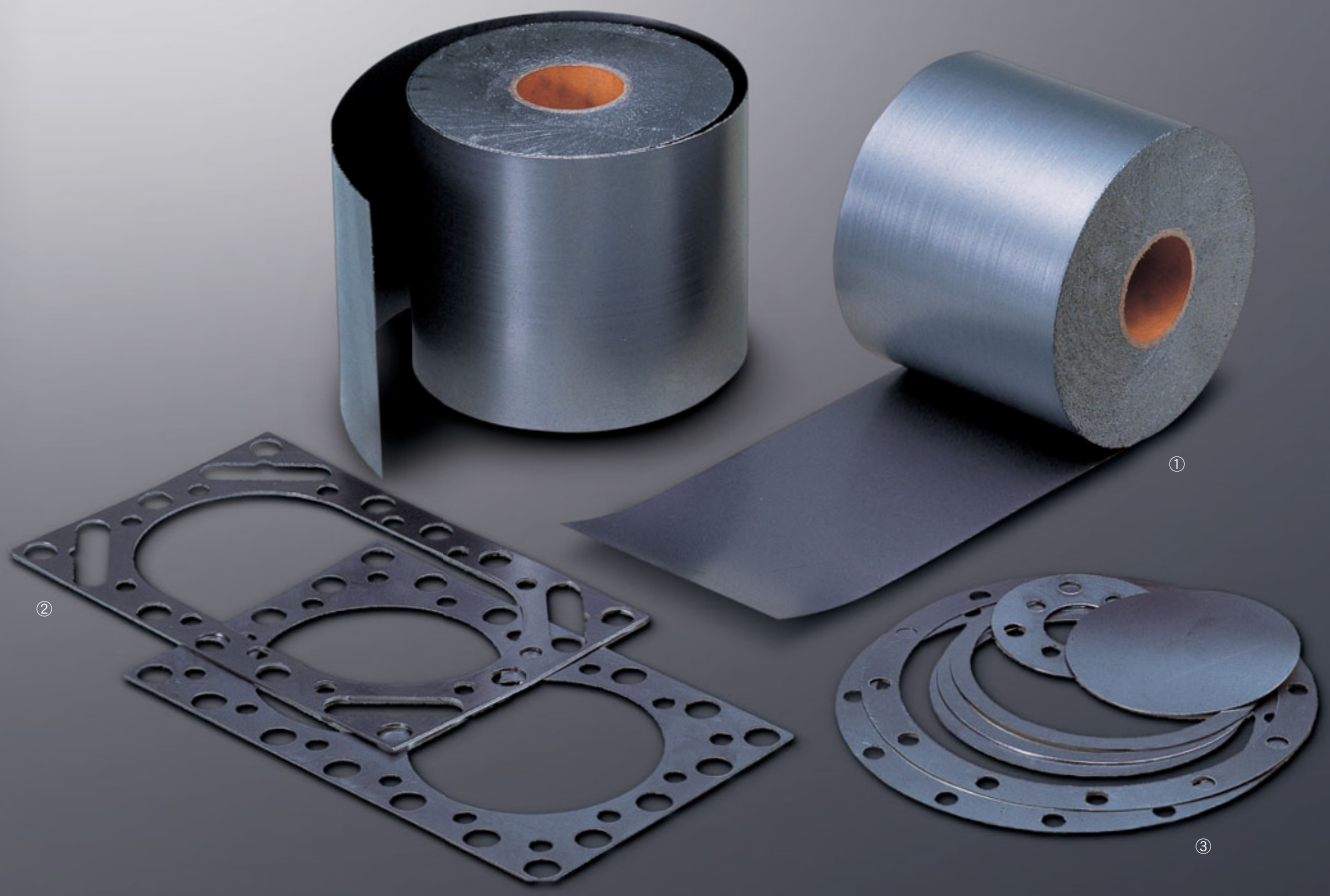
CARBON-GRAPHITE PRODUCTS

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 produced only from natural graphite without using a binder, it is stable in the wide range of temperature (-200℃～3200℃ inert atmosphere) enabling it to be used.

Flexibility, Compressibility recovery properties

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

Excellent Chemical Resistance

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

Excellent Thermal and Electrical Conductivity

Thermal and electrical conductivity are excellent parallel to surface, and PERMA-FOIL® is optimum as a heat release material and as a heat transfer material.

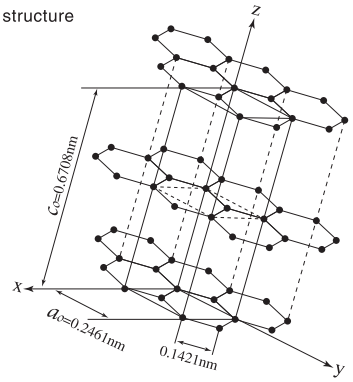
※Patent Number 3691836

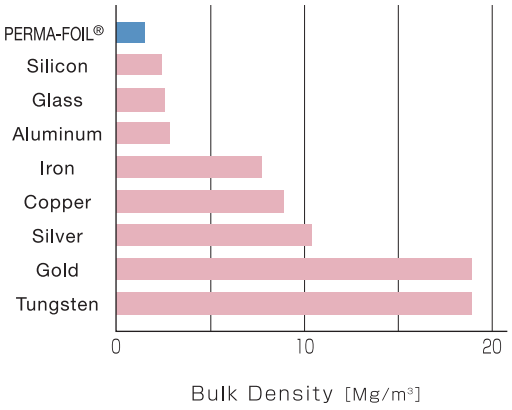
Excellent Purity

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.

