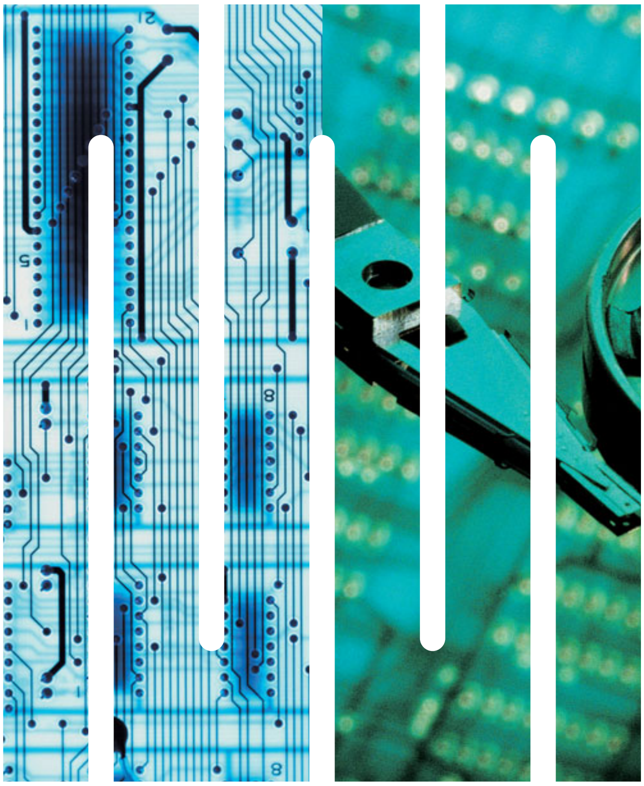
TOYO TANSO CARBON PRODUCTS

Special Graphite and Compound Material Products



TOYO TANSO
Inspiration for Innovation

People and carbon
An everlasting relationship.

Carbon has been a part of our life since ancient times. The benefits of carbon have never been far away from humans, making our lives more plentiful and comfortable. In 1974, we were the first company in Japan to successfully develop isotropic graphite, and thereafter rapidly expanding its possibilities. Isotropic graphite become a crucial material of state-of-the-art technologies in industries such as semi-conductors and aerospace. Currently, this material is being used in a wide range of applications over an ever-increasing number of fields. Toyo Tanso is dedicated to unlocking the unlimited potential of carbon and aims to ensure that the beneficial relationship between people and carbon is one that lasts forever.

TOYO TANSO

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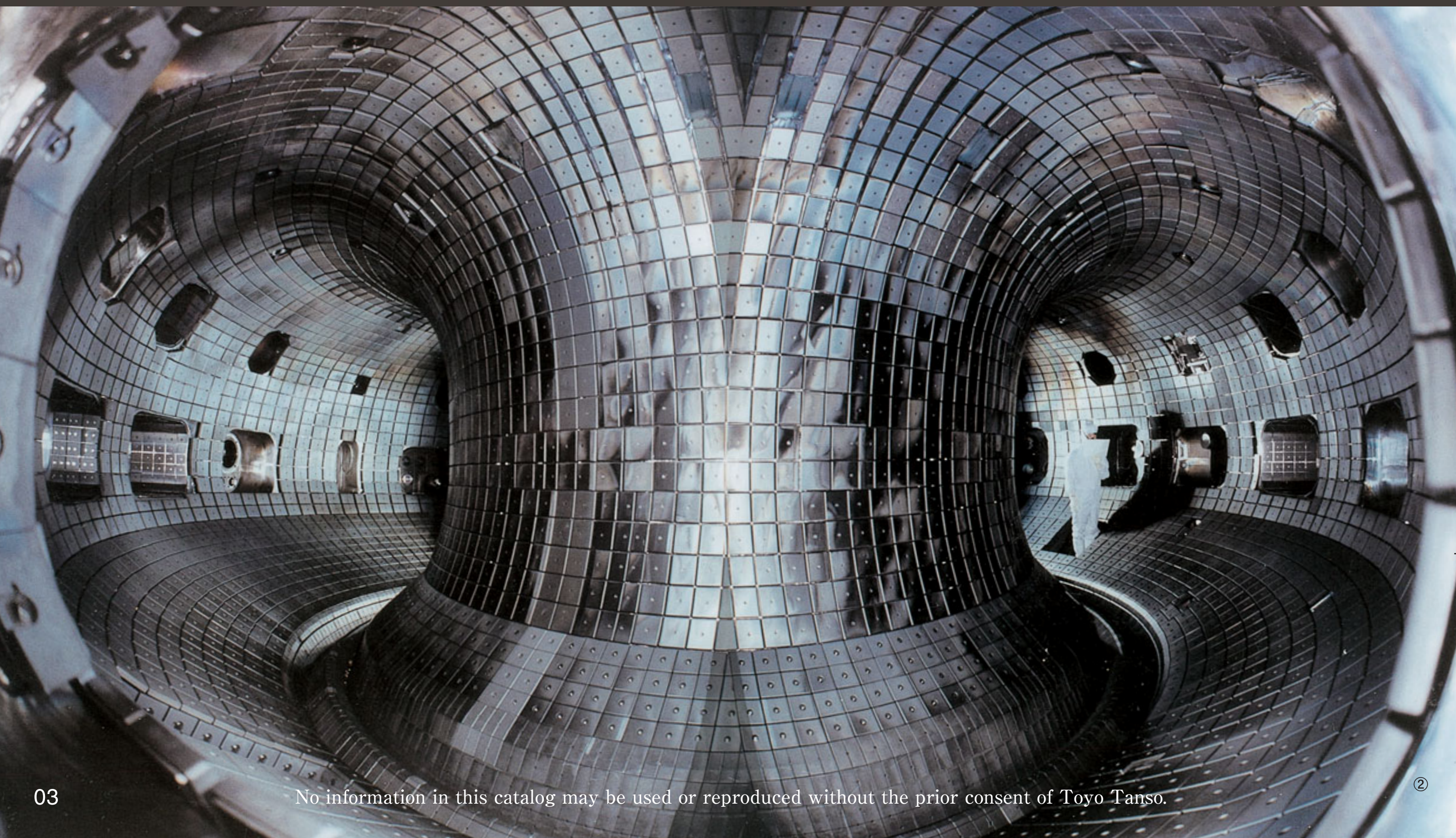

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TOYO TANSO

Features of Special Graphite Products

The demand from industry over the years has been for carbon with ever more finer and stable properties. In this context, Toyo Tanso was the pioneer in our industry in developing "isotropic graphite." This is a graphite material with an isotropic structure and properties, created through the cold isostatic press of micro particles. Our isotropic graphite products are used across a wide field of industries. These include: the semi-conductor industry, where innovation is rapidly advancing; the environmentally friendly renewable energy industry; the mold industry, where accuracy is such a priority; and the atomic power industry, where high reliability is essential. Our excellence is recognized by our customers, with whom we grow together. The synergistic effect between our exclusive high purity technology and various coating technologies will ensure that in the future too, we use our position as a leading company to continue to unlock the unlimited potential of carbon.

■ Isotropic Graphite

Conventional graphite was anisotropic, which limited its use in many applications. However, isotropic graphite in the same cross section direction has no difference in its properties, making a material that is easy to design and use.

