



CARBON-GRAPHITE PRODUCTS

















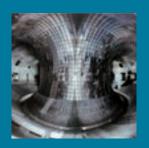




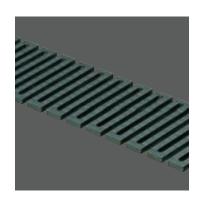




















TOYO T/NSO

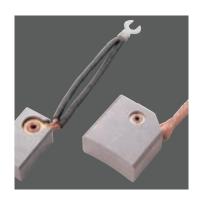












People and carbon An everlasting relationship.

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 everincreasing 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.

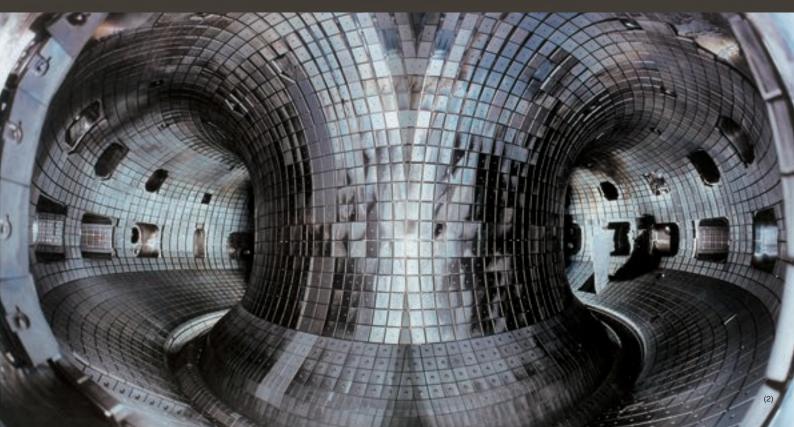


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Special Graphite



- (1) Single crystal silicon manufacturing equipment
- (2) Critical plasma testing equipment (JT-60)
 * Photographs provided by the Japan Atomic Energy Agency



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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.

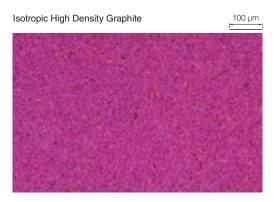
■ Excellent Chemical Resistance

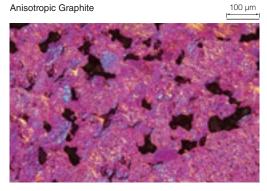
With the exception of some strong oxidizers, it is chemically stable. Graphite can be used stably even in environments that cause some metals to corrode.

■ Lightweight and Easy to Machine

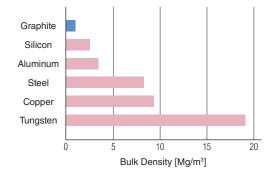
The bulk density is low as compared with metallic materialsenabling a lightweight design. In addition, it has excellent mechanical machining properties-facilitating accurate shaping processes.

■ Isotropic Graphite and Anisotropic Graphite



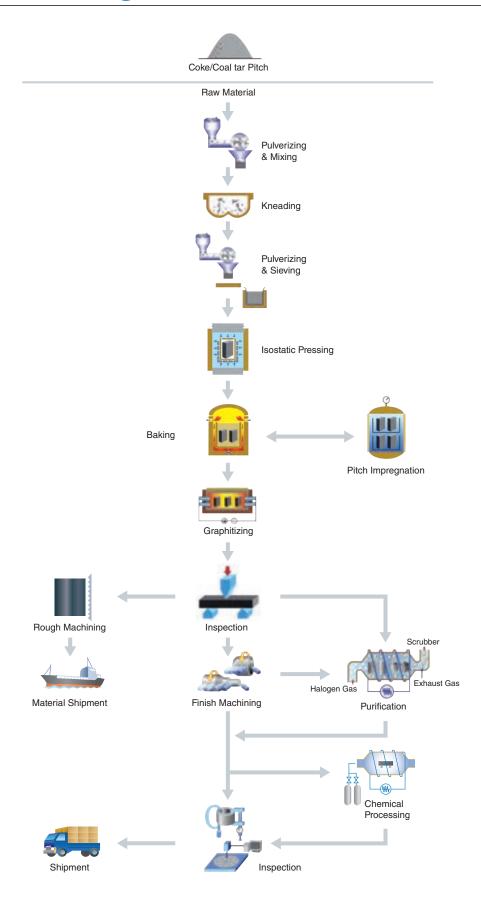


Isotropic high density graphite is different from conventional graphite in that it is isotropic and has a micro particle structure, creating a very strong and highly reliable material with a small variation. This isotropic graphite material resolves the problems associate with conventional anisotropic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





Manufacturing Process





Application

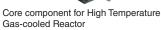
Toyo Tanso's special graphite products are highly regarded for their excellent performance and reliability and are used across a wide range of fields that are essential in our everyday lives. In the environmental and energy industry, our products are used for solar cell manufacturing, atomic power and 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







Photographs provided by the Japan Atomic Energy Agency





Plasma First Wall * Photographs provided by the Japan Atomic Energy Agency







■ 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



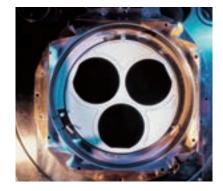
Single crystal silicon manufacturing equipment



Crucible









■ 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







- Continuous Casting
 Dies
 Mandrels
- Hot Press

Dies Punch Sleeves

Spacers



- Vacuum Evaporation Crucibles
- Gas Analysis Crucibles
- Optical Fiber
 Manufacturing Applications
 Heaters
 Muffle Tube



Hot Press Mold (Cut Model)



Continuous Casting Dies



Vacuum Evaporation Crucibles



















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-66	1.82	75	14.4	70	134	46	12.6	7.1	80	180 x 450 x 850
ISO-68	1.82	80	15.5	76	172	54	13.2	5.6	70	230 x 540 x 1000
TTK-50	1.80	70	13.0	60	130	40	11.5	5.1	100	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: $\mu\Omega$ ·m= $\mu\Omega$ ·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

		Content					
Element	Ultra High Purity Graphite	High Purity Graphite	Regular Graphite	Measurement Method			
Li	<0.001	< 0.001	< 0.03	ICP-MS			
В	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			

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

- * The figures above are examples of actual 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

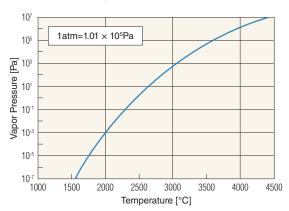
■ Initial Reaction Temperatures With Various Substances

* Extracted from other publications

Reacant	Initial Reaction Temperature	Compound of Reaction
Aluminum	800°C	Al ₄ C ₃
Boron	1600°C	B ₄ C
Iron	600 to 800°C	Fe₃C
Sodium	400 to 450°C	C ₆₄ Na Intercalation compound (when O ₂ is present)
Cobalt	218°C	CoC, Co ₃ C
Molybdenum	700°C	Mo ₂ C
Nickel	1310°C	Ni Carbonizing in Ni
Silicon	1150°C	SiC
Copper	_	
Magnesium	_	
Lead	_	
Tin	_	
Tungsten	1400°C	W ₂ C, WC (in hydrogen)
Potassium	300°C	C ₈ K Other intercalation compounds
Lithium	500°C	Li ₂ C ₂
Beryllium	900°C	Be ₂ C (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, AI, AI ₄ C ₃
Beryllium oxide	960°C	CO, Be, Be ₂ C
Magnesium oxide	1350°C	CO, Mg
Zirconium oxide (IV)	1300°C	CO, Zr, ZrC

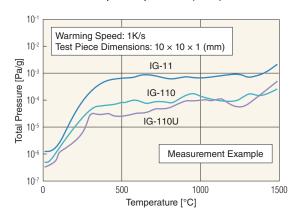
■ Vapor Pressure

* 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

		•	, T
Atmosphere/ Gaseous species	Initial Reaction Temperatures/ Reaction Temperatures	Genesis phenomenon or Produced Compound	Remarks
Air	420 to 460°C	Oxidation/CO, CO2	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 ₂ O)	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 ₂ H ₂ , C ₂ H ₄ , C ₂ H ₆ or so at more high temperature
Nitrogen (N ₂)	Inert at more than room temperature	Sublimation	Produce CyanogenC ₂ N 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 ₂ F 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

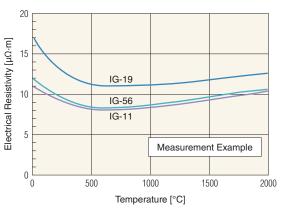
In an oxidizing atmosphere, graphite reacts with oxygen at a relatively low temperature. However, in a non-oxidizing atmosphere, graphite is chemically and thermally and extremely stable material, enabling a broad range of applications.



Property Data

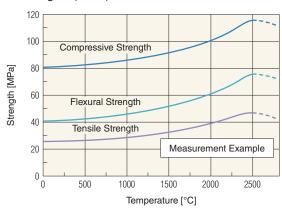
■ High Temperature Properties

■ Electrical Resistivity



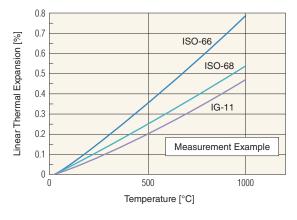
Since thermal characteristics differ from grade to grade, the coefficient of electrical resistivity must be carefully studied when selecting a grade for a heating element.

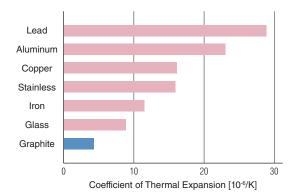
■ Strengths (IG-11)



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

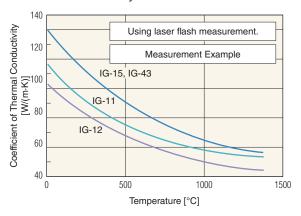


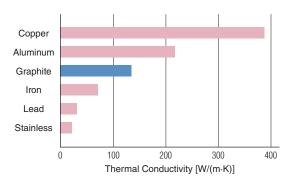


Compared with general metals, the coefficient of thermal expansion for graphite is extremely low. As a result, when used in high temperature applications, the dimensional accuracy is very stable.

$$\begin{array}{l} \text{Reference:} \\ \text{Coefficient of (10 °/K)} \\ \text{Thermal Expansion} \end{array} = \frac{\text{Linear Thermal Expansion (\%)} \times 10^{\circ 2}}{\text{Temperature Difference (°C)}} \end{array}$$

■ Thermal Conductivity



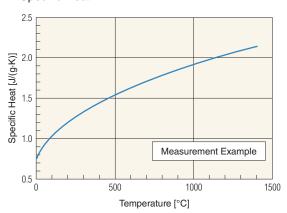


The thermal conductivity of graphite is fairly high, while the coefficient of thermal expansion is very low. These characteristics contribute to its superior thermal shock resistance. The relationship between thermal conductivity and electrical resistivity of graphite in room temperature is indicated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

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

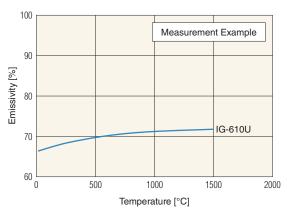


■ Specific Heat



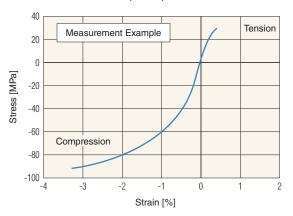
Due to the anisotropic nature of its crystals, the specific heat of graphite at room temperature stays at 1/3 of that of general solids. The specific heat value is essential in various thermodynamic functions. At high temperatures, specific heat values are similar regardless of the graphite grades.

