SIGRADUR GLASSY CARBON PRODUCT INFORMATION

SPI SUPPLIES

SPI Supplies
206 Garfield Avenue,
West Chester, PA 19380, USA

SPI Supplies® Sigradur Glassy (Vitreous) Carbon Products

Why is glassy carbon also called "vitreous" carbon?

Glassy carbon or vitreous carbon is a non-graphitizing or non-graphitizable carbon which combines glassy and ceramic properties with those of graphite. Unlike graphite, glassy carbon has a fullerene-related microstructure. This leads to a great variety of unique materials properties.

Carbon comes in many forms and there is no other element that can take on so many different appearances, properties and morphologies. We are all familiar with many synthetic polymers, for example "Nylon", which can be found as a yarn in a sweater, tire cord, molded part or an extruded film. We are familiar with carbon as diamond and carbon as graphite, again two forms with dramatically different properties.

Carbon can also be prepared in the glassy state, sometimes called the vitreous state. The glassy carbon products offered by SPI Supplies are completely amorphous with no crystallinity. X-ray diffraction shows only an "amorphous halo". When the glassy carbon is fractured, it exhibits the fracture face that is characteristic of a glassy material. Glassy carbon has a range of properties and applications that makes it a new and exciting material for research and production applications.

How the SPI Supplies® SIGRADUR vitreous carbon differs from graphite:

From an analytical standpoint, graphite gives strong x-ray diffraction peaks, indicating a high degree of "order" and a high level of x-ray diffraction determined crystallinity. The SPI Supplies Brand of glassy carbon exhibits no diffraction peaks and exhibits only an amorphous halo.

Most graphites (excluding HOPG and pyrolytic graphite) exhibit considerable porosity. The SPI Supplies Sigradur of glassy carbon is quite dense, certainly much more so than graphite. This might sound like a contradiction, but when one looks at the density of glassy carbon in comparison to the theoretical density of the graphite crystal, its density is less, specifically ~ 1.5 vs. 2.25. Because graphite normally has considerable porosity, the ~ 1.5 density is higher than the typical graphite (excluding HOPG and pyrolytic graphite). As a consequence of this high density and the lack of porosity that plagues ordinary graphite, the SPI Supplies glassy carbon can be polished to a mirror finish. It looks like a "black glass".

Another important property of the SPI Supplies Sigradur of glassy carbon is it a good thermal conductivity, which imparts to it a high level of resistance to thermal shock (making possible its application for crucibles).

Applications for Glassy Carbon:

- Microscopy and Microanalysis
- Metallurgical
- Laboratory Research
- Vacuum Evaporation
- Semiconductor and Electronics
- Nuclear
- Aerospace

Glassy Carbon Characteristic Properties

- High Purity
- Resistance in inert gas or vacuum up to 3000°C and in air up to 600°C
- Corrosion resistance
- Impermeability to gas and liquids
- High hardness and strength, almost like that of a ceramic
- Low density
- High surface quality with excellent polishing characteristics (to a black mirror reflective finish
- Good resistance to thermal shock
- Good electrical conductivity
- Inductive coupling in high-frequency fields
- No wetting by many saline, metallic and ceramic melts
- Biocompatibility
- Surface coating with metallic and ceramic materials
- Physical and chemical properties are isotropic

Chemical Resistance:

Theoretically, glassy carbon should behave like any other form of carbon, I.E. graphite, but it is far less reactive because of the higher density relative to the normally more porous graphite. Its resistance is more akin to HOPG and high density pyrolytic graphite. The main reason for the impressive chemical resistance is a consequence of the disordered structure and the inability to form intercalation compounds. This gives rise to high resistance to corrosion by acid and alkaline agents and melts. Because of the high purity, glassy carbon is appropriate for applications in chemical analysis, semiconductor and ultratrace analysis.

Thermal Properties:

Depending on grade, the material can be taken as high as 2500°C without any significant devitrification. Above that temperature some devitrification will occur and there will be a nucleation and growth of a graphite phase. Remember, the higher the density the higher the temperature will be at which these transition occurs.

Note: that the Sigradur glassy carbon products can be heated in air, depending on grade selected, up to 600°C without undergoing any reaction but above this temperature, any heating should be done strictly either under vacuum or in an inert environment such as argon. If vacuum is not used for higher temperatures, there will be a reaction and the formation of CO and CO_2. A similar kind of reaction will occur above 600°C with water or water vapor, resulting in the evolution of CO and H_2.

Surface State:

Our standard product exhibits an "as produced" surface that is shiny and mirror-like. They are not mechanically polished. Mechanical polishing is possible; however, we do not offer this option. In electrochemical applications the properties of as manufactured and re-prepared electrodes maybe different even through the surface appears identical.

Available Grades:

SPI Supplies offers glassy carbon in two grades, Sigradur K and Sigradur G, each with its own set of properties and which are based on the final heat treatment temperature of the glassy carbon:

Grade	Heat Temperature
Sigradur K	1100° C
Sigradur G	2200° C

	Sigradur K	**Sigradur G**
Bulk Density, (g/cm^3)	1.54	1.42
Ash Values (acc to DIN 51903), (ppm)	< 100	< 100
Maximum Service Temperature, (°C)	1000	3000
Open Porosity, (%)	0	0
Permeability Coefficient, (cm^2/s)	10^{-11}	10^{-9}
Vickers Hardness, (HV[1])	340	230
Flexural Strength[1], (N/mm^2)	210	260
Compressive Strength[2], (kN/mm^2)	580	480
Young's Modulus[1], (kN/mm^2)	35	35
Coefficient of Thermal Expansion (20 - 2000°C, (1/K)	2.5×10^{-6}	2.6×10^{-6}
Thermal Conductivity (30°C), (W/(K.m)	4.6	6.3
Specific electrical resistance	50 ohm µm	45 ohm µm

[1] 4-point bending test; geometry of specimen; circular rod, diameter 3 mm, length 60 mm
[2] Geometry of specimen: circular rod, diameter 7 mm, length 10 mm

Electrochemical Application:

For electrochemical application we recommend using only Sigradur because of the much greater corrosion resistance and better electrical conductivity of this grade.

Revised: KM

Date: 04/25