■ High Reliability

Isotropic graphite is stronger than conventional graphite due to its micro particle structure. This produces a highly reliable material with a small characteristic variation.

■ Ultra Heat Resistance

In an inert atmosphere, stable use is possible even in extremely high temperatures of 2,000°C or more. The material has low thermal expansion and a high coefficient of thermal conductivity, giving it excellent thermal shock resistance and heat distribution properties, with low thermal deformation. It also has a special characteristic whereby its strength increases as the atmospheric temperature gets higher up unitil 2500°C .

■ Excellent Electrical Conductivity

The high and excellent heat resistance mean graphite is the optimum material for applications such as high temperature heaters.

■ Excellent Chemical Resistance

With the exception of some strong oxidizers, it is chemically stable. Carbon can be used stably even in environments that cause some metals to corrode.

■ Lightweight and Easy to Machine

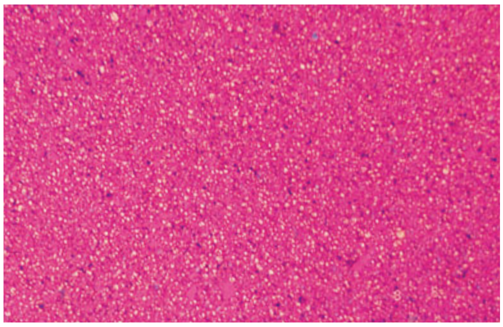
The bulk density is low as compared with metallic materials-enabling a lightweight design. In addition, it has excellent mechanical machining properties-facilitating accurate shaping processes.

① Single crystal silicon manufacturing equipment

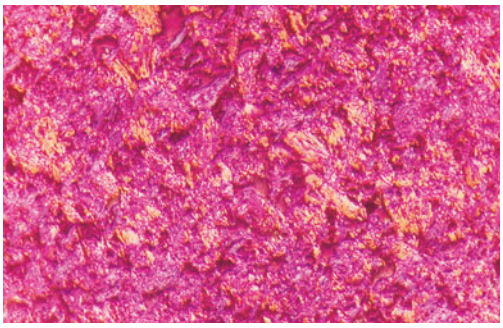
② Critical plasma testing equipment (JT-60) ※Photographs provided by the Japan Atomic Energy Research Institute

■ Isotropic Graphite and Anisotropic Graphite

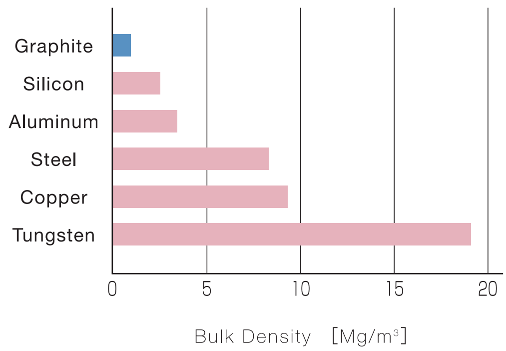
Isotropic High Density Graphite 100μm



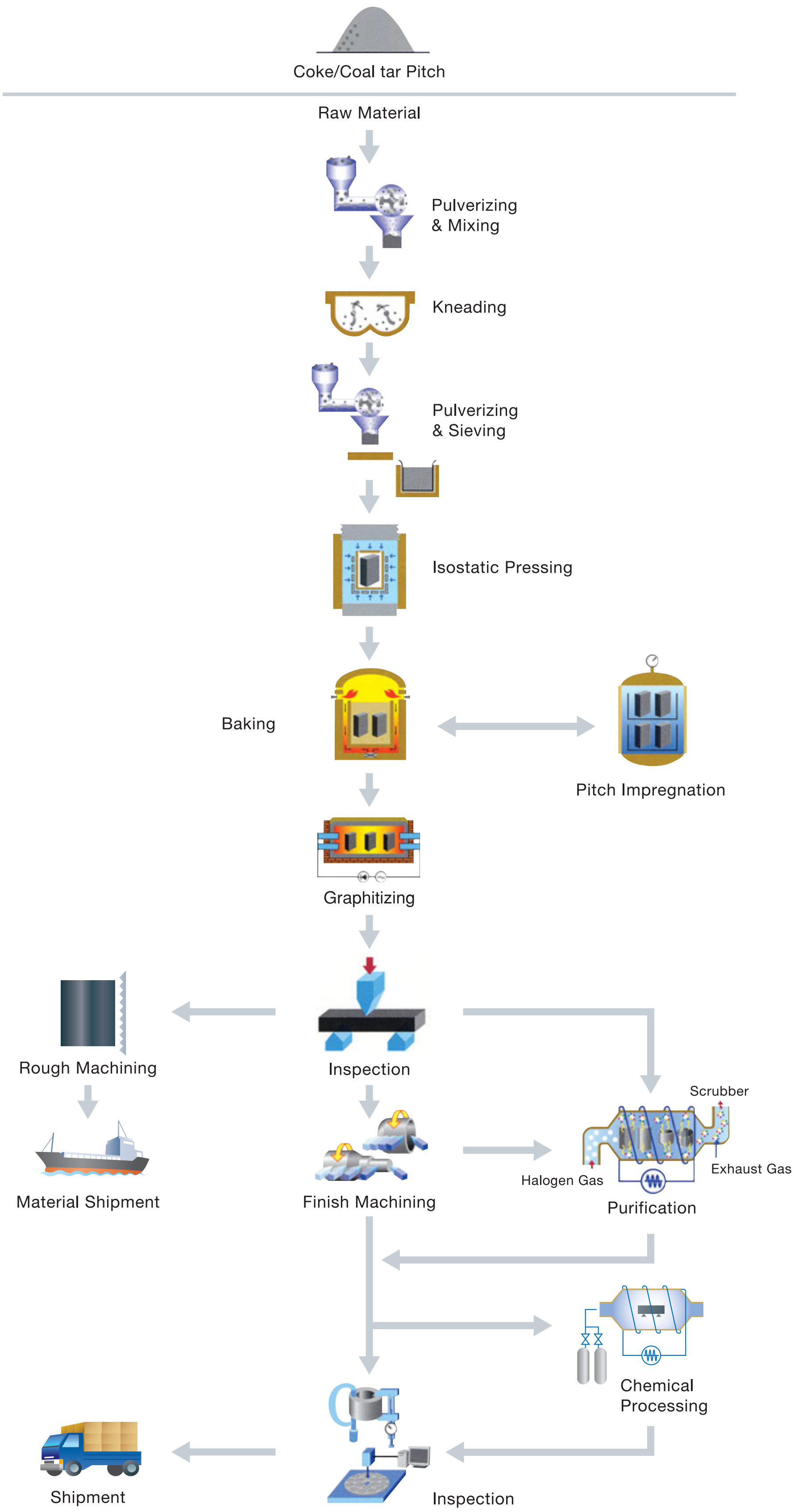
Anisotropic Graphite 100μm



Isotropic high density graphite is different from conventional graphite in that it is isotropic and has a micro particle structure, creating a very strong and highly reliable material with a small variation. This isotropic graphite material resolves the problems associated with conventional anisotropic graphite.