■ Emissivity



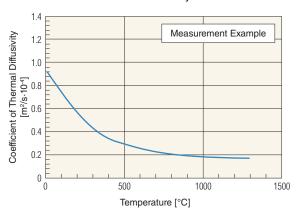
■ Physical Properties

■ 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.

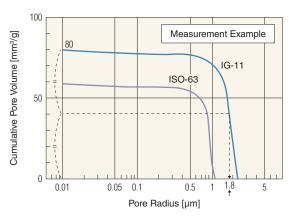
■ Coefficient of Thermal Diffusivity



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.



■ 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 $80/2 = 40 \text{ mm}^3/\text{g} \rightarrow 1.8 \mu\text{m}$



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	Machining	g Surface Re for Carbon	oughness	Finishing Method	Machining Surface Roughness for Metal			
(For reference)	Ry	Ra	Rz	Metriod	Ry	Ra	Rz	
VVVV	√Ry3	0.75/	√Rz3	Honing Lapping	√Ry0.8	0.2	√Rz0.8	
VVV	√Ry12	3.0	√Rz12	Grinder, Lathe Miller	√Ry6.3	1.6	√Rz6.3	
\vee	√Ry35	8.75/	√Rz35	Lathe Miller	√Ry25	6.3	√Rz25	
∇	√Ry100	25/	√Rz100	Lathe Miller	√Ry100	25/	√Rz100	
~	No pa	rticular sta	indard	Saw Machine	No pa	rticular sta	ndard	

^{* 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 Dime	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

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.

 $^{^{\}star}$ The above information can be applied when graphite is machined by Toyo Tanso in Japan.

C/C composite

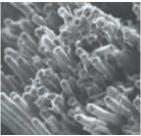


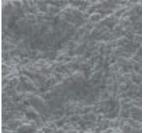




Features of C/C Composite Products

C/C composite (<u>C</u>arbon Fiber Reinforced <u>C</u>arbon 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.





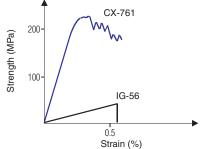
C/C composite (×1000)

Artificial graphite (×200)

High mechanical strength, high elasticity, and high toughness

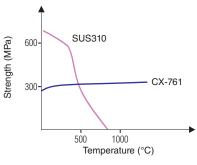
C/C composites have higher strength, higher elasticity, and resistance to cracking and chipping, compared to isotropic graphite materials. C/C composites can be used with assurance, as the fractures do not propagate rapidly in them.





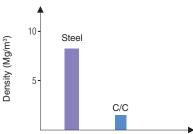
■ Ultra heat resistance

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.



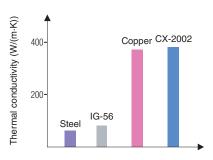
■ Light-weight and easy to handle

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



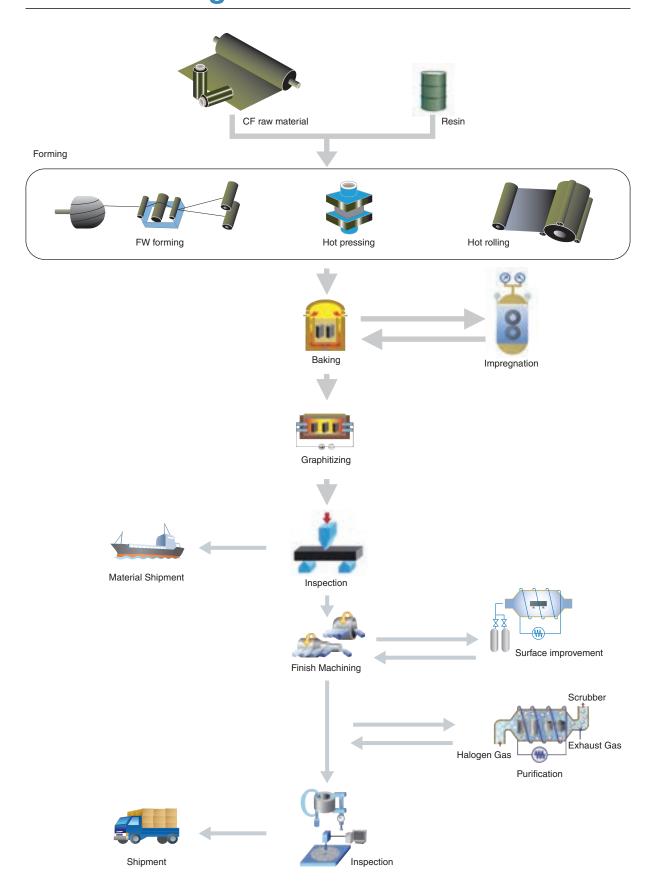
■ High thermal conductivity

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

■ Automobiles, other means of transport, etc

• For sliding components



Clutch





■ General industrial furnaces

• For heat treatment furnaces





Property Data

■ Typical properties

Shape	Material	Bulk Density (Mg/ m³)	Electrical Resistivity (μΩ·m)	Flexural Strength (MPa)	Flexural modulus (GPa)	Tensile strenght (MPa)		cient of Expansion 3K (10 ⁻⁶ /K)	Condi	rmal uctivity m·k))	C/C type	Description
		_	_	_	_	_	(⊥)	(//)	(⊥)	(//)		
	CX-741	1.51	23	140	46	185	8.1	<1	6	35		Medium strength (Molding method A)
	CX-761	1.58	20	185	55	250	8.4	<1	9	44		High strength (Molding method A)
Flat plate	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	2DC/C	High strength (Molding method B)
	CX-31	1.61	22	90	23	98	4.1	<1	12	52		Nut and bolt components
	C/C-2011)	1.50	30	147	47	127	8.2	<1	5	20		Medium strength, nut and bolt components
D61	CX-743	1.48	24	130	_	_	7.8	<1	5	34		Profiles
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
Cylinders	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	-		FW crucibles
Culindara	C/C-FW ¹⁾	150	12	245	_	245	_	<1	5	30	FWC/C	FW hot press molds
Cylinders	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	10	04		

^{*} The figures above are typical values, and are not guaranteed.

■ 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

* Please contact us for other sizes	3.
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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)



dimensions



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

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

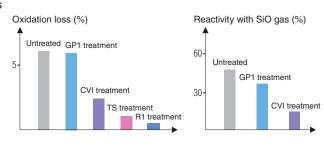
■ Different surface improvements

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.





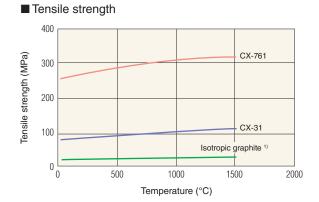
¹⁾ Manufactured by Ohwada Carbon Industrial Co., Ltd.;
2) The direction of lamination of the felt is designated as the Z-axis and the directions within the plane as X- and Y-axes.

^{*} The figures above are examples of measured values and are not guaranteed.
* ICP-AES: Inductively coupled plasma atomic emission spectroscopy, AAS: Atomic absorption spectrometry

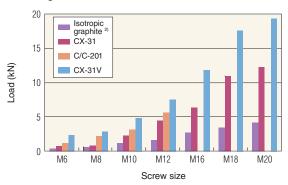
^{*} CX-510V is a high purity material

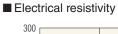


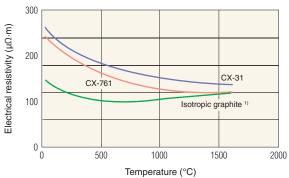
■ Flexural strength 300 CX-761 Flexural strength (MPa) 200 CX-31 100 Isotropic graphite 0 200 400 600 800 1000 1200 1400 Temperature (°C)



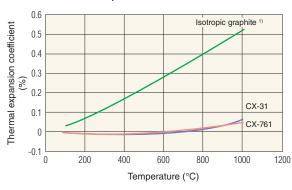
■ Strength of screw thread



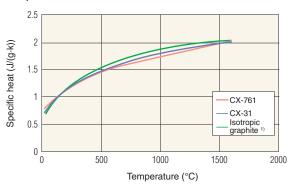




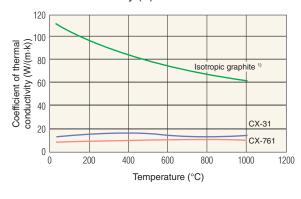
■ Linear thermal expansion coefficient



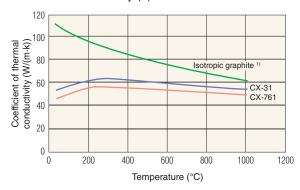
■ Specific heat



\blacksquare Thermal conductivity (\bot)



■ 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.

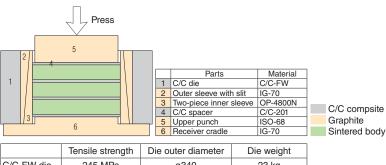
■ Hot press mold

■ 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



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

The tensile strength of the C/C composite is higher than of ordinary carbon, which permits 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:

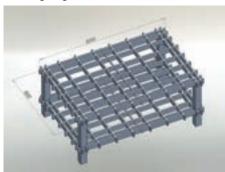
The electricity needs for heating the tray is about a quarter of what is needed for the steel tray.

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

 $\mathsf{PERMA}\text{-}\mathsf{FOIL}^{\scriptscriptstyle{\top}\!\!\mathsf{M}}$ has excellent chemical resistance (acid, base) and is chemically stable.

■ Excellent Thermal and Electrical Conductivity

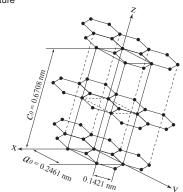
Thermal and electrical conductivity are excellent parallel to surface, and PERMA-FOIL $^{\infty}$ is optimum as a heat release material and as a heat transfer material.

