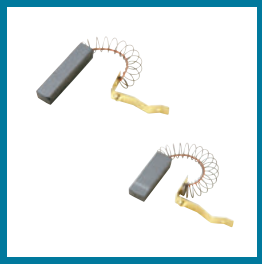
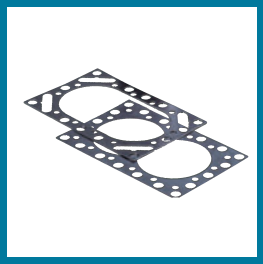
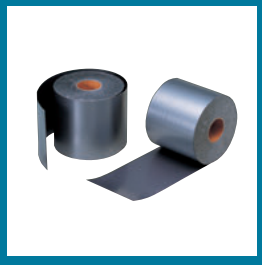


TOYO TANSO

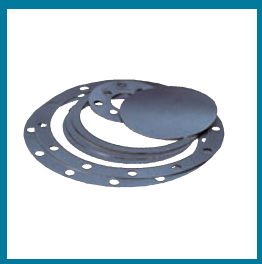
CARBON-GRAPHITE PRODUCTS





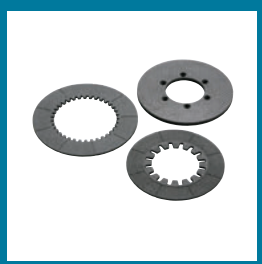




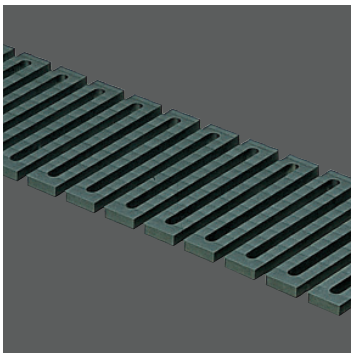


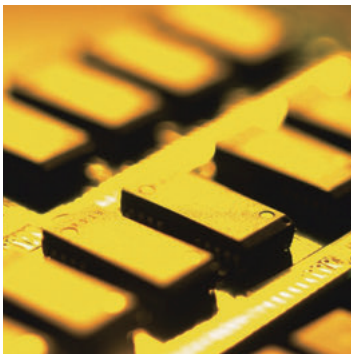
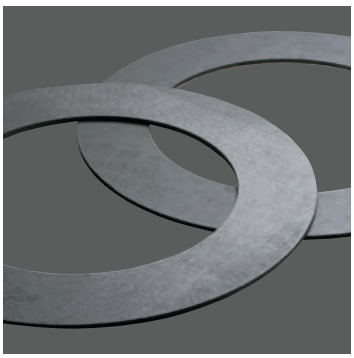










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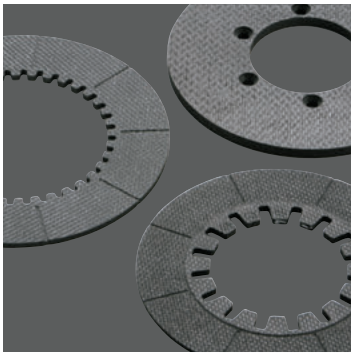
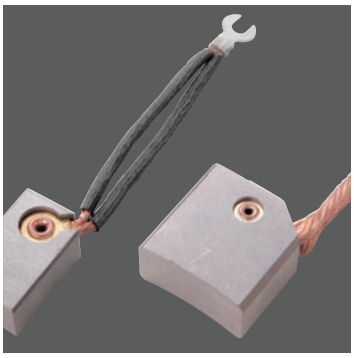






People and carbon
An everlasting relationship.

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 semiconductors 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

CNovel™

Porous Carbon

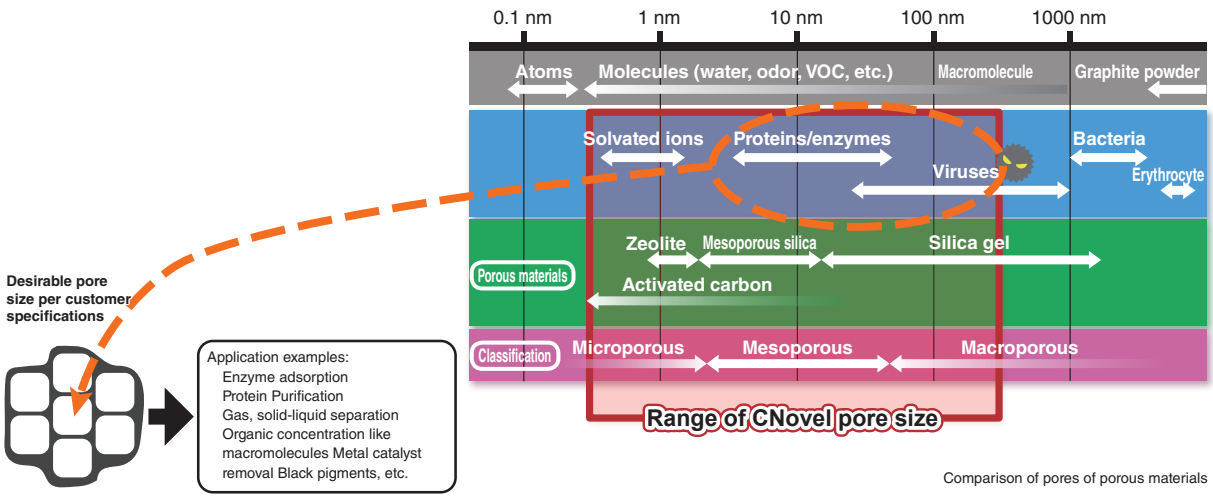
CNovel™ features a uniqueness that has led to its being studied for use in new fields where conventional carbon is not being used, such as the automobile manufacturing, medical care, information communications, and environmental fields.

Features of CNovel™ Products

CNovel™ has a special, high-mesoporous structure which is unlike that of typical carbon materials like activated carbon. It is a new carbon material which has been considered difficult to obtain as an industrial material.
One particular property is the structure called “inter-connected pores”, which are mesopores connected to each other.

■ Adjustable mesopore size and volume

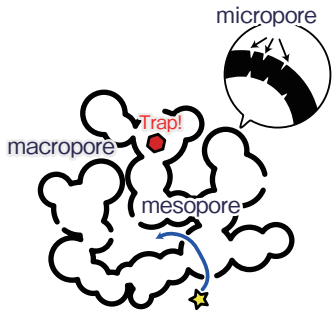
CNovel™ achieves controlled functionalization that conventional carbon materials can’t.



Comparison of pores of porous materials

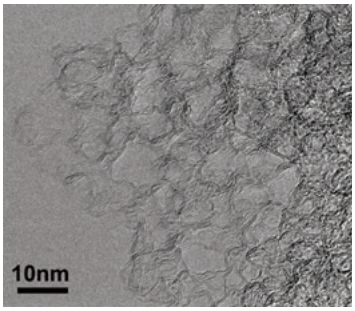
■ Notable response performance of adsorption-desorption and electron/ion mobility

The “Inter-connected pores” promote the internal diffusion of substances inside pores.



Schematic diagram

Both mesopores and micropores exist, with the mesopores being adjoined to make Inter-connected pores.



TEM photo

The dark colored area is a carbon wall, with the area surrounded by that being mesopores.

■ Adjustable surface chemical states

CNovel™ can control chemical functions without changing physical properties. Because of this, it can control chemical functions, such as the wetting properties of water, by controlling surface conditions.

QR Code
(Link to Website)

Videos of experiments currently viewable on YouTube

Property Data

■ Representative physical properties

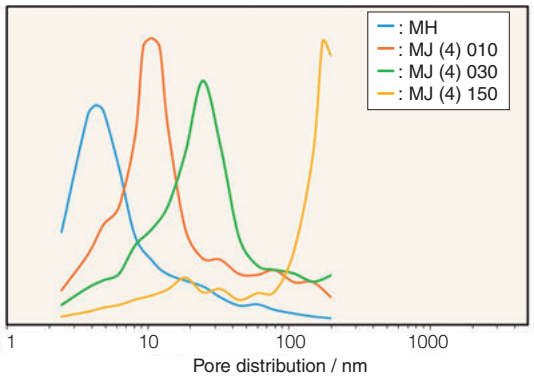
Grade	BET surface area	Designed mesopore diameter	Capacity of all pores	Capacity of all micropores	Bulk density
	$m2\ g^{-1}$	nm	$mL\ g^{-1}$	$mL\ g^{-1}$	$g\ mL^{-1}$
MH	1500	5	1.7	0.5	0.15
MJ(4)010	1100	10	2.0	0.4	0.10
MJ(4)030	800	30	2.0	0.3	0.10
MJ(4)150	300	150	0.4	0.1	0.10

The figures above are typical values, and not guaranteed.

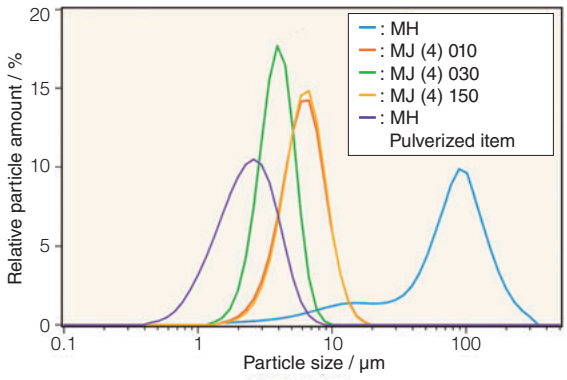
■ Properties of each grade

Grade	Properties	Application examples
MH	Large surface area, chemical stability and resistance. This grade is applicable to various applications.	Adsorbent, Electrodes, Electrical conductor, Gas separators
MJ(4)010	Low bulk density, good diffusivity. This grade serves the purposes of cost-saving and reducing process lead time.	Filler, Inks, Heat carrier, Electrodes, Separators, Adsorbent, Shock resistance
MJ(4)030	Porous carbon with large mesopores. It acts for adsorption and separation, particularly for organic vapor or proteins including the macromolecules.	Filter, Separators, Adsorbent, Column filler for analysis, Concentration
MJ(4)150	Larger pores (macropores) than mesopores. This grade can be applied to adsorption and separation, such as for proteins that could not be adsorbed in the mesopores.	Filter, Separators, Adsorbent, Concentration

■ Pore distribution



■ Particle size distribution



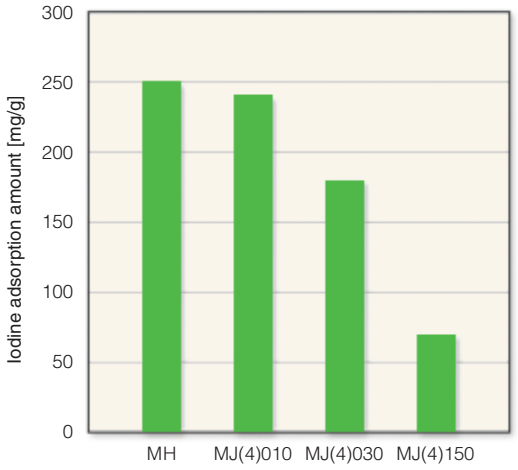
■ Electrical resistivity

	Grade	Electrical resistivity
		Ω cm
CNovel	MH	0.51
	MH Pulverized item	0.09
	MJ(4)010	0.15
	MJ(4)030	0.12
	MJ(4)150	0.10
Carbon black		0.03 to 0.3

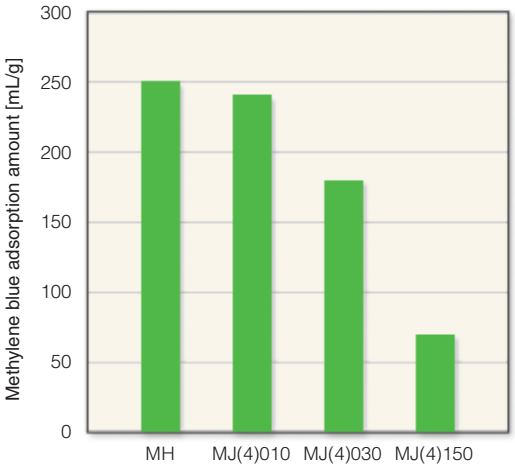
■ Adsorption Comparison Data

Taking advantage of the pores' adsorption functions, CNovel™ extends its usage in applications such as filters and analysis equipment, as well as electrical and heat energy storage devices.

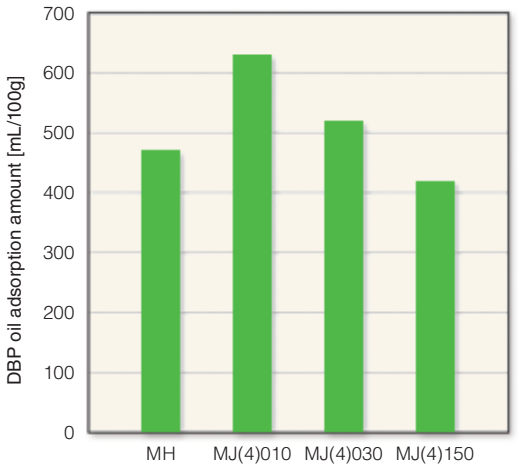
■ Iodine*1



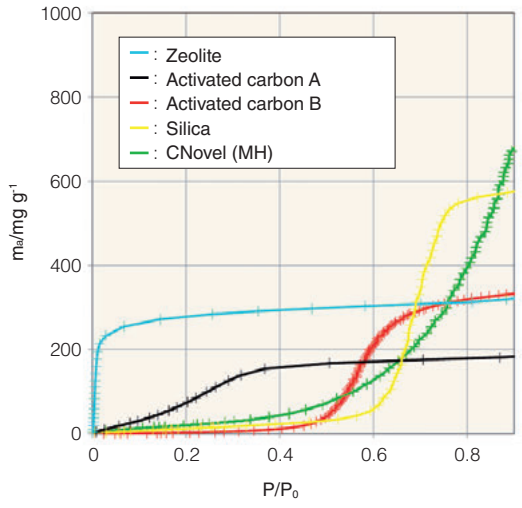
■ Methylene blue*1



■ Dibutyl phthalate (DBP)*2



■ Water

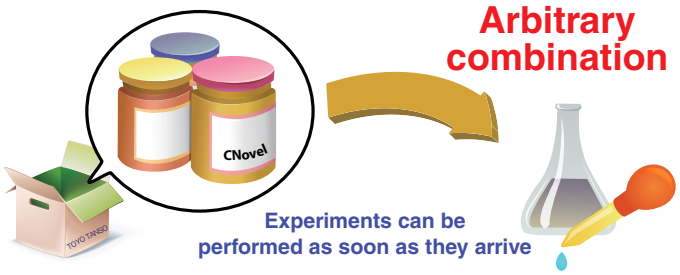


The figures above are typical values, and not guaranteed.
*1 Measurement methods used comply with JIS K1474.
*2 Measurement methods used comply with JIS K6221.

■ CNovel™ Sample Kit (Now on Sale)

For details, please contact your local distributor.

Contents: 3 x 50 g containers



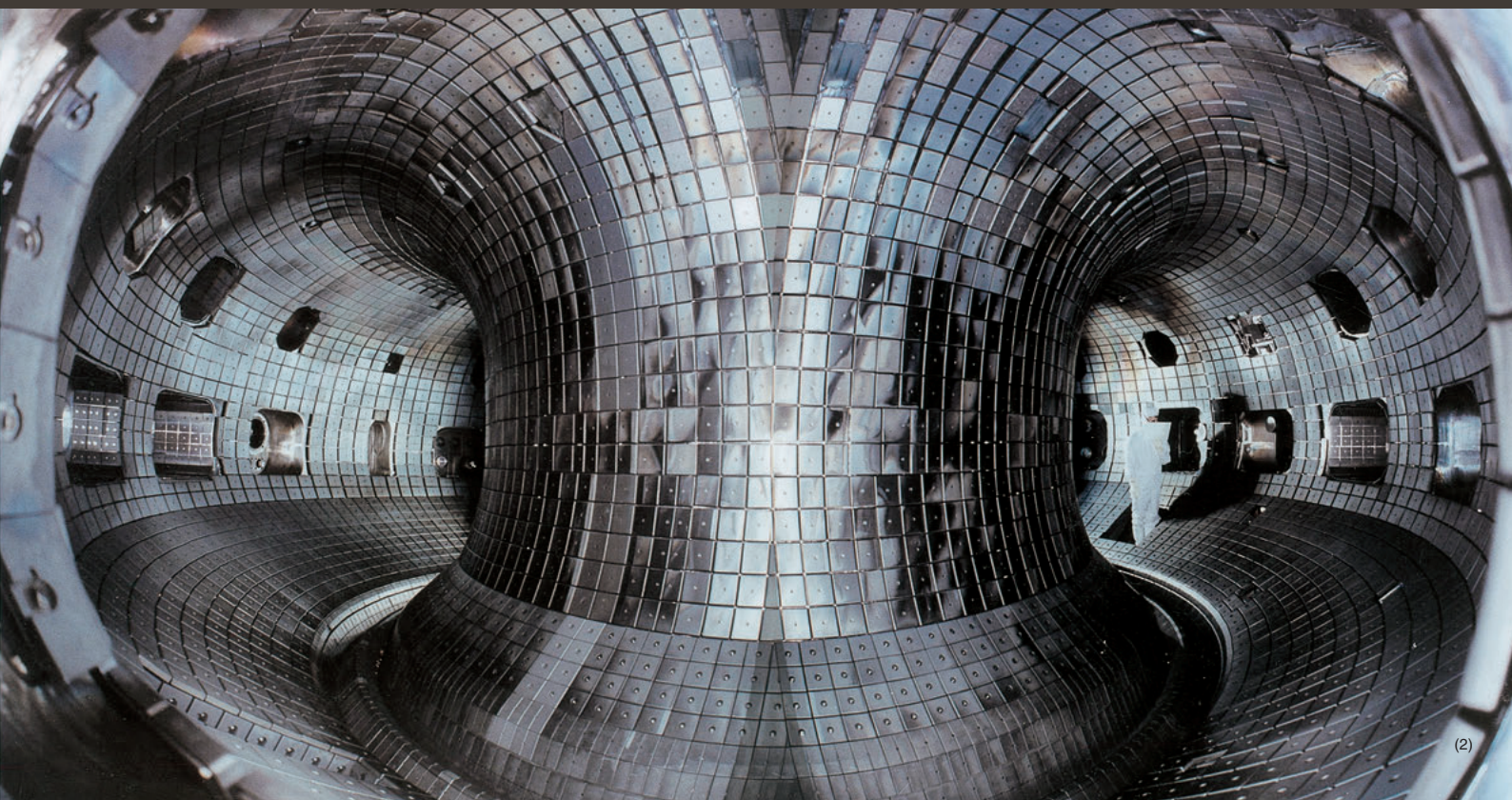
Sales in kg-size quantities is possible from 1 container.
Please feel free to contact us.

Special Graphite

(1) Single crystal silicon manufacturing equipment

(2) Critical plasma testing equipment (JT-60)
* Photographs provided by National Institutes for Quantum and Radiological Science and Technology

(1)



(2)

Features of Special Graphite Products

The demand from the industry over the years has been for carbon with increasingly tighter and stable properties. In this context, Toyo Tanso was the pioneer in our industry in developing “isotropic graphite.” This is a graphite material with micro particles and an isotropic structure and properties which created through Cold Isostatic pressing (CIP). 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 until 2,500°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

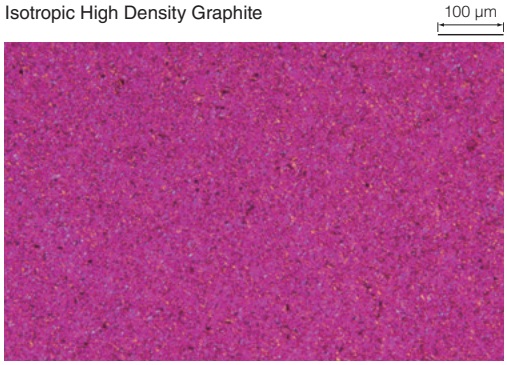
With the exception of some strong oxidizers, it is chemically stable. Graphite can be used stably even in environments that cause some metals to corrode.

■ Lightweight and Easy to Machine

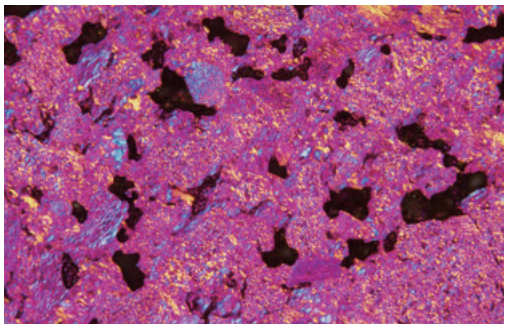
The bulk density is low as compared with metallic materials-enabling a lightweight design. In addition, it has excellent mechanical machining properties-facilitating accurate shaping processes.

■ Isotropic Graphite and Anisotropic Graphite

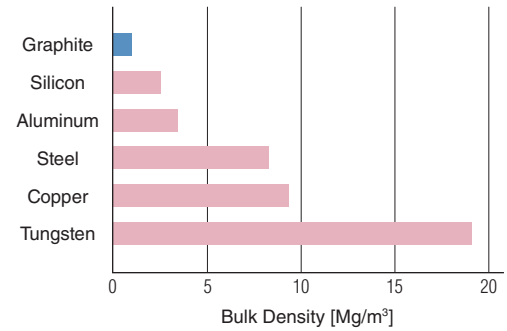
Isotropic High Density Graphite



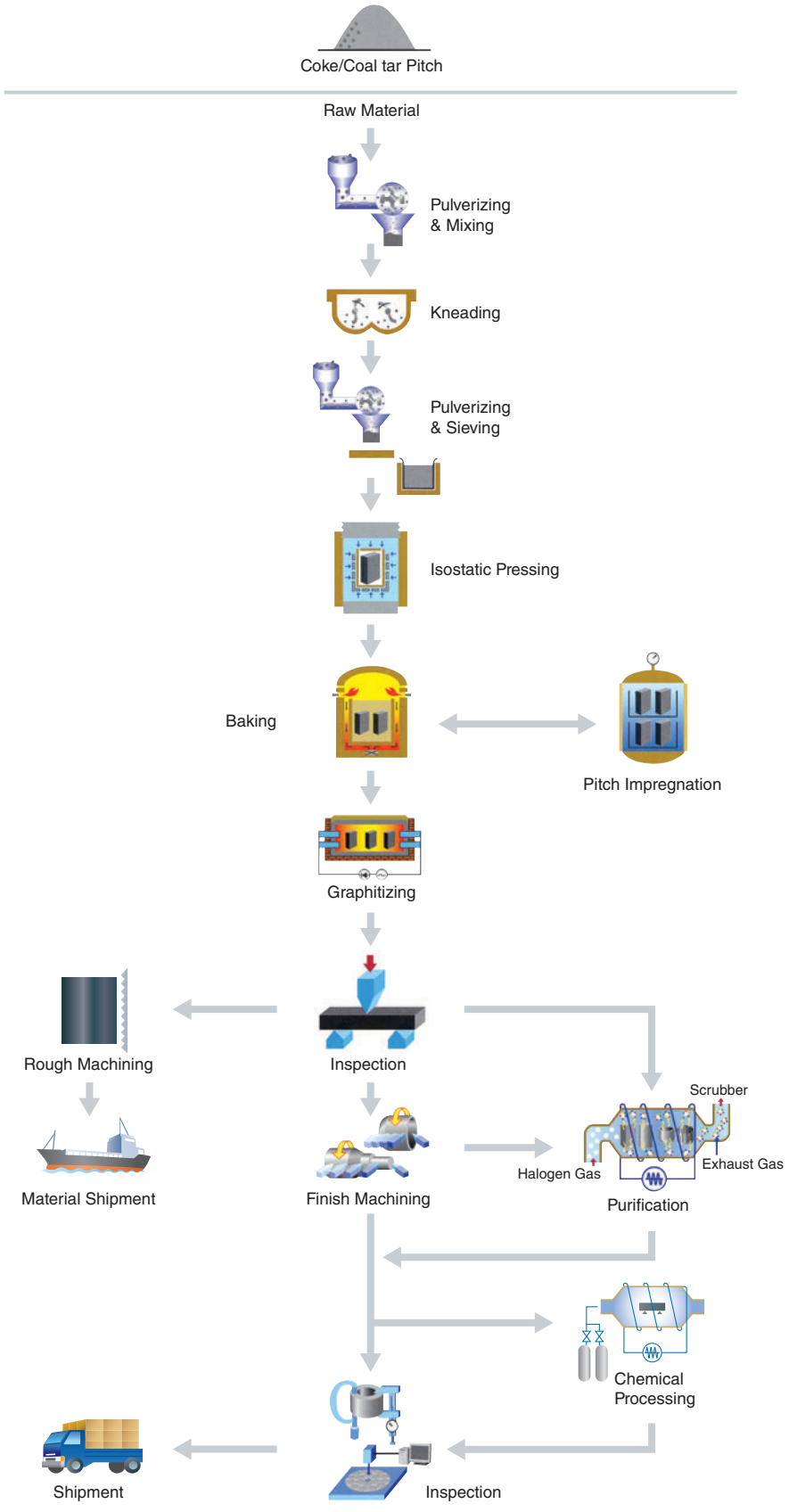
Anisotropic Graphite



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 associate with conventional anisotropic graphite.