Manufacturing Process

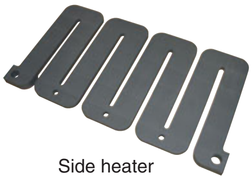


Application

Toyo Tanso's special graphite products are highly regarded for their excellent performance and reliability and are used across a wide range of fields that are essential in our everyday lives. In the environmental and energy industry, our products are used for solar cell manufacturing, atomic power and aerospace applications. In the electronics industry, we provide materials for polycrystalline silicon and single crystal silicon manufacturing, components in ion implantation equipment, and high-frequency device manufacturing. Basic applications of our products include industrial furnaces, continuous casting dies such as those for copper alloys, optical fibers, and EDM electrodes for mold manufacture. We are also active in supplying products to industries with strong future potential, such as those involved in liquid crystal and white LEDs.

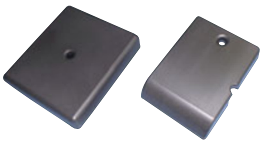
■Environment and Energy

- ●Solar Cell and Wafer Manufactureing
- ●Atomic Power : High Temperature Gas Cooled Reactor, Nuclear Fusion
- ●Fluorine Electrolysis
- ●Nuclear Fusion
- ●Fuel Cells
- ●Aerospace



Side heater

PECVD plate



Nuclear Fusion Reactor
Plasma First Wall
※Photo courtesy of Japan Atomic Energy Agency

Rectangular Crucibles

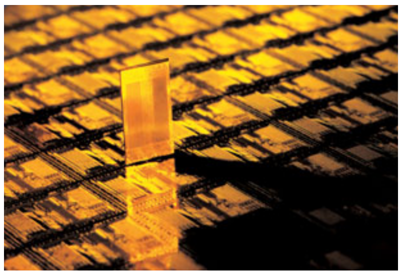
■Electoronics

●Silicon Semi-conductor Manufacturing Applications

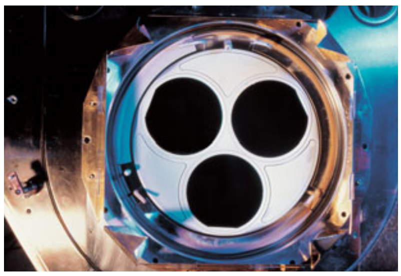
Polycrystalline silicon manufacture
Single crystal silicon manufacturing equipment
Susceptors for epitaxial growth
Plasma CVD electrodes
Ion implantation
Glass sealing jigs

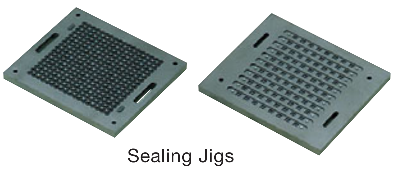
FW type Crucible
(filament winding)

Crucible



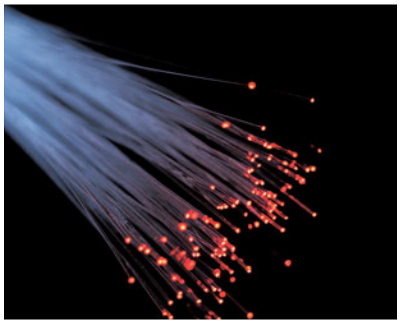
Heater





Sealing Jigs

Electoronics



●Compound Semi-conductor Manufacturing Applications

Crystal Manufacturing Equipment Parts
MOCVD Susceptors

MOCVD susceptor

●LCD Panel Manufacturing Applications

Heater Panels
Electrode for plasma Etching

Pancake susceptor

●Hard Disk Manufacturing Applications

Sputtering Targets

Metallurgical

●Continuous Casting

Dies
Mandrels

Hot Press Mold
(Cut Model)

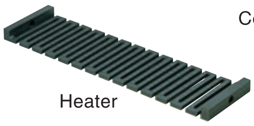
●Hot Press

Dies
Sleeves
Spacers

Continuous Casting Dies

●Industrial Furnace

Heaters
Trays



Heater

●Vacume Evaporation Crucibles

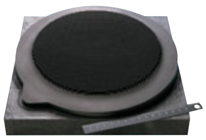
●Gas Analysis Crucibles

Vacuum Evaporation
Crucibles

●Optical Fiber Manufacturing Applications

Heaters
Muffle Tube

●EDM Electrodes

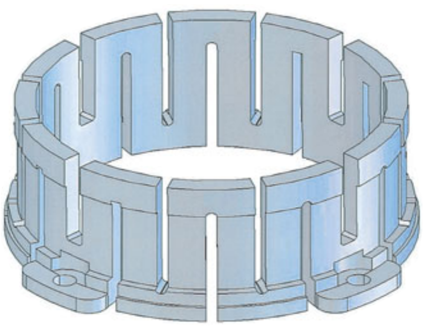


EDM Electrodes

Toyo Tanso Analysis Technology

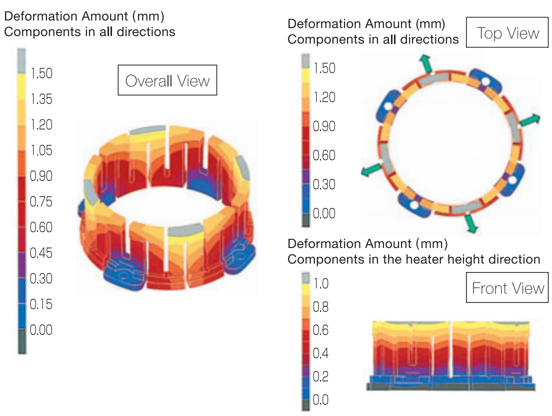
Toyo Tanso uses the high-precision analysis equipment and technology to collect a large amount of data. Based on this, we strive to improve the quality of present products, develop new materials, and lead the way in the research and development of new fields; strengthening our basic technology and elemental technology capabilities. We work together with our customers in the design, analysis and verification of products, responding quickly and effectively to customers needs, and putting particular emphasis on providing a technological service that enables customers to use our products with peace of mind.

■3D CAD Design Example

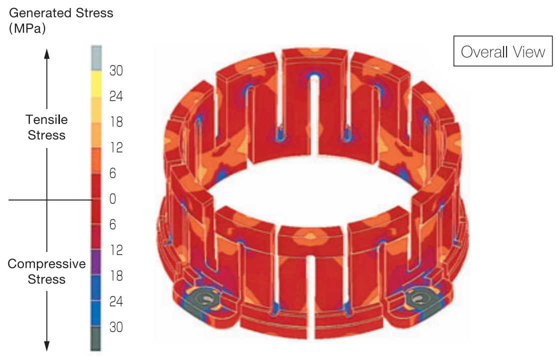


■Finite element method Analysis Example (FEM)

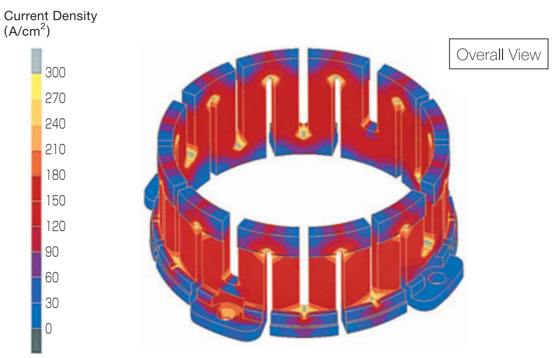
■Thermal Deformation Analysis Results



■Thermal Stress Analysis Results



■Current Density Distribution Results



Toyo Tanso uses the finite element method (FEM) to analyze factors such as product thermal deformation, thermal stress, and current density distribution, under conditions that are appropriate for our customers. We provide our customers with an integrated support system in the design process.