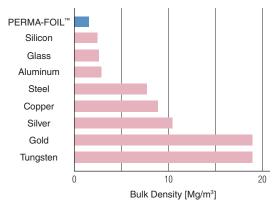
Patent Number 3691836 (JP)

■ Excellent Purity

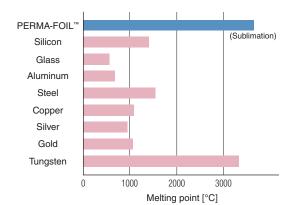
High purity products that have undergone high temperature treatment with halogen gas have a very high purity. Since it has extremely high purity, it is optimum for components in semiconductor, IT, or nuclear energy industry application. * Patent Number 2620606 (JP)

Graphite crystal structure





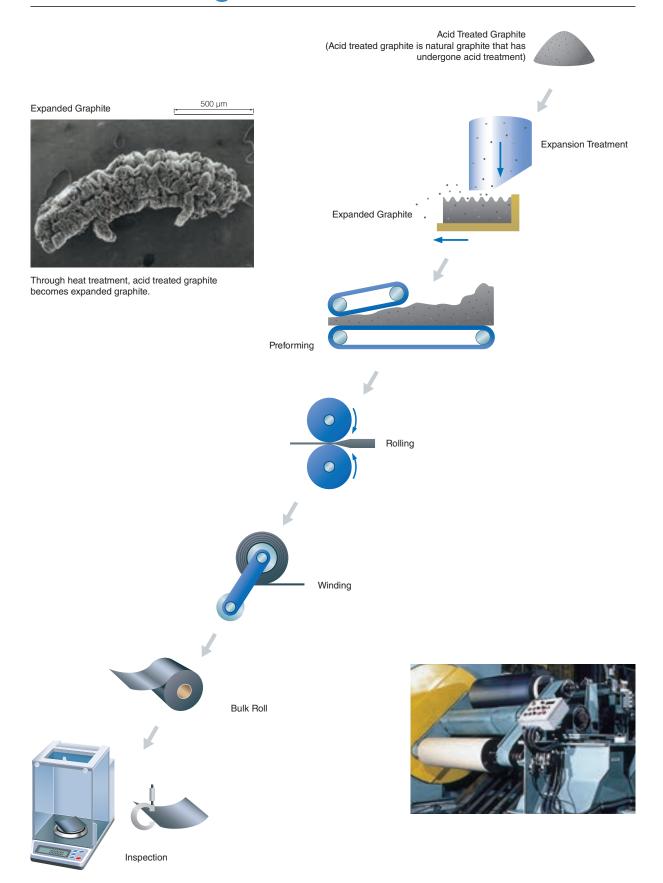
It is extremely light when compared with other metals.



It has excellent heat resistance.



Manufacturing Process





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		
PF-R2	Thermal stable property improved version of standard products	Automotive gaskets General industrial packing	
PF-HP	Low ash content products		Roll products Cut 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			Grade							
		Unit	PF	PF-R2	PF-HP	PF-G3	PF-UHPL	PF-UHP, UHPU		
Operation Temperature		°C	-200 to 3200							
Thicl	kness	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/m³	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		
Oxidati	on Loss	mass %	40	25	40	3	5	5		
Initial Oxidation	n 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		
Compres	sion Rate	%			4	7				
Recove	ery Rate	%			1:	5				
Stress Re	lease Rate	%	1.0							
Ash C	Content	mass %	0.5	0.5	0.1	0.5	<20 mass ppm	<10 mass ppm		
р	Н	-	5.1	5.1	5.1	5.1	7.0	7.0		
Gas Permeability (Nitrogen, 0.1MPa Differential Pressure)		m²/s	1.3 x 10 ⁻¹⁰							
Coefficient of Thermal	Parallel to surface	1/K	5 x 10 ⁻⁶							
Expansion	Perpendicular to surface	I/K	2 x 10 ⁻⁴							
Thermal	Parallel to surface	14//m 14)	200							
Conductivity (25°C)	Perpendicular to surface	W/(m·K)	5							
Electrical Resistivity	Parallel to surface	μΩ·m			7					
(25°C)	' Dermandiauler			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/m³.
- * Oxidation loss is the result of the measurement for 1 hour at 670°C.
- Oxidation loss is the result of the measurement for 1 nour at 6/0°C.

 * Initial oxidation temperature represents the Starting temperature of mass decrease by the result of the measurement using a thermobalance in the air atmosphere.

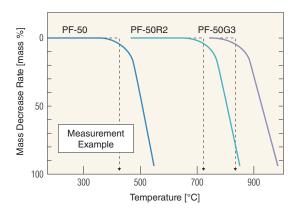
 * The measurement temperature range for the coefficient of thermal expansion is 300 to 400°C.

 * There are standard size for each grade, thickness or bulk density.

 * There are constraints of size depending on the size, thickness and bulk density.

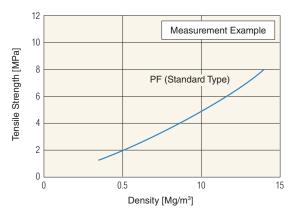
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

■ Initial Oxidation Temperature



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

■ Relationship Between Density and Tensile Strength



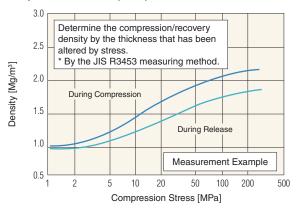
High density products have high strength.



Property Data

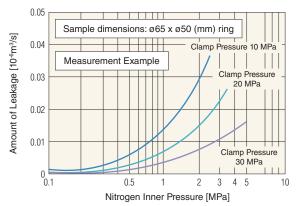
■ Excellent Compressibility Recovery Properties

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



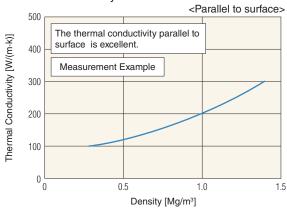
■ High Sealing Properties

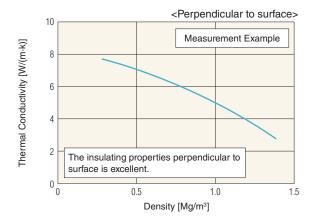
The relationship between clamp pressure and amount of leakage (PF-50)



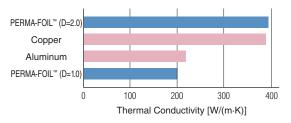
■ Effective of Compression Stress to Each Properties

Thermal conductivity

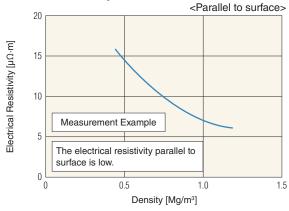


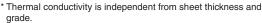


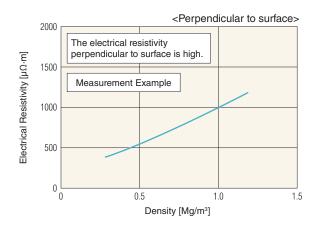
High density products have an extremely high thermal conductivity.



Electrical Resistivity

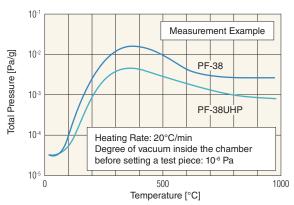








■ Thermal Desorption Spectrum (TDS)



Have an extremely low emitted gas amount.

■ Chemical Resistance

	Conce	Room temperature (30 Day Immersion)			50°C (30 Day Immersion)			85°C (6 Hour Immersion)		
Chemical Substance	Concentration (mass%)	Thickness Increase	Weight Increase	Appearance	Thickness Increase	Weight Increase	Appearance	Thickness Increase	Weight Increase	Appearance
Sulfuric Acid	90				Δ	×	0	Δ	×	0
Sulluffic Acid	95	Δ	×	Δ	Δ	×	×			
Nitric Acid	10	0	0	0	0	0	0			
TVIIIIC ACIG	20	0	0	0	0	0	0			
Sulfuric Acid + Nitric Acid = 9:1		×	×	×						
Hydrochloric Acid	36				0	0	0	0	0	0
Phosphoric Acid	85				0	Δ	0	0	Δ	0
Hydrofluoric Acid	46	0	0	0						
Ammonia Water	28	0	0	0						
Sodium Hydroxide	25	0	0	0	0	0	0	0	0	0
Methanol	100	0	0	0						
Acetone	100	0	0	0						
Gasoline	100	0	0	0						

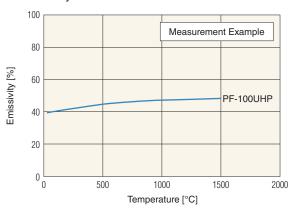
- * O...No Change A...Slight Change X...Significant Change * Chemical resistance is independent from sheet thickness and grade.

■ Initial Reaction Temperatures with Various Substances

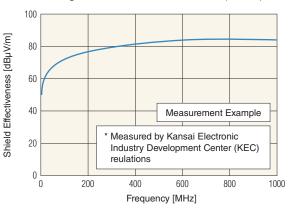
* Extracted from other publications

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	Fe₃C		
Cobalt	218°C	CoC, Co ₃ C		
Lead	No Reaction	_		
Aluminum Oxide	1280°C	CO, AI, AI ₄ C ₃		
Magnesium Oxide	1350°C	CO, Mg		
Zirconium Oxide	1300°C	CO, Zr, ZrC		

■ Emissivity



■ Electromagnetic Shield Characteristics (PF-50)



High electromagnetic shield characteristics.

■ Impurity Analysis Example

Units: mass ppm

. , ,						
Element	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				

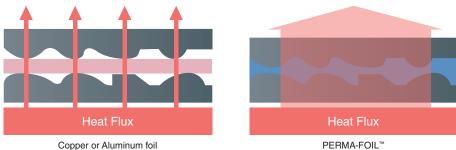
Toyo Tanso has a wide range of carbon and graphite grades available to meet your requirements. Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.



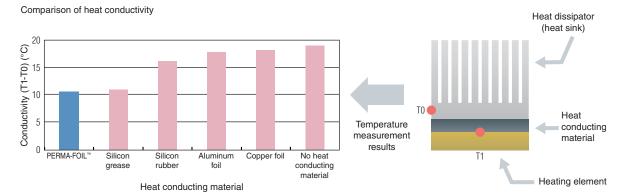
Excellent heat conduction and pressure equalization effects of PERMA-FOIL™

■ 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.

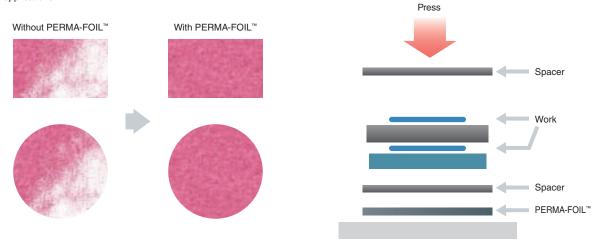


PERMA-FOIL™



■ 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
- · 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





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 self-lubricating properties due to its layered crystal structure, making it appropriate for use in high-temperature atmospheres and in applications 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.

■ Excellent Thermal Durability

There are virtually no changes in the mechanical strength and slide properties due to heat. Refer to the table on page 36 for the thermal durability of each material.

■ Excellent Chemical Resistance

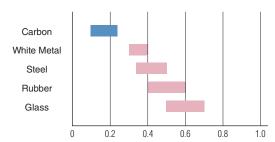
With the exception of inorganic chemicals (strong oxidizers), carbon has excellent chemical resistance. The chemical resistance of each material is shown in the table on page 39.