Manufacturing Process

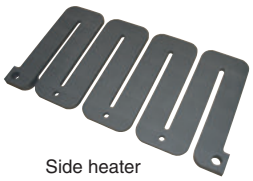


Application

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 various manufacturing process such as polycrystalline silicon and single crystal silicon, white LEDs, and high-frequency device. 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.

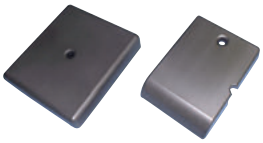
■ Environment and Energy

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

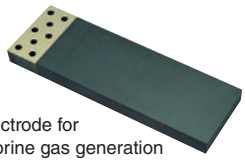


Side heater

Core component for High Temperature Gas-cooled Reactor
* Photographs provided by the Japan Atomic Energy Agency



Nuclear Fusion Reactor Plasma First Wall
* Photographs provided by National Institutes for Quantum and Radiological Science and Technology



Electrode for fluorine gas generation

■ Electronics

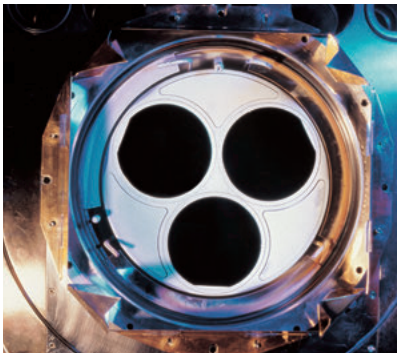
- Silicon Semi-conductor Manufacturing Applications
  - Polycrystalline silicon manufacture
  - Single crystal silicon manufacturing equipment
  - Susceptors for epitaxial growth
  - Plasma CVD electrodes
  - Ion implantation
  - Hermetic sealing jigs

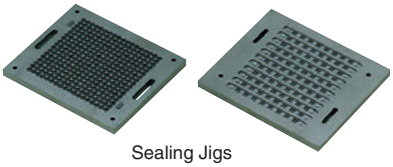
Single crystal silicon manufacturing equipment

Crucible

Reflector

Heater





Sealing Jigs

■ Electronics

- Compound Semi-conductor Manufacturing Applications
  - Crystal Manufacturing Equipment Parts
  - MOCVD Susceptors
- LCD Panel Manufacturing Applications
  - Heater Panels
  - Electrode for plasma Etching
- Hard Disk Manufacturing Applications
  - Sputtering Targets

MOCVD susceptor

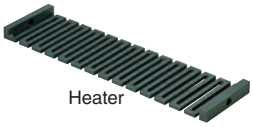
Pancake susceptor

■ Metallurgical

- Continuous Casting
  - Dies
  - Mandrels
- Hot Press
  - Dies
  - Punch
  - Sleeves
  - Spacers
- Industrial Furnace
  - Heaters
  - Trays
- Vacuum Evaporation Crucibles
- Gas Analysis Crucibles
- Optical Fiber Manufacturing Applications
  - Heaters
  - Muffle Tube
- EDM Electrodes

Hot Press Mold
(Cut Model)

Continuous Casting Dies



Heater

Vacuum Evaporation
Crucibles

EDM Electrodes

Property Data

■ Typical Properties

Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Compressive Strength	Tensile Strength	Young's Modulus	Coefficient of Thermal Expansion	Thermal Conductivity	Standard Size
	Mg/m³	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 x 620 x 1000 ø585 x 1050
IG-12	1.78	55	12.5	39	88	28	10.8	4.7	100	305 x 620 x 1000 ø585 x 1050
IG-15	1.90	60	9.5	54	103	29	11.8	4.8	140	230 x 620 x 1000
IG-19	1.75	60	17.0	38	88	25	9.5	4.6	80	ø400 x 900 305 x 620 x 1000
IG-43	1.82	55	9.2	54	90	37	10.8	4.8	140	300 x 540 x 850
IG-45	1.88	55	9.0	60	110	40	12.0	4.9	140	300 x 540 x 850
IG-56	1.77	57	12.2	43	88	27	10.3	4.7	100	1050 x 1050 x 450 ø740 x 730
IG-70	1.83	58	10.0	47	103	31	11.8	4.6	130	305 x 620 x 1000 ø460 x 1050
ISEM-1	1.68	45	13.5	36	69	20	8.8	4.2	90	305 x 620 x 1000
ISEM-2	1.78	55	11.0	41	83	25	9.8	4.6	120	305 x 620 x 1000
ISEM-3	1.85	60	10.0	49	103	29	11.8	5.0	130	305 x 620 x 1000
ISEM-8	1.78	63	13.4	52	106	34	10.1	5.6	90	305 x 620 x 1050
ISO-63	1.78	76	15.0	65	135	46	12.0	5.6	70	230 x 540 x 1000
ISO-68	1.82	80	15.5	76	172	54	13.2	5.6	70	230 x 540 x 1000
TTK-4	1.78	72	14.0	73	135	49	10.9	5.0	90	210 x 510 x 950
TTK-5	1.78	80	15.5	80	150	53	11.6	5.7	80	210 x 510 x 950
TTK-8	1.77	78	15.0	80	155	55	12.0	5.3	80	100 x 400 x 700
TTK-9	1.77	90	18.0	92	180	67	13.0	5.8	70	100 x 400 x 700
SIC-6	1.85	60	10.0	49	103	29	11.8	5.0	130	305 x 620 x 1000
SIC-12	1.77	65	14.1	47	93	29	10.8	5.0	80	305 x 620 x 1000
HPG-51	1.78	73	14.3	75	140	50	11.0	5.1	90	210 x 510 x 950
HPG-53	1.78	81	15.7	80	156	55	11.8	5.8	80	210 x 510 x 950
HPG-59	1.91	88	13.5	100	210	74	12.7	5.7	95	100 x 500 x 950
HPG-81	1.77	80	15.1	83	161	58	12.2	5.2	80	100 x 400 x 700
HPG-83	1.77	92	18.2	96	187	70	13.3	5.9	70	100 x 400 x 700

* 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/cm² × 0.098 GPa=kgf/mm² × 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.

■ Impurity Analysis Example

Unit: mass ppm

Element	Content			Measurement Method
	Ultra High Purity Graphite	High Purity Graphite	Regular Graphite	
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			Measurement Method
	Ultra High Purity Graphite	High Purity Graphite	Regular Graphite	
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 measurement, 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

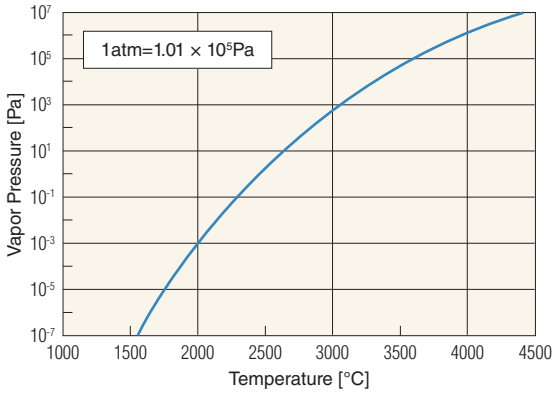
■ Initial Reaction Temperatures With Various Substances

* Extracted from other publications

Reacant	Initial Reaction Temperature	Compound of Reaction
Aluminum	800°C	Al_4C_3
Boron	1600°C	B_4C
Iron	600 to 800°C	Fe_3C
Sodium	400 to 450°C	$C_{64}Na$ Intercalation compound (when O_2 is present)
Cobalt	218°C	CoC, Co_3C
Molybdenum	700°C	Mo_2C
Nickel	1310°C	Ni Carbonizing in Ni
Silicon	1150°C	SiC
Copper	—	
Magnesium	—	
Lead	—	
Tin	—	
Tungsten	1400°C	W_2C, WC (in hydrogen)
Potassium	300°C	C_8K Other intercalation compounds
Lithium	500°C	Li_2C_2
Beryllium	900°C	Be_2C (in a vacuum or He)
Boron oxide	1200°C	CO, B
Vanadium oxide (V)	438°C	CO, V
Iron oxide (III)	485°C	CO, Fe
Titanium oxide (IV)	930°C	CO, Ti, TiC
Silicon dioxide	1250°C	CO, Si, SiC
Alumina	1280°C	CO, Al, Al_4C_3
Beryllium oxide	960°C	CO, Be, Be_2C
Magnesium oxide	1350°C	CO, Mg
Zirconium oxide (IV)	1300°C	CO, Zr, ZrC

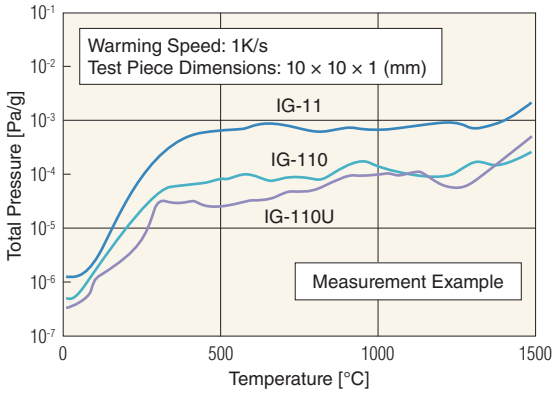
■ Vapor Pressure

* 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 highly purified or ultra highly purified graphite, which emits less gas.

■ Reactivity With Various Atmosphere/Gas species

* Extracted from other publications

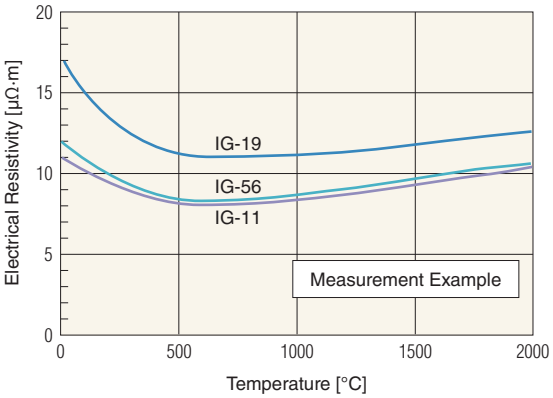
Atmosphere/ Gaseous species	Initial Reaction Temperatures/ Reaction Temperatures	Genesis phenomenon or Produced Compound	Remarks
Air	420 to 460°C	Oxidation/CO, CO_2	Approx. 100°C higher in case of high purity graphite
Oxygen (O_2)	420 to 460°C	Oxidation/CO, CO_2	React with atomic oxygen at normal temperature
Steam (H_2O)	Approx. 650°C	Oxidation/CO, CO_2, H_2	
Carbon dioxide (CO_2)	Approx. 900°C	Oxidation/CO	
Hydrogen (H_2)	Approx. 700°C	Methanation/CH_4	Produce C_2H_2, C_2H_4, C_2H_6 or so at more high temperature
Nitrogen (N_2)	Inert at more than room temperature	Sublimation	Produce CyanogenC_2N_2 during discharge and in 2700°C high pressure N_2 atmosphere
Chlorine (Cl_2)	Inert at more than room temperature	Sublimation	Produce intercalation compound in a lower temperature than 0°C
Fluorine (F_2)	420 to 1900°C	Fluorination/CF	Produce CF_4, C_2F_6 or so up to temperature
Argon (Ar)	Inert at any temperature	Sublimation	
Vacuum	—	Sublimation	In the higher temperature and vacuum atmosphere, the easier sublimate

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

Property Data

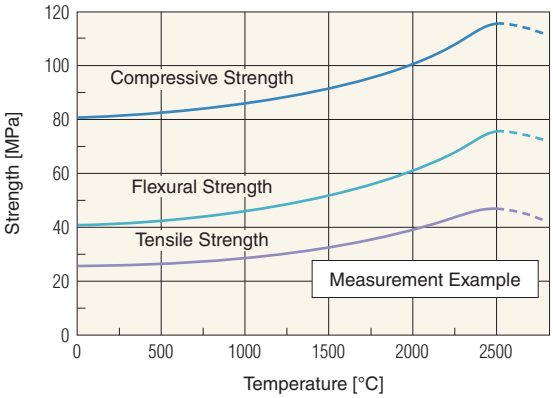
■ High Temperature Properties

■ Electrical Resistivity



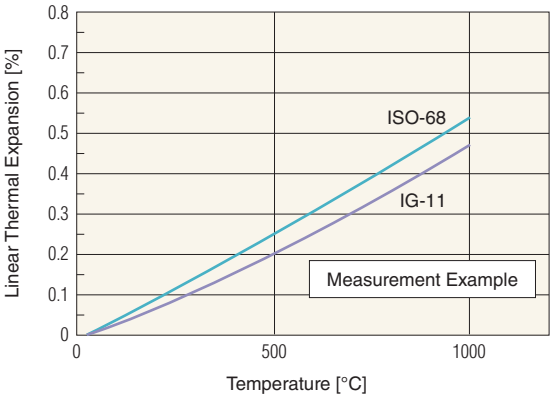
Since thermal characteristics differ from grade to grade, the coefficient of electrical resistivity must be carefully studied when selecting a grade for a heating element.

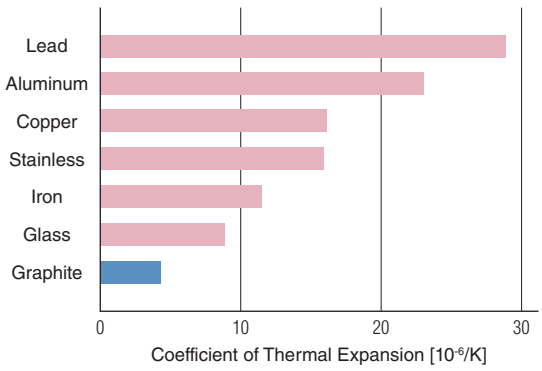
■ Strengths (IG-11)



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

■ Linear Thermal Expansion

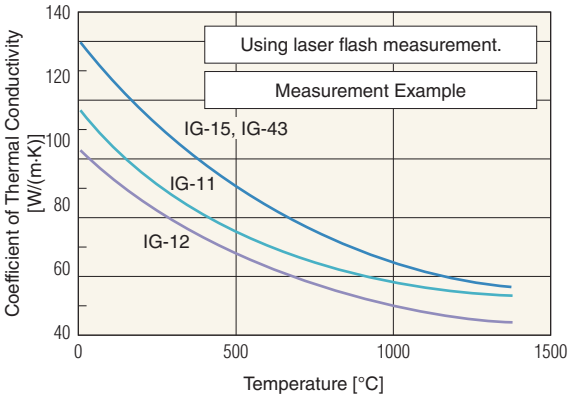


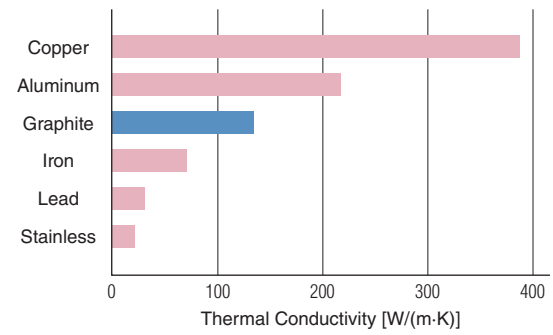


Compared with general metals, the coefficient of thermal expansion for graphite is extremely low. As a result, when used in high temperature applications, the dimensional accuracy is very stable.

Reference:
Coefficient of Thermal Expansion (10⁻⁶/K) = Linear Thermal Expansion (%) × 10⁻² / Temperature Difference (°C)

■ Thermal Conductivity

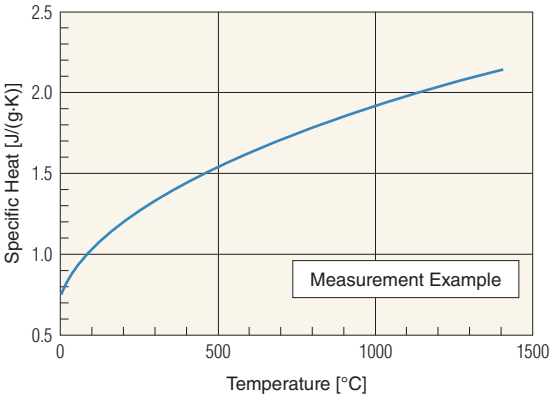




The thermal conductivity of graphite is fairly high, while the coefficient of thermal expansion is very low. These characteristics contribute to its superior thermal shock resistance. The relationship between thermal conductivity and electrical resistivity of graphite in room temperature is indicated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

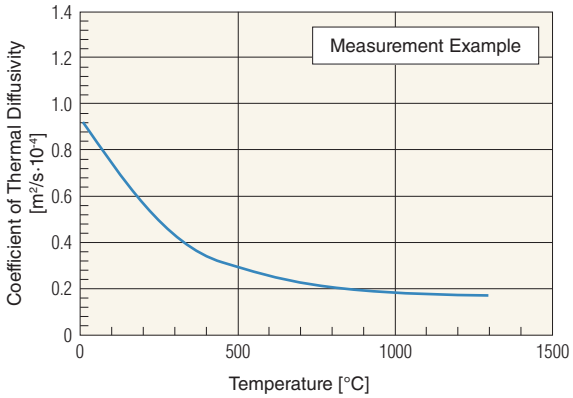
Thermal Conductivity [W/(m·K)] = 0.13 × 10⁴ / Electrical Resistivity (μΩ·m)

■ 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.

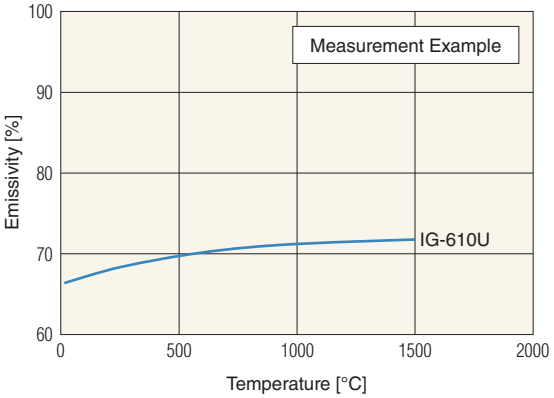
■ Coefficient of Thermal Diffusivity



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.

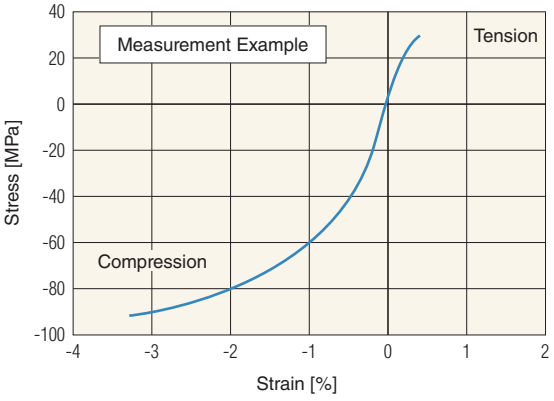
Reference:
Coefficient of Thermal Diffusivity $= \frac{\text{Thermal Conductivity}}{\text{Specific Heat} \times \text{Density}}$

■ Emissivity



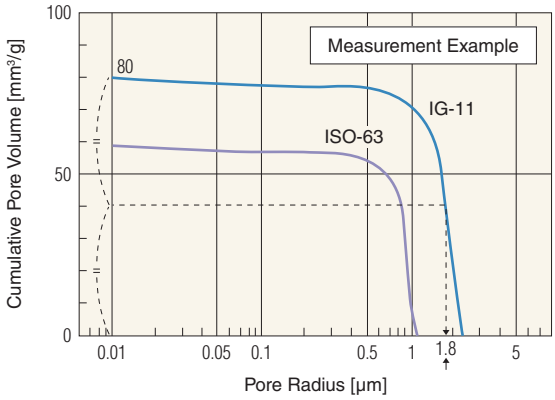
■ Physical Properties

■ 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 = 40 mm³/g→1.8 μm

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 reference)	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 carbon and graphite grades available to meet your requirements.
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

CARBON-GRAPHITE PRODUCTS

C/C composite

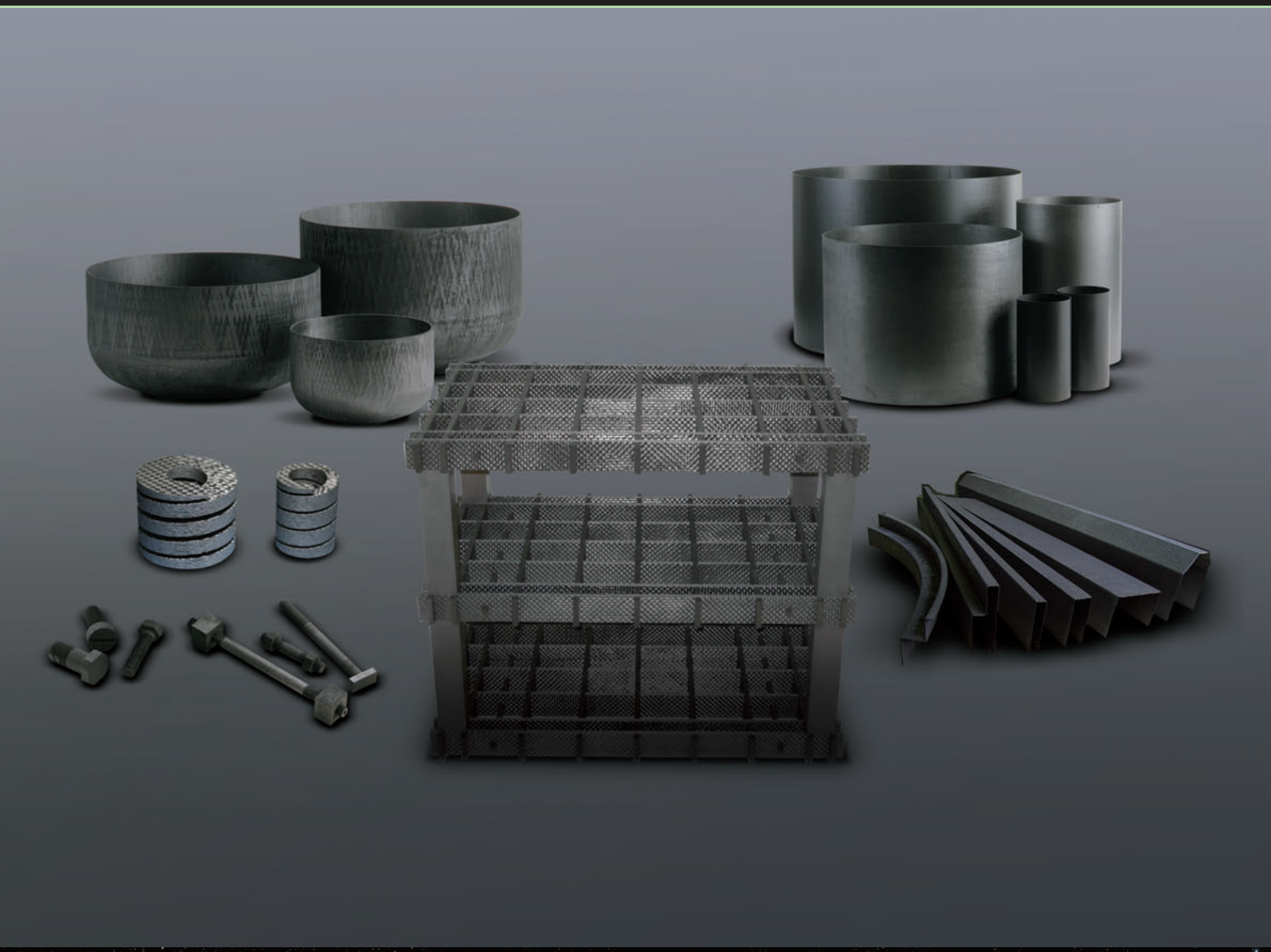
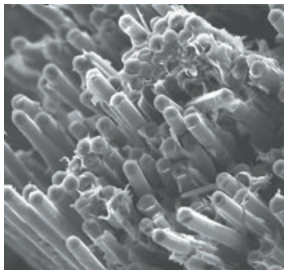


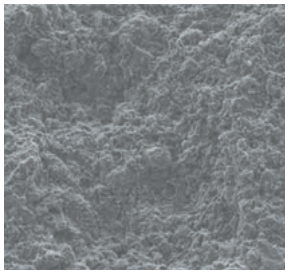
Image: provided by JAXA
Illustrated by Akihiro Ikeshita

Features of C/C Composite Products

C/C composite (Carbon Fiber Reinforced Carbon Composite) is a carbon-carbon composite material reinforced by high strength carbon fiber, which has superior properties such as light weight, high mechanical strength, and high elasticity. Because of their unique features, our C/C composites (CX series) are used in a wide range of fields such as electronics, environment and energy, general industrial furnaces, and automobiles and other means of transport.