Property Data

Typical Properties of Isotropic Graphite

Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Compressive Strength	Tensile Strength	Young's Modulus	Coefficient of Thermal Expansion	Thermal Conductivity	Standard Size
	Mg/m^3	HSD	μΩ·m	MPa	MPa	MPa	GPa	$10^{-6}/K$	W/(m·K)	(mm)
IG-11	1.77	51	11.0	39	78	25	9.8	4.5	120	305×620×1000 D585×1050
IG-12	1.78	55	12.5	39	88	28	10.8	4.7	100	305×620×1000 D585×1050
IG-15	1.90	60	9.5	54	103	29	11.8	4.8	140	230×620×1000
IG-19	1.75	60	17.0	38	88	25	9.5	4.6	80	D585×1050
IG-43	1.82	55	9.2	54	90	37	10.8	4.8	140	300×540×850
IG-45	1.88	55	9.0	60	110	40	12.0	4.9	140	300×540×850
IG-56	1.77	57	12.2	43	88	27	10.3	4.7	100	1050×1050×450 D760×700
IG-70	1.83	58	10.0	47	103	31	11.8	4.6	130	305×620×1000 D460×1050
ISEM-1	1.68	45	13.5	36	69	20	8.8	4.2	90	305×620×1000
ISEM-2	1.78	55	11.0	41	83	25	9.8	4.6	120	305×620×1000
ISEM-3	1.85	60	10.0	49	103	29	11.8	5.0	130	305×620×1000
ISEM-8	1.78	63	13.4	52	106	34	10.1	5.6	90	305×620×1000
ISO-63	1.78	76	15.0	65	135	46	12.0	5.6	70	230×540×1000
ISO-66	1.82	75	14.4	70	134	46	12.6	7.1	80	180×450×850
ISO-68	1.82	80	15.5	76	172	54	13.2	5.6	70	230×540×1000
SIC-6	1.85	60	10.0	49	103	29	11.8	5.0	130	305×620×1000
SIC-12	1.77	65	14.1	47	93	29	10.8	5.0	80	305×620×1000
TTK-4	1.78	72	14.0	73	135	49	10.9	5.0	90	210×510×950
TTK-5	1.78	80	15.5	80	150	53	11.6	5.7	80	210×510×950
TTK-50	1.80	70	13.0	60	130	40	11.5	5.1	100	305×620×1000

※The figures above are typical values, and are not guaranteed.
※The measurement temperature range for the coefficient of thermal expansion is 350 to 450°C.
※Unit conversion: μΩ·m＝μΩ·cm×0.01 MPa＝kgf/cm^2×0.098 GPa＝kgf/mm^2×0.0098 W/(m·K)＝kcal/h·m·°C×1.16
※There are other product sizes in addition to those described above. Contact Toyo Tanso for details.
※Size or specification of material may be changed without notice.
※Standard size is nominal dimension.

Impurity Analysis Example

Unit: mass ppm

Element	Content: Ultra High Purity Graphite	Content: High Purity Graphite	Content: Regular Graphite	Measurement Method
Li	<0.001	<0.001	<0.03	ICP-MS
B	0.10	0.15	3	ICP-MS
Na	<0.002	<0.002	<0.5	ICP-MS
Mg	<0.001	0.004	0.2	ICP-MS
Al	<0.001	0.012	14	ICP-MS
Si	<0.1	<0.1	2	UV
K	<0.03	0.04	2	FL-AAS
Ca	<0.01	0.08	6	FL-AAS
Ti	<0.001	<0.001	33	ICP-MS

Element	Content: Ultra High Purity Graphite	Content: High Purity Graphite	Content: Regular Graphite	Measurement Method
V	<0.001	0.018	40	ICP-MS
Cr	<0.004	0.006	<0.3	ICP-MS
Mn	<0.001	<0.001	<0.2	ICP-MS
Fe	<0.02	0.06	26	ICP-MS
Co	<0.001	<0.001	<0.3	ICP-MS
Ni	<0.001	0.006	4	ICP-MS
Cu	<0.002	<0.002	<1	ICP-MS
Zn	<0.002	<0.002	<0.6	ICP-MS
Pb	<0.001	<0.001	<1	ICP-MS

※The figures above are examples of actual measurements, and are not guaranteed.
※ICP-MS: Inductively Coupled Plasma Mass Spectrometer, FL-AAS: Flameless Atomic Absorption Spectrometer, UV: Absorption Spectrophotometer.
※The impurity content of regular graphite is approximately 400 mass ppm; however, a higher purity is required for applications such as semi-conducting industries. At Toyo Tanso, we can use a high temperature halogen treatment to purify the graphite to the mass ppm levels requested by our customers.

Chemical Properties

Initial Reaction Temperatures With Various Substances

※Extracted from other publications

Reactant	Initial Reaction Temperature	Compound of Reaction
Aluminum	800℃	Al_4C_3
Boron	1600℃	B_4C
Iron	600~800℃	Fe_3C
Sodium	400~450℃	$C_{64}Na$ Intercalation compound (when O^2 is present)
Cobalt	218℃	CoC, Co_3C
Molybdenum	700℃	Mo_2C
Nickel	1310℃	Ni Carbonizing in Ni
Silicon	1150℃	SiC
Copper	―――	
Magnesium	―――	
Lead	―――	
Tin	―――	
Tungsten	1400℃	W_2C, WC (in hydrogen)
Potassium	300℃	C_8K Other intercalation compounds
Lithium	500℃	Li_2C_2
Beryllium	900℃	Be_2C (in a vacuum or He)
Boron oxide	1200℃	CO, B
Vanadium oxide (V)	438℃	CO, V
Iron oxide (III)	485℃	CO, Fe
Titanium oxide (IV)	930℃	CO, Ti, TiC
Silicon dioxide	1250℃	CO, Si, SiC
Alumina	1280℃	CO, Al, Al_4C_3
Beryllium oxide	960℃	CO, Be, Be_2C
Magnesium oxide	1350℃	CO, Mg
Zirconium oxide (IV)	1300℃	CO, Zr, ZrC

Initial Reaction Temperatures in Gas

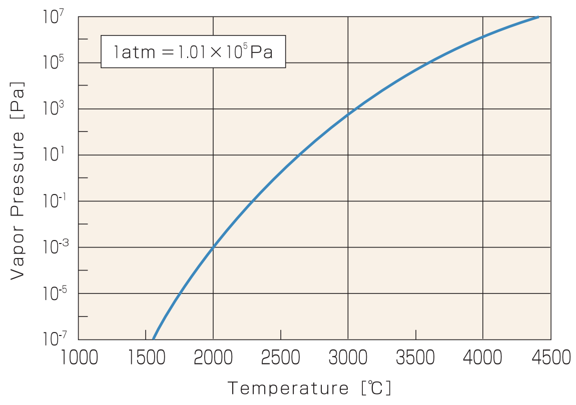
※Extracted from other publications

Atmospheric Gas	Initial Reaction Temperature	Reaction
Air	380~400℃	Oxidization
Water vapor	700~750℃	Oxidization
Carbon dioxide	800~900℃	Oxidization
Hydrogen	1000~1200℃	Methanation
Nitrogen	2000~2500℃	Cyaniding
Chlorine	2500℃	Graphite sublimation
Argon	3000℃	Graphite sublimation
Vacuum	2200℃	Graphite sublimation

In an oxidizing atmosphere, graphite reacts with oxygen at a relatively low temperature. However, in a non-oxidizing atmosphere, graphite is chemically and thermally an extremely stable material, enabling a broad range of applications.

