics is a broad term that encompasses three different types of materials: tool ceramics, structural ceramics, and functional ceramics.

Structural ceramics– These materials are engineered for high strength, thermal shock, and chemical resistance. They also exhibit excellent hardness and resistance to oxidation, corrosion, and wear. Such properties make them suitable for unfriendly environments. Some of the widely used structural ceramics include silicon carbide ceramics, silicon nitride ceramics, and alumina ceramics.

Tool ceramics – These materials are used in the production of industrial goods, kitchenware, cookware, and tableware. The most popular types of tool ceramics include diamond (naturally occurring form), cemented carbide, cubic boron nitride, etc.

Functionality ceramics– These materials are created to have electro-optical properties like LEDs or lasers. They vary depending on the different physical properties that in turn make them useful for specific functions. In the case of optical ceramics, the materials exhibit high amounts of transparency, luminescence, fluorescence, and electrochromic effects. Examples include silicon dioxide, tungsten trioxide, and cadmium telluride. Functionality ceramics can further be divided into magnetic, semiconductor, and dielectric.

Silicon Carbide Abrasives

Silicon carbide ceramic abrasive is composed of carborundum, chemically known as SiC. It is a compound made up of closely packed silicon and carbon molecules. It occurs naturally as a moissanite mineral, and its grains are bonded together using heat (1200 ℃ ~ 1400 ℃), also known as the sintering process. Its ability to withstand heavy abrasion and economical production make it a perfect choice for abrasives. It has low thermal expansion and is lightweight too. Depending on the application requirements, it can be applied as both loose and solid abrasive material.

Silicon carbide particles are laminated on paper for use as sandpapers. The hard compound is popular in modern lapidary thanks to its production economics. While in industrial operations, it is used for honing, grinding, sandblasting, and water-jet cutting. Silicon carbide ceramics exhibit oxidation resistance, good thermal conductivity, and, electrical conductivity.

Features that make Silicon carbide the best choice for abrasive use

Silicon carbide is the most corrosion-resistant ceramic and can retain its strength in temperatures as high as 1400 ℃. The salient features that make it the first choice as an abrasive are:

- High strength ceramic
- Lightweight material
- Ability to maintain strength at very high temperatures:
- High abrasion resistance
- High corrosion resistance
- Very economical to produce

The best and most valuable benefits of using silicon carbide abrasive are as follows:

- Faster blast times thanks to its breakneck cutting speeds
- Negligible presence of magnetic content and contamination
- Superior cutting speeds that' s to its hardness and strength
- Much lighter composition relative to other metallic blast streams
- Low cost of procurement and manufacturing
- A broad range of grit sizes
- Environment-friendly biodegradable material

Further, we discuss each of the properties of SiC that make it an able candidate for use as abrasive material:

Physical properties

We discussed quite a few of the physical properties of silicon carbide in this article. In actual measurements, its density is 3.20 grams per cubic meter, with a hardness of 9.5 Mohs. As the thermal expansion parameters for silicon carbide remain low, it is resistant to thermal shocks and exhibits low thermal conductivity.

Chemical properties

Silicon carbide has strong anti-chemical properties. It is resistant to acid attacks yet not stable in alkaline conditions. As the material is subjected to extremely high temperatures in the range of 1300-1400℃, an outer protective layer containing silicon dioxide gets formed. This layer provides cover to the inner silicon carbide crystal. As this protective layer thickens, it resists the silicon carbide molecules from combining with other chemicals.

Electrical properties

The electrical conductivity of silicon carbide is inversely proportional to its ambient temperature. As the temperature goes up, the electrical conductivity goes down. When silicon carbide is kept at a constant temperature condition, it exhibits the properties of a semiconductor. The overall electrical conductivity of silicon carbide can be altered based on its varying impurities.

Brief History of Silicon Carbide Ceramics

Silicon carbide has been produced since 1893 primarily as an abrasive. The sintering process is used to achieve close bonding among the SiC molecules to get hard ceramic material. Commercial silicon carbide substrates have been supplied to the industry since 1987.