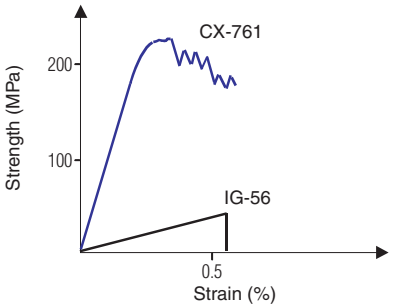
C/C composite (×1000)



Artificial graphite (×200)

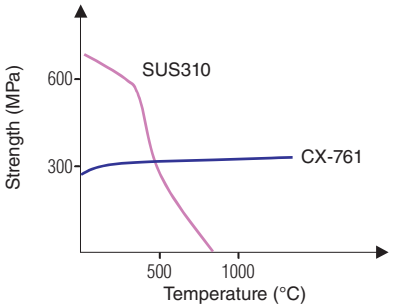
■ High mechanical strength, high elasticity, and high toughness

C/C composites have higher strength, higher elasticity, and resistance to cracking and chipping, compared to isotropic graphite materials. C/C composites can be used with assurance, as the fractures do not propagate rapidly in them.



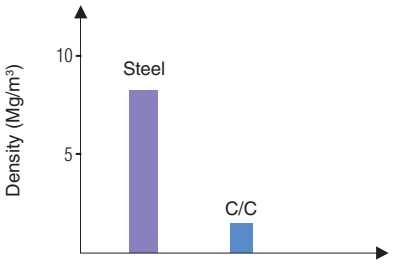
■ Ultra heat resistance

C/C composites have higher strength at high temperatures compared to metallic materials. They can be used even at ultra-high temperatures of 2000°C or higher in inert atmospheres.



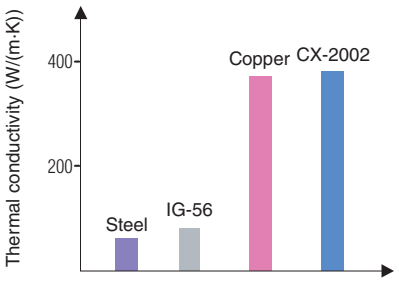
■ Light-weight and easy to handle

C/C composites have low density compared to metallic materials, and therefore, make light weight designing possible.

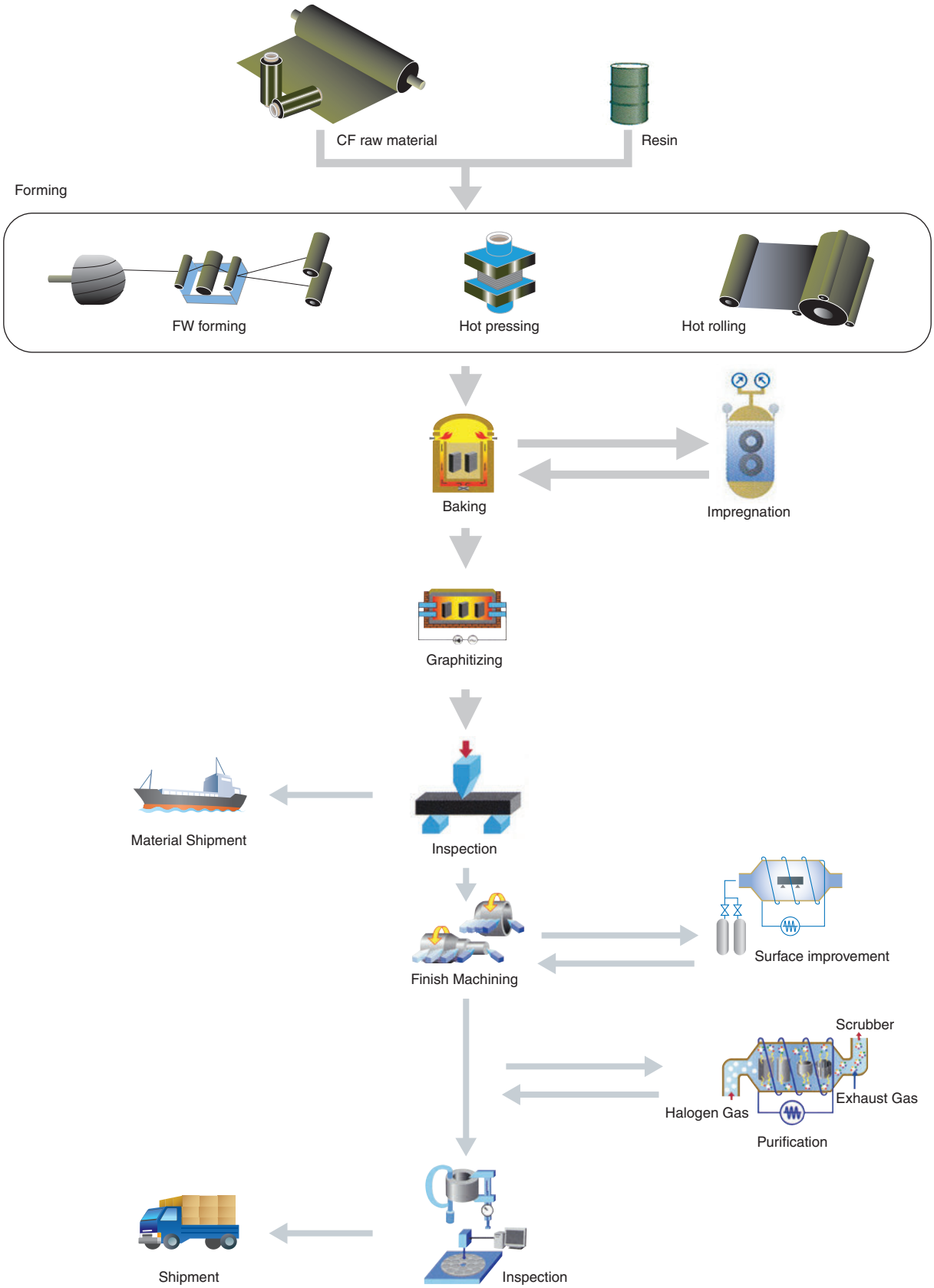


■ High thermal conductivity

A thermal conductivity higher than copper has been achieved (in CX-2002) through the use of carbon structure control technology, which involves our superior chemical vapor infiltration (CVI) treatment.



Manufacturing Process



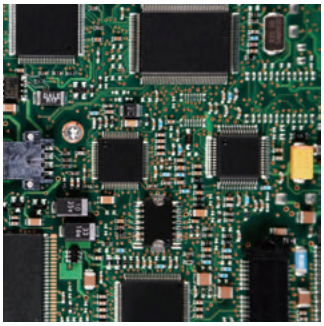
Application

■ Electronics

● For production of single crystal silicon

Crucibles

Heat shields



■ Environment and Energy

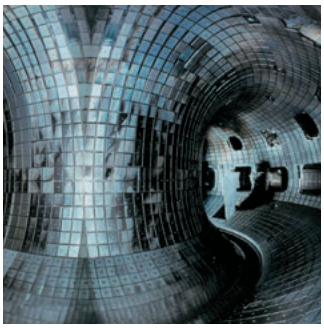
● For production of silicon for solar cells

Rectangular crucibles

Carrier tray for PECVD

● For nuclear energy plants

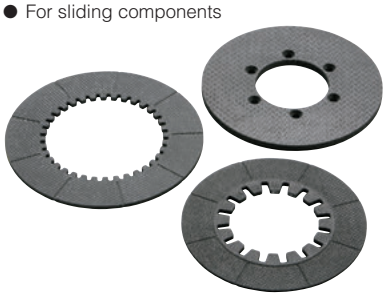
Armor tiles



* Photographs provided by the Japan Atomic Energy Agency

■ Automobiles, other means of transport, etc

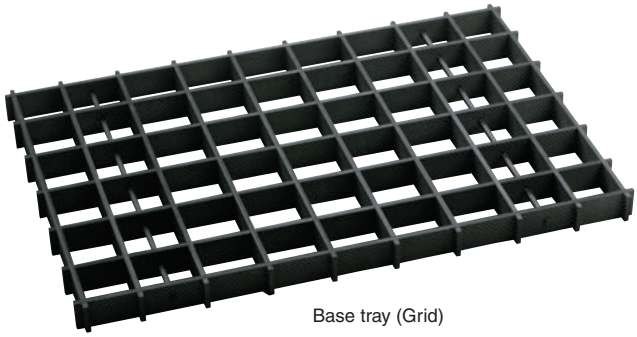
● For sliding components



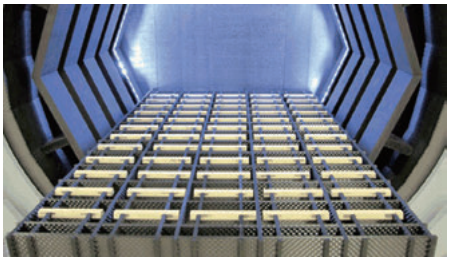
Clutch

■ General industrial furnaces

● For heat treatment furnaces



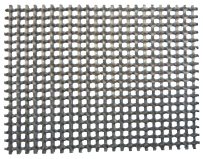
Base tray (Grid)



Heat treatment furnace

Basket

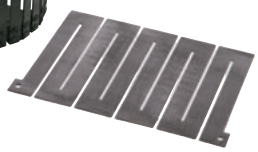
Multi-layer tray



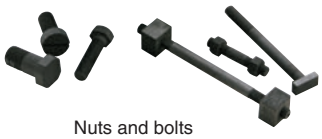
Mesh tray

Wavy tray

Internal driving parts of furnaces



Heaters



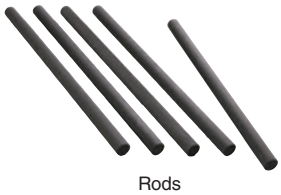
Nuts and bolts

Spring

Protective cover for thermal insulation

● For hot press furnaces

Die



Rods

C/C composite

Property Data

■ Typical properties

Shape	Material	Bulk Density (Mg/m³)	Electrical Resistivity (μΩ·m)	Flexural Strength (MPa)	Flexural modulus (GPa)	Tensile strenght (MPa)	Coefficient of Thermal Expansion RT to 1273K (10^{-6}/K)		Thermal Conductivity (W/(m·k))		C/C type	Description
		—	—	—	—	—	(⊥)	(//)	(⊥)	(//)		
Flat plate	CX-741	1.51	23	140	46	185	8.1	<1	6	35	2DC/C	Medium strength (Molding method A)
	CX-761	1.58	20	185	55	250	8.4	<1	9	44		High strength (Molding method A)
	CX-742	1.48	24	130	42	170	7.8	<1	5	34		Medium strength (Molding method B)
	CX-762	1.58	21	170	50	185	8.2	<1	8	42		High strength (Molding method B)
	CX-31	1.61	22	90	23	98	4.1	<1	12	52		Nut and bolt components
	C/C-201[1]	1.50	30	147	47	127	8.2	<1	5	20		Medium strength, nut and bolt components
Profiles	CX-743	1.48	24	130	—	—	7.8	<1	5	34		Profiles
	CX-763	1.58	21	170	—	—	8.2	<1	8	42		Profiles with high strength
Cylinders	CX-45	1.44	24	105	34	114	8	<1	4	34		Medium strength cylinder
	CX-47	1.52	23	140	45	154	8	<1	6	35		High strength cylinder
Crucibles	CX-510V	1.57	13	195	—	290	7	<1	7	-	FWC/C	FW crucibles
Cylinders	C/C-FW[1]	150	12	245	—	245	—	<1	5	30		FW hot press molds
	CX-55	1.60	11	195	—	290	7.4	<1	7	-		FW cylinders
Tiles	CX-2002U[2]	1.65	2.7, 3.4, 5.1 (X, Y, Z)	47, 43, 17 (X, Y, Z)	—	35, 30, 11 (X, Y, Z)	5.3 (Z)	1.7, 2.3 (X, Y)	190 (Z)	390, 320 (X, Y)	felt C/C	Use in nuclear energy plants
	Isotropic graphite (IG-56)	1.77	12	43	10	27	4.7		104			

* The figures above are typical values, and are not guaranteed.
1) Manufactured by Ohwada Carbon Industrial Co., Ltd.;
2) The direction of lamination of the felt is designated as the Z-axis and the directions within the plane as X- and Y-axes.

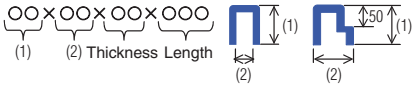
■ Available sizes

Grade	Dimensions (mm)
CX-741, CX-761	2000*1500*0.8 -30
CX-742, CX-762	3000*1500*0.8 -30
CX-31	Max.850*400 3.2-90t
C/C-201	1020*970*1-12 970*720*1-12
CX-45, CX-47	Inner diameter ø300-1400, 1400L
CX-743, CX-763	U-profile 80*20-145*1.2*1000

Grade	Dimensions (mm)
CX-743, CX-763	h-profile 107*44*1.5*1000
CX-510V	Max.inner diameter ø1168 (46" crucibles available)
C/C-FW	Max. ø950*800h, 20-150t
CX-55	Inner diameter ø10-1400, 1400L
CX-2002U	40*150*150 (X*Y*Z)

* Please contact us for other sizes.

U-and h-profiles' dimensions



■ An example of impurity analysis of CX-510V (A high purity treated product)

Unit: mass ppm

Element	Na	Mg	Al	K	Ca	Ti	V	Cr	Fe	Ni	Cu
Content	<0.05	<0.02	<0.08	<0.1	<0.04	<0.09	<0.07	<0.07	<0.04	<0.1	<0.08
Method of measurement	AAS	ICP-AES	ICP-AES	AAS	ICP-AES	ICP-AES	AAS	ICP-AES	ICP-AES	ICP-AES	ICP-AES

* The figures above are examples of measured values and are not guaranteed.
* ICP-AES: Inductively coupled plasma atomic emission spectroscopy, AAS: Atomic absorption spectrometry
* CX-510V is a high purity material

■ Different surface improvements

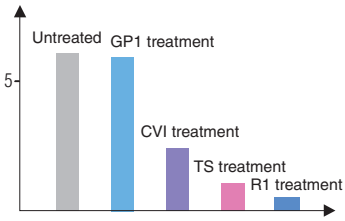
Advantageous properties are imparted by using Toyo Tanso's proprietary surface improvement technologies.

■ Details of surface improvements and their effects

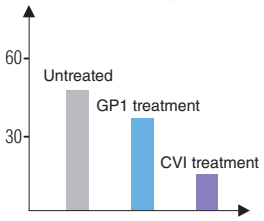
Glassy carbon coated GLASTIX KOTE™ (GP1 treatment)	Impregnation/coating with glassy carbon; it prevents dust formation.
Pyrolytic graphite impregnation (CVI treatment)	Impregnation/coating with pyrolytic carbon; it improves resistance against SiO gas.
Inorganic compound-impregnation (R1 treatment)	Impregnation with inorganic matter; it improves oxidation resistance.
SiC/C composites (TS treatment)	A treatment to convert the surface into SiC; it improves oxidation resistance and prevents dust formation.

*Abbreviation for Chemical Vapor Infiltration

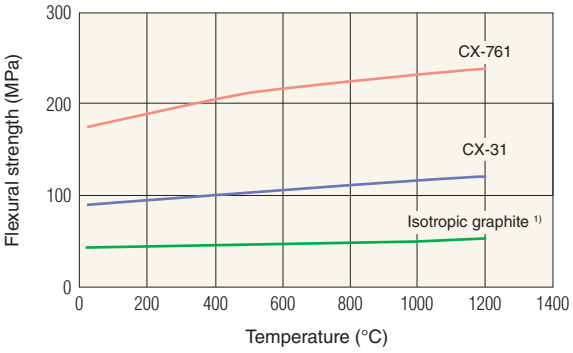
Oxidation loss (%)



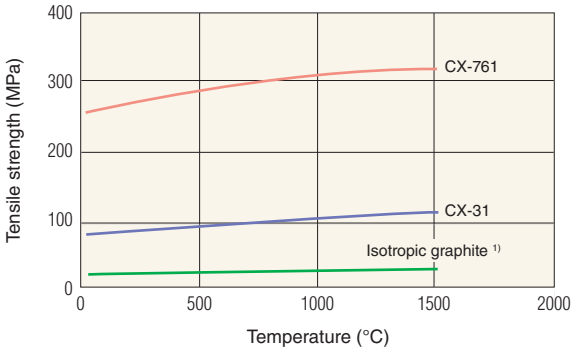
Reactivity with SiO gas (%)



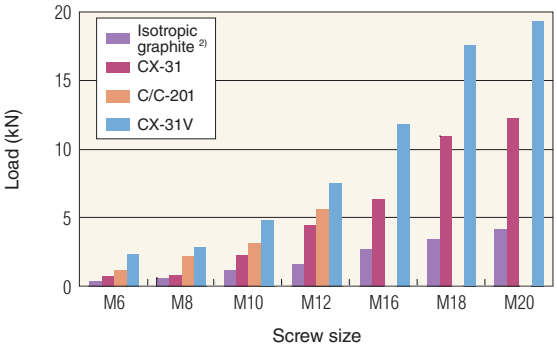
■ Flexural strength



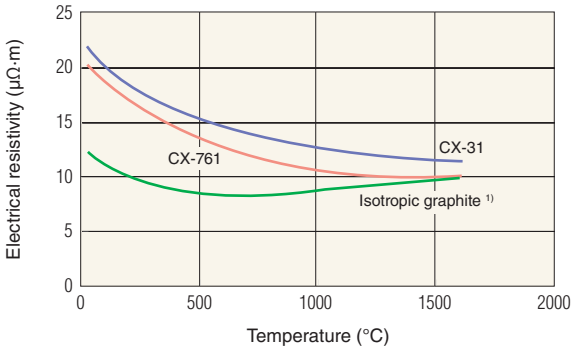
■ Tensile strength



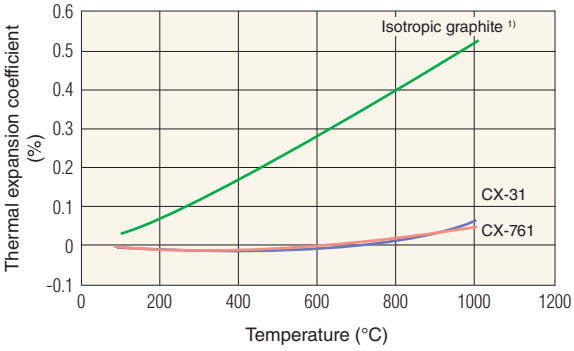
■ Strength of screw thread



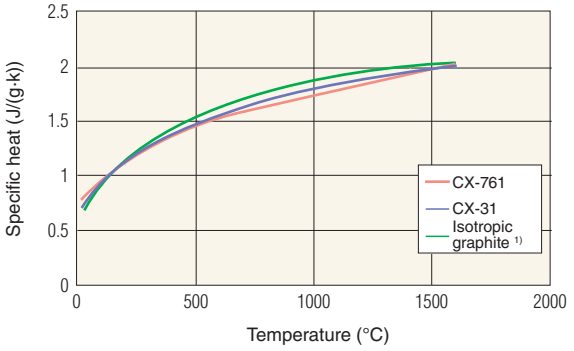
■ Electrical resistivity



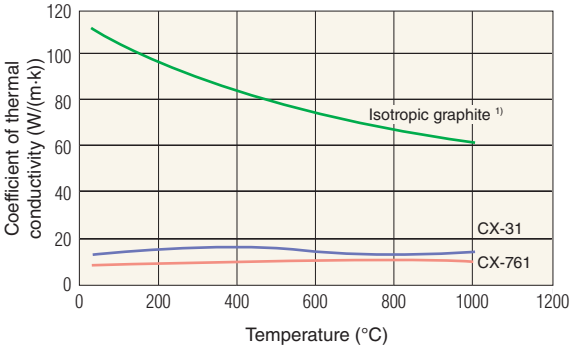
■ Linear thermal expansion coefficient



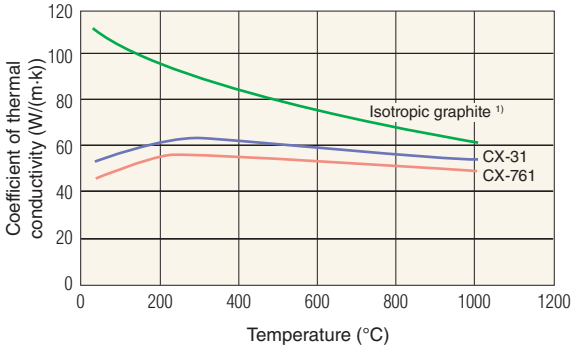
■ Specific heat



■ Thermal conductivity (⊥)



■ Thermal conductivity (//)



1) Our product: Large-sized isotropic graphite material, IG-56
2) Our product: High strength isotropic graphite material, ISO68

Examples of Designing C/C Composite Products

We select suitable materials and design products according to customer's use conditions and requirements.

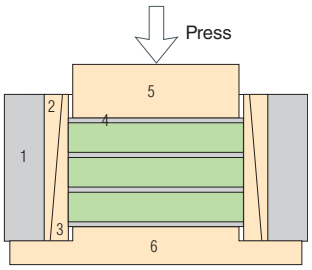
■ Hot press mold

■ Features

1. The device can be made smaller, and the cost of installing the facility reduced.
2. Large-sized sintered bodies can be made, which improves productivity.
3. Heat capacity is less, which can reduce energy costs.

■ Designing

<Design example> Molding pressure: 30 MPa; Job diameter: 200 mm; Height: 250 mm



	Parts	Material
1	C/C die	C/C-FW
2	Outer sleeve with slit	IG-70
3	Two-piece inner sleeve	OP-4800N
4	C/C spacer	C/C-201
5	Upper punch	ISO-68
6	Receiver cradle	IG-70

C/C compsite
Graphite
Sintered body

	Tensile strength	Die outer diameter	Die weight
C/C-FW die	245 MPa	ø340	23 kg
Carbon die	31 MPa	ø520	83 kg

The tensile strength of the C/C composite is higher than of ordinary carbon, which permits a small die outer diameter to be used. This enables the designing of compact equipment.
Manufacturer: Ohwada Carbon Industrial Co., Ltd.

[Examples of products]

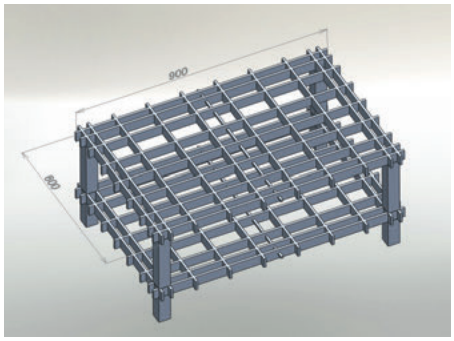
■ Heat treatment tray

■ Features

1. Light weight:
   The density is one fifth of steel and it is easy to handle.
   Weight comparison example: A 900 x 600 x 40 tray made of steel weighs about 85 kg, whereas one made of C/C composite would weigh about one tenth as much, i.e., 8.5 kg.
   (In this calculation, the thickness of the steel tray was kept at twice that of the C/C tray, taking the high temperature strength into account.)
2. High mechanical strength:
   About 10 times that of steel at 1000°C
3. Ultra heat resistant:
   The strength is not reduced, and there is no deformation, even at 2000°C in non-oxidizing atmospheres.
4. Energy saving and environment-friendly:
   The electricity needs for heating the tray is about a quarter of what is needed for the steel tray.
5. Maintenance-free:
   No repairs are needed as there is no deformation.

* The details may differ depending on the design and use conditions.