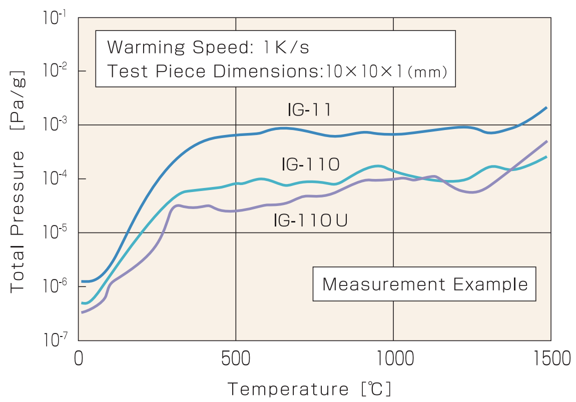
Vapor Pressure

※Extracted from other publications



Graphite is an extremely stable material in temperatures under 2,200°C. However, the vapor pressure increases in higher temperatures and high vacuums, so caution must be exercised with regard to the accelerated wearing of graphite.

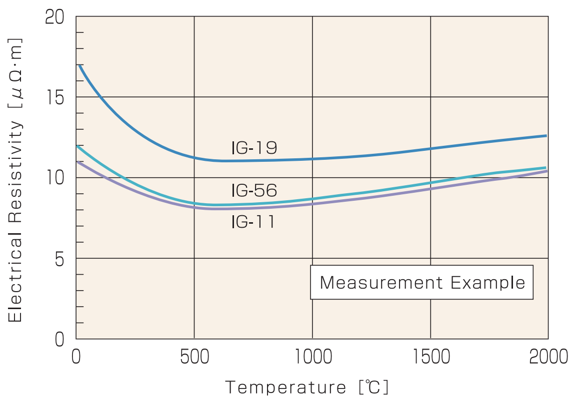
Thermal Desorption Spectrum (TDS)



Graphite emits absorbed gas when in high temperatures. Some applications such as semi-conducting industries must use high purified or ultra high purified graphite, which emits less gas.

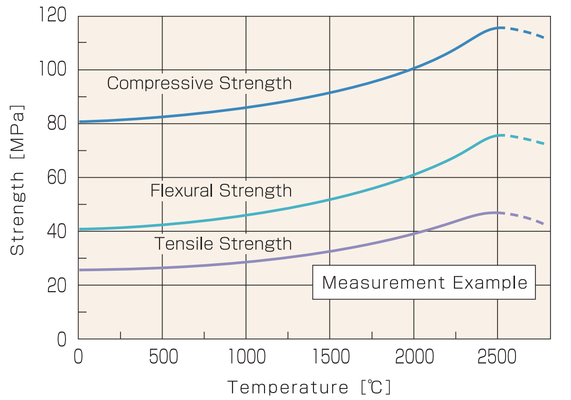
High Temperature Properties

Electrical Resistivity



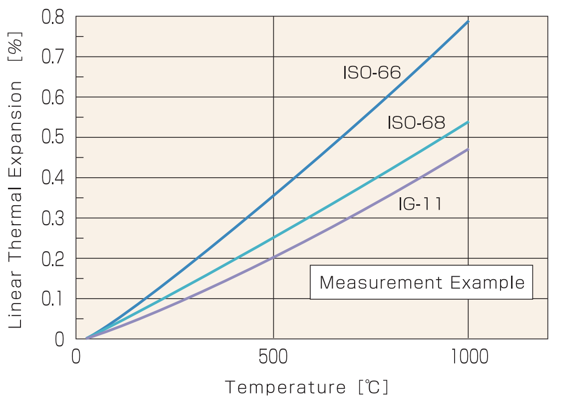
Since thermal characteristics differ from grade to grade, the coefficient of electrical resistivity must be carefully studied when selecting a grade for a heating element.

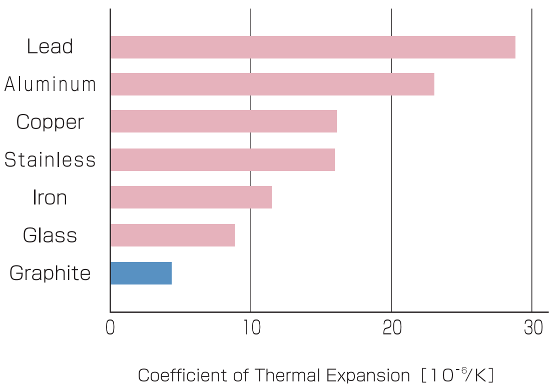
Strengths (IG-11)



An unparalleled characteristic of graphite, which makes it indispensable in high temperature applications, is that as the temperature rises (up to 2,500C), the strength also increases. Strength reaches levels approximately double those at room temperature.

Linear Thermal Expansion

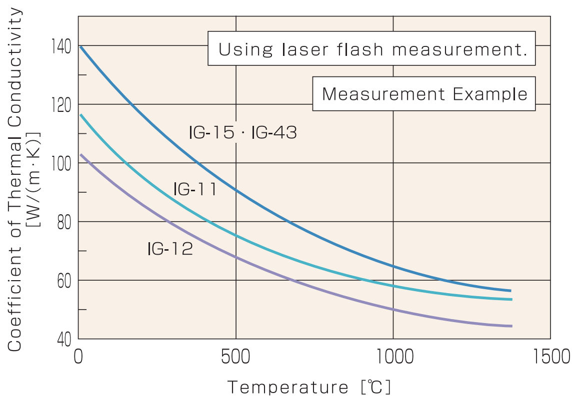


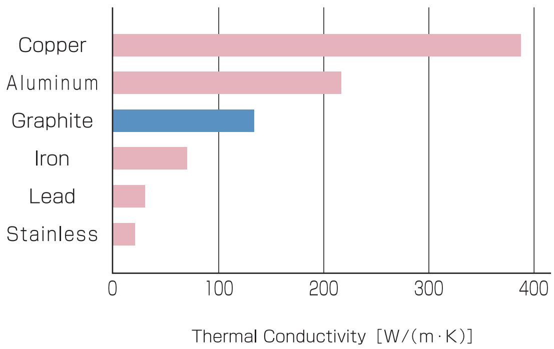


Compared with general metals, the coefficient of thermal expansion for graphite is extremely low. As a result, when used in high temperature applications, the dimensional accuracy is very stable.

$$\text{Reference: Coefficient of Thermal Expansion } (10^{-6}/K) = \frac{\text{Linear Thermal Expansion } (\%) \times 10^{-2}}{\text{Temperature Difference } (℃)}$$

Thermal Conductivity

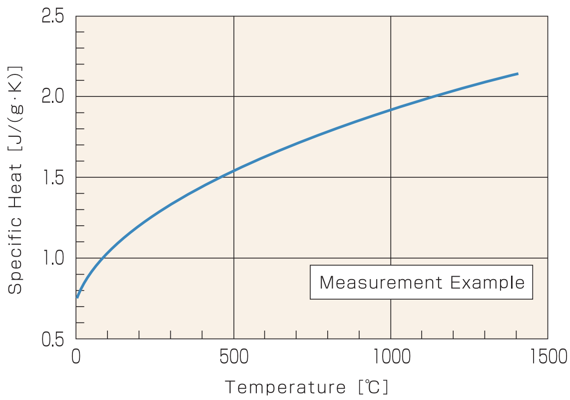




The thermal conductivity of graphite is fairly high, while the coefficient of thermal expansion is very low. These characteristics contribute to its superior thermal shock resistance. The relationship between thermal conductivity and electrical resistivity of graphite in room temperature is indicated below.