■ Thermal Shock Resistance

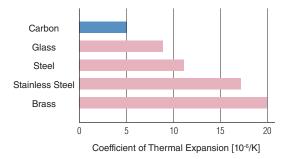
The coefficient of thermal expansion is lower than metal materials, and it has good thermal conductivity. This means that the material hardly ever cracks, even during rapid temperature changes.

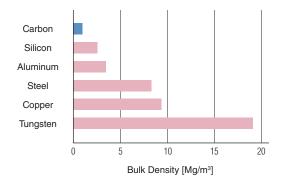
■ Supports Lightweight Designs

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



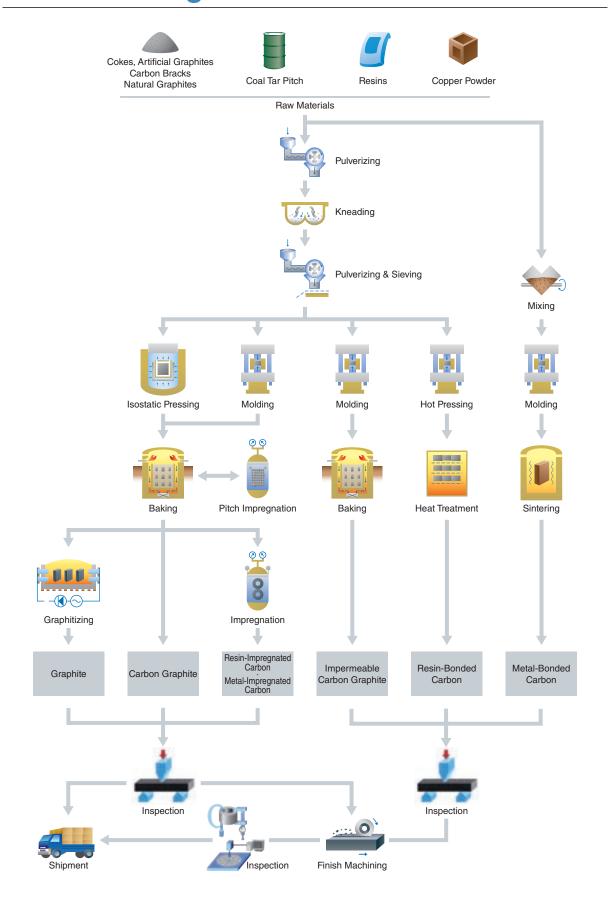
Dynamic Coefficient of Friction on a Steel Surface [Atmospheric Room Temperature]







Manufacturing Process

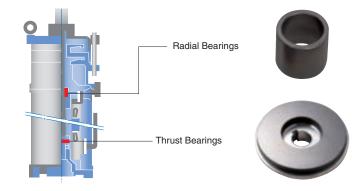




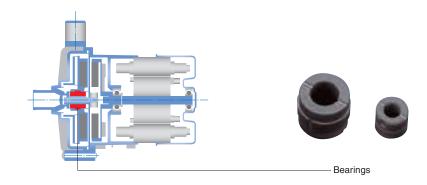
Application

■ 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

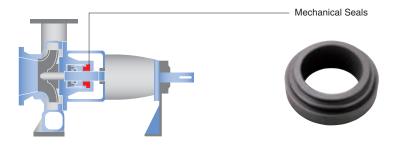


Household hot water circulation pumps Vending machine circulation pumps Dishwashers Plywood dryer



■ 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

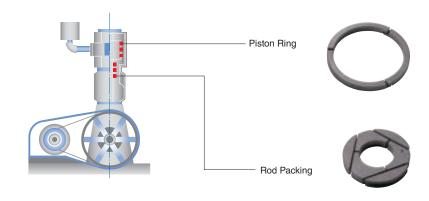






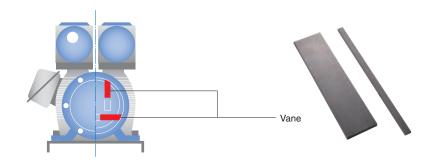
■ Packing

Reciprocal compressors Screw compressors Steam turbines Hydroelectric power generators



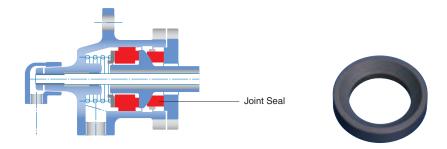
■ Vanes

Various vacuum pumps Air blowers Flow meters Oscillating compressors Jet heaters



■ Joint Seals

Papermaking dryers Drum dryers Mixing mills Printers



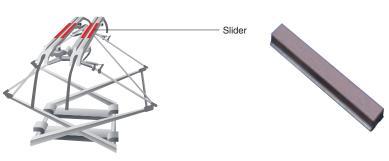
■ Valve Seats

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

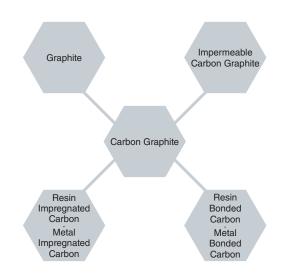
It is a non-impregnated material with excellent impermeability. It is easily mass-produced by die-molding to any desirable shape.

■ 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/m³	HSD	MPa	MPa	GPa	10 ⁻⁶ /K	W/(m·K)	°C
Cranbita	IG-11	1.77	51	39	78	10	4.5 a)	120	400
Graphite	ISO-68	1.82	80	76	172	13	5.6 a)	70	450
	KC-36	1.72	65	48	135	15	3.5	15	300
	KC-57	1.78	105	70	270	20	4.0	5	350
Carbon	KC-67	1.77	72	60	185	20	3.5	10	350
Graphite	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
	KC-360	1.78	75	58	165	17	4.0	15	250
	KC-570*	1.85	110	84	370	22	5.0	5	300
Resin-	KC-573*	1.85	110	85	370	22	5.5	5	250
Impregnated	KC-670*	1.87	87	78	240	22	5.0	10	300
Carbon	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
	KC-5709*	2.25	110	100	430	27	5.0	5	400
Metal-	KC-6709*	2.30	88	90	300	27	5.0	13	400
Impregnated Carbon	IKC-6809	2.67	88	105	300	21	6.0	80	450
Oarbon	PC-78A	2.90	95	110	410	27	6.5	13	350
	TS-002	2.31/2.75	63/70	113/78	300/205	18/16	4.5/5.2	80/80	500
SiC/C	TS-003	2.28/1.82	83/80	116/76	410/172	30/13	5.4/5.6	70/70	400
Composites	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	IG-11R1	1.85	55	46	92	11	4.5 a)	120	500
Compound-	IG-43R1	1.88	57	59	108	12	4.8 a)	140	500
Impregnated Carbon	ISO-68R1	1.87	84	83	190	15	5.6 a)	70	500
	TUG-105	1.67	90	60	250	20	4.0	_	250
	TUG-110	1.78	105	90	290	20	4.0	_	250
Impermeable	TUG-120	1.68	95	70	245	20	4.0	_	250
Carbon	TUG-308	1.87	90	65	215	23	3.5	_	250
Graphite	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
	W-1500	1.77	70	75	175	15	23.0 b)	_	150
	W-3500*	1.63	85	90	250	12	30.0 b)	_	200
Resin-Bonded	LS	1.77	60	70	100	15	15.0 b)	_	150
Carbon	NLA	1.70	75	85	175	15	23.0 ы	_	150
	MR-10*	1.43	78	100	230	10	35.0 b)	_	200
Metal-Bonded	GM-1	4.60	18	25	55	_	12.0	_	200
Carbon	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/cm² x 0.098 GPa=kgf/mm² x 0.0098 W/(m·K)=kcal/h·m·°C x 1.16



Product Selection Table by Usage

						Bear	rings						S	eal Rin	igs		
			Non	-Lubrio	cated			_	ubricat	_				hanica	Seal		
Composition	Grade	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	
0 11	IG-11	0															
Graphite	ISO-68	0															
	KC-36			0													
	KC-57						0	0									
	KC-67			0				0									
Carbon Graphite	KC-83K			0				0									
	KP-001								0								
	KP-002									0							
	KC-360		0	0													
	KC-570, KC-573						0					0					
Resin-Impregnated Carbon	KC-670, KC-673							0					0				
	KC-830K							0					0				
	KC-5709						0				0	0				0	
	KC-6709						0	0					0				
Metal-Impregnated Carbon	IKC-6809						0										
	PC-78A																
	TS-002						0				0	0				0	
	TS-003						0				0						
SiC/C Composites	TS-004											0				0	
	TS-005						0				0	0				0	
	IG-11R1	0															
Inorganic Compound-	IG-43R1	0															
Impregnated Carbon	ISO-68R1	0															
	TUG-105								0								
	TUG-110													0		0	
	TUG-120								0								
Impermeable Carbon Graphite	TUG-308													0		0	
	TUG-309								0					0			
	TUG-3095				0												
	TUG-505													0			
	W-1500					0				0					0		
	W-3500					0				0					0		
Resin-Bonded Carbon	LS					0											
	NLA									0							
	MR-10																
	GM-1																
Metal-Bonded Carbon	GM-5		0														



	Joint Seal					ıgs					Vai	nes		Slider		Spe Applic	ecial ations
	_	oint Se	al		Co	mpress			Seals	Val	Z	Ē	Tro	-Fo	-Fo		
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	Valve Seat	Non-Lubricated	Lubricated	Trolley wheels and shoes	For trains	For brakes	Jigs for glass production	Structural materials for high temperatures
						0		0					0				
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- * ©···Most appropriate O···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.