■ Designing



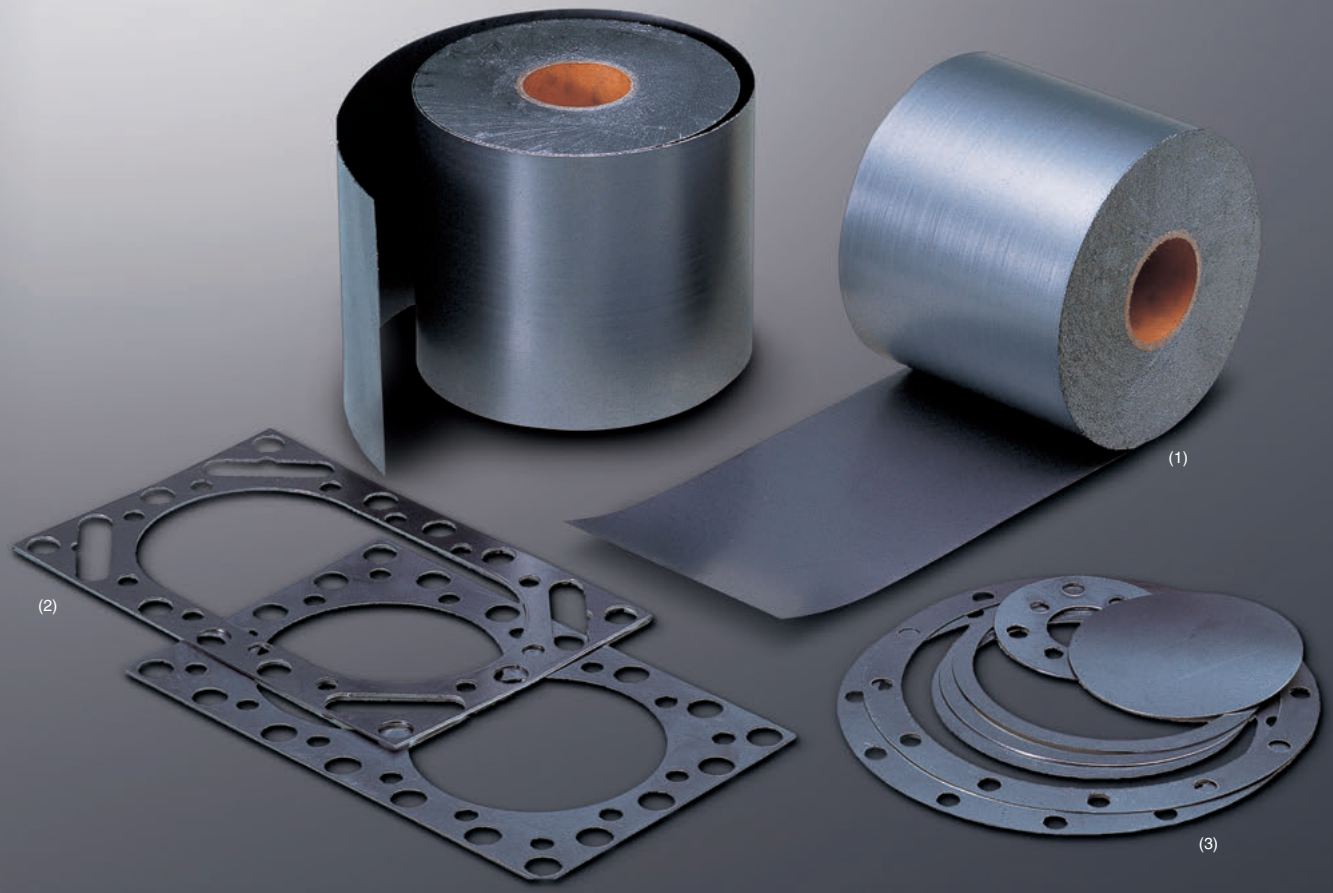
Load capacity (Kgf)	Size (mm)
≤500	900 x 600 x 40
≤750	900 x 600 x 45
≤1000	900 x 600 x 50

[Examples of products]

CARBON-GRAPHITE PRODUCTS

PERMA-FOIL™

Graphite Sheet



(1) PERMA-FOIL™ Roll Products
(2) PERMA-FOIL™ Punching Processed Product Samples
(3) PERMA-FOIL™ Punching Processed Product Samples

Features of PERMA-FOIL™

PERMA-FOIL™ is a generic term for the flexible graphite sheet that Toyo Tanso developed through our original manufacturing technology. It is a sheet graphite product that is formed using select acid treated natural graphite, which is then compressed after undergoing high temperature expansion. Only natural graphite is used as a raw material, which yields highly flexible carbon with excellent heat resistance and chemical resistance. Other features include a high compressibility recovery rate, excellent airtightness, and a high thermal conductivity.

Excellent Self-Lubrication

PERMA-FOIL™ has self-lubricating properties due to its layered crystal structure, making it appropriate for use in high-temperature atmospheres and in fields where fluids and lubricants are avoided. In particular, its coefficient of friction in an unlubricated condition is low compared with other materials, making adhesion difficult to occur.

Stable in the wide range of temperature

Since PERMA-FOIL™ is produce only from natural graphite without using a binder, it is stable in the wide range of temperature (-200°C to 3200°C inert atmosphere) enabling it to be used.

Flexibility, Compressibility recovery properties

This graphite sheet has flexibility and high recovery from compressive stress, which previously unobtainable with existing graphite products. Good matching with counter materials make it ideal for use as a sealing material.

Excellent Chemical Resistance

PERMA-FOIL™ has excellent chemical resistance (acid, base) and is chemically stable.

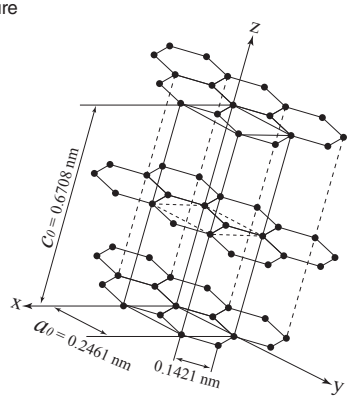
Excellent Thermal and Electrical Conductivity

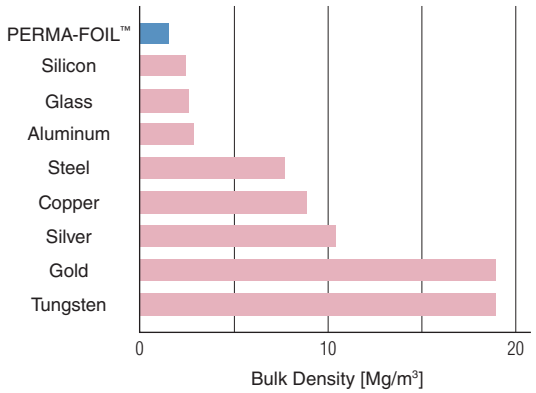
Thermal and electrical conductivity are excellent parallel to surface, and PERMA-FOIL™ is optimum as a heat release material and as a heat transfer material.
* Patent Number 3691836 (JP)

Excellent Purity

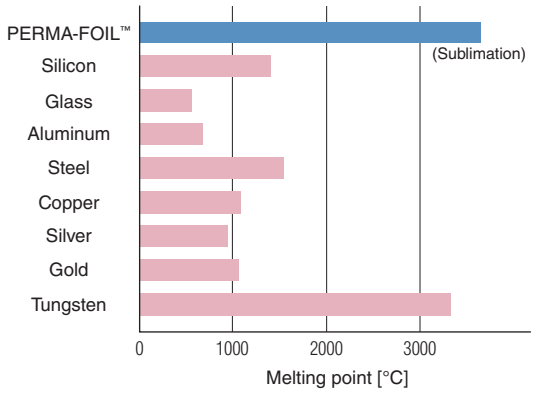
High purity products that have undergone high temperature treatment with halogen gas have a very high purity. Since it has extremely high purity, it is optimum for components in semiconductor, IT, or nuclear energy industry application.
* Patent Number 2620606 (JP)

Graphite crystal structure





It is extremely light when compared with other metals.

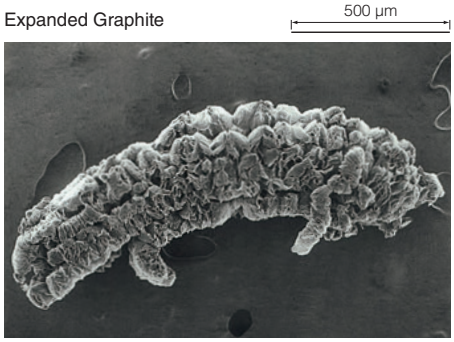


It has excellent heat resistance.

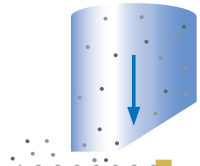
Manufacturing Process

Acid Treated Graphite
(Acid treated graphite is natural graphite that has undergone acid treatment)

Expanded Graphite

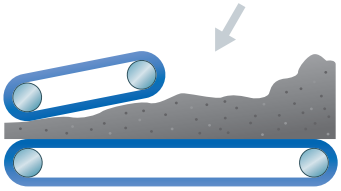


Through heat treatment, acid treated graphite becomes expanded graphite.

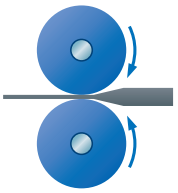


Expansion Treatment

Expanded Graphite

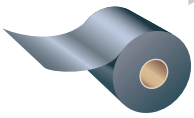


Preforming



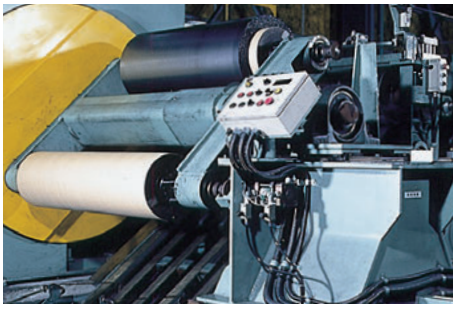
Rolling

Winding



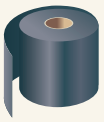
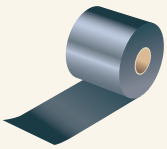
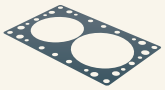
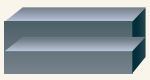
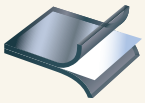
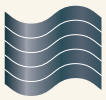
Bulk Roll

Inspection



Grade and Application

PERMA-FOIL™ has excellent sealing properties, durability, and machinability. Our high purity products have gone through our unique purification process and are optimum as components in the nuclear energy industry, as spacers and packing used in the semiconductor industry, as radiator plates used in the electronics industry, and as other such components. Grades are arranged for all kinds of applications including: automotive gaskets, general industrial packing, parts for semiconductor equipment, corrosion resistant seals, IT industry applications, and a wide range of other applications. We produce this product in a wide array of sizes and shapes including rolls, cut sheets and custom shapes made to customer specification.

Grade	Characteristics	Application	Forms of Supplies
PF	Graphite Sheet Standard products	Automotive gaskets General industrial packing	  Roll products Cut products   
PF-R2	Thermal stable property improved version of standard products		
PF-HP	Low ash content products		
PF-G3	Corrosion resistance and thermal stable property improved version of R2 Products	Heat resistant gasket Packing	
PF-UHP, UHPU, UHPL	High Purity products	Parts for high purity furnace for semiconductor and nuclear applications. Heat conducting material Heat spreader.	
PF-A	Bonded products (Thickness ≥ 1.5 mm)	Heat insulation material General industrial packing	
PF-SUS, AL	SUS, AL Foil Laminated products	Automotive gaskets General industrial packing	
Gather Sheet S	Gather sheets with adhesive tape	Flange gasket	
PF Powder 4, 8F	Pulverized graphite sheet	General industrial packing Battery parts	Powder

* For available dimensions, please contact our sales department.

Property Data

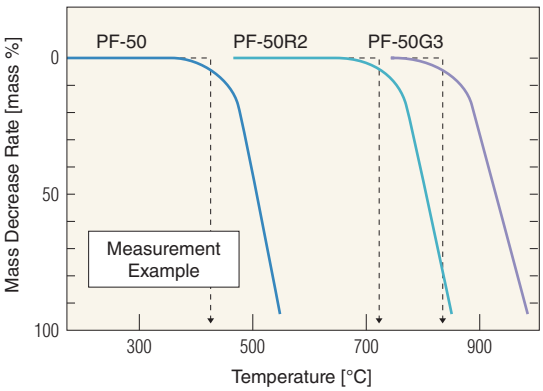
■ Typical properties

Item		Unit	Grade					
			PF	PF-R2	PF-HP	PF-G3	PF-UHPL	PF-UHP, UHPU
Operation Temperature		°C	-200 to 3200					
Thickness		mm	0.2 to 1.0	0.2 to 1.5	0.05 to 1.0	0.2 to 1.0	0.38	0.1 to 1.5
Bulk Density		Mg/m^3	0.5 to 1.1	0.5 to 1.1	0.5 to 2.0	0.5 to 1.1	1.0	1.0, 0.9
Oxidation Loss		mass %	40	25	40	3	5	5
Initial Oxidation Temperature		°C	440	730	630	850	820	820
Tensile Strength		MPa	4.9	5.2	4.9	5.1	6.3	6.3
Sulfur Content		mass ppm	1000	1000	1000	1000	<1	<1
Chlorine Content		mass ppm	<10	<10	<10	<10	<3	<3
Compression Rate		%	47					
Recovery Rate		%	15					
Stress Release Rate		%	1.0					
Ash Content		mass %	0.5	0.5	0.1	0.5	<20 mass ppm	<10 mass ppm
pH		-	5.1	5.1	5.1	5.1	7.0	7.0
Gas Permeability (Nitrogen, 0.1MPa Differential Pressure)		m^2/s	1.3×10^{-10}					
Coefficient of Thermal Expansion	Parallel to surface	1/K	5×10^{-6}					
	Perpendicular to surface		2×10^{-4}					
Thermal Conductivity (25°C)	Parallel to surface	W/(m·K)	200					
	Perpendicular to surface		5					
Electrical Resistivity (25°C)	Parallel to surface	μΩ·m	7					
	Perpendicular to surface		1,000					
Flamability		-	Equivalent to UL94 V-0					

* The figures above are typical values, and are not guaranteed.
* Property data with the density of 1.0 Mg/m^3.
* Oxidation loss is the result of the measurement for 1 hour at 670°C.
* Initial oxidation temperature represents the Starting temperature of mass decrease by the result of the measurement using a thermobalance in the air atmosphere.
* The measurement temperature range for the coefficient of thermal expansion is 300 to 400°C.
* There are standard size for each grade, thickness or bulk density.
* There are constraints of size depending on the size, thickness and bulk density.

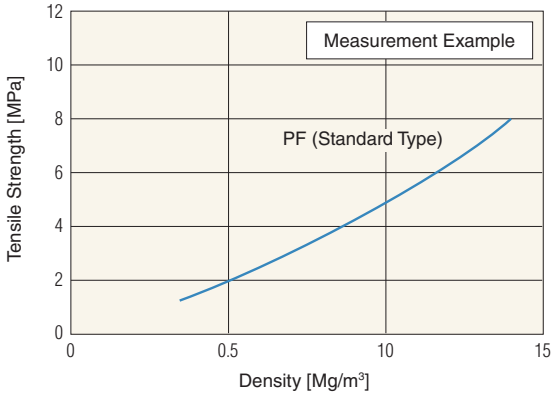
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

■ Initial Oxidation Temperature



We have several grades that may suit customers' heat resistance requirements.

■ Relationship Between Density and Tensile Strength

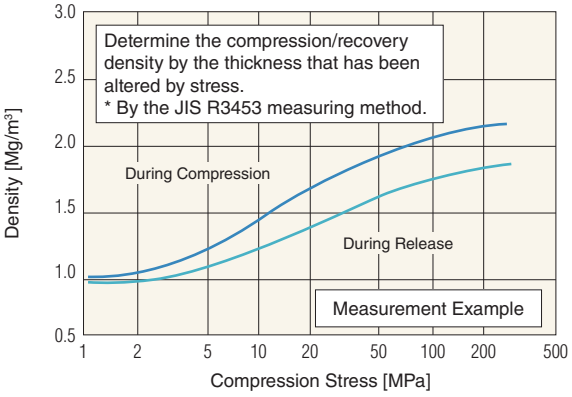


High density products have high strength.

Property Data

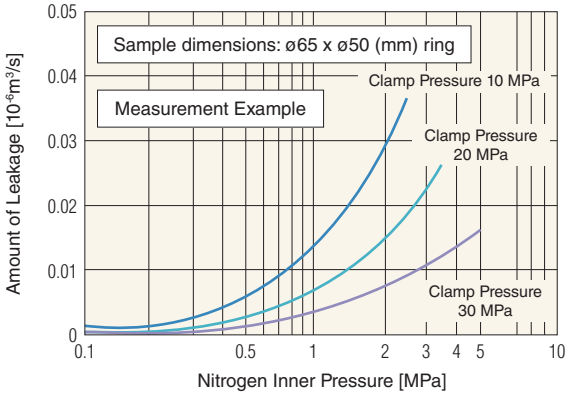
■ Excellent Compressibility Recovery Properties

The relationship between density and compression stress during Compression and release (PF-50)



■ High Sealing Properties

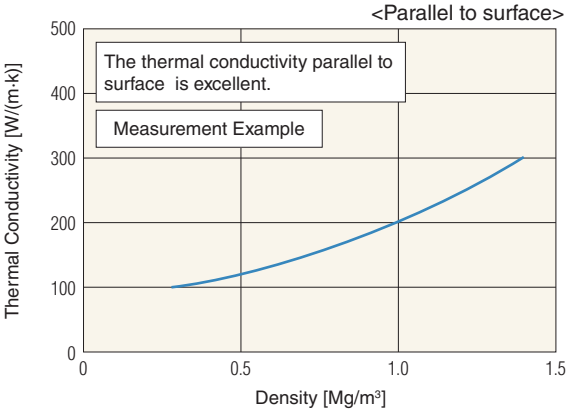
The relationship between clamp pressure and amount of leakage (PF-50)



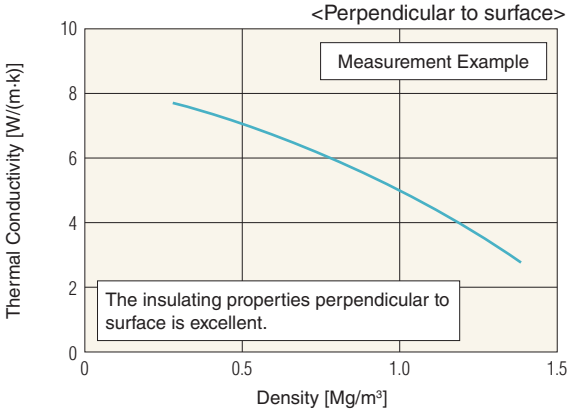
■ Effective of Compression Stress to Each Properties

Thermal conductivity

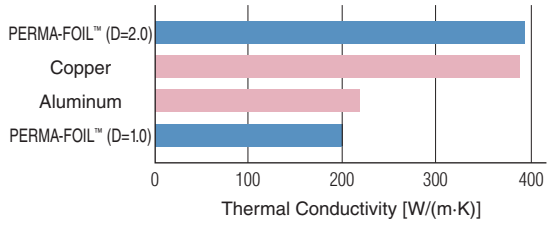
<Parallel to surface>



<Perpendicular to surface>

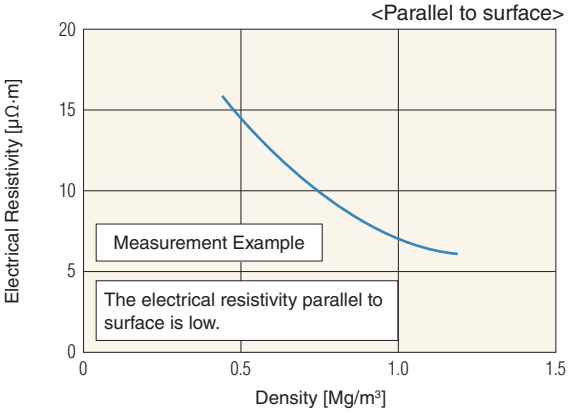


High density products have an extremely high thermal conductivity.

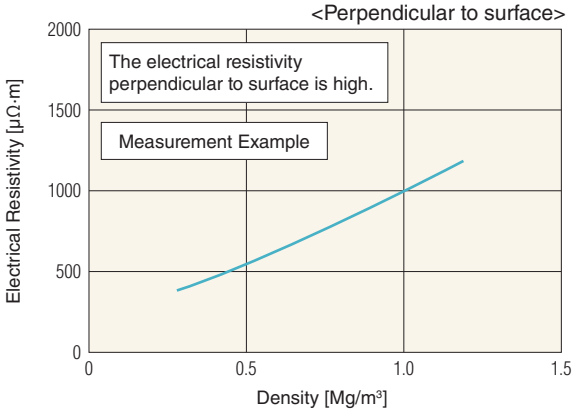


Electrical Resistivity

<Parallel to surface>

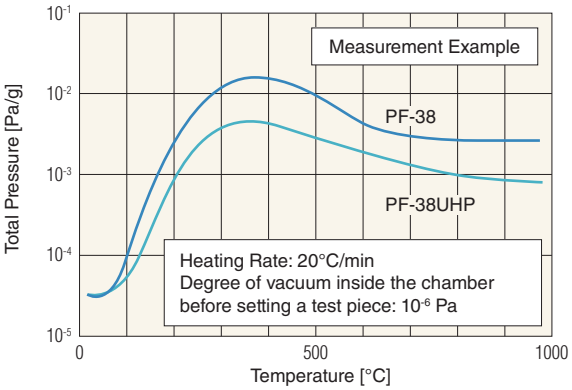


<Perpendicular to surface>



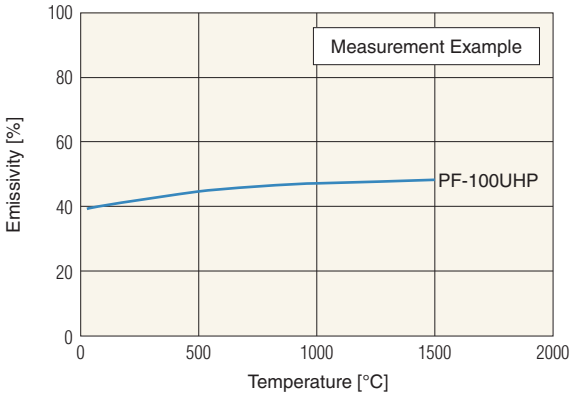
* Thermal conductivity is independent from sheet thickness and grade.

■ Thermal Desorption Spectrum (TDS)



Have an extremely low emitted gas amount.

■ Emissivity

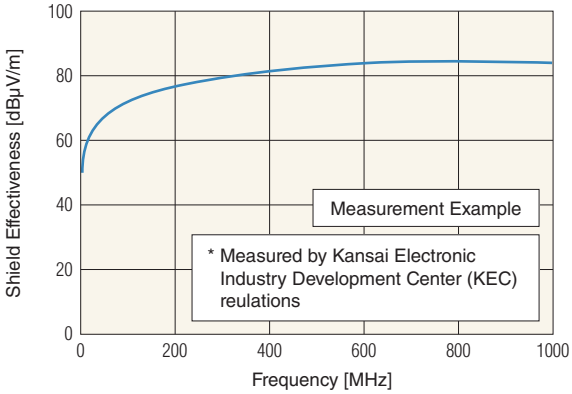


■ Chemical Resistance

Chemical Substance	Concentration (mass%)	Room temperature (30 Day Immersion)			50°C (30 Day Immersion)			85°C (6 Hour Immersion)		
		Thickness Increase	Weight Increase	Appearance	Thickness Increase	Weight Increase	Appearance	Thickness Increase	Weight Increase	Appearance
Sulfuric Acid	90				△	×	○	△	×	○
	95	△	×	△	△	×	×			
Nitric Acid	10	○	○	○	○	○	○			
	20	○	○	○	○	○	○			
Sulfuric Acid + Nitric Acid = 9:1		×	×	×						
Hydrochloric Acid	36				○	○	○	○	○	○
Phosphoric Acid	85				○	△	○	○	△	○
Hydrofluoric Acid	46	○	○	○						
Ammonia Water	28	○	○	○						
Sodium Hydroxide	25	○	○	○	○	○	○	○	○	○
Methanol	100	○	○	○						
Acetone	100	○	○	○						
Gasoline	100	○	○	○						

* ○···No Change △···Slight Change ×···Significant Change
* Chemical resistance is independent from sheet thickness and grade.

■ Electromagnetic Shield Characteristics (PF-50)



High electromagnetic shield characteristics.

■ Initial Reaction Temperatures with Various Substances

* Extracted from other publications

Reactant	Initial Reaction Temperature	Compounds of Reaction
Silicon Dioxide	1250°C	CO, Si, SiC
Copper	No Reaction	—
Magnesium	No Reaction	—
Iron	600 to 800°C	Fe_3C
Cobalt	218°C	CoC, Co_3C
Lead	No Reaction	—
Aluminum Oxide	1280°C	CO, Al, Al_4C_3
Magnesium Oxide	1350°C	CO, Mg
Zirconium Oxide	1300°C	CO, Zr, ZrC

■ Impurity Analysis Example

Units: mass ppm

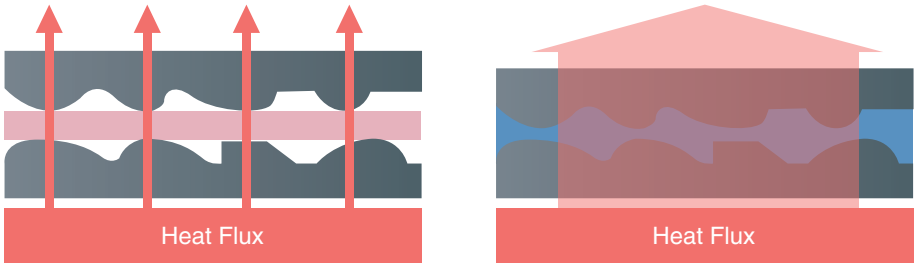
Element	Element	
	Standard Products	Purified Products
Li	<0.01	<0.01
Na	46	<0.05
K	1.9	<0.1
Cu	1.0	<0.08
Be	<0.02	<0.02
Mg	0.7	<0.02
Ca	40	<0.04
Zn	<0.1	<0.1
Al	90	<0.08
V	0.7	<0.07
S	1000	<1.0
Fe	160	<0.04
Ni	<0.1	<0.1

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

Excellent heat conduction and pressure equalization effects of PERMA-FOIL™

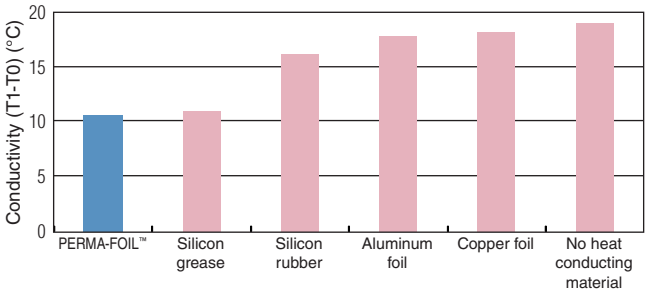
■ Heat conduction effects

PERMA-FOIL™ possessed high thermal conductivity in the surface direction parallel to the surface, and has flexibility that allows it to adhere closely to other materials, which improves heat transmission from heat source to the heat sink.