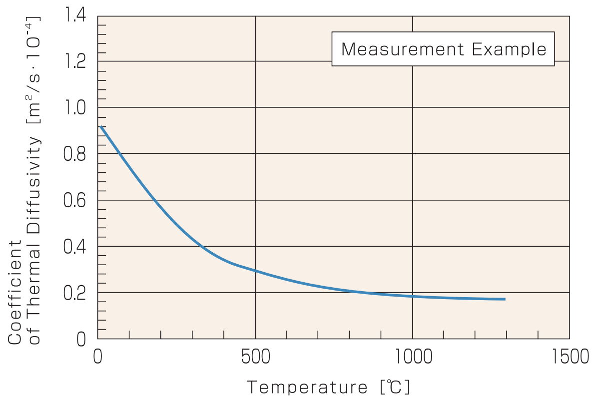
$$\text{Thermal Conductivity [W/(m·K)]} = \frac{0.13 \times 10^{4}}{\text{Electrical Resistivity } (\mu\Omega \cdot m)}$$

Specific Heat



Due to the anisotropic nature of its crystals, the specific heat of graphite at room temperature stays at 1/3 of that of general solids. The specific heat value is essential in various thermodynamic functions. At high temperatures, specific heat values are similar regardless of the graphite grades.

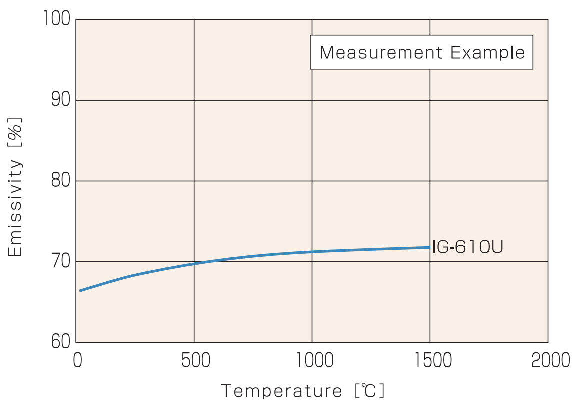
Coefficient of Thermal Diffusivity



This chart shows that the higher the temperature rises, the faster the heat is transmitted. The thermal diffusivity of graphite is superior to other materials.

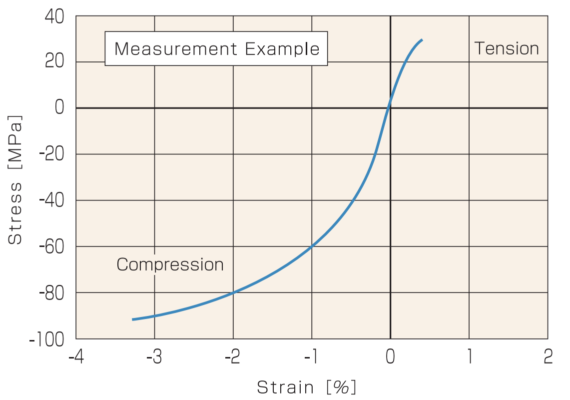
Reference:
$$\text{Coefficient of Thermal Diffusivity} = \frac{\text{Thermal Conductivity}}{\text{Specific Heat} \times \text{Density}}$$

Emissivity



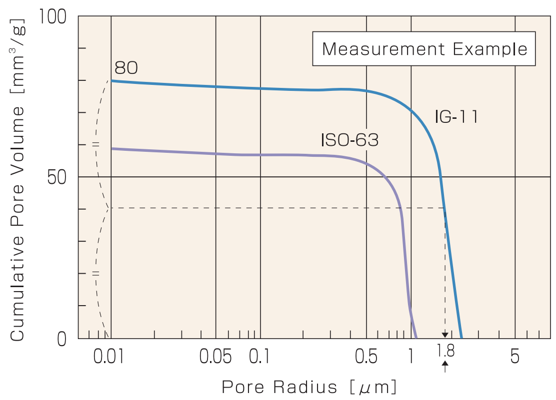
Physical Properties

Stress Strain Curve (IG-12)



Graphite generally shows elastic-plastic deformation. The fracture behavior is different under tension and under compression, so caution must be exercised.

Pore Distribution Curve



This shows the pore distribution through the mercury penetration method. The pore distribution has a close relationship with gas permeability and other unique properties of graphite. The halfway position of the cumulative pore volume indicates the average pore radius.

Example: For IG-11 80/2=40mm^3/g→1.8μm

Machining

Surface Roughness Standards

Since carbon products are porous, it is difficult to obtain a surface finish that is equivalent to metal. The table on the right shows the correspondence of the "Surface Finish Symbol" and surface roughness standards, Ry & Ra & Rz.

Surface Roughness Standards

Finish Symbol (For refarence)	Machining Surface Roughness for Carbon			Finishing Method	Machining Surface Roughness for Metal		
	Ry	Ra	Rz		Ry	Ra	Rz
▽▽▽▽	√Ry3	0.75	√Rz3	Honing Lapping	√Ry0.8	0.2	√Rz0.8
▽▽▽	√Ry12	3.0	√Rz12	Grinder, Lathe Miller	√Ry6.3	1.6	√Rz6.3
▽▽	√Ry35	8.75	√Rz35	Lathe Miller	√Ry25	6.3	√Rz25
▽	√Ry100	25	√Rz100	Lathe Miller	√Ry100	25	√Rz100
～	No particular standard			Saw Machine	No particular standard		

※ 3.0 means that Ra 3.0 micro miter is the maximum.

Machining Dimension Tolerance

If the tolerance is not specified on the customer drawing, apply the intermediate grade of JIS B 0405.

Dimension Tolerance Standards

Unit:mm

Nominal Dimension Category		Tolerance
0.5 or more	6 or less	±0.1
Exceeding 6	30 or less	±0.2
Exceeding 30	120 or less	±0.3
Exceeding 120	400 or less	±0.5
Exceeding 400	1000 or less	±0.8
Exceeding 1000	2000 or less	±1.2

※The above information can be applied when graphite is machined by Toyo Tanso in Japan.

Toyo Tanso has a wide range of graphite grades available to meet every kind of need.
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

PERMA KOTE Products

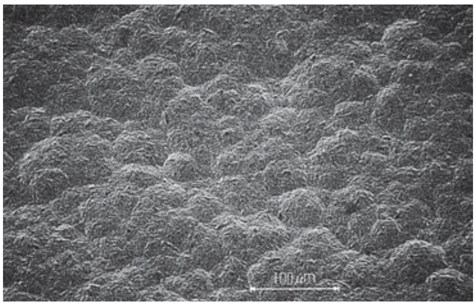
PERMA KOTE is a product created by coating the surface of highly purified isotropic graphite with a fine layer of silicon carbide by means of a proprietary Toyo Tanso Chemical Vapor Deposition (CVD) process.