					Cor	nposi	tion	
		Conc		Gra		Carbo		Resin
Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	Graphite	Non-Impregnated	Resin-Impregnated	Metal-Impregnated	in Bonded
Ammonia (Gas)	NH₃	100	Н	0	0	0	0	0
Chlorine (Gas)	Cl2	100	Н	0	0	0	×	×
Hydrogen Chloride (Gas)	HCI	100	Н	0	0	0	×	×
Bromine (Gas)	Br ₂	100	С	×	×	×	×	×
Hydrogen Bromide (Gas)	HBr	100	Н	0	0	0	×	×
Sulfur Dioxide (Gas)	SO ₂	100	Ι	0	0	0	×	×
Fluorine (Gas)	F ₂	100	С	×	×	×	×	×
Hydrogen Fluoride (Gas)	HF	100	W	0	0	0	×	×
Ammonium Hydroxide	NH₄OH	25	W	0	0	0	0	0
Potassium	кон	60	С	0	0	0	0	0
Hydroxide		60	Н	0	0	×	×	×
Sodium Hydroxide	NaOH	60	С	0	0	0	0	×
		60	Н	0	0	×	×	×
Sodium Chlorite	NaClO ₂	20	Н	×	×	×	×	×
Sulfurous Acid	H ₂ SO ₃	100	С	0	0	0	0	×
Hydrochloric Acid	HCI	36	Н	0	0	0	×	×
Aqua Regia (Hydrochloric Acid/ Nitric Acid)	HCI/HNO₃	100	С	0	0	0	×	×
Potassium	KMnO ₄	7	С	0	0	0	0	0
Permanganate	14411104	7	Н	×	×	×	×	×
		20	С	0	0	0	×	×
		20	Н	0	0	0	×	×
Chromic Acid	H ₂ CrO ₄	40	С	0	0	0	X	×
		40	Н	0	×	×	×	×
		60	С	×	×	×	×	×
Mixed Acid (Nitric Acid/Sulfuric Acid)	HNO3/ H2SO4	100	С	×	×	×	×	×
		38	Н	0	0	0	×	×
Nitric Acid	HNO₃	65	С	0	×	×	×	×
	111403	65	W	0	×	×	×	×
		65	Н	×	×	×	×	×

					Cor	nposi	tion	
		Conce		Graphite		Carbo iraphi		Resir
Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	nite	Non-Impregnated	Resin-Impregnated	Metal-Impregnated	Resin Bonded
0 1		7	Н	0	×	×	×	×
Sodium Hypochlorite	NaCIO	13	W	0	×	×	×	×
Туросполо		23	С	×	×	×	×	×
Hydrofluoric Acid	HF	40	W	0	×	×	×	×
Hydrolldoric Acid	ПГ	60	С	×	×	×	×	×
Fuming Sulfuric Acid	H ₂ SO ₄ +SO ₃	98	С	×	×	×	×	×
Sulfuric Acid	H₂SO₄	48	Н	0	0	0	×	×
Sullulic Acid	H23O4	98	Н	×	×	×	×	×
Phosphoric Acid	H ₃ PO ₄	85	С	0	0	0	0	0
Priosprioric Acid	H3F U4	85	Н	0	0	0	×	×
Acetone	CH ₃ COCH ₃	100	С	0	0	0	0	×
Aniline	C ₆ H ₅ NH ₂	100	С	0	0	0	0	0
Ether	R-O-R	100	С	0	0	0	0	0
Formic Acid	НСООН	100	С	0	0	0	×	×
Citric Acid	C ₆ H ₈ O ₇	100	С	0	0	0	0	0
Glycerin	C ₃ H ₅ (OH) ₃	100	С	0	0	0	0	×
Chloroform	CHCl₃	100	С	0	0	0	×	0
Carbon Tetrachloride	CCl ₄	100	С	0	0	0	0	0

^{*} H···100°C W···50°C C···20°C O···Resistant ×···Infused

Carbon Brush





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

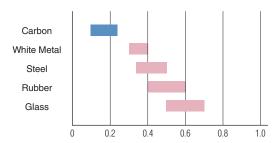
With its excellent electrical conductivity, carbon can offer a stable, optimal level of electrical resistivity, which is enhanced by appropriate selection of materials and production process depending on the application.

■ Outstanding durability

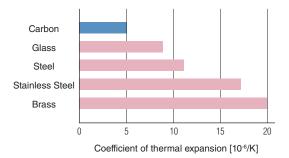
Carbon has low coefficient of thermal expansion, which means that it hardly has changes in shape or quality even at high temperatures. It is also resistant to the softening and melt-down that can occur due to sparking during operations, and does not fuse with other metals.

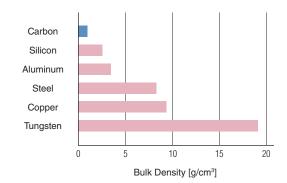
■ Superior ridability during sliding contact

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.



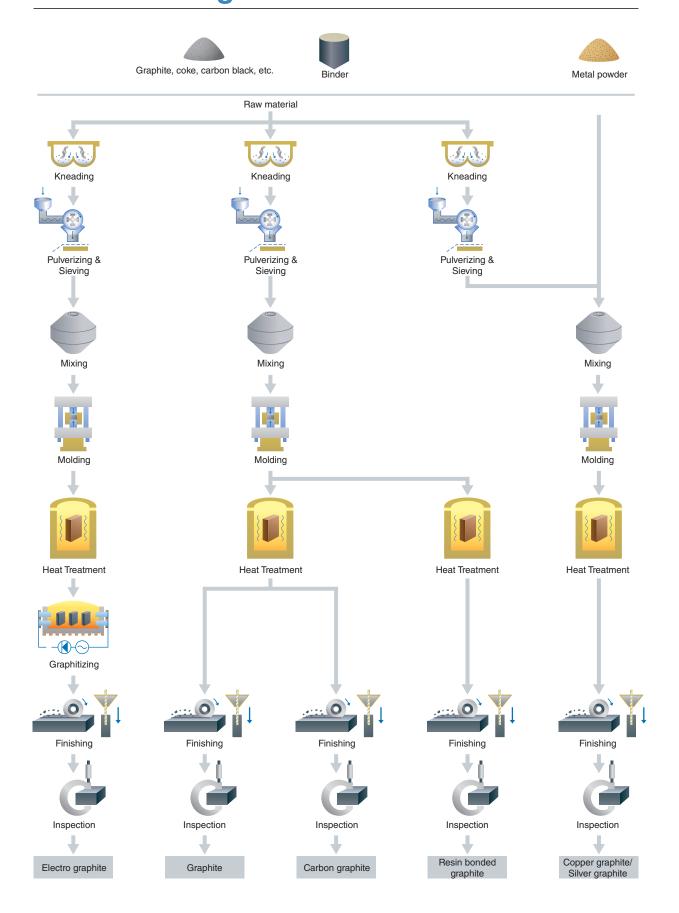
Coefficient of dynamic friction with steel surface [in air room temperature]







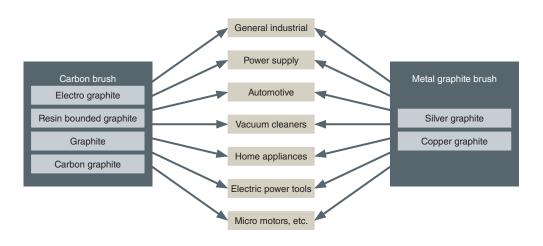
Manufacturing Process

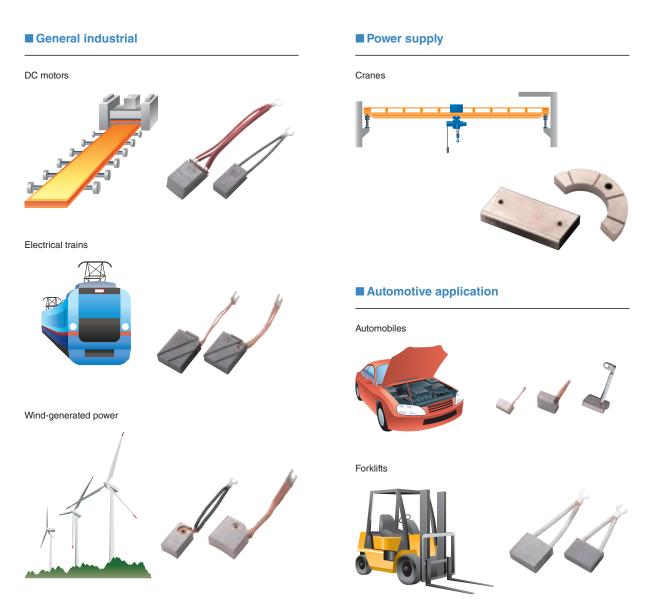




Brush Types and Applications: Some Examples

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.







■ Vacuum cleaners

Vacuum cleaners



■ Home appliances

Washing machines





■ Power tools

Disk grinders



■ 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 μΩ·m	Flexural Strength	Cofficient of friction	Contact voltage drop V	Max. peripheral speed m/s	Max. current density A/cm²	Features/applications
	401	1.68	18	9	10	М	М	30	10	Good film formation. Suitable for slip rings that easily generate streaking.
	502	1.77	51	11	37	М	М	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	М	М	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.
Ф	176	1.62	28	14	16	М	М	45	12	Good film formation. Good communication performance. Suitable for DC motors up to medium capacity.
Electrographite	BZ-229	1.6	23	22	11	М	М	40	12	Moderate film adjusting function. Suitable for medium and higher capacity mill motors.
phite	BZ-256	1.61	28	19	14	М	М	40	12	Better film formation than BZ-229. Suitable for medium and higher capacity mill motors.
	213	1.61	32	23	16	М	М	40	12	Better film adjusting effect than 176. Suitable for DC motors up to medium capacity.
	321	1.74	62	34	31	М	М	35	10	Good wear resistance.
	TH-03	1.75	68	40	35	М	М	35	10	Suitable for traction motors.
	351A	1.63	49	47	22	Н	М	40	10	Standard material for commutation brushes. Suitable for medium capacity DC motors.
	641	1.64	59	75	12	Н	М	40	10	Suitable for difficult commutation high capacity DC motors and universal motors.
	402	1.71	24	10	18	М	М	25	10	Has film adjusting effect. Suitable for thick film slip rings.
Graphite	801	1.65	30	35	19	М	М	45	15	Good wear resistance. Suitable for pump motors for power steering.
ohite	TR-52	1.74	30	14	16	М	М	40	12	Better commutation performance than 788. Suitable for forklifts of 48V or more.
	TR-19	1.51	33	200	19	М	М	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		
9		g/cm ³	HSC	μΩ·m	MPa		V	m/s	A/cm ²			
	M-90	6.30	15	0.32	108	М	VL	20	25			
	M-1T	6.19	13	0.27	108	М	VL	22	22	High strength copper alloy type. Suitable for contacts and grounds.		
	M-2T	5.70	15	0.50	80	М	VL	25	20			
	M-1H	6.83	6	0.04	87	М	VL	25	20			
	M-1	5.41	12	0.08	42	L	VL	30	25	High copper content.		
	M-1F	5.30	18	0.15	49	L	VL	30	25	Very low temperature rise and contact voltage drop. Suitable for high electrical capacity		
	M-2H	4.93	13	0.10	34	L	VL	30	20	generators and motors.		
	M-2HF	4.80	18	0.33	44	М	VL	30	20			
	M-2	4.40	15	0.50	29	L	VL	30	20			
Cop	M-2F	4.35	15	0.50	44	М	VL	30	20	The copper content amount is next to M1, M-2H		
Copper Graphite I	М-3Н	4.04	16	0.70	29	М	VL	30	18	class and has good wear resistance. Suitable for large capacity generators and slip rings for		
Graph	M-3HF	4.05	20	0.60	44	М	VL	30	18	general rotary machine.		
nite I	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, is superior in roughing resistance. It is applicab for small/med capacity generators and motors.		
	M-550	2.96	25	2.50	39	М	L	35	15	Good wear resistance. Particularly suitable for		
	M-750	2.32	23	6.00	32	М	L	35	15	stainless steel slip rings.		
	788	2.02	23	9.00	23	М	М	45	12	Good dimensional stability in high temperature. Suitable for forklifts of 48V or less.		
	M-2TB	5.74	12	0.48	65	М	VL	25	20			
	M-1B	5.30	10	0.10	43	L	VL	30	25	Same application as the above M-1 and M-2. But does not contain lead.		
	M-2B	4.34	13	0.28	31	L	VL	30	20			
	MF-302	2.65	18	3.00	23	М	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	М	L	30	20			
	MF-202	2.05	10	38.0	23	Н	М	30	15	Suitable for DC19.2V cleaners.		
Col	MF-203	2.05	10	30.0	23	L	М	30	15			
Copper Graphite II	MF-301	2.40	15	10.0	23	М	М	30	20	Suitable for DC24V cleaners.		
Graph	MF-401	2.67	18	10.0	21	М	М	30	20	Suitable for DC19.2V cleaners.		
ite II	MF-204	3.78	15	0.30	40	М	L	30	25	Suitable for DC7.2V power tools.		
	MF-205	3.00	20	0.80	28	М	L	30	20	Suitable for DC24V power tools.		
	MF-701	2.26	18	10.0	30	М	М	30	20	Suitable for DC22-36V power tools.		
	MF-201	2.25	10	30.0	23	М	М	30	15	Suitable for household coffee mills.		
	MF-601	2.05	10	50.0	23	М	М	30	15	Suitable for electric wheelchair.		