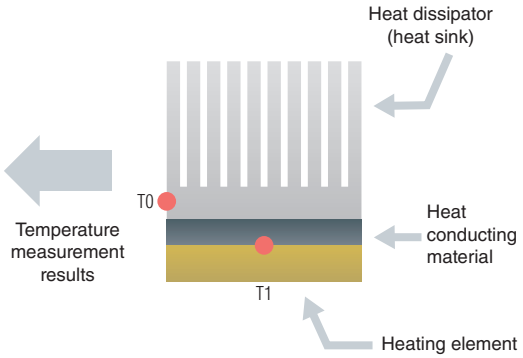


Copper or Aluminum foil　　PERMA-FOIL™

Comparison of heat conductivity

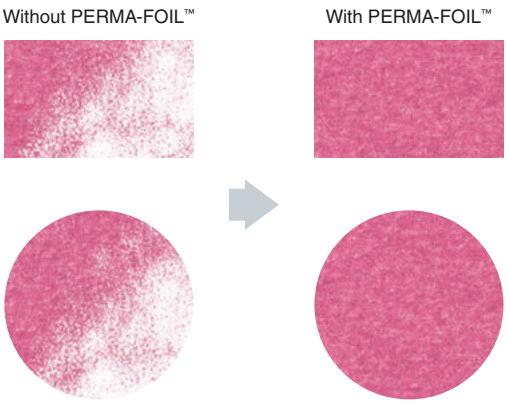


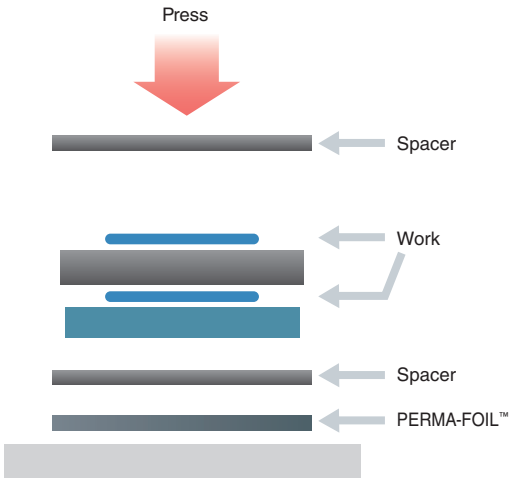
Heat conducting material



■ Pressure equalization effects

PERMA-FOIL™ has high cushioning properties that allow the even application of pressure to the substrate in hot press and thermal bonding applications.





● Example applications

- Components for semiconductor fabrication equipment
- Heat transfer applications in electronic equipment
- Automotive gaskets
- Packing material for chemical plants
- Insulation material for furnace interiors
- High-purity components for use in furnace interiors

Carbon Products for Mechanical applications

(1) Rod Packing
(2) Labyrinth Seal
(3) Radial Bearing
(4) Thrust Bearing
(5) Shoe
(6) Slider
(7) Joint Seal
(8) Trolley Wheel
(9) Valve Seat
(10) Vane
(11) Rotor
(12) Piston Ring
(13) Mechanical Seal
(14) Bearing

Features of Carbon Products for Mechanical applications

Carbon sliding materials have excellent self-lubricating properties, heat resistance and chemical resistance. This means they can be used in high-temperature atmospheres where ordinary metal sliding materials cannot and in fields where fluids and lubricants are inappropriate. Toyo Tanso's IG, KC and TUG product series bring together the technical and development capabilities in the field of sliding materials that have been cultivated over many years, to meet the various demands of our customers.

■ Excellent Self-Lubrication

Carbon has excellent self-lubricating properties, making it appropriate for use in high-temperature atmospheres and in applications where fluids and lubricants are to be avoided. In particular, its coefficient of friction in an unlubricated condition is low compared with other materials, making adhesion difficult to occur.

■ Excellent Thermal Durability

There are virtually no changes in the mechanical strength and slide properties due to heat. Refer to the table on page 40 for the thermal durability of each material.

■ Excellent Chemical Resistance

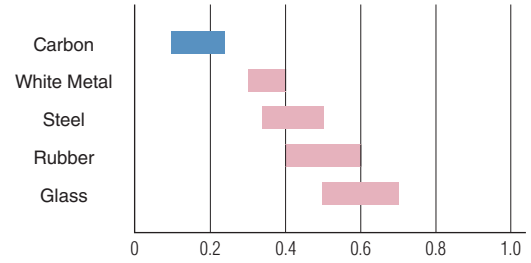
With the exception of inorganic chemicals (strong oxidizers), carbon has excellent chemical resistance. The chemical resistance of each material is shown in the table on page 43.

■ Thermal Shock Resistance

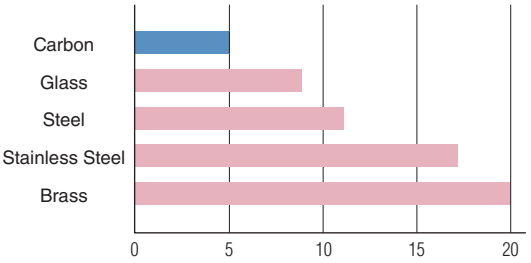
The coefficient of thermal expansion is lower than metal materials, and it has good thermal conductivity. This means that the material hardly ever cracks, even during rapid temperature changes.

■ Supports Lightweight Designs

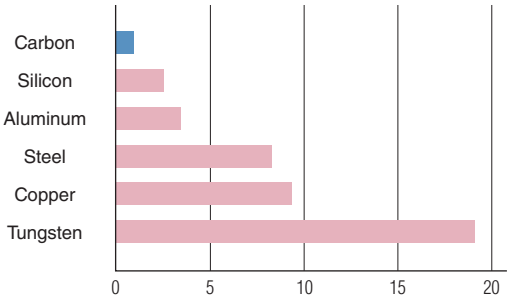
The bulk density is low compared to metal materials, which support lightweight machinery designs and a reduction in friction noise.



Dynamic Coefficient of Friction on a Steel Surface [Atmospheric Room Temperature]

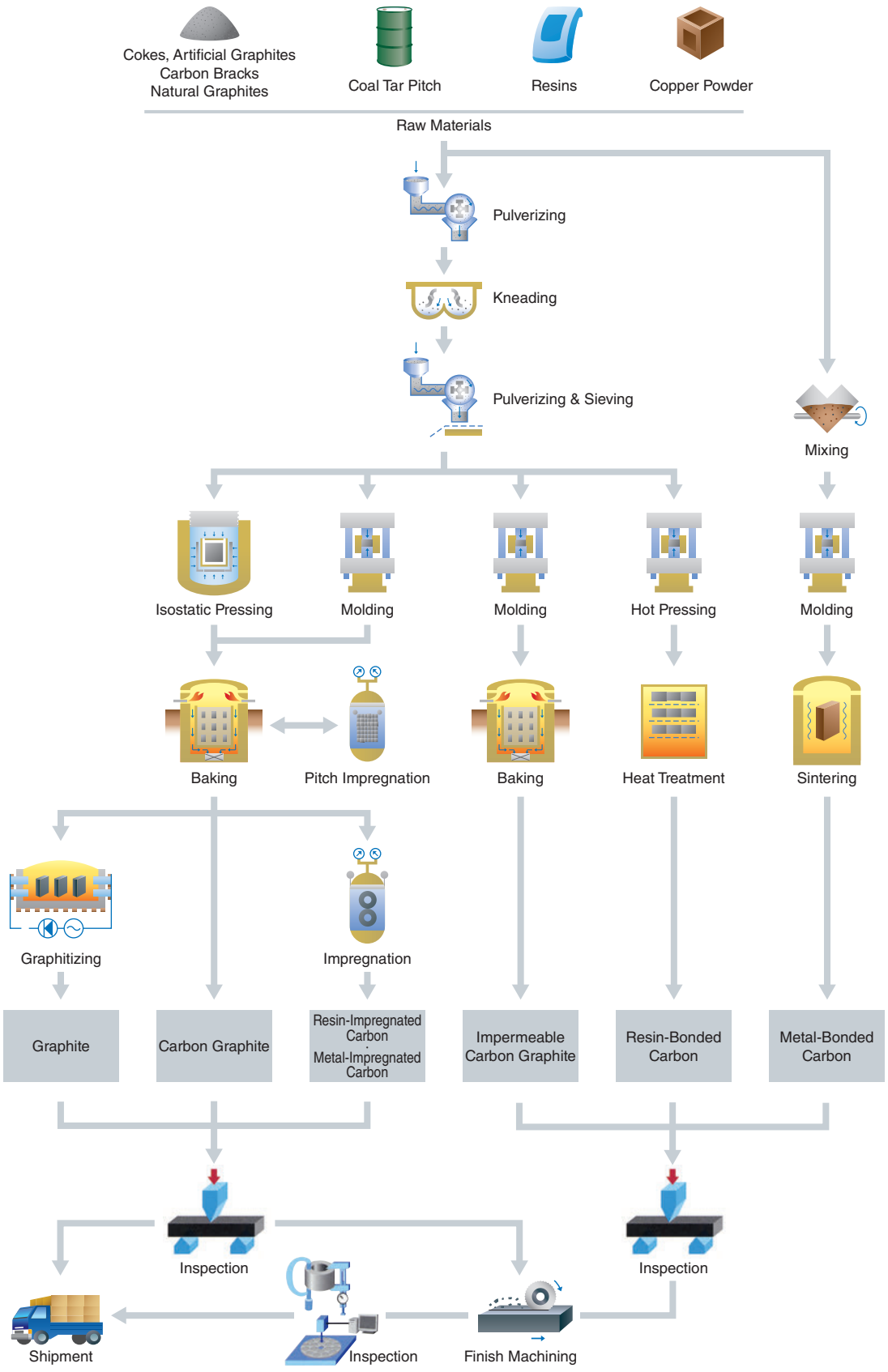


Coefficient of Thermal Expansion [10^{-6}/K]



Bulk Density [Mg/m^3]

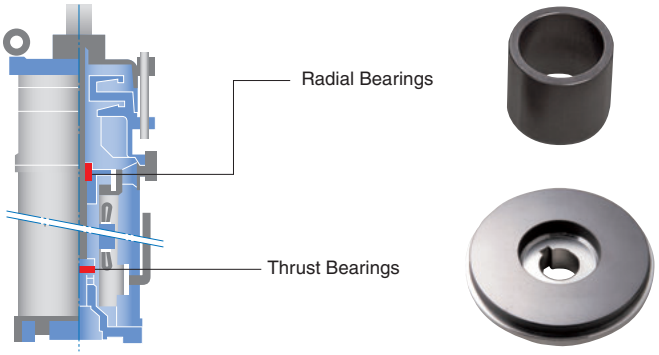
Manufacturing Process



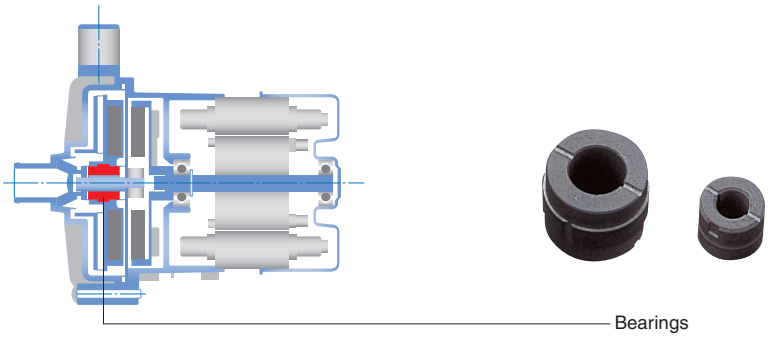
Application

■ Bearings

Deep well underwater motor pumps
Pumps for oil refining and petrochemical processes
Pumps for power station processes
Pumps for general industries
Chemical pumps
Marine pumps
Flowmeter pumps

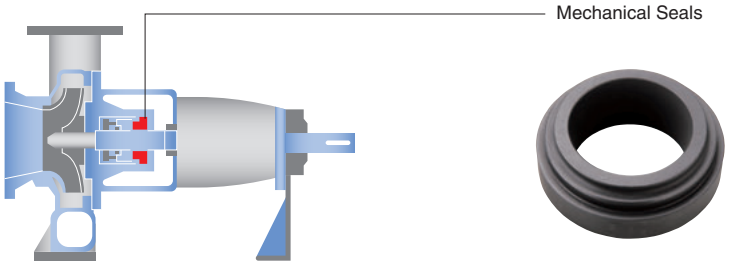


Household hot water circulation pumps
Vending machine circulation pumps
Dishwashers
Plywood dryer

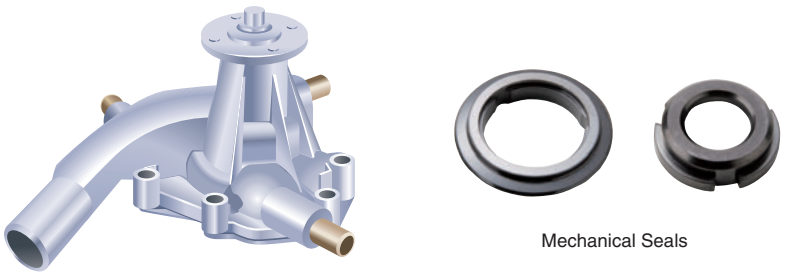


■ Seal rings

Pumps for oil refining and petrochemical processes
Pumps for power station processes
Pumps for general industries
Chemical pumps
Agitator
Marine pumps

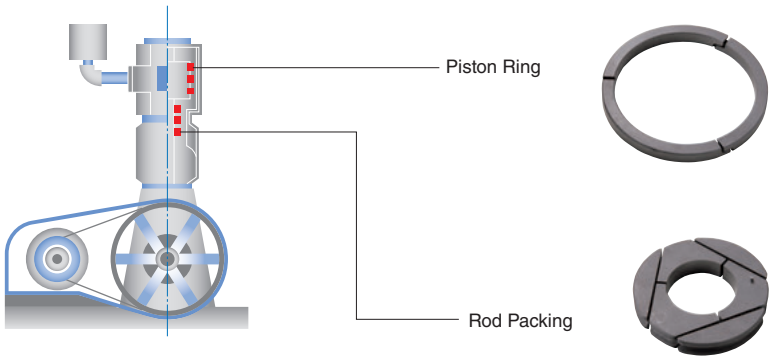


Automobile water pumps
Household hot water circulation pumps
Refrigerator compressors



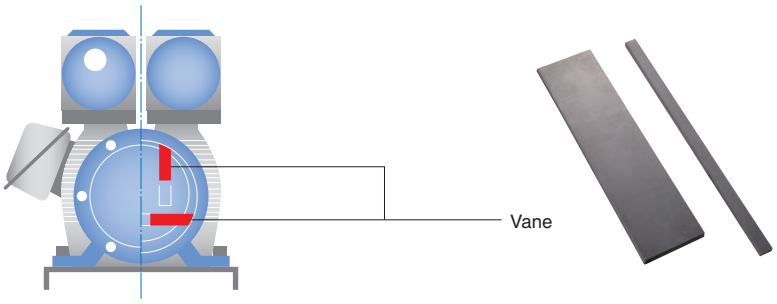
■ Packing

Reciprocal compressors
Screw compressors
Steam turbines
Hydroelectric power generators



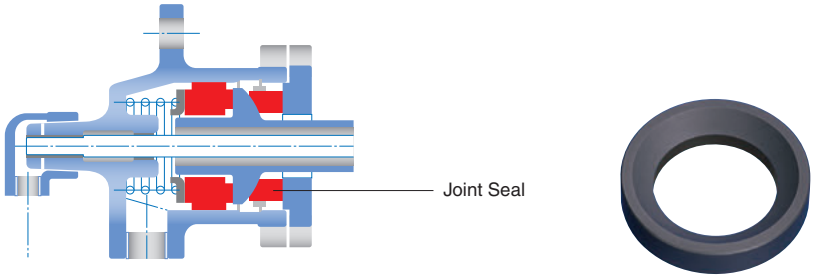
■ Vanes

Various vacuum pumps
Air blowers
Flow meters
Oscillating compressors
Jet heaters



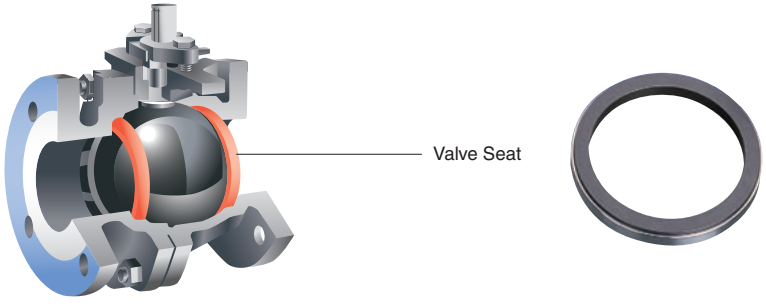
■ Joint Seals

Papermaking dryers
Drum dryers
Mixing mills
Printers



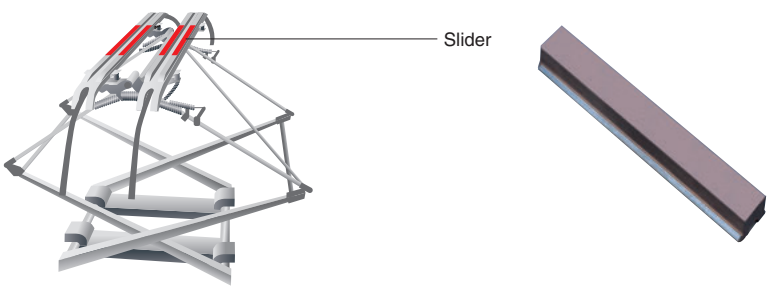
■ Valve Seats

Ball valves



■ Pantograph Sliders

JR regular lines
Japanese private railways



Typical Properties

We provide many different kinds of carbon products as sliding materials for mechanical applications, including graphite, carbon graphite, resin-impregnated carbon, metal-impregnated carbon, SiC/C composites, inorganic-compound impregnated carbon, impermeable graphite, resin-bonded carbon and metal-bonded carbon. Select the product most appropriate for your application.

■ Graphite

It has excellent heat and chemical resistant characteristics compared with other compositions, and virtually no charge in factors such as the slide properties.

■ Carbon Graphite

It is a general carbon sliding material composed of carbon and graphite. We provide products suitable for your applications.

■ Resin-Impregnated Carbon and Metal-Impregnated Carbon

Resin or metal is impregnated in the pores in carbon to improve strength, impermeability and slide properties.

■ SiC/C Composites

It has excellent slurry and blister resistance. The composite layer depth can be 2 to 4 mm from the surface layer.

■ Inorganic Compound-Impregnated Carbon

Inorganic compound is impregnated into isotropic graphite.
It has anti-oxidizing properties in high-temperature atmospheres.

■ Impermeable Carbon Graphite

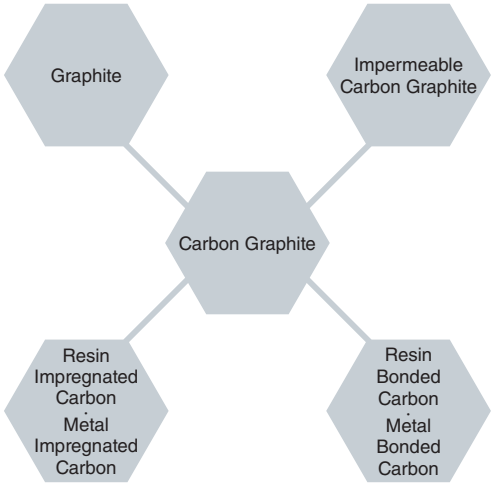
It is a non-impregnated material with excellent impermeability.
It is easily mass-produced by die-molding to any desirable shape.

■ Resin-Bonded Carbon

It is a carbon and resin bonded material. It is easily mass-produced by die-molding to any desirable shape.

■ Metal-Bonded Carbon

It is a sintered material with carbon and metal. It has self-lubricating properties, and is appropriate for fields where lubricants are avoided.



The slide properties of carbon are greatly affected by the usage conditions (e.g. pressure, circumferential velocity, contacting materials, atmosphere, temperature, etc.).
Toyo Tanso has a wide range of carbon and graphite grades available to meet your requirements.
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

Composition	Grade	Bulk Density	Hardness	Flexural Strength	Compressive Strength	Young's Modulus	Coefficient of Thermal Expansion	Thermal Conductivity	Thermal Durability
		Mg/m^3	HSD	MPa	MPa	GPa	$10^{-6}/K$	W/(m·K)	°C
Graphite	IG-11	1.77	51	39	78	10	4.5 a)	120	400
	ISO-68	1.82	80	76	172	13	5.6 a)	70	450
Carbon Graphite	KC-36	1.72	65	48	135	15	3.5	15	300
	KC-57	1.78	105	70	270	20	4.0	5	350
	KC-67	1.77	72	60	185	20	3.5	10	350
	KC-83K	1.74	80	55	160	15	4.0	10	350
	KP-001	1.72	90	70	240	17	5.0	4	250
	KP-002	1.73	60	58	170	17	3.5	7	250
Resin-Impregnated Carbon	KC-360	1.78	75	58	165	17	4.0	15	250
	KC-570*	1.85	110	84	370	22	5.0	5	300
	KC-573*	1.85	110	85	370	22	5.5	5	250
	KC-670*	1.87	87	78	240	22	5.0	10	300
	KC-673*	1.87	87	78	245	22	5.5	10	250
	KC-830K	1.84	90	70	205	17	5.0	10	300
	IKC-433	1.97	70	70	140	20	6.0	139	200
Metal-Impregnated Carbon	KC-5709*	2.25	110	100	430	27	5.0	5	400
	KC-6709*	2.30	88	90	300	27	5.0	13	400
	IKC-6809	2.67	88	105	300	21	6.0	80	450
	PC-78A	2.90	95	110	410	27	6.5	13	350
SiC/C Composites	TS-002	2.31/2.75	63/70	113/78	300/205	18/16	4.5/5.2	80/80	500
	TS-003	2.28/1.82	83/80	116/76	410/172	30/13	5.4/5.6	70/70	400
	TS-004	2.28/1.92	83/86	116/88	410/235	30/15	5.4/7.5	70/60	200
	TS-005	2.28/2.67	83/88	116/105	410/300	30/21	5.4/6.0	70/80	500
Inorganic Compound-Impregnated Carbon	IG-11R1	1.85	55	46	92	11	4.5 a)	120	500
	IG-43R1	1.88	57	59	108	12	4.8 a)	140	500
	ISO-68R1	1.87	84	83	190	15	5.6 a)	70	500
Impermeable Carbon Graphite	TUG-105	1.67	90	60	250	20	4.0	—	250
	TUG-110	1.78	105	90	290	20	4.0	—	250
	TUG-120	1.68	95	70	245	20	4.0	—	250
	TUG-308	1.87	90	65	215	23	3.5	—	250
	TUG-309	1.85	80	55	185	20	3.5	—	250
	TUG-3095	1.81	75	50	170	20	3.5	—	250
	TUG-505	1.89	80	68	185	20	3.0	—	250
Resin-Bonded Carbon	W-1500	1.77	70	75	175	15	23.0 b)	—	150
	W-3500*	1.63	85	90	250	12	30.0 b)	—	200
	LS	1.77	60	70	100	15	15.0 b)	—	150
	NLA	1.70	75	85	175	15	23.0 b)	—	150
	MR-10*	1.43	78	100	230	10	35.0 b)	—	200
Metal-Bonded Carbon	GM-1	4.60	18	25	55	—	12.0	—	200
	GM-5	6.20	18	205	350	—	12.0	—	400

* The figures above are typical values, and are not guaranteed.
* The SiC/C composite values show both of the "SiC/C composite layer" and "substrate (+ impregnation)".
* The SiC/C composite thermal durability shows that of the "substrate (+ impregnation)".
* Thermal durability varies with usage conditions. Values provided for reference purposes only.
* The measurement temperature range for the coefficient of thermal expansion is: a) 350 to 450°C, b) 50 to 150°C, and others: 100 to 200°C.
* Unit conversion: MPa=kgf/cm^2 x 0.098 GPa=kgf/mm^2 x 0.0098 W/(m·K)=kcal/h·m·°C x 1.16

Product Selection Table by Usage

Composition	Grade	Bearings										Seal Rings					
		Non-Lubricated					Lubricated					Mechanical Seal					
		For high temperatures	For high loads	For low loads	For high load mass production	For low load mass production	For high loads	For low loads	For high load mass production	For low load mass production	For slurry resistance	For high loads	For low loads	For high load mass production	For low load mass production	For blister resistance	
Graphite	IG-11	○															
	ISO-68	○															
Carbon Graphite	KC-36			◎													
	KC-57						○	◎									
	KC-67			○				○									
	KC-83K			○				○									
	KP-001								◎								
	KP-002									◎							
Resin-Impregnated Carbon	KC-360		○	◎													
	KC-570, KC-573						◎					◎					
	KC-670, KC-673							◎					◎				
	KC-830K							◎					○				
Metal-Impregnated Carbon	KC-5709						◎				○	◎				○	
	KC-6709						○	◎					○				
	IKC-6809						○										
	PC-78A																
SiC/C Composites	TS-002						◎				◎	◎				◎	
	TS-003						◎				◎						
	TS-004											◎				◎	
	TS-005						◎				◎	◎				◎	
Inorganic Compound-Impregnated Carbon	IG-11R1	○															
	IG-43R1	◎															
	ISO-68R1	◎															
Impermeable Carbon Graphite	TUG-105								◎								
	TUG-110													◎		○	
	TUG-120								◎								
	TUG-308													◎		○	
	TUG-309								○					○			
	TUG-3095				○												
	TUG-505													○			
Resin-Bonded Carbon	W-1500					○				○					○		
	W-3500					◎				◎					◎		
	LS					○											
	NLA									◎							
	MR-10																
Metal-Bonded Carbon	GM-1																
	GM-5		◎														

	Seal Rings											Vanes		Slider			Special Applications	
	Joint Seal					Compressors			Shaft Seals		Valve Seat	Non-Lubricated	Lubricated	Trolley wheels and shoes	For trains	For brakes	Jigs for glass production	Structural materials for high temperatures
	For high loads	For low loads	For high load mass production	For low load mass production	For large sizes	For air	For special gas	For dry gas	For steam	For hydropower								
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* ◎···Most appropriate ○···Appropriate
* A variety of stock sizes are available.
Please contact our sales team for details.
* The maximum dimensions are subject to change due to manufacturing technology developments.
* There are additional products for special applications that are not show in the table.