■PERMA KOTE Characteristics

- ●The silicon carbide layer has excellent oxidation resistance, corrosion resistance and chemical resistance.
- ●The silicon carbide layer is stable at high temperatures and is extremely hard.
- ●Prevents the parting and scattering of graphite particles, and the emission of gas and impurities from the graphite substrate.
- ●Both the graphite substrate and silicon carbide layer are of high purity.
- ●Both the graphite substrate and silicon carbide layer have a high thermal conductivity, and excellent heat distribution properties.
- ●Material is designed so that cracks and delamination do not occur.

PERMA KOTE Surface SEM

100μm

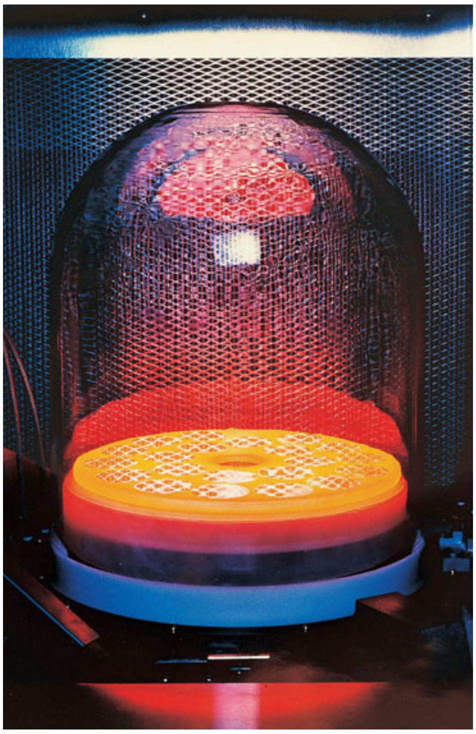


■Coating Thickness

The standard thickness is 120 μm; however this can be modified within a range of 20 to 500 μm.

■Application

- ●Susceptors for silicon epitaxial growth
- ●Single crystal silicon manufacturing equipment
- ●MOCVD susceptors
- ●Heaters
- ●Heat spreaders
- ●Oxidation resistance components



Silicon Epitaxial Growth System

PERMA KOTE Property Data

Corrosion Resistance

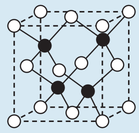
Name	Chemical Formula	Concentration (%)	Temperature (℃)	Time (h)	Change in Mass (g/m^2)
Hydrofluoric acid	HF	47	80	144	−1.0
Hydrochloric acid	HCl	36	Boiling point	144	0
Sulfuric acid	H_2SO_4	97	110	144	0
Nitric acid	HNO_3	61	Boiling point	144	0
Hydrofluoric acid+nitric acid	$HF+HNO_3$ (1:1)	100	80	288	−1.0
Nitric acid + sulfuric acid	$HNO_3+H_2SO_4$ (1:1)	100	25	288	−1.0
Sodium hydroxide	$NaOH$	20	80	288	0
Phosphoric acid	H_3PO_4	100	100	192	−1.0
Nitrohydrochloric acid	$HCl+HNO_3$ (3:1)	100	80	192	0

Reactivity With Various Substances (In a Vacuum)

Reactant	Chemical Formula	1200℃×3h	1600℃×3h
Aluminum	Al	○	△
Boron	B	◎	◎
Cobalt	Co	△	×
Chromium	Cr	△	×
Copper	Cu	○	△
Iron	Fe	×	×
Molybdenum	Mo	◎	○
Nickel	Ni	◎	×
Lead	Pb	△	×
Silicon	Si	◎	○
Tin	Sn	◎	△
Tantalum	Ta	◎	◎
Titanium	Ti	◎	○
Vanadium	V	◎	×
Tungsten	W	◎	○
Alumina	Al_2O_3	◎	×
Boron oxide	B_2O_3	◎	◎
Chromium oxide (Ⅲ)	Cr_2O_3	◎	×
Iron oxide (Ⅲ)	Fe_2O_3	×	×
Magnesium oxide	MgO	◎	△
Manganese oxide (Ⅳ)	MnO_2	◎	×
Lead oxide (Ⅱ)	PbO	○	△
Silicon dioxide	SiO_2	◎	△
Titanium oxide (Ⅳ)	TiO_2	◎	○
Vanadium oxide (Ⅴ)	V_2O_5	◎	△
Zirconium oxide (Ⅳ)	ZrO_2	◎	○

※◎…No reaction ○…Slight reaction
△…Reaction ×…Significant reaction

Layer Properties

Crystal Structure	β-SiC(Cubic System) Structure 
Bulk Density	3.2Mg/m^3
Hardness	2800HK
Electrical Resistivity	0.2Ω·m (through the fall-of-potential method)
Flexural Strength	170MPa (through 3-point bending)
Young's Modulus	320GPa (through the deflection method)

※The figures above are extracted from other publications or are measurement examples, and are not guaranteed.

Impurity Analysis Example

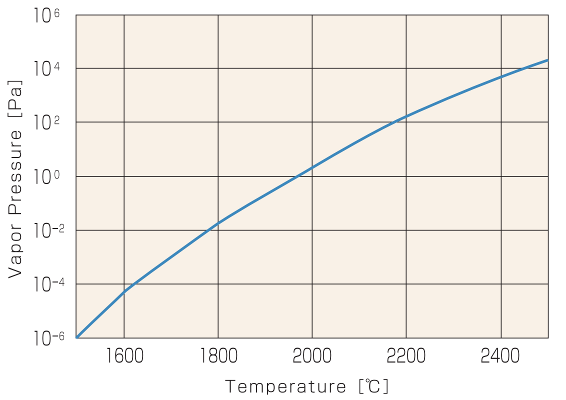
Unit:mass ppm

Element	Content
B	0.15
Na	0.02
Al	0.01
Cr	<0.1
Fe	0.02
Ni	<0.01

※Measurement method:Glow Discharge Mass Spectrometry
※The figures above are measurement examples and are not to be guaranteed.

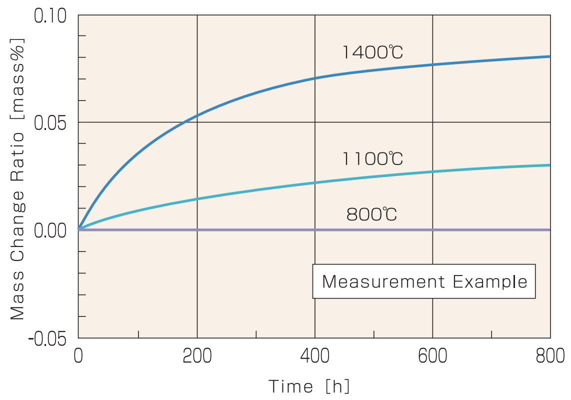
■Silicon Carbide Vapor Pressure

※Extracted from the ultra high temperature melting point material handbook



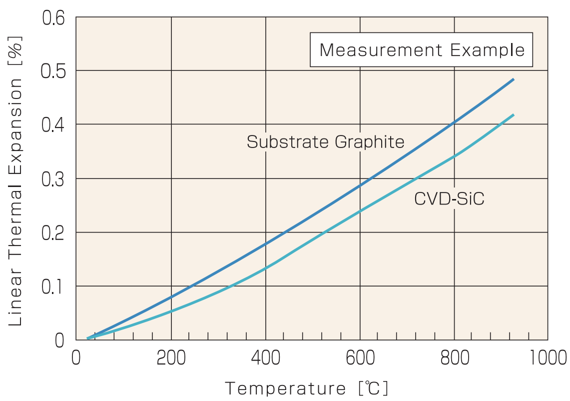
PERMA KOTE is extremely stable at high temperatures.