^{*} 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
9		g/cm ³	HSC	μΩ·m	MPa		V	m/s	A/cm ²	
Silver	SX-50	3.20	15	2.70	29	М	VL	20	12	Very low temperature rise and contact voltage
er grap	SX-70	4.45	15	0.25	40	М	VL	20	15	drop. Suitable for low current tachometers and
graphite	SX-90	6.85	18	0.05	84	М	VL	20	22	grounds contacts.

Composition	Grade	Bulk Density	Hardness	Electrical Resistivity	Flexural Strength	Coefficient of friction	Contact voltage drop	Max. peripheral speed	Max. current density	Features/applications	
9		g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm ²		
	X-03	1.50	12	200	15	L	Н	54	20		
	X-09	1.52	14	260	15	L	Н	54	20		
	X-17	1.54	15	330	18	L	Н	54	20	Goode ridability.	
	X-72	1.47	19	380	14	L	Н	48	20	Suitablle for 100-120V high efficiency cleaners.	
	X-87	1.50	17	380	22	L	Н	54	20		
	X-88	1.52	14	360	20	L	Н	54	20		
	X-05	1.48	15	400	18	L	Н	50	20		
	X-10	1.52	15	270	17	L	Н	50	20	Goode ridability.	
	X-78	1.51	17	370	22	L	Н	48	20	Suitablle for 100-120V high input cleaners.	
	X-80	1.51	17	360	22	L	Н	48	20		
Resin	X-13	1.48	19	700	22	L	Н	50	15		
Resin bounded graphite	X-85	1.48	20	400	14	L	Н	48	20		
nded (X-89	1.53	19	350	21	L	Н	48	20	Good commutation performance.	
graph	X-93	1.50	18	640	27	L	Н	50	15	Suitable for 120-240V cleaners.	
ite	X-95	1.51	19	640	24	L	Н	50	15		
	X-97	1.45	19	430	14	L	Н	50	20		
	X-11	1.35	15	1100	14	L	VH	54	13		
	X-73	1.52	24	920	24	L	VH	40	13	Good commutation performance.	
	X-91	1.35	15	1100	17	L	VH	54	13	Suitable for 200-240V cleaners.	
	X-94	1.36	14	1200	17	L	VH	54	13		
	X-04	1.36	17	1600	11	L	VH	54	10		
	X-08	1.29	14	1600	14	L	VH	54	10	Suitable for 200-240V cleaners, small motors.	
	X-96	1.31	14	1600	16	L	VH	54	10		
	B-2	1.75	25	390	24	L	Н	25	8	Suitable for juicers, dryers. Moldable by press to size up to 18 mm length max.	

^{*} 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.

^{*} 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:

^{*} 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		
	0.0	g/cm³	HSC	μΩ·m	MPa		V	m/s	A/cm ²			
	C-3	1.62	35	240	24	L	Н	35	13	Comparative low resistivity.		
	107	1.62	34	100	29	L	Н	35	13	Suitable for 100-120V power tools.		
	113	1.58	37	290	27	L	Н	35	13			
	C-1	1.49	30	330	13	L	Н	35	12	Suitable for 100V-120V and 200-240V cleaners.		
	TX-174	1.55	36	390	24	L	Н	35	18			
	105S	1.55	36	390	24	L	Н	35	18			
	108	1.55	36	390	24	L	Н	35	18	Good commutation performance, wear resistance.		
	110	1.54	37	350	20	L	Н	35	13	Good breaking action. Suitable for 100-120V and 200-240V power tools		
	118	1.64	34	390	23	L	Н	35	18	and cleaners.		
	129	1.64	34	620	20	L	Н	35	18			
	106	1.52	33	680	15	М	VH	35	13	Good commutation performance and wear		
	111	1.61	37	600	23	М	VH	35	13	resistance. Suitable for 200-240V cleaners.		
	114	1.62	35	900	20	М	VH	35	13			
Cark	122	1.62	42	840	22	М	VH	35	13	Good commutation performance.		
on g	124	1.60	47	790	26	М	VH	35	13	Suitable for 200-240V power tools and washing machines.		
Carbon graphite	127	1.53	33	850	21	М	VH	35	13			
Ф	116	1.62	35	900	20	М	VH	35	13	Good commutation performance and wear resistance. Suitable for 200-240V power tools.		
	119	1.59	42	1300	20	М	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	Н	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	Н	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	Н	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	Н	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.		

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.

^{*} 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)

⁽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.



Design Data

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

		1	1		apo or ou		(5.5 52	,		
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	C2-1	C2-2	C2-3	C2-4	C2-5	C2-6	C2-7	C2-8	C2-9	C2-10
tamped soldering	C2-11	C2-12								
	C4-1	C4-2	C4-3	C4-4	C4-5	C4-6	C4-7	C4-8	C4-9	C4-10
C4 Copper pipe (one) Ribetting	C4-11	C4-12	C4-13	C4-14	C4-15	C4-16	C4-17	C4-18	C4-19	C4-20
	G4-21									
C5 Copper	C5-1	C5-2	C5-3	C5-4	C5-5	C5-6	C5-7	C5-8	C5-9	C5-10
pipe (two) Ribetting	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 dim	ension tolerance	Space betwee	n brush/holder	Brush length
Nominal Dimensions	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	tolerance
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.

$$16^{-0.04}_{-0.15}\times~25^{-0.04}_{-0.13}\times~40^{~\pm0.8}~{\mbox{(two pieces)}}$$

* 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.

$$16^{\,-\,(0.14\,+\,a)}_{\,-\,(0.13\,+\,a)}\times\,25^{\,-\,(0.04\,+\,b)}_{\,-\,(0.13\,+\,b)}\times\,40^{\,\pm0.8}$$

* 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)

	Recommended values								Reference
Nominal	Maximum Minimum		Independent wire diameter 0.05 mm		Independent wire diameter 0.08 mm		<u> </u>		Allowable current
cross-section mm ²		weight	Number of wires/wire diameters	Cross- section calculation	Number of wires/wire diameters	Cross- section calculation	Number of wires/wire diameters	Cross- section calculation	+15% -10%
	mm	g/m	mm	mm²	mm	mm²	mm	mm²	Α
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

Termin							Onit: mm
Number	Dimensional diagrams	Installation screw		_	Dimensions	,	
	-	(meter screw)	d	В	G	L	t
		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
T-1		5	5.5 ^{+0.3} _{-0.1}	13 ± 0.4	6.5	20 ± 1	0.8 1.0
T-2		6	6.5 ^{+0.3} _{-0.1}	16 ± 0.4	8	24 ± 1	1.0
	T-1 T-2	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
	- - - - - - - - - -	5	5.5 ^{+0.3} _{-0.1}	13 ± 0.8	6.5	20 ± 1.5	0.4 0.5
T-13		6	6.5 ^{+0.3} _{-0.1}	16 ± 0.8	8	24 ± 1.5	0.4 0.5
	ДД Т-3	8	8.5 ^{+0.3} _{-0.1}	19 ± 1	9.5	29 ± 1.5	0.4 0.5
		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
T-4		5	5.5 ^{+0.3} _{-0.1}	13 ± 0.4	6.5	> 13	0.8 1.0
T-5	-G- -G- -L	6	6.5 ^{+0.3} _{-0.1}	16 ± 0.4	8	> 16	1.0
	T-4 T-5	8	8.5 ^{+0.3} _{-0.1}	19 ± 0.5	9.5	> 19	1.0 1.2
			10.5 ^{+0.3} _{-0.1}	23 ± 0.5	12	> 25	1.2
	- d -	5	5.5 ^{+0.3} _{-0.1}	13 ± 0.8	6.5	20 ± 1	0.4 0.5
T-6		6	6.5 ^{+0.3} _{-0.1}	16 ± 0.8	8	24 ± 1	0.4 0.5
T-7	B	8	8.5 ^{+0.3} _{-0.1}	19 ± 1	9.5	29 ± 1	0.6 0.8
	T-6 T-7	10	10.5 +0.4 -0.1	23 ± 1	11.5	35 ± 1	0.6 0.8
		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
T-8 T-9		6	6.5 ^{+0.3} _{-0.1}	16 ± 1	8	> 14	1.0 1.2
	T-8 T-9	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 Prod	lucts
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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

■ Application

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

■ PYROGRAPH™ Property Data

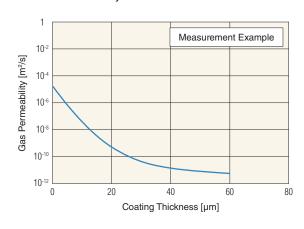
■ Impurity Analysis Example

Unit: mass ppm

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

^{*} Measurement method: Glow Discharge Mass Spectrometry

■ Gas Permeability



PYROGRAPH™ Cross Section

20 µm



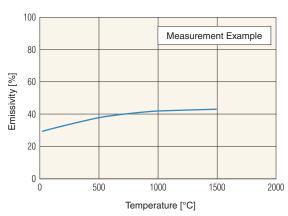
The column-shaped structure of the pyrolytic carbon layer means that the structure is extremely fine.

■ General Physical Properties

Item	Unit	Parallel to Coating Surface	Perpendicular to Coating Surface
Bulk Density	Mg/m³	2.2	2.2
Hardness	HSD	100	_
Electrical μΩ·m		2.00 to 4.00	2 to 5 x 10 ³
Coefficient of Thermal Expansion	of Thermal 10 ⁻⁶ /K		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

■ Emissivity



^{*} The figures above are measurement examples, and are not to be guaranteed.