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

Chemical Resistance

With the exception of some inorganic chemicals (strong oxidizers), carbon is resistant to chemical corrosion. Carbon has excellent chemical resistance when compared to general metal materials, and so is used in a wide variety of applications. Refer to the table below for the chemical resistance of carbon for mechanical application, as compared to general chemicals. The chemical resistance varies according to the chemical density, temperature and carbon composition, so please contact Toyo Tanso for further details.

Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	Composition				
				Graphite	Carbon Graphite			Resin Bonded
					Non-Impregnated	Resin-Impregnated	Metal-Impregnated	
Ammonia (Gas)	NH_3	100	H	○	○	○	○	○
Chlorine (Gas)	Cl_2	100	H	○	○	○	×	×
Hydrogen Chloride (Gas)	HCl	100	H	○	○	○	×	×
Bromine (Gas)	Br_2	100	C	×	×	×	×	×
Hydrogen Bromide (Gas)	HBr	100	H	○	○	○	×	×
Sulfur Dioxide (Gas)	SO_2	100	H	○	○	○	×	×
Fluorine (Gas)	F_2	100	C	×	×	×	×	×
Hydrogen Fluoride (Gas)	HF	100	W	○	○	○	×	×
Ammonium Hydroxide	NH_4OH	25	W	○	○	○	○	○
Potassium Hydroxide	KOH	60	C	○	○	○	○	○
		60	H	○	○	×	×	×
Sodium Hydroxide	NaOH	60	C	○	○	○	○	×
		60	H	○	○	×	×	×
Sodium Chlorite	$NaClO_2$	20	H	×	×	×	×	×
Sulfurous Acid	H_2SO_3	100	C	○	○	○	○	×
Hydrochloric Acid	HCl	36	H	○	○	○	×	×
Aqua Regia (Hydrochloric Acid/ Nitric Acid)	HCl/HNO_3	100	C	○	○	○	×	×
Potassium Permanganate	$KMnO_4$	7	C	○	○	○	○	○
		7	H	×	×	×	×	×
Chromic Acid	H_2CrO_4	20	C	○	○	○	×	×
		20	H	○	○	○	×	×
		40	C	○	○	○	×	×
		40	H	○	×	×	×	×
		60	C	×	×	×	×	×
Mixed Acid (Nitric Acid/Sulfuric Acid)	HNO_3/ H_2SO_4	100	C	×	×	×	×	×
Nitric Acid	HNO_3	38	H	○	○	○	×	×
		65	C	○	×	×	×	×
		65	W	○	×	×	×	×
		65	H	×	×	×	×	×

Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	Composition				
				Graphite	Carbon Graphite			Resin Bonded
					Non-Impregnated	Resin-Impregnated	Metal-Impregnated	
Sodium Hypochlorite	NaClO	7	H	○	×	×	×	×
		13	W	○	×	×	×	×
		23	C	×	×	×	×	×
Hydrofluoric Acid	HF	40	W	○	×	×	×	×
		60	C	×	×	×	×	×
Fuming Sulfuric Acid	$H_2SO_4+SO_3$	98	C	×	×	×	×	×
Sulfuric Acid	H_2SO_4	48	H	○	○	○	×	×
		98	H	×	×	×	×	×
Phosphoric Acid	H_3PO_4	85	C	○	○	○	○	○
		85	H	○	○	○	×	×
Acetone	CH_3COCH_3	100	C	○	○	○	○	×
Aniline	$C_6H_5NH_2$	100	C	○	○	○	○	○
Ether	R-O-R	100	C	○	○	○	○	○
Formic Acid	HCOOH	100	C	○	○	○	×	×
Citric Acid	$C_6H_8O_7$	100	C	○	○	○	○	○
Glycerin	$C_3H_5(OH)_3$	100	C	○	○	○	○	×
Chloroform	$CHCl_3$	100	C	○	○	○	×	○
Carbon Tetrachloride	CCl_4	100	C	○	○	○	○	○

* H···100°C W···50°C C···20°C ○···Resistant ×···Infused

Carbon Brush

(1) Carbon brushes for general industrial application
(2) Carbon brushes for power supply application
(3) Carbon brushes for automotive application
(4) Carbon brushes for home appliances
(5) Carbon brushes for micro motor
(6) Carbon brushes for electric power tool
(7) Carbon brushes for vacuum cleaner
(8) Carbon brushes with cut-off device

Features of Carbon Brush Products

The carbon brush plays the important role of sending electrical current between motionless and rotating parts by sliding contact. Since the performance of the brush has a significant impact of the performance of rotating machine, the choice of brush is a critical factor. At the Toyo Tanso Group, we develop and produce carbon brushes for a variety of customer needs and purposes, applying the superior technology and quality assurance know-how that we have developed over our many years of research in the field. Our products exude minimum impact on the environment, and can be used for many different applications.

Excellent self-lubrication and abrasion resistance

Carbon has self-lubricating properties and low coefficient of friction due to its layered crystal structure, making it highly abrasion resistant. The carbon is thus characterized by outstanding abrasion resistance and low friction under conduction, which is important for carbon brush.

Superior conductivity

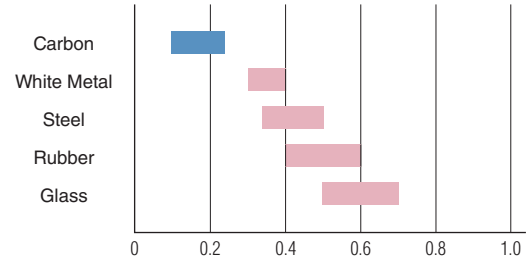
With its excellent electrical conductivity, carbon can offer a stable, optimal level of electrical resistivity, which is enhanced by appropriate selection of materials and production process depending on the application.

Outstanding durability

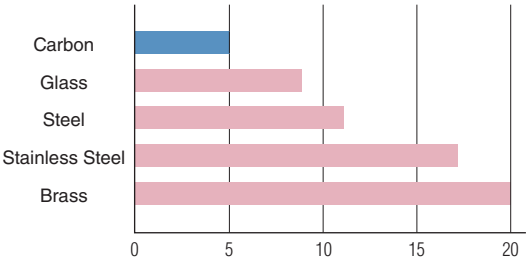
Carbon has low coefficient of thermal expansion, which means that it hardly has changes in shape or quality even at high temperatures. It is also resistant to the softening and melt-down that can occur due to sparking during operations, and does not fuse with other metals.

Superior ridability during sliding contact

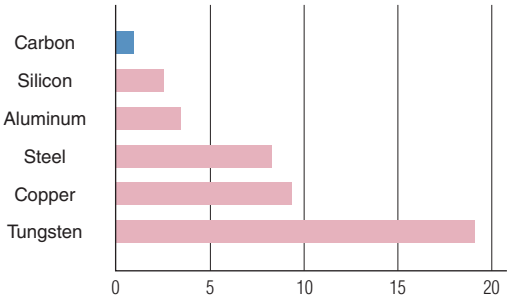
Compared to conductive metal in general, bulk density and the Young's modulus are small in carbon, hence carbon has superior ridability during sliding contact.



Coefficient of dynamic friction with steel surface [in air room temperature]

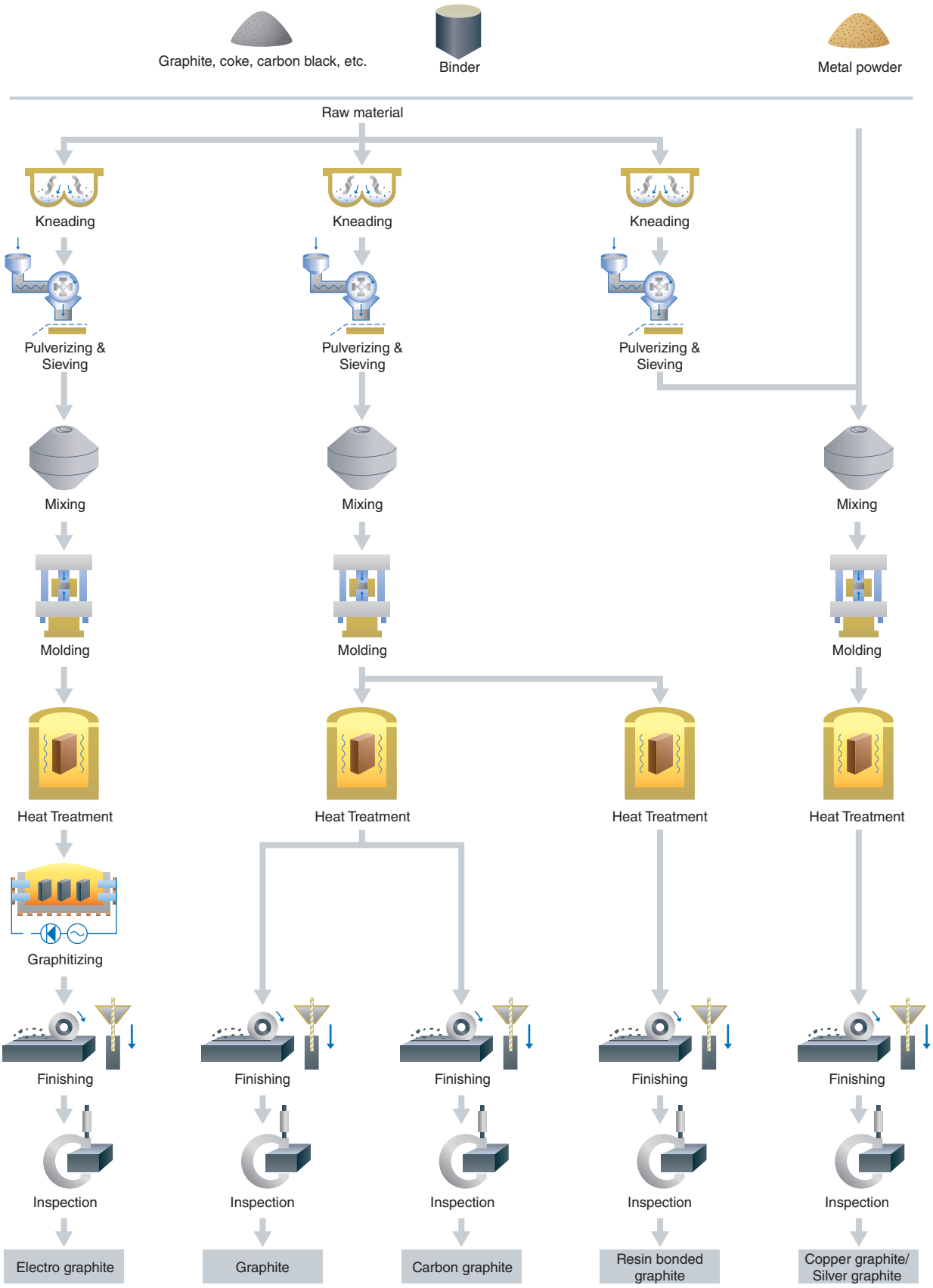


Coefficient of thermal expansion [10^{-6}/K]



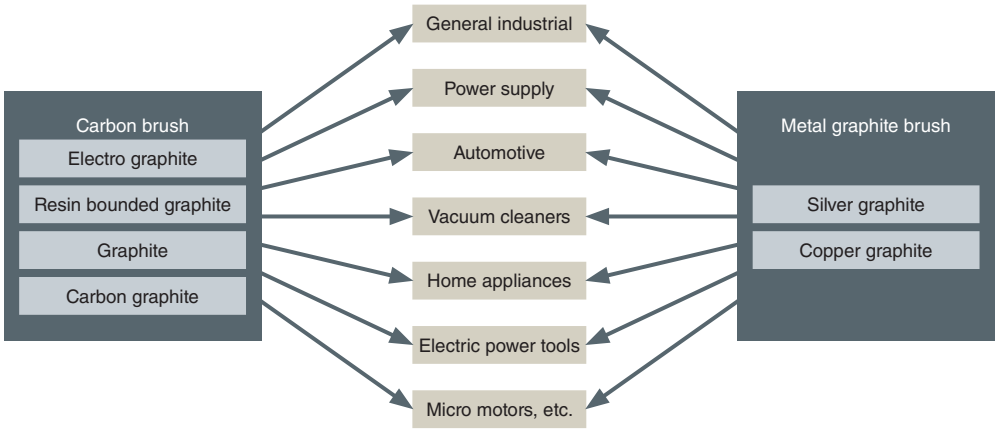
Bulk Density [g/cm^3]

Manufacturing Process



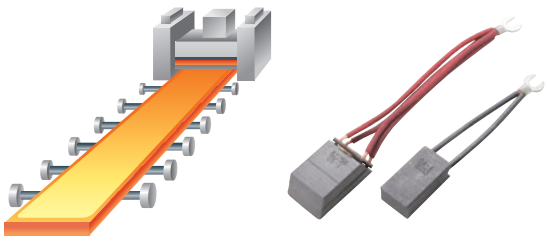
Brush Types and Applications: Some Examples

At Toyo Tanso group, we offer an entire array of brushes, including for general industrial use, vacuum cleaners, automotive, home electronic appliances, power tool motors, electrical supply, micro motors, and more.

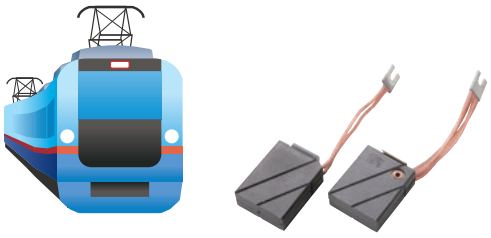


■ General industrial

DC motors



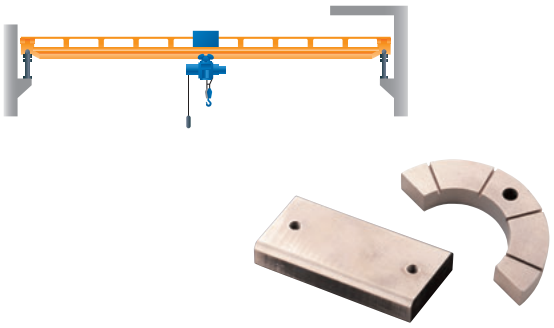
Electrical trains



Wind-generated power

■ Power supply

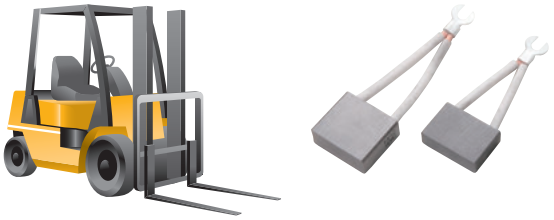
Cranes



■ Automotive application

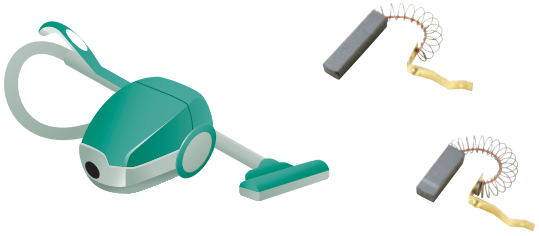
Automobiles

Forklifts



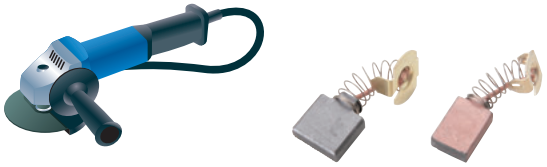
■ Vacuum cleaners

Vacuum cleaners



■ Power tools

Disk grinders

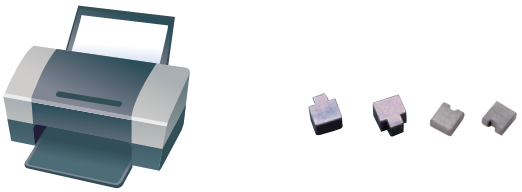


■ Home appliances

Washing machines

■ Micro motors, etc.

Printers

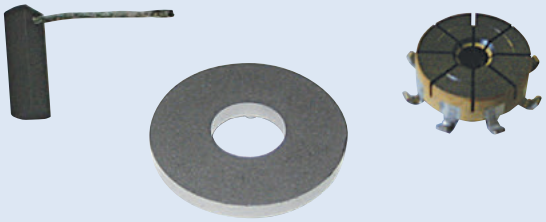


Product Descriptions

The Toyo Tanso Group is constantly researching ways to achieve top performance with our brushes for each of their various purposes. We have successfully developed a range of new products up through the present time, including special coated brushes, carbon brush with cut-off device, vehicle fuel pump brushes and carbon discs, and more.

■ Brushes and Carbon Disks for Vehicle Fuel Pumps

Carbon is the answer to the many conditions required for the commutator for vehicle fuel pumps. Toyo Tanso has developed optimal brush materials and low-wear carbon disc for commutator. We can propose the ideal carbon brush material to match usage conditions.



■ Carbon brush with cut-off device

At the end of their lifespan, brushes tend to incur greater sparking from commutation, as the spring pressure deteriorates. The brush with cut-off device quickly cuts electric current when brush is worn out to reduce commutator loss. Toyo Tanso offers cut-off design depend on brush type and application.

■ The washing machine brush

Extremly long life brushes are required for commutator motor for drum-type washing machine. Toyo Tanso offers a long- lasting brush that performs well even during the machine's reverse cycle.

■ The Specially Coated Brush

This brush features a thin conductive metal film coating on the surface. The coating serves to cut loss associated with electrical resistance and rises in temperatures without sacrificing life time and commutation properties of the brush. These brushes are used in small high-speed vacuum cleaners, power tool motors, and more.

Typical Properties

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Cofficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications
		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm²	
Electrographite	401	1.68	18	9	10	M	M	30	10	Good film formation. Suitable for slip rings that easily generate streaking.
	502	1.77	51	11	37	M	M	25	10	Good roughing resistance because of fine grain isotropic structure. Suitable for low speed, small capacity DC motors and slip rings.
	503	1.68	46	13	29	M	M	30	10	Same as 502, good roughing resistance because of fine grain isotropic structure. Suitable for small/med capacity motors of faster speed than 502.
	176	1.62	28	14	16	M	M	45	12	Good film formation. Good communication performance. Suitable for DC motors up to medium capacity.
	BZ-229	1.6	23	22	11	M	M	40	12	Moderate film adjusting function. Suitable for medium and higher capacity mill motors.
	BZ-256	1.61	28	19	14	M	M	40	12	Better film formation than BZ-229. Suitable for medium and higher capacity mill motors.
	213	1.61	32	23	16	M	M	40	12	Better film adjusting effect than 176. Suitable for DC motors up to medium capacity.
	321	1.74	62	34	31	M	M	35	10	Good wear resistance. Suitable for traction motors.
	TH-03	1.75	68	40	35	M	M	35	10	
	351A	1.63	49	47	22	H	M	40	10	Standard material for commutation brushes. Suitable for medium capacity DC motors.
	641	1.64	59	75	12	H	M	40	10	Suitable for difficult commutation high capacity DC motors and universal motors.
Graphite	402	1.71	24	10	18	M	M	25	10	Has film adjusting effect. Suitable for thick film slip rings.
	801	1.65	30	35	19	M	M	45	15	Good wear resistance. Suitable for pump motors for power steering.
	TR-52	1.74	30	14	16	M	M	40	12	Better commutation performance than 788. Suitable for forklifts of 48V or more.
	TR-19	1.51	33	200	19	M	M	40	12	Good wear resistance. Suitable for 3-phase commutator motor.

* Coefficient of friction: H···0.25 or greater M···0.20-0.25 (Measuring conditions/Slip ring: Copper; Speed: 9.3 m/second; Current: 0 A)
* Contact voltage drop: M···0.5-1.0 V/unit (Measuring conditions/Slip ring: Copper; Speed: 9.3 m/second; Current: DC10 A/cm sq.)
* The above figures are typical values, and are not guaranteed.

Maximum peripheral speed and maximum current density differ depending on the commutator and slip ring conditions and conditions of use. The information listed to the right and above represents general examples. Before choosing a product, consult with our staff about your particular needs.

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Cofficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications
		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm²	
Copper Graphite I	M-90	6.30	15	0.32	108	M	VL	20	25	High strength copper alloy type. Suitable for contacts and grounds.
	M-1T	6.19	13	0.27	108	M	VL	22	22	
	M-2T	5.70	15	0.50	80	M	VL	25	20	
	M-1H	6.83	6	0.04	87	M	VL	25	20	High copper content. Very low temperature rise and contact voltage drop. Suitable for high electrical capacity generators and motors.
	M-1	5.41	12	0.08	42	L	VL	30	25	
	M-1F	5.30	18	0.15	49	L	VL	30	25	
	M-2H	4.93	13	0.10	34	L	VL	30	20	
	M-2HF	4.80	18	0.33	44	M	VL	30	20	
	M-2	4.40	15	0.50	29	L	VL	30	20	The copper content amount is next to M1, M-2H class and has good wear resistance. Suitable for large capacity generators and slip rings for general rotary machine.
	M-2F	4.35	15	0.50	44	M	VL	30	20	
	M-3H	4.04	16	0.70	29	M	VL	30	18	
	M-3HF	4.05	20	0.60	44	M	VL	30	18	
	M-3	3.78	17	1.00	29	L	VL	30	18	
	M-4	3.48	17	2.00	25	L	L	30	18	Middle grade between graphite and metal graphite and has features of both. In particular, it is superior in roughing resistance. It is applicable for small/med capacity generators and motors.
	M-550	2.96	25	2.50	39	M	L	35	15	Good wear resistance. Particularly suitable for stainless steel slip rings.
	M-750	2.32	23	6.00	32	M	L	35	15	
	788	2.02	23	9.00	23	M	M	45	12	Good dimensional stability in high temperature. Suitable for forklifts of 48V or less.
	M-2TB	5.74	12	0.48	65	M	VL	25	20	Same application as the above M-1 and M-2. But does not contain lead.
	M-1B	5.30	10	0.10	43	L	VL	30	25	
	M-2B	4.34	13	0.28	31	L	VL	30	20	
Copper Graphite II	MF-302	2.65	18	3.00	23	M	L	30	20	Suitable for automobile DC12V fan.
	MF-501	3.00	20	0.90	28	L	L	30	20	Suitable for automobile DC12V winch.
	MF-101	2.90	18	2.20	28	M	L	30	20	Suitable for DC19.2V cleaners.
	MF-202	2.05	10	38.0	23	H	M	30	15	
	MF-203	2.05	10	30.0	23	L	M	30	15	
	MF-301	2.40	15	10.0	23	M	M	30	20	Suitable for DC24V cleaners.
	MF-401	2.67	18	10.0	21	M	M	30	20	Suitable for DC19.2V cleaners.
	MF-204	3.78	15	0.30	40	M	L	30	25	Suitable for DC7.2V power tools.
	MF-205	3.00	20	0.80	28	M	L	30	20	Suitable for DC24V power tools.
	MF-701	2.26	18	10.0	30	M	M	30	20	Suitable for DC22-36V power tools.
	MF-201	2.25	10	30.0	23	M	M	30	15	Suitable for household coffee mills.
	MF-601	2.05	10	50.0	23	M	M	30	15	Suitable for electric wheelchair.
	MF-1001	2.45	20	5.00	28	L	M	30	20	Suitable for use with 14.4 and 18 VDC power tools.

* Coefficient of friction: H···0.25 or greater M···0.20-0.25 L···0.20 or less (Measuring conditions/Slip ring: Copper; Speed: 9.0 m/second; Current: 0 A)
* Contact voltage drop: M···0.5-1.0 V/unit, L···0.25-0.50 V/unit; VL: 0.25 or less/unit (Measuring conditions/Slip ring: Copper; Speed: 9.0 m/second; Current: DC10 A/cm sq.)
* The above figures are typical values, and are not guaranteed.

Typical Properties

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Coefficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications
		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm²	
Silver graphite	SX-50	3.20	15	2.70	29	M	VL	20	12	Very low temperature rise and contact voltage drop. Suitable for low current tachometers and grounds contacts.
	SX-70	4.45	15	0.25	40	M	VL	20	15	
	SX-90	6.85	18	0.05	84	M	VL	20	22	

* Coefficient of friction: M···0.20-0.25 (Measuring conditions/Slip ring: Copper; Speed: 9.0 m/second; Current: 0 A)
* Declining contact voltage: VL···Less than 0.25 V/unit (Measuring conditions/Slip ring: Copper; Speed: 9.0 m/s; Current: DC10 A/cm sq.)
* The above figures are typical values, and are not guaranteed.