- In the year 1905, the first meteorite was discovered to carrysilicon carbide in its mass
- 1907was the year that saw the first silicon carbide-based LED (Light Emitting Diode)
- In 1955, LELY came up with the concept of high-quality carbonation of silicon carbide to enable its use as an electronic material
- The year 1958 witnessed the world' s first conference on silicon carbides onin Boston

Different types of Silicon Carbide Ceramics

- **Sintered silicon carbide**– The material is produced by mixing non-oxide sintering aids (metals and metal oxides that do not decompose in SiC) with fine and pure silicon carbide powder. The processes follow steps like isostatic pressing, die press, and injection molding operations.
- **Nitride bonded silicon carbide**– The material exhibits exceptional wear and corrosion resistance. It is formed by bonding nitrogen with silicon carbide molecules as they are fired along with silicon or other additives.
- **Reaction bonded silicon carbide**– When molten silicon is subjected to porous carbon (or graphite), the chemical reaction produces reaction bonded silicon carbide. It is also known as siliconized silicon carbide.
- **Clay-bonded silicon carbide**– The material is formed when silicon carbide fine powder is sintered using clay as a sintering additive. The sintering process is carried out at a temperature of 1350°C. The material thus obtained typically has a porosity of 24%.
- **Chemical-vapor-deposited silicon carbide**– The chemical vapor deposition process is carried out on silicon carbide molecules in the presence of a volatile silane derivative in combination with hydrogen and nitrogen. This substance mix is heated in the range of 900 – 1200°C to get chemical-vapor-deposited silicon carbide.

Types of Silicon Carbide Abrasives available in the market

Silicon Carbide Powder (Chemically produced)

This is the most commonly available silicon carbide abrasive. It is produced by reacting and pyrolyzing vaporized polysiloxanes to produce silicon carbide powder. The simple one-step

heating process is simple and economical. A vaporized polysiloxane is introduced to a hot 1600° C reaction chamber which is able to convert polysiloxane vapor into silicon carbide powder.

Silicon Carbide Sandpaper

Silicon carbide sandpaper is used for dry and wet sanding processes. It is also used to get rid of rust using its course grits. It is efficiently applied for processes like refinishing wood flooring and deburring glass and metals. Artists often use it to give marble and stone sculptors a suitable finish.

Silicon Carbide Sandpaper Sheet

The sandpaper sheet consists of hard yet sharp silicon carbide grits. As the size of grits is small and grits are brittle, it does not have a long usage life. Used for various sanding works for surfaces like marble, metal, stone, glass, hard plastics, etc.

Silicon Carbide Powder

This is a naturally occurring mineral. The powdered form is widely used in abrasion processes like water-jet cutting, grinding, and sandblasting. The silicon carbide powders are an ideal grinding medium for rough polishing and fine grinding of ferrous metals, semiconductors, and even ceramics.

Silicon Carbide Grinding Wheel

Grinding machines are fitted with wheels for continuous operation and application over larger surface areas. The grinding wheel’ s core is often made out of composite materials. Silicon carbide grinding wheel is used for non-ferrous metals because of its fast cutting ability. The sharp grits are hence used over soft metals. Wheels coated with green silicon carbide can be used on carbide surfaces. At the same time, black silicon carbide-coated wheels find their use on stone and plastic sufaces.

Silicon Carbide Sharpening Stone

Sharpening stone is popularly used to sharpen knives made of stainless steel material. Silicon carbide sharpening stone can quickly sharpen knives without much wear. The 9-10 Mohs of hardness make them a durable material for long term usage.

Industrial operations where silicon abrasives are useful:

- Spray booths for different applications
- Reservoir blasting using hydraulic fluids
- Refinishing antique stoves
- As a lighting medium for blasting

- Outdoor metallic material blast finishing and etching (e.g., light poles, patio furniture, etc.)
- Truck bed preparation
- Deburring and polishing glass and metals
- Polishing jewelry

Silicon Carbide Raw Material Manufacturer in China

Henan Superior Abrasives Co.,Ltd has more than 20 years of experience in the abrasive field. We are the leading supplier of silicon carbide and related products in China. We provide black silicon carbide, silicon quartz sand, and petroleum coke product. The materials are electrofused at high temperatures to get grains of hexagonal crystals. Black silicon carbide grains have low thermal expansion, high electrical and thermal conductivity, and are extremely hard. They are available in the following sizes:

- Black silicon carbide macro split
- Black silicon carbide macro grits
- Black silicon carbide micro powder

Green silicon carbide, which is higher in quality than black silicon carbide, has a hardness close to the diamond. It provides an excellent polishing and grinding medium. A material that is not affected by the presence of any chemicals. They are available in the following sizes:

- Green silicon carbide micro powder
- Green silicon carbide macro grits