The figures above are extracted from other publications, and are not to be

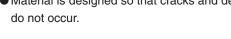


PERMA KOTE™ Products

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

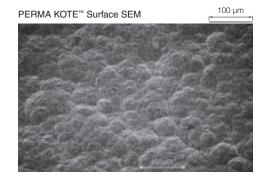


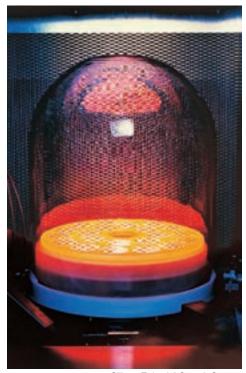
■ Coating Thickness

The standard thickness is 120 $\mu\text{m};$ 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	HCI	36	Boiling point	144	0
Sulfuric acid	H ₂ SO ₄	97	110	144	0
Nitric acid	HNO₃	61	Boiling point	144	0
Hydrofluoric acid + nitric acid	HF + HNO₃ (1:1)	100	80	288	-1.0
Nitric acid + sulfuric acid	HNO ₃ + H ₂ SO ₄ (1:1)	100	25	288	-1.0
Sodium hydroxide	NaOH	20	80	288	0
Phosphoric acid	H₃PO₄	100	100	192	-1.0
Nitrohydrochloric acid	HCI + HNO₃ (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	0	Δ
Boron	В	0	0
Cobalt	Co	Δ	×
Chromium	Cr	Δ	×
Copper	Cu	0	Δ
Iron	Fe	×	×
Molybdenum	Мо	0	0
Nickel	Ni	0	×
Lead	Pb	Δ	×
Silicon	Si	0	0
Tin	Sn	0	Δ
Tantalum	Ta	0	0
Titanium	Ti	0	0
Vanadium	V	0	×
Tungsten	W	0	0
Alumina	Al ₂ O ₃	0	×
Boron oxide	B ₂ O ₃	0	0
Chromium oxide (III)	Cr ₂ O ₃	0	×
Iron oxide (III)	Fe ₂ O ₃	×	×
Magnesium oxide	MgO	0	Δ
Manganese oxide (IV)	MnO ₂	0	×
Lead oxide (II)	PbO	0	Δ
Silicon dioxide	SiO ₂	0	Δ
Titanium oxide (IV)	TiO ₂	0	0
Vanadium oxide (V)	V ₂ O ₅	0	Δ
Zirconium oxide (IV)	ZrO ₂	0	0

* O...No reaction $\triangle \cdots \text{Reaction}$

O...Slight reaction
×...Significant reaction

■ Layer Properties

	ß-SiC (Cubic System) Structure		
Crystal Structure	0:Si •:C		
Bulk Density	3.2 Mg/m ³		
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

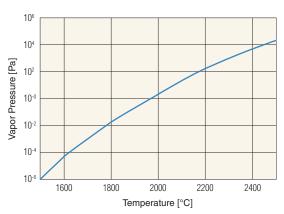
Element	Content
В	0.15
Na	0.02
Al	0.01
Cr	<0.1
Fe	0.02
Ni	<0.01

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



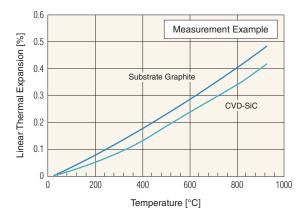
■ Silicon Carbide Vapor Pressure

*Extracted from the ultra high temperature melting point material handbook

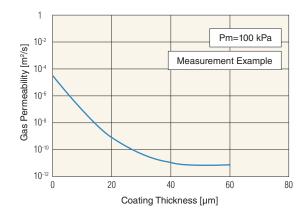


PERMA KOTE™ is extremely stable at high temperatures.

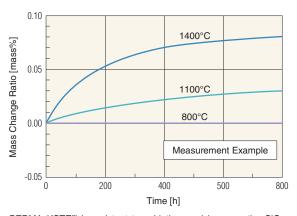
■ Coefficient of Thermal Expansion for CVD-SiC and Substrate graphite



■ Gas Permeability

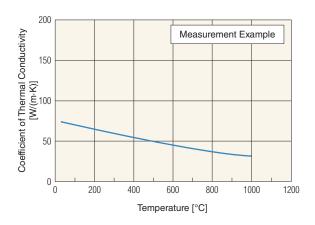


■ Oxidation

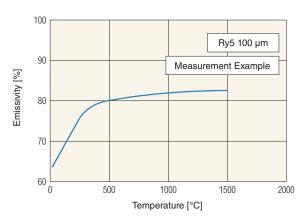


PERMA KOTETM is resistant to oxidation; and because the SiO_2 protective layer is formed at over $800^{\circ}C$, the substrate graphite is protected from oxidation.

■ Thermal Conductivity



■ 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.

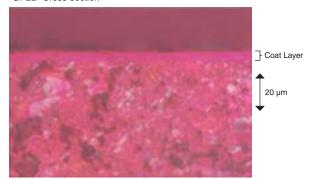
■ Features

- 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.

■ Application

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

"GP2B" Cross-section



■ 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%

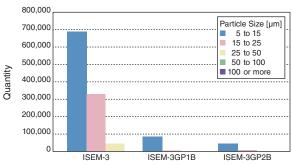
Example of physical properties when using ISEM-3 as a graphite substrate and applying GLASTIX KOTE™ GP series processing. (Rate of change with measured value of ISEM-3 substrate as the standard)

Test piece dimensions:

 $10 \times 10 \times 60$ mm: Bulk density, hardness, electrical resistivity, flexural strength

 $10 \times 10 \times 10$ mm: Compressive strength

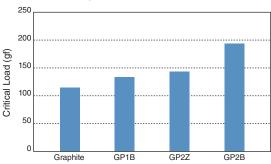
■ Dust Reduction Effect



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

■ 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

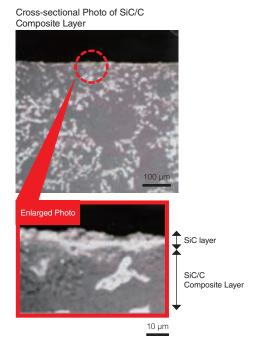
- SiC/C composite layer can be applied to an entire product or just the areas required.
- Composite layer can be formed from the surface to deep within the material.

[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.

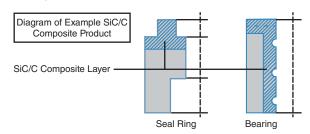
■ Application

Metallurgic members
 Mechanical seals
 ■ Bearings



■ 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.

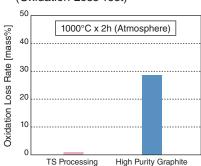
The inner diameter of the bearing can be processed after becoming a composite, thereby falling within the tolerance.

■ 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)





New Developed Products

To deliver unique products to you, the customer, Toyo Tanso works constantly on cutting-edge research and development. By pursuing the possibilities offered by alternatives to conventional materials, we conduct joint research with users around the world and will continue to be proactively involved in product development for generations to come.

■ Porous Carbon CNovel[™]

Manufactured using our unique technologies, porous carbon contains numerous holes of even size of approximately several tens of nanometers in diameter and features a special structure in which these holes are interconnected. Unlike activated carbon and other existing porous carbon materials, CNovel™ is a new material with controlled mesopores (2 to 50 nm), which until now have been considered difficult to manufacture and obtain as an industrial material. Depending on preparation conditions, it is possible to (1) control specific surface area and (2) adjust pore size. CNovel™ is starting to attract attention for use in applications such as those in the environment and energy sector and in machine applications, in which it has conventionally been difficult to use porous carbon materials, in addition to conventional activated carbon applications.



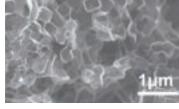


Image of transmission electron microscope

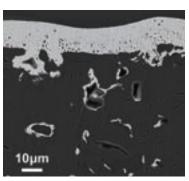
Product appearance

■ Metal Carbide-coated Graphite MetalizeKote[™]

MetalizeKote[™] is a coating product that forms a layer of metal carbide (carbonized metal) on the surface of a graphite material via a proprietary Toyo Tanso method, and is available in Cr- and Fe-based coatings. The formation of a metal carbide causes the graphite surface to become metal-like, making it possible to prevent the generation of graphite particles as well as control the carburization (denaturation) of the other material. Utilizing this property, MetalizeKote[™] is starting to attract attention for use in jig and industrial furnace applications, in which it has conventionally not been possible to use graphite materials and coating products.



Product appearance



SEM cross-section image

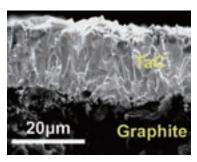


■ TaC-coated Graphite EVEREDKOTE[™]-B

In recent years, silicon carbide (SiC), gallium nitride (GaN), aluminum nitride (AIN), zinc oxide (ZnO), and other materials have attracted attention as next-generation power devices. These monocrystalline manufacturing processes involve high temperatures and harsh environments using corrosive gases such as ammonia and hydrogen chloride. The use of conventional components under such environmental conditions shortens lifetimes due to heat and corrosive gases. EVEREDKOTE™-B is a composite material consisting of a graphite material coated with TaC. With a melting point of approximately 4,000°C, this TaC coating provides ultra-high thermal durability. Moreover, it is crack-free and has excellent thermal shock resistance. These properties of the TaC coating protect the graphite substrate, extending component life.



Product appearance



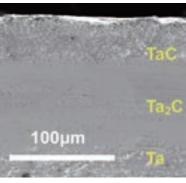
SEM cross-section image

■ TaC-Ta Composite EVEREDKOTE™-K

EVEREDKOTE[™]-K is a composite material jointly developed with Kwansei Gakuin University that consists of tantalum carburized so that the surface forms a layer of TaC. Like EVEREDKOTE[™]-B, EVEREDKOTE[™]-K has high-temperature characteristics, and moreover has many other characteristics such as seize resistance and mechanical strength. It can therefore be used in high-temperature environments such as those experienced by structural parts used in furnace interiors.



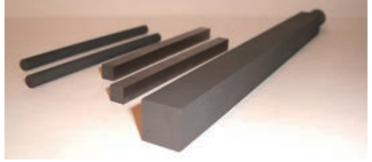
Product appearance



SEM cross-section image

■ Metal/Carbon Composites KLASTA MATE™

KLASTA MATE™ has a structure in which metal is homogeneously dispersed in a carbon material. It can be used with a wide range of dopant species and concentrations as well as with two or more elements. Like graphite, KLASTA MATE™ has excellent workability and can be processed into complex shapes. As a vapor source for arc discharge, KLASTA MATE™ is suitable for manufacturing metallofullerenes and carbon nanotubes. Moreover, as a vapor source for arc ion plating and a target material for sputtering, it is also suited to metal-doped DLC film formation.



Product appearance





Technical Services

Toyo Tanso can offer various machining or treatments for materials which customer supplies. Our outstanding technologies based on carbon manufacturing enable us to respond to the high expectations of customers request, such as high difficult manufacturing, quality progress of materials.