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Coefficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications
		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm²	
Resin bounded graphite	X-03	1.50	12	200	15	L	H	54	20	Goode ridability. Suitablle for 100-120V high efficiency cleaners.
	X-09	1.52	14	260	15	L	H	54	20	
	X-17	1.54	15	330	18	L	H	54	20	
	X-72	1.47	19	380	14	L	H	48	20	
	X-88	1.52	14	360	20	L	H	54	20	
	X-05	1.48	15	400	18	L	H	50	20	Goode ridability. Suitablle for 100-120V high input cleaners.
	X-10	1.52	15	270	17	L	H	50	20	
	X-78	1.51	17	370	22	L	H	48	20	
	X-80	1.51	17	360	22	L	H	48	20	
	X-13	1.48	19	700	22	L	H	50	15	Good commutation performance. Suitable for 120-240V cleaners.
	X-85	1.48	20	400	14	L	H	48	20	
	X-89	1.53	19	350	21	L	H	48	20	
	X-93	1.50	18	640	27	L	H	50	15	
	X-95	1.51	19	640	24	L	H	50	15	
	X-97	1.45	19	430	14	L	H	50	20	
	X-11	1.35	15	1100	14	L	VH	54	13	Good commutation performance. Suitable for 200-240V cleaners.
	X-73	1.52	24	920	24	L	VH	40	13	
	X-91	1.35	15	1100	17	L	VH	54	13	
	X-94	1.36	14	1200	17	L	VH	54	13	
	X-04	1.36	17	1600	11	L	VH	54	10	Good commutation performance. Suitable for 200-240V cleaners, small motors.
	X-08	1.29	14	1600	14	L	VH	54	10	
	X-96	1.31	14	1600	16	L	VH	54	10	
	B-2	1.75	25	390	24	L	H	25	8	Suitable for juicers, dryers. Moldable by press to size up to 18 mm length max.

* Coefficient of friction: L···Less than 0.20 (Measuring conditions/Current density: AC10 A/cm sq.; Speed: 20 m/second; Spring pressure: 50 kPa)
* Contact voltage drop: VH···Greater than 3.0 V/unit; H···2.0-3.0 volts/unit (Measuring conditions/Current density: AC10 A/cm sq.; Speed: 20 m/second; Spring pressure: 50 kPa)
* The above figures are typical values, and are not guaranteed.

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Coefficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications
		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm²	
Carbon graphite	C-3	1.62	35	240	24	L	H	35	13	Comparative low resistivity. Suitable for 100-120V power tools.
	107	1.62	34	100	29	L	H	35	13	
	113	1.58	37	290	27	L	H	35	13	
	C-1	1.49	30	330	13	L	H	35	12	Suitable for 100V-120V and 200-240V cleaners.
	TX-174	1.55	36	390	24	L	H	35	18	Good commutation performance, wear resistance. Good breaking action. Suitable for 100-120V and 200-240V power tools and cleaners.
	105S	1.55	36	390	24	L	H	35	18	
	108	1.55	36	390	24	L	H	35	18	
	118	1.64	34	390	23	L	H	35	18	
	129	1.64	34	620	20	L	H	35	18	
	106	1.52	33	680	15	M	VH	35	13	Good commutation performance and wear resistance. Suitable for 200-240V cleaners.
	111	1.61	37	600	23	M	VH	35	13	
	114	1.62	35	900	20	M	VH	35	13	Good commutation performance. Suitable for 200-240V power tools and washing machines.
	122	1.62	42	840	22	M	VH	35	13	
	124	1.60	47	790	26	M	VH	35	13	
	127	1.53	33	850	21	M	VH	35	13	
	119	1.59	42	1300	20	M	VH	35	13	Good commutation and sliding performance. Suitable for 200-240V power tools and washing machines.
	B-1	1.75	47	450	13	L	H	25	8	Suitable for small power tools and juicers. Moldable with lead wire by press to size up to L12 mm max.
	C-2	1.55	44	660	17	L	H	25	10	Suitable for small power tools and juicers. Moldable with lead wire by press to size up to L15 mm max.
	C-2N	1.58	18	660	14	L	H	25	10	Suitable for small power tools and juicers. Moldable with lead wire by press to size up to L15 mm max. Better noise prevention and film adjusting effect than C-2.
	FX-08	1.66	32	590	19	L	H	25	10	Suitable for small power tools and juicers. Moldable with lead wire by press to size up to 18 mm max. Better noise prevention and film adjusting effect than C-2.

* Coefficient of friction: M···0.20-0.25, L···Less than 0.20
  (Measuring conditions/Current density: AC10 A/cm sq.; Speed: 20 m/second; Spring pressure: 50 kPa)
* Contact voltage drop: VH···Greater than 3.0 V/unit; H···2.0-3.0 volts/unit
  (Measuring conditions/Current density: AC10 A/cm sq.; Speed: 20 m/second; Spring pressure: 50 kPa)
* The above figures are typical values, and are not guaranteed.

Maximum peripheral speed and maximum current density differ depending on the commutator and slip ring conditions and conditions of use. The information listed to the left and above represents general examples. Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

Design Data

■ Reference: methods to mount lead wire and shape of carbon brush (JIS C2802)

C1 No lead wire	 C1-1	 C1-2	 C1-3	 C1-4	 C1-5	 C1-6	 C1-7	 C1-8	 C1-9	 C1-10
C2 Copper powder tamped soldering	 C2-1	 C2-2	 C2-3	 C2-4	 C2-5	 C2-6	 C2-7	 C2-8	 C2-9	 C2-10
	 C2-11	 C2-12								
C4 Copper pipe (one) Ribetting	 C4-1	 C4-2	 C4-3	 C4-4	 C4-5	 C4-6	 C4-7	 C4-8	 C4-9	 C4-10
	 C4-11	 C4-12	 C4-13	 C4-14	 C4-15	 C4-16	 C4-17	 C4-18	C4-19	C4-20
	C4-21									
C5 Copper pipe (two) Ribetting	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
	C5-11	C5-12	C5-13	C5-14	C5-15	C5-16	C5-17	C5-18		
C6 Segmented rhomboid	C6-1	C6-2	C6-3	C6-4						

■ Tolerance for Thickness, Width, and Length (JIS C2802)

Tolerance for the thickness, width, and length of the brush as well as that of the inner dimensions of the brush holder are as follows:

Unit: mm

Nominal Dimensions	Brush thickness/width tolerance		Holder inner dimension tolerance		Space between brush/holder		Brush length tolerance
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	
1.6 / 2 / 2.5	-0.09	-0.03	+0.05	+0.01	0.14	0.04	±0.3
3.2	-0.09	-0.03	+0.07	+0.02	0.16	0.05	±0.3
4 / 5	-0.11	-0.03	+0.07	+0.02	0.18	0.05	±0.3
6.3 / 8 / 10	-0.11	-0.03	+0.09	+0.03	0.20	0.06	±0.3
12.5 / 16	-0.13	-0.04	+0.10	+0.03	0.23	0.07	±0.5
20 / 25	-0.13	-0.04	+0.12	+0.04	0.25	0.08	±0.5
32 / 40 / 50	-0.15	-0.05	+0.15	+0.05	0.30	0.10	±0.8
64 / 80	-0.15	-0.05	+0.18	+0.06	0.33	0.11	±0.8
100 / 125	—	—	—	—	—	—	±1.0

* Segment brush thickness tolerance of up to 0.02 mm is permissible unless otherwise specified.
  However, note that the maximum dimensions of the brush cannot be altered.

Display example $16^{-0.04}_{-0.15} \times 25^{-0.04}_{-0.13} \times 40^{\pm 0.8}$ (two pieces)

* For brushes that has higher thermal expansion, such as metal graphite brushes, the heat expansion dimensions of the above nominal dimensions can be reduced and the above tolerance applied. This is up to the discretion of the manufacturer, and agreement must be reached with the user.
  Note that the nominal dimensions in such cases will be displayed as in the table. Letters “a” and “b” in the examples refer to heat expansion.

Display example $16^{-(0.14+a)}_{-(0.13+a)} \times 25^{-(0.04+b)}_{-(0.13+b)} \times 40^{\pm 0.8}$

* Tolerance for the inner dimensions of the holder apply to brush thickness and width direction for the perpendicular-shaped holder.
  However, for items such as backlash holders, which do not depend on the interval between brush and holder for brush stability, the maximum specification of the interval thickness direction can be altered upon agreement with the user.

Design Data

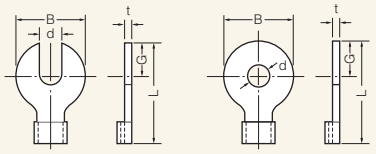
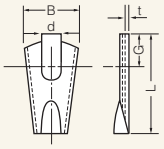
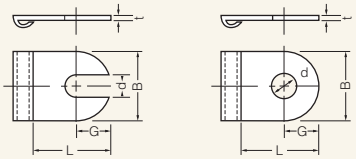
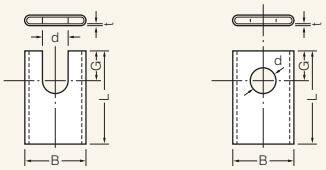
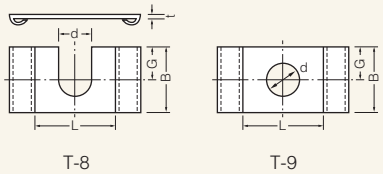
■ Lead Wire Structure (JIS C2802)

Nominal cross-section mm²	Recommended values								Reference
	Maximum OD	Minimum weight	Independent wire diameter 0.05 mm		Independent wire diameter 0.08 mm		Independent wire diameter 0.10 mm		Allowable current +15% -10%
			Number of wires/wire diameters	Cross-section calculation	Number of wires/wire diameters	Cross-section calculation	Number of wires/wire diameters	Cross-section calculation	
	mm	g/m	mm	mm²	mm	mm²	mm	mm²	A
0.06	0.5	0.48	3/10/0.05	0.06	12/0.08	0.06	—	—	2
0.10*	0.6	0.72	3/17/0.05	0.10	20/0.08	0.10	—	—	3
0.15*	0.7	1.00	3/26/0.05	0.15	30/0.08	0.15	—	—	4
0.20*	0.8	1.40	3/34/0.05	0.20	40/0.08	0.20	—	—	4.8
0.25	1.0	2.00	3/42/0.05	0.25	3/17/0.08	0.26	—	—	5.5
0.30	1.1	2.20	3/51/0.05	0.30	3/20/0.08	0.30	—	—	6
0.35	1.1	2.80	3/60/0.05	0.35	3/23/0.08	0.35	3/15/0.10	0.35	7
0.40	1.2	2.90	—	—	3/27/0.08	0.41	3/17/0.10	0.40	8
0.50	1.3	4.00	—	—	3/33/0.08	0.50	3/21/0.10	0.49	9
0.75*	1.6	5.60	—	—	3/50/0.08	0.75	3/32/0.10	0.75	12
0.90	1.7	6.50	—	—	7/26/0.08	0.91	7/16/0.10	0.88	13
1.00	1.8	8.00	—	—	7/28/0.08	0.99	7/18/0.10	0.99	15
1.25	2.0	10	—	—	7/36/0.08	1.27	7/23/0.10	1.26	17.5
1.40	2.1	11	—	—	7/40/0.08	1.41	7/25/0.10	1.37	19
1.50*	2.2	13	—	—	7/43/0.08	1.51	7/27/0.10	1.48	20
2.00	2.4	16	—	—	7/57/0.08	2.01	7/36/0.10	1.98	24
2.50	2.7	20	—	—	7/71/0.08	2.50	7/46/0.10	2.53	28
3.20	3.0	26	—	—	7/91/0.08	3.20	7/58/0.10	3.19	32
3.50	3.2	28	—	—	7/100/0.08	3.52	7/64/0.10	3.52	34
4.00	3.3	32	—	—	7/114/0.08	4.01	7/73/0.10	4.01	38
4.50	3.5	36	—	—	7/127/0.08	4.47	7/82/0.10	4.15	40
5.50	3.7	44	—	—	7/157/0.08	5.52	7/100/0.10	5.50	45
6.00	4.2	48	—	—	7/170/0.08	5.98	7/109/0.10	5.99	50
6.50	4.4	52	—	—	—	—	7/119/0.10	6.54	53
8.00	4.7	64	—	—	—	—	7/146/0.10	8.03	60
10.00	5.3	80	—	—	—	—	7/182/0.10	10.01	75
12.50	5.9	100	—	—	—	—	7/7/32/0.10	12.32	85
16.00	6.7	128	—	—	—	—	7/7/42/0.10	16.16	100

* Figures based on JIS C3664 standards (IEC60228).
* The material of lead wire having 0.05/0.08 mm independent diameter is based on JIS 3103 while lead wire having 0.10 mm independent diameter is based on JIS3102.
* Where the lead wire is fitted into a tube, lead wire thickness can be adjusted upon agreement with the user.
* Where there is a possibility of excess current or insufficient cooling capability, adjust the lead wire thickness upon agreement with the user.

■ Terminal shape and dimensions (JIS C2802)

Unit: mm

Number	Dimensional diagrams	Installation screw (meter screw)	Dimensions				
			d	B	G	L	t
T-1 T-2	 T-1 T-2	3	3.5 +0.2 −0.2	8 ± 0.3	4	12 ± 1	0.5 0.8
		4	4.5 +0.3 −0.1	10 ± 0.3	5	15 ± 1	0.8
		5	5.5 +0.3 −0.1	13 ± 0.4	6.5	20 ± 1	0.8 1.0
		6	6.5 +0.3 −0.1	16 ± 0.4	8	24 ± 1	1.0
		8	8.5 +0.3 −0.1	19 ± 0.5	9.5	29 ± 1	1.0 1.2
		10	10.5 +0.3 −0.1	23 ± 0.5	12	40 ± 1	1.2
T-13	 T-3	5	5.5 +0.3 −0.1	13 ± 0.8	6.5	20 ± 1.5	0.4 0.5
		6	6.5 +0.3 −0.1	16 ± 0.8	8	24 ± 1.5	0.4 0.5
		8	8.5 +0.3 −0.1	19 ± 1	9.5	29 ± 1.5	0.4 0.5
T-4 T-5	 T-4 T-5	3	3.5 +0.2 −0.2	8 ± 0.3	4	> 8	0.5 0.8
		4	4.5 +0.3 −0.1	10 ± 0.3	5	> 10	0.8
		5	5.5 +0.3 −0.1	13 ± 0.4	6.5	> 13	0.8 1.0
		6	6.5 +0.3 −0.1	16 ± 0.4	8	> 16	1.0
		8	8.5 +0.3 −0.1	19 ± 0.5	9.5	> 19	1.0 1.2
		10	10.5 +0.3 −0.1	23 ± 0.5	12	> 25	1.2
T-6 T-7	 T-6 T-7	5	5.5 +0.3 −0.1	13 ± 0.8	6.5	20 ± 1	0.4 0.5
		6	6.5 +0.3 −0.1	16 ± 0.8	8	24 ± 1	0.4 0.5
		8	8.5 +0.3 −0.1	19 ± 1	9.5	29 ± 1	0.6 0.8
		10	10.5 +0.4 −0.1	23 ± 1	11.5	35 ± 1	0.6 0.8
T-8 T-9	 T-8 T-9	4	4.5 +0.3 −0.1	10 ± 1	5	> 10	0.8 1.0
		5	5.5 +0.3 −0.1	14 ± 1	7	> 12	0.8 1.0
		6	6.5 +0.3 −0.1	16 ± 1	8	> 14	1.0 1.2
		8	8.5 +0.3 −0.1	20 ± 1	10	> 18	1.0 1.2
		10	10.5 +0.3 −0.1	23 ± 1	12	> 26	1.2

* Where there is no tolerance indicated (excluding t), it is the G dimension ±10%
* The t dimensions for T-8 can be 1.2 for screw numbers 4 and 5, and 1.5 for screw numbers 6 and 8.

Surface Improvement Products/New Developed Products/Technical Services

At Toyo Tanso, we believe in the boundless possibilities of carbon, and our basic and applied research initiatives never stop.



Surface Improvement Products

- PYROGRAPH™ Products
- PERMA KOTE™ Products
- GLASTIX KOTE™ Products
- Toyo Siliconized Graphite

Analytical technologies

Surface Improvement Products

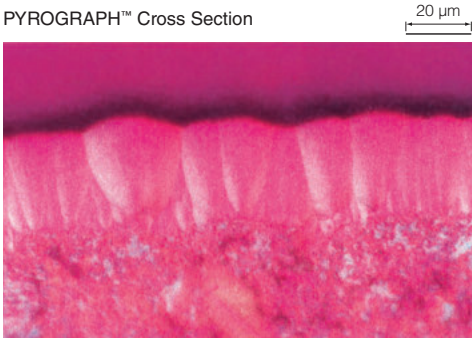
PYROGRAPH™ Products

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 particles, 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

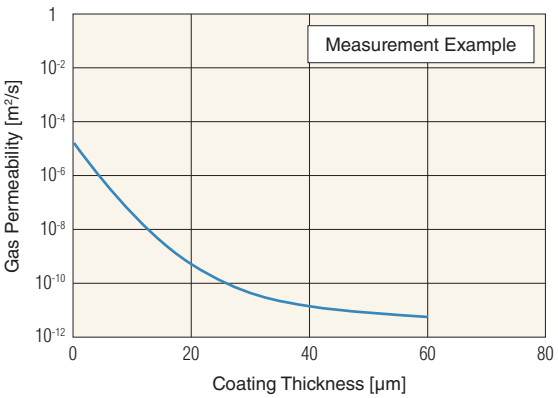
* Measurement method: Glow Discharge Mass Spectrometry
* The figures above are measurement examples, and are not to be guaranteed.

■ General Physical Properties

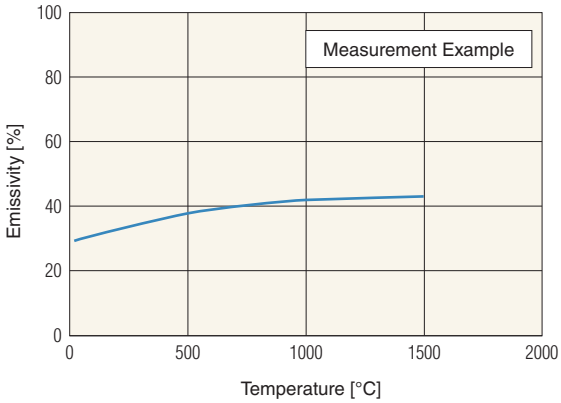
Item	Unit	Parallel to Coating Surface	Perpendicular to Coating Surface
Bulk Density	Mg/m^3	2.2	2.2
Hardness	HSD	100	—
Electrical Resistivity	µΩ·m	2.00 to 4.00	2 to 5 x 10^3
Coefficient of Thermal Expansion	10^{-6}/K	1.7	28
Tensile Strength	MPa	98 to 147	Extremely weak
Young's Modulus	GPa	29 to 39	—
Thermal Conductivity	W/(m·K)	170 to 420	2 to 4

* The temperature range for the coefficient of thermal expansion is RT to 1,000°C.
* The figures above are extracted from other publications, and are not to be guaranteed.

■ Gas Permeability



■ Emissivity



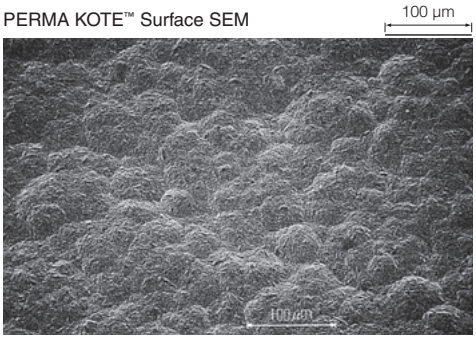
PERMA KOTE™ Products

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

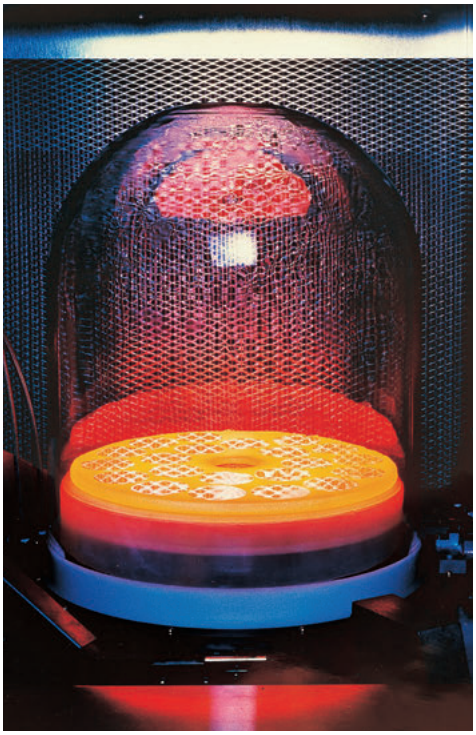


■ Coating Thickness

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

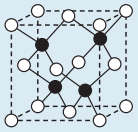
Name	Chemical Formula	Concentration (%)	Temperature (°C)	Time (h)	Change in Mass (g/m²)
Hydrofluoric acid	HF	47	80	144	-1.0
Hydrochloric acid	HCl	36	Boiling point	144	0
Sulfuric acid	H_2SO_4	97	110	144	0
Nitric acid	HNO_3	61	Boiling point	144	0
Hydrofluoric acid + nitric acid	HF + HNO_3 (1:1)	100	80	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°C x 3h	1600°C x 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	ß-SiC (Cubic System) Structure 
Bulk Density	3.2 Mg/m³
Hardness	2800HK
Electrical Resistivity	0.2 Ω·m (through the fall-of-potential method)
Flexural Strength	170 MPa (through 3-point bending)
Young's Modulus	320 GPa (through the deflection method)

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

■ Impurity Analysis Example

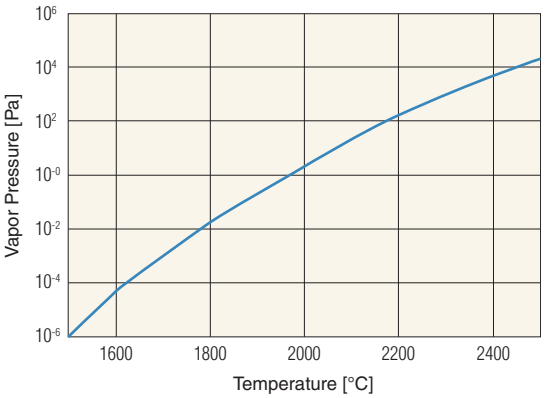
Unit: mass ppm

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.

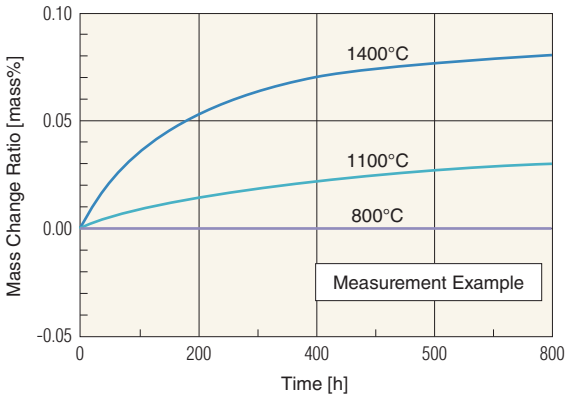
■ Silicon Carbide Vapor Pressure

*Extracted from the ultra high temperature melting point material handbook



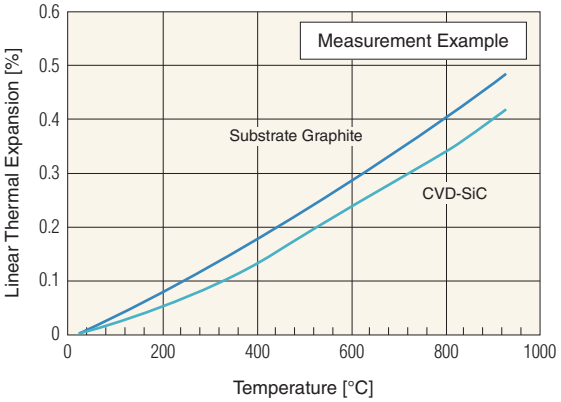
PERMA KOTE™ is extremely stable at high temperatures.

■ Oxidation

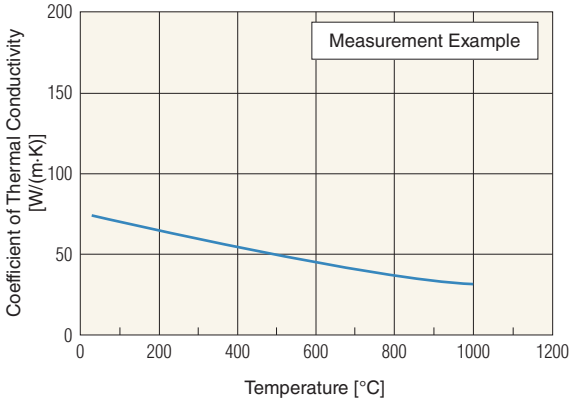


PERMA KOTE™ is resistant to oxidation; and because the SiO_2 protective layer is formed at over 800°C, the substrate graphite is protected from oxidation.