■Oxidization

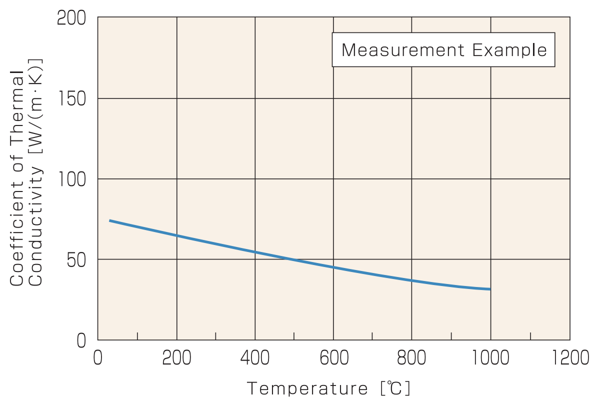


PERMA KOTE is resistant to oxidization; and because the SiO_2 protective layer is formed at over 800℃, the substrate graphite is protected from oxidization.

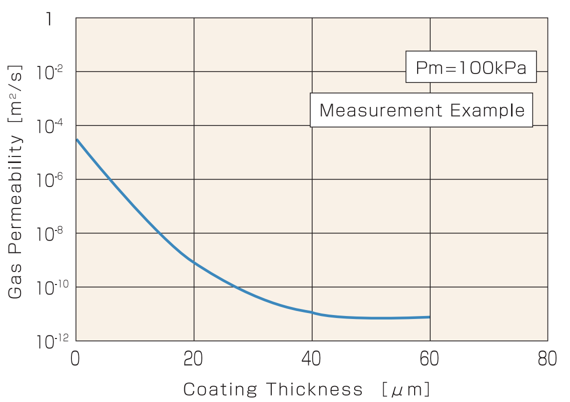
■Coefficient of Thermal Expansion for CVD-SiC and Substrate graphite



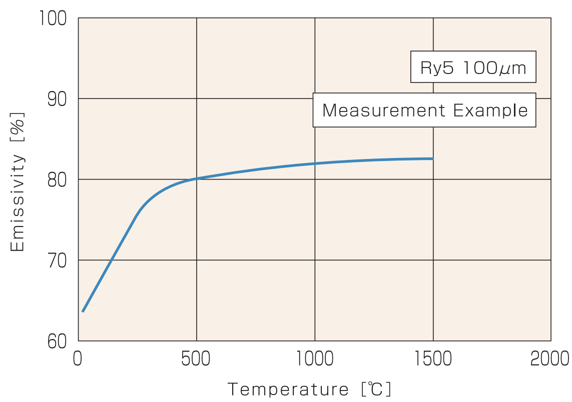
■Thermal Conductivity



■Gas Permeability



■Emissivity



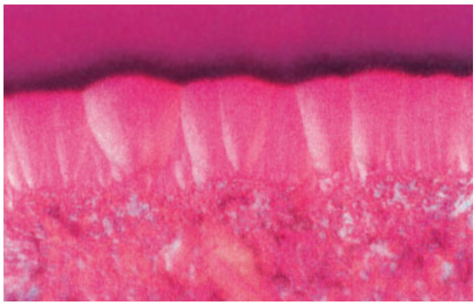
PYROGRAPH Products

PYROGRAPH is a product created by coating the surface of highly purified isotropic graphite with a fine layer of pyrolytic carbon by means of a proprietary Toyo Tanso Chemical Vapor Deposition (CVD) process.

PYROGRAPH Characteristics

- the pyrolytic carbon layer is extremely fine
- ultrapure
- the layer coating ensures extremely low gas permeability
- excellent corrosion resistance against gas
- excellent oxidation resistance at low temperatures
- excellent heat resistance
- prevents the parting and scattering of graphite prticles, and the emission of gas and impurities from the graphite substrate

PYROGRAPH Cross Section



The column-shaped structure of the pyrolytic carbon layer means that the structure is extremely fine.

Application

- Single crystal silicon manufacturing equipment
- Tube for atomic absorption spectroscopy
- OLED manufacturing equipment

PYROGRAPH Property Data

Impurity Analysis Example

Unit:mass ppm

Element	Content
B	<0.01
Na	0.03
Al	0.02
Cr	<0.10
Fe	<0.01
Ni	<0.01

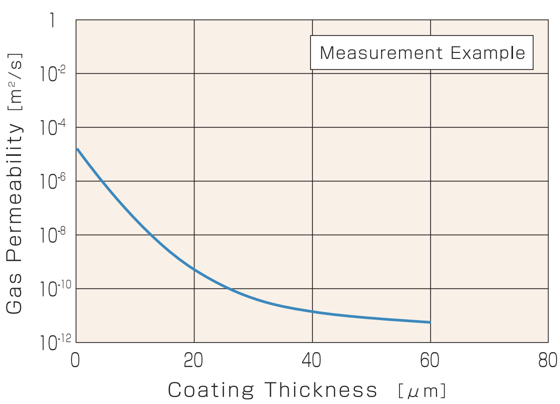
※*Measurement method: Glow Discharge Mass Spectrometry
※The figures above are measurement examples, and are not to be guaranteed.

General Physical Properties

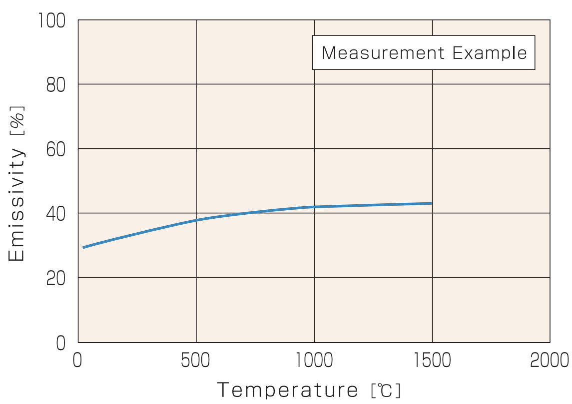
Item	Unit	Parallel to Coating Surface	Perpendicular to Coating Surface
Bulk Density	Mg/m^3	2.2	2.2
Hardness	HSD	100	—
Electrical Resistivity	$\mu\Omega\cdot m$	2.00~4.00	$2\sim5\times10^3$
Coefficient of Thermal Expansion	$10^{-6}/K$	1.7	28
Tensile Strength	MPa	98~147	Extremely weak
Young's Modulus	GPa	29~39	—
Thermal Conductivity	W/(m·K)	170~420	2~4

※The temperature range for the coefficient of thermal expansion is RT to 1,000℃.
※The figures above are extracted from other publicatuons, and are not to be guaranteed.

Gas Permeability



Emissivity



TOYO TANSO

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TOYO TANSO
Inspiration for Innovation

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