■ Graphite and Carbon machining

High difficulty machining

Thin-wall machining

We can successfully perform challenging thin-wall machining work by optimizing jigs and machining methods. (Example: Hollow cylinder with thickness of 0.2 mm)

3D machining

We prepare a 3D model based on drawings and write programs to manufacture the desired product. Upon request, we are also able to measure an actual product and produce items based on the actual dimensions.

Special internal-diameter machining

We can perform special, internal–diameter machining work to make monolithic items without cutting the workpiece into sections. (Maximum machinable dimensions: ø300 mm L = 400 mm)





3D Machining



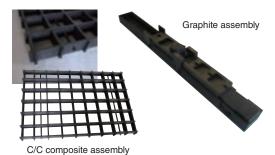
Assembly Services

Graphite assembly

Our ability to manufacture products from the design stage right through to the machining and assembly stages allows us to put products together and conduct operation tests after assembly.

C/C composite assembly

Our ability to manufacture products from the design stage right through to the machining and assembly stages allows us to ship products after checking assembly precision.



Other machinings

Large sealing rings

We can produce sealing rings for large machinery, which are notoriously hard to manufacture. By producing products with precise parallelism, flatness, surface roughness, and other, we ensure that our sealing rings are able to maintain highly airtight seals. (Maximum machinable diameter: ø500 mm)

Shrink fitting and assembly

We can shrink fit carbon and metal, and can also assemble products using adhesion. (Maximum machinable diameter: Up to $\emptyset 600$ mm)

Sectional machining

We can perform sophisticated machining tasks such as ensuring that there are no gaps (no light leakage) between mating surfaces, as required in sectioned products used in compressor piston rings and similar applications. Consult us regarding shapes and numbers of sections. (Maximum machinable diameter: ø1,400 mm)

· Porous materials

By using a multi-head machining center we are able to precision-machine very demanding porous items quickly.

Vanes

From mass-produced products for automobiles to low-volume madeto-order products for general industry, we can produce a wide range of vanes—which require very demanding dimensional precision—with consistent quality.







■ Heat Treatment

Baking Treatment

Heat treatment up to 1000°C

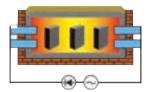
We can conduct heat treatment (at a temperature of up to around 1000°C) under non-oxidizing atmospheres.

Even when organic gases are produced, we can take measures for it.



Graphitizing Treatment

 Heat treatment up to 3000°C We can conduct heat treatment (at a temperature of up to around 3000°C), filling supplied material together with coke powder into the furnace, and then applying electrical resistance heating.



Various Heat Treatments

Toyo Tanso's various heat treatment Various heat treatments using treatment furnaces other than those described above are also available.

Article	Conditions for Heat Treatment					
Treatment Method	Vacuum Treatment	N ₂ or Ar Treatment	H ₂ Treatment	Halogen Treatment		
Available size (mm)	1500W x 1400H x 2000L		ø1050 x 830H			
MAX Temperature (°C)	2000	2300	1500			
Pressure	Vacuum (Less than 0.5 KPa)	Decompression Control (20 to 86 KPa)	Normal I	Pressure		

■ High Purity Treatment

By heat treating a graphite material in a halogen gas environment, impurities in materials are removed. Using high purity treatment makes it possible to keep metal impurities in the graphite material to 5 ppm or below.

Conditions for High Purification		
«MAX» 2300		
1500W x 1400H x 2000L		
Depends on the grade of product		
Less than 5		

^{*} The treatment results above were obtained using Toyo Tanso graphite material.

■ Surface Improvement

SiC Coating PERMA KOTE™

A dense layer of silicon carbide (SiC) is created via chemical vapor deposition (CVD).

- Protects substrate from ambient environment
- Controls generation of particles and gas from substrate
- Allows modification, etc., of substrate surface
- Maximum dimensions: ø1,050 x 830 mm

PERMA KOTE™ Surface SEM



Article	Conditions for SiC Coating
MAX size (mm)	ø1050 x 830H
Thickness of SiC layer (µm)	120±30
Metal impurities content (mass ppm) *by GDMS method	B: 0.15 / Na: 0.02 Al: 0.01 / Cr: <0.1 Fe: 0.02 / Ni: <0.01

Please consult on deciding the thickness of SiC

■ Pyrolytic Graphite Coating PYROGRAPH™

Pyrolytic carbon is coated via chemical vapor deposition (CVD).

- Improves gas impermeability
- Controls generation of particles and gas from substrate
- Improves chemical resistance

Glasslike carbon

Glasslike carbon impregnates or covers the substrate.

- Improves gas impermeability
- Controls generation of particles from substrate

SiC/C compostes

Technology developed utilizing Toyo Tanso's isotropic graphite manufacturing technology and silicon carbide (SiC) research results.

PYROGRAPH™ Cross Section



Glasslike Carbon Cross Section



Structure of SiC/C composite layer





■ Impregnation

Pitch impregnation

Pressure-based pitch impregnation treatment

We can impregnate the porosities in the supplied material with pitch by pressure and can also be add baking to carbonize it.

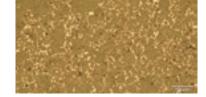
Example applications: Refractory materials, electrode materials, ceramics, etc., in applications such as increasing product size, new product development, and more.



Metal impregnation

We can impregnate the porosities in the supplied material with metal (copper, metals containing copper, and antimony) by pressure under high temperature.

• Improvement of strength, electrical conductivity, thermal conductivity, and impermeability



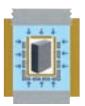
Resin impregnation

We can impregnate the porosities in the supplied material with resin (phenol and furan resins) by pressure under room temperature and then heat it (at a temperature of up to around 250°C). Improves strength and impermeability (airtightness)

■ Forming

Hydraulic forming

Cold Isostatic Pressing (CIP) is widely-accepted as an effective molding method in the fields of ceramics, refractories and powder metallurgy. We can conduct powder molding into various shapes by applying uniform pressure.



■ Measurement

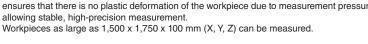
Dimension measurement

3D measurement machine (contact type)

We use manual equipment, automatic CNC measurement equipment, and other equipment, to measure objects with dimensions of up to 1,600 (X) x 3,000 (Y) x 1,200 (Z) mm. We also have microscopes, and probes as small as ø0.5 mm (contact), allowing high precision measurement of a variety of shapes regardless of workpiece size.

> Crysta-Apex (Mitutoyo Corporation) Specification

- Measurement Range (X.Y.Z)
 Max size 1600 x 3000 x 1200 mm 2. Max weight 3500 kg 3. Accuracy (µm) MPEE 6.0 + 5.5 L/1000
- CNC image measurement equipment (non-contact type) We perform non-contact measurement using CCD cameras and laser equipment. This ensures that there is no plastic deformation of the workpiece due to measurement pressure, allowing stable, high-precision measurement.



QV ACCEL (Mitutoyo Corporation) Specification

- 1. Measurement Range (X.Y.Z) Max size 1500 x 1750 x 100 mm
- 2. Max weight 50 kg
- 3. Accuracy (µm)

Mesurement Accuracy of Flantness (X.Y) 3.5 + 4 L/1000







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

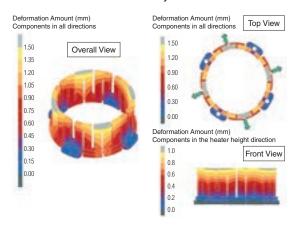
Toyo Tanso recreates three-dimensional images of products on a computer via 3D CAD, and improves the quality of the finished product by checking shape details before product processing. We also offer design support via 3D CAD based on your schematic diagrams and design information.



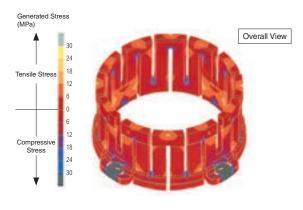
■ Finite element method (FEM analysis examples)

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, manufactures, processes, and develops various carbon products, including isotropic graphite products, 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) Isotropic graphite

This graphite has a micro particle composition and is manufactured using CIP molding methods for high density, high strength, and no direction in physical properties. Application: semiconductors, hot press, metallurgy

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)
	OT-2470B	1.77	51	11.0	39	78	4.5	120	305 × 620 × 1000
	OT-2475	1.77	57	12.2	43	88	4.7	100	1000 × 1000 × 450
Granhita	OT-2477	1.83	58	10.0	47	103	4.6	130	ø660 × 900
Graphite	OT-7660	1.78	63	13.4	52	106	5.6	90	305 × 620 × 1000
	OP-9068	1.82	80	15.5	76	172	5.6	70	230 × 540 × 1000
	OT-2450	1.68	45	13.5	36	69	4.2	90	305 × 620 × 1000

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

(2) 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)

(3) 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)
	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
	OT-5200G	1.72	28	5.0	15	32	1.0	200	ø350 × 1800
	OP-4800	1.74	43	7.5	27	44	4.4	150	670 × 450 × 1500
Graphite	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	ø770 × 1900
	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.

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(4) 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
Carbon Graphite	OT-670	1.77	72	-	60	185	3.5	-	ø140 × 200
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

(5) 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
	P-3100	1.90	63	29	52	127	5	250
Electrographite Resin	P-4800	1.85	55	26	40	96	5	250
Impregnated	F-3200	1.88	69	27	49	118	5	250
	F-4800	1.83	50	25	38	86	5	250
Carbon Graphite Resin Impregnated	F-670	1.87	87	-	78	240	5	300

(6) 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%
Artificial Grapfille Fowder	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
	#20 to 40	0.5	1.0	98.0	0.35 to 1.0 mm	90% or more
Artificial Graphite Particle	#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

 $^{^{\}star}$ Other graphite powder not listed here is also available. Contact us for details.

■ Examples of Main Applications by Material

Field	Part Name	Applicable Material Product Number		
Semiconductor	Electrodes for silicon (polycrystal) manufacturing equipment	OT-2470BS, OT-2475S, OT-2477S		
Semiconductor	Parts for ion implantation equipment, furnace parts	OT-7660S, OP-9068S, OP-4800NS		
	Hot press molds, dies	C/C-FW, OP-9068, OT-2477, OT-2475		
Hot Press	Punches, push rods, spacers, cradles	OP-9068, OT-2477, OT-2475		
	C/C mold sleeves	OT-2477, OP-4800N		
	Furnace parts, trays, sample cases	OP-4800, OT-5220, OT-5200, OP-9001, C/C201		
Motollure	Heating elements	OP-4800, OP-4850, OT-2470B		
Metallurgy	Melting crucibles, gas analysis crucibles	OT-5220, OP-4800, OT-2470B		
	Jigs for glass bottles and fused quartz	OP-8420, C/C-201, OT-2470BS		
Mechanical	Mechanical seals, joint seals	P-3100, F-3200, F-670		
Wiconamoai	Bearings, pump rotary vanes	1 0100,1 0200,1 070		
Electrical	Trolley wheels, sliders	P-4800, P-3100, OT-520		
Electrical	Electrodes for EDM	OT-7660		
Powder	For various filling material	TEG200, TEG300, OP-240		
Fowder	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.



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