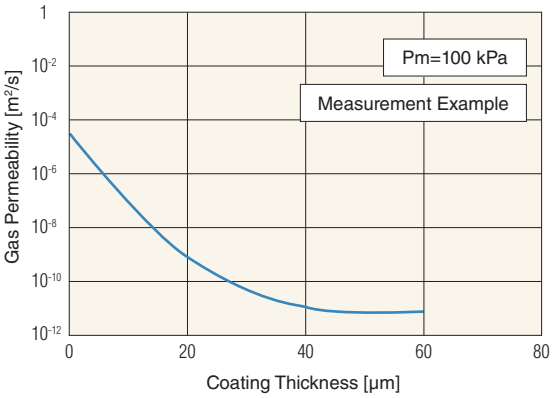
■ Coefficient of Thermal Expansion for CVD-SiC and Substrate graphite



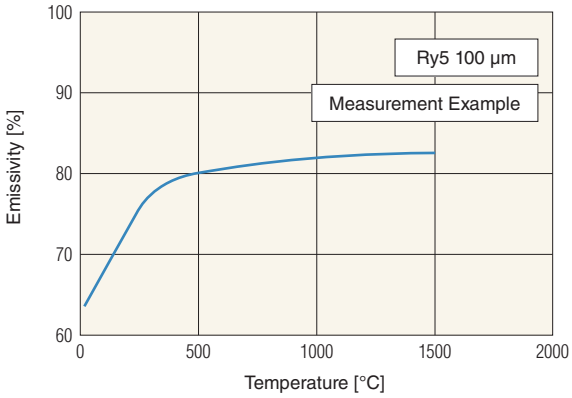
■ Thermal Conductivity



■ Gas Permeability



■ Emissivity



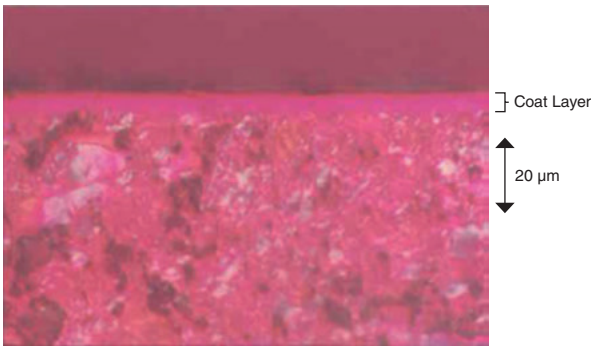
Glass-like Carbon Coated GLASTIX KOTE™

GLASTIX KOTE™ is a material impregnated or coated with glass-like carbon on a graphite or neighboring surface.
It enables use of various Toyo Tanso graphite materials as a substrate, and it does not lose its substrate properties. Not only does this material offer enhanced durability against scratching and other friction, it also reduces the generation of dust.

■ Features

- Able to use various Toyo Tanso graphite materials as a substrate.
- Does not lose graphite substrate properties.
- Able to reduce the generation of graphite powder.
- Enhanced durability against scratching and other friction.

"GP2B" Cross-section



■ Application

- Parts for silicon single crystal pulling devices
- Parts for epitaxial growth
- Dies for continuous casting
- Glass sealing jigs

■ Properties/Test Data

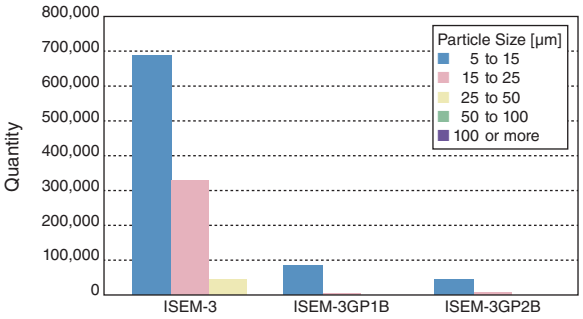
■ General Physical Properties

Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Compressive Strength
ISEM-3	0	0	0	0	0
GP1B	0	+3%	0	+8%	+3%
GP2Z	0	+3%	–	+7%	+4%
GP2B	0	+3%	0	+13%	+3%

* Example of physical properties when using ISEM-3 as a graphite substrate and applying GLASTIX KOTE™ GP series processing.
(Rate of change with measured value of ISEM-3 substrate as the standard)

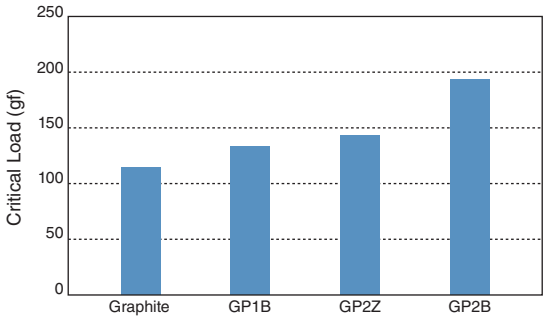
Test piece dimensions:
10 × 10 × 60 mm: Bulk density, hardness, electrical resistivity, flexural strength
10 × 10 × 10 mm: Compressive strength

■ Dust Reduction Effect



GLASTIX KOTE™ processing can greatly reduce the amount of carbon dust generated.
* This is the result of measuring the number of fine particles in the cleaning solution.

■ Scratch Strength Comparison



The durability against scratching with GLASTIX KOTE™ processing nearly doubled, and a similar improvement in wear resistance can be expected.
* Critical load indicates the vertical load when the surface begins to show damage.

Toyo Siliconized Graphite SiC/C Composites

Toyo Siliconized graphite is a material with a composite layer of silicon carbide (SiC) and graphite (C).
The material has excellent properties of both silicon carbide and graphite, and not only are they ideal for sliding material applications, the surface layer of the graphite substrate is covered with a fine SiC layer, making it ideal for high-temperature atmosphere applications as well.

■ Features

- SiC/C composite layer can be applied to an entire product or just the areas required.
- Composite layer can be formed from the surface to deep within the material.

[Sliding Material Applications]

- Excellent blister resistance and enhanced wear and oxidation resistance.
- Graphite substrate does not lose workability.

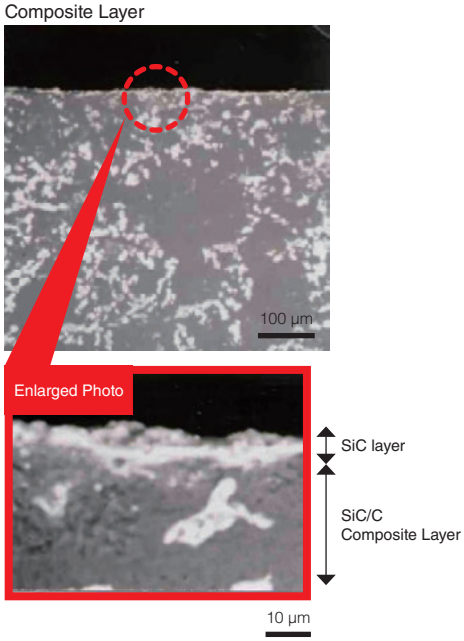
[High-temperature Atmosphere Applications]

- A SiC layer forms on the processing surface, enhancing oxidation resistance and reducing scattering from the graphite substrate.

■ Application

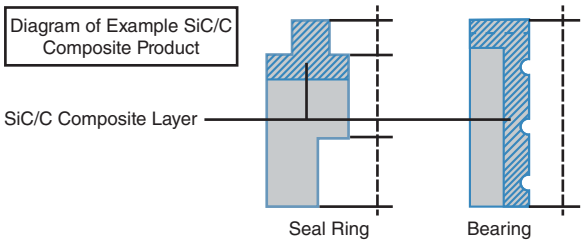
- Metallurgic members
- Mechanical seals
- Bearings

Cross-sectional Photo of SiC/C Composite Layer



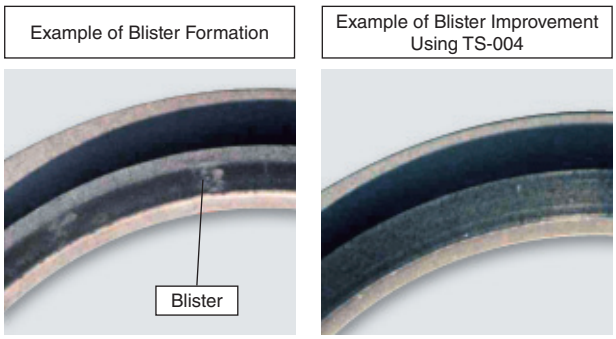
■ Properties/Test Data

■ Diagram of Example SiC/C Composite Product



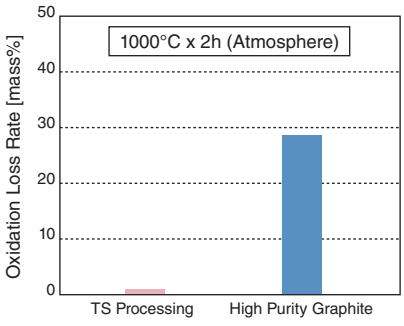
SiC/C composite layer can be applied to an entire product or just the areas required.
The inner diameter of the bearing can be processed after becoming a composite, thereby falling within the tolerance.

■ Sliding Application (Blister Test)



Because the material retains a high mechanical strength and the sliding surface has a moderate surface roughness, it is easy to form a lubricating layer on the sliding surface, and it is difficult for blisters to form when using liquid oil.

■ High-temperature Atmosphere Application (Oxidation Loss Test)

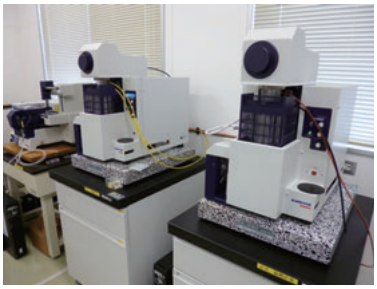


Analytical technologies

Toyo Tanso employs analytical technologies using a diverse range of analysis equipment to develop new materials and pursue research and development into material design and new applications. We also respond to a wide range of customer requests such as manufacturing process improvement, and also contribute to identifying and problem solving. In this way, we continually strive to provide better products and more sophisticated technologies and services through analytical technologies.

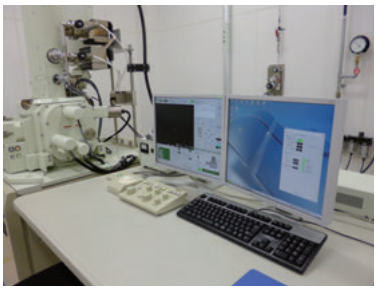
■ Thermal analysis

Graphite material has excellent thermal durability, and as it is often used in high-temperature environments, it is important to understand the way it behaves when heat is applied to a material. Toyo Tanso has a wide variety of thermal analysis equipment (TMA, TG-DTA, etc.), and can provide data to meet your usage conditions. Based on this data, we provide a range of services that can help with material selection including: heat stress calculation and FEM analysis, etc., for component design; analysis of chemical reactions and state changes due to heat; and analysis of material wear in oxidizing atmospheres.



■ Structural and surface analysis

Graphite material is polycrystalline and porous in nature, and differs greatly in terms of surface shape and internal structure due to differences in raw materials and manufacturing methods. To select and develop materials suited to your application, it is therefore important to have an understanding of a variety of structures. Toyo Tanso uses all sorts of measurement equipment suited to these analyses (XRD, FE-SEM, polarizing microscopes, etc.,) depending on the purpose, and conducts a range of analysis from the macro to the nanoscale level.



■ Element analysis

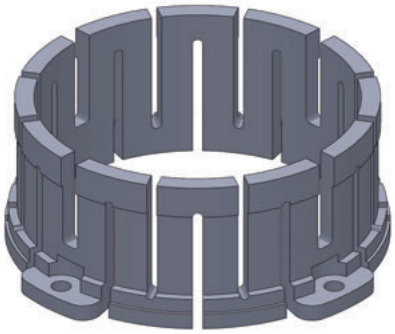
As graphite materials can be made with a high degree of purity, they are frequently used in applications where it is necessary to avoid contaminants such as semiconductor fabrication equipment. In applications where a high degree of purity is required, analysis of trace contaminants is an important analysis tool. Toyo Tanso has a variety of element analysis equipment (ICP-OES, XRF, etc.,) and is ready to respond to your requests.

■ Physical properties

We provide data on basic physical properties such as tensile, compression, and flexural strength as well as modulus of elasticity, all of which are essential for component/material design.

■ 3D CAD drawings

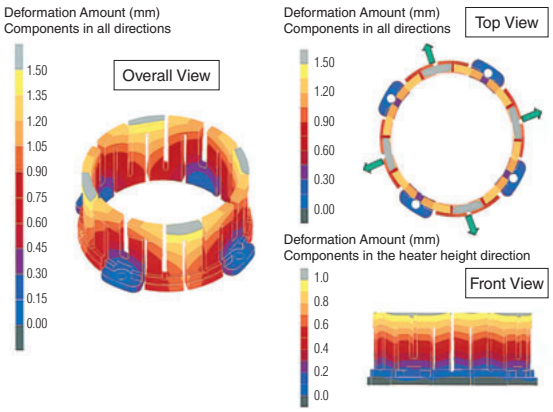
Toyo Tanso recreates three-dimensional images of products on a computer via 3D CAD, and improves the quality of the finished product by checking shape details before product processing. We also offer design support via 3D CAD based on your schematic diagrams and design information.



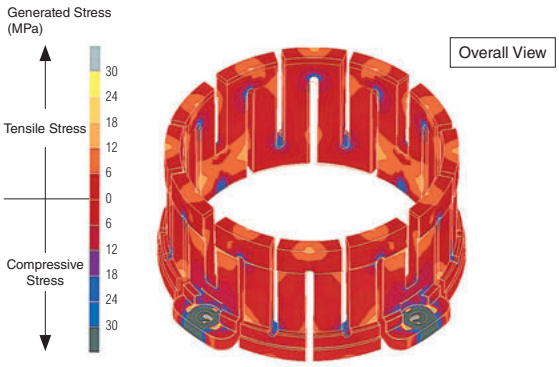
■ Finite element method (FEM analysis examples)

By analyzing heat deformation, heat stress, current density distribution, and other factors in complex product shapes using FEM computer simulations depending on your environment, Toyo Tanso offers comprehensive support of design processes for improving product performance, reducing costs, improving product development speed, etc.

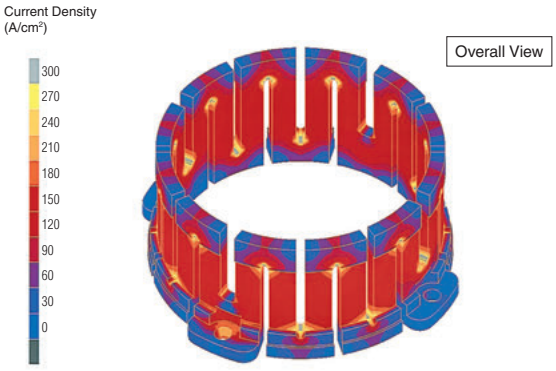
■ Thermal Deformation Analysis Results



■ Thermal Stress Analysis Results



■ Current Density Distribution Results



Lineup of Ohwada Carbon Industry Products

Ohwada Carbon Industry, a member of the Toyo Tanso group of companies, processes isotropic graphite, as well as manufactures, processes, and develops various carbon products, including C/C composites, extruded graphite, and molded graphite. These products are being widely adopted as the main parts of cutting edge technology in the semiconductor, automotive, metallurgy, and mechanical industries.

■ Product Lineup

(1) C/C composites

This composite graphite material has a high strength reinforced with carbon fiber, and it can be manufactured into a flat or cylindrical material.
Application: hot press, metallurgy

Product Number	Bulk Density Mg/m³	Hardness HSD	Electrical Resistivity μΩ-m	Flexural Strength MPa	Compressive Strength MPa	Tensile Strength MPa	Young's Modulus Gpa	Coefficient of Thermal Expansion 10^{-6}/K	Standard Size (mm)
C/C-201	1.50	80	30	147	225	127	47	1.0	700 × 970 × 1 to 12
C/C-FW	1.50	80	12	245	147	245	60	1.0	ø900 (OD) × 800 (H)

(2) Extruded graphite

This graphite is manufactured using an extrusion molding method, and it can accommodate both large and long sizes. Application: general industrial furnace members (heaters, trays, insulation members, etc.)

Composition	Product Number	Bulk Density Mg/m³	Hardness HSD	Electrical Resistivity μΩ-m	Flexural Strength MPa	Compressive Strength MPa	Coefficient of Thermal Expansion 10^{-6}/K	Thermal Conductivity W/(m·k)	Standard Size (mm)
Graphite	OT-5200	1.76	41	7.5	27	44	4.4	180	ø500 × 1800
	OT-5220	1.75	35	7.3	29	49	4.0	174	ø100 × 1500
	OP-4800	1.74	43	7.5	27	44	4.4	150	670 × 450 × 1500
	OP-4800N	1.73	34	5.0	20	39	1.2	230	670 × 450 × 1585
	OP-4850	1.75	35	8.0	24	45	3.5	162	560 × 560 × 1800
	OP-7800H	1.79	45	8.2	22	42	2.1	180	ø760 × 1800
	OP-9001	1.66	30	10.0	13	24	2.7	130	ø960 × 1000
	OP-4600	1.74	35	7.0	21	38	3.4	150	ø700 × 1800
Carbon	OT-520	1.66	60	40.0	31	98	5.5	12	ø500 × 1800

Note: High purity graphite material is indicated with the letter "S" at the end of the product number.

(3) Molded graphite

This graphite is manufactured using a die molding method, and it can provide various composition types. Application: jigs for glass production, etc.

Composition	Product Number	Bulk Density Mg/m³	Hardness HSD	Electrical Resistivity μΩ-m	Flexural Strength MPa	Compressive Strength MPa	Coefficient of Thermal Expansion 10^{-6}/K	Thermal Conductivity W/(m·k)	Standard Size (mm)
Graphite	OP-8430	1.80	60	11.0	50	98	5.0	120	105 × 320 × 640
Natural Graphite	OT-104	1.77	12	9.0	10	20	2.0	140	100 × 419 × 500
Semi-graphite	OP-8420	1.78	96	30.0	59	167	6.0	30	105 × 320 × 640

(4) Resin impregnated material

This product is made of composite resin-impregnated carbon for enhanced sliding properties such as wear resistance and impermeability.
Application: various sliding members (bearings, seal rings, packing)

Composition	Product Number	Bulk Density Mg/m³	Hardness HSD	Tensile Strength MPa	Flexural Strength MPa	Compressive Strength MPa	Coefficient of Thermal Expansion 10^{-6}/K	Heat-resistant Temperature °C
Electrographite Resin Impregnated	P-3100	1.90	63	29	52	127	5	250
	P-4800	1.85	55	26	40	96	5	250
	F-3200	1.88	69	27	49	118	5	250
	F-4800	1.83	50	25	38	86	5	250

(5) Carbon and graphite powder

We offer carbon and graphite powder in a variety of particle sizes. Application: carbonized material, filling material

Composition	Product Number	Volatility %	Ash Content %	Fixed Carbon %	Particle Size Range	
Artificial Graphite Powder	TEG200	0.2	0.5	99.0	44 μm or less	30 to 60%
	TEG300	0.2	0.5	99.0	44 μm or less	80% or more
Carbon Powder	OP-240	1.0	0.5	98.5	106 μm or less	90% or more
Artificial Graphite Particle	#20 to 40	0.5	1.0	98.0	0.35 to 1.0 mm	90% or more
	#1 to 5	0.5	1.0	98.0	1 to 5 mm	90% or more
	#5 to 15	0.5	1.0	98.0	5 to 15 mm	80% or more

* Other graphite powder not listed here is also available. Contact us for details.

■ Examples of Main Applications by Material

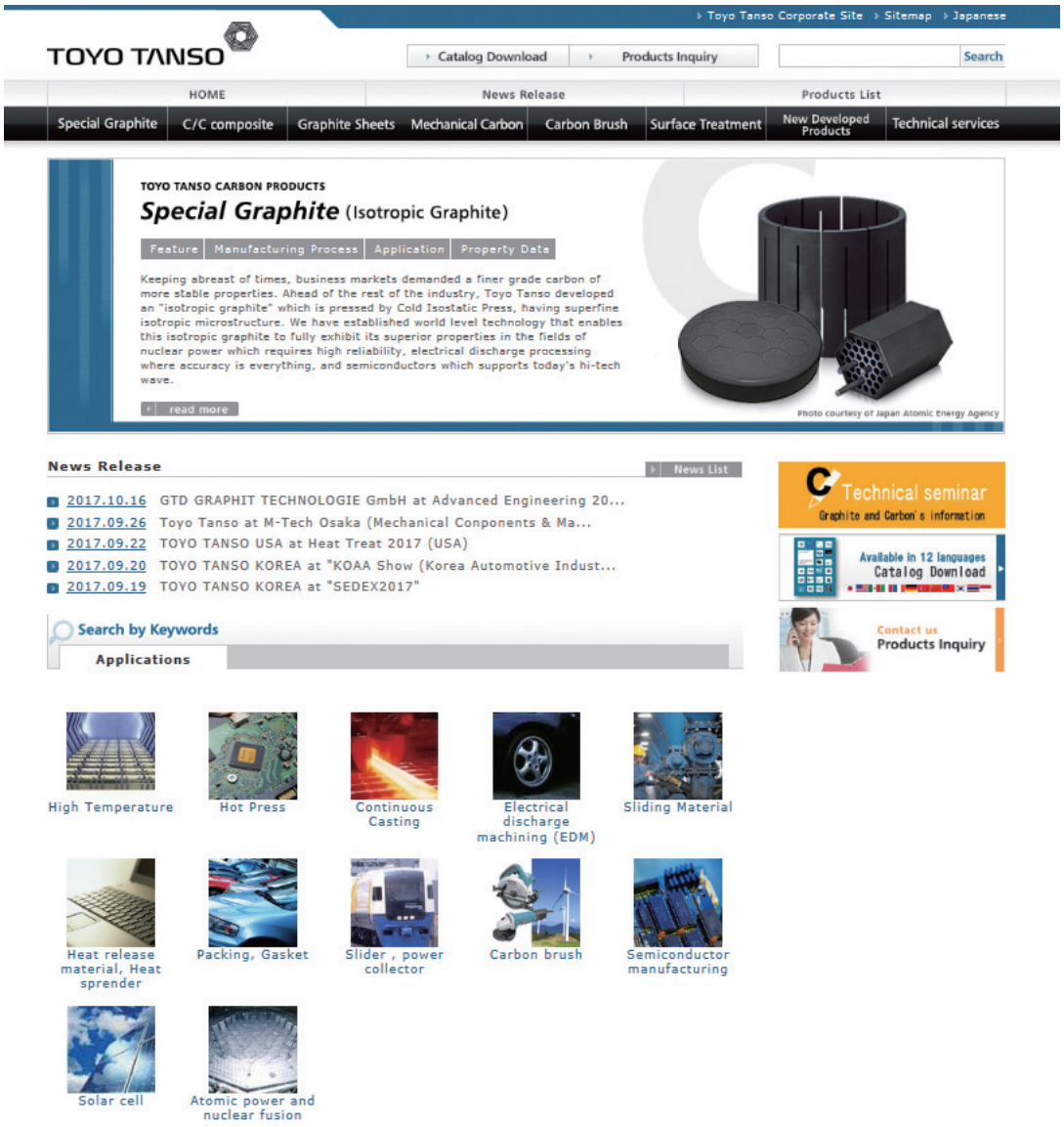
For details on special graphite product applications, please refer to the special graphite product page of this catalog.

Field	Part Name	Applicable Material Product Number
Hot Press	Hot press molds, dies	C/C-FW
	C/C mold sleeves	OP-4800N
Metallurgy	Furnace parts, trays, sample cases	OP-4800, OT-5220, OT-5200, OP-9001, C/C201
	Heating elements	OP-4800, OP-4850
	Melting crucibles, gas analysis crucibles	OT-5220, OP-4800
	Jigs for glass bottles and fused quartz	OP-8420, C/C-201
Mechanical	Mechanical seals, joint seals	P-3100, F-3200
	Bearings, pump rotary vanes	
Electrical	Trolley wheels, sliders	P-4800, P-3100
Powder	For various filling material	TEG200, TEG300, OP-240
	Graphite particle to prevent oxidation and for carbonized material	#20 to 40, #1 to 5, #5 to 15

· The listed data are the representative properties and are not guaranteed values.
· The listed product applications are examples. Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

Product Site Introduction

At Toyo Tanso's product site, products are introduced based on product- and application-groups. Information on services to enhance customer knowledge of carbon is also available, such as technical seminar info, catalog and technical material downloads, and sample kit sales.
Why not give it a try?



■ Technical Seminars

Toyo Tanso provides seminars regarding our company's products.
Future seminar dates will be shown on this page where applications can also be submitted.

■ Catalog Download

Toyo Tanso's product catalog comes in 12 languages and can be downloaded in PDF form.

■ Product Inquiry

Feel free to submit inquiries regarding our company's products here. You will be subsequently contacted by one of our company's sales representatives.

TOYO TANSO

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