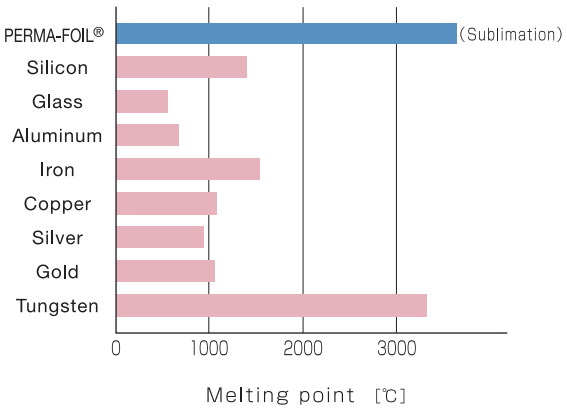
※Patent Number 2620606

Graphite crystal structure





It is extremely light when compared with other metals.



It has excellent heat resistance.

Manufacturing Process

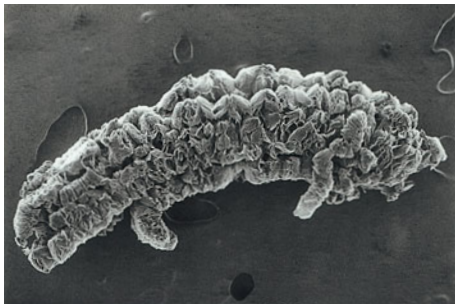
Acid Treated Graphite

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

Expansion Treatment

Expanded Graphite

Expanded Graphite



Through heat treatment, acid treated graphite becomes expanded graphite.

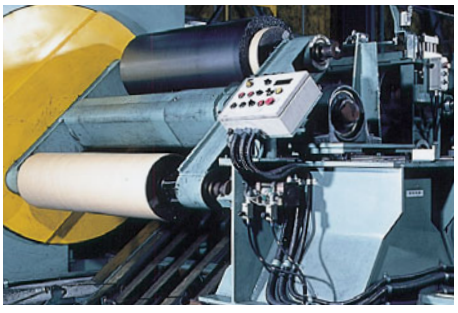
Preforming

Rolling

Winding

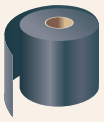
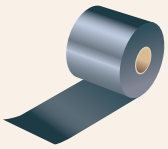
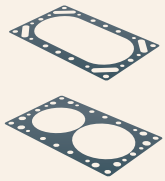
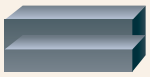
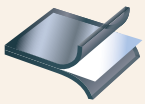
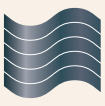
Bulk Roll

Inspection



Grade and Application

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

Grade	Characteristics	Application	Forms of Supplies
PF	PERMA-FOIL® Standard products	Automotive gaskets General industrial packing	  Roll products Cut products
PF-R2	Heat resistance improved version of standard products		
PF-HP	Low ash content products		
PF-G3	Corrosion resistance and Heat resistance 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≧1.5mm)	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 expanded graphite products	General industrial packing Battery parts	Powder

※For available dimensions, please contact our sales department.

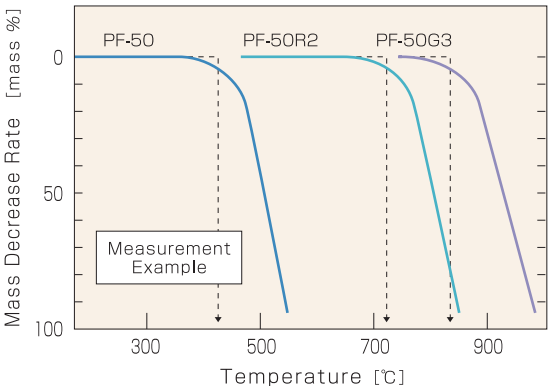
Property Data

■ Typical properties

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

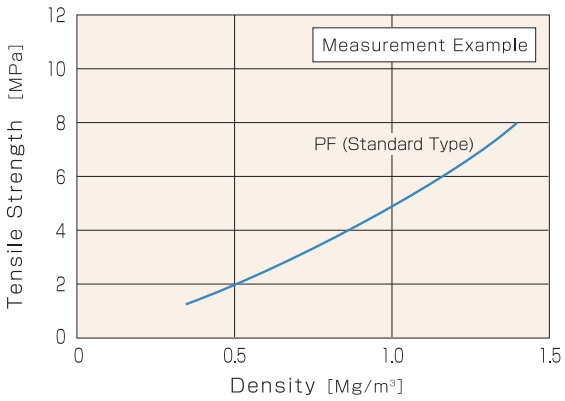
※The figures adove are typical values ,and are not guaranteed.
※Property data with the density of $1.0Mg/m^3$.
※Oxidation loss is the result of the measurement for 1hour at 670℃.
※Initial oxidation temperature represents the kick-off temperature of mass decrease by the result of the measurement using a thermobalance in the air atmosphere.
※The measurement temperature range for the coefficient of thermal expansion is 300 to 400℃.
※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

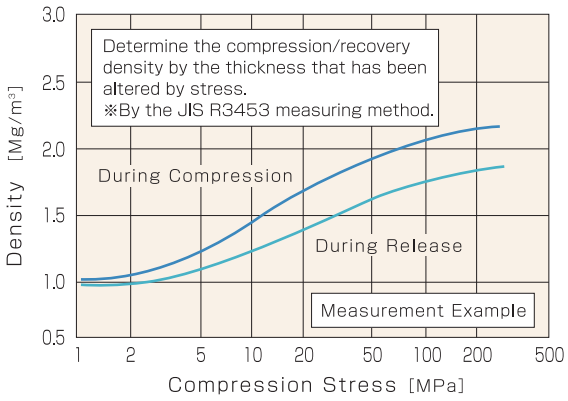


High density products have high strength.

PERMA-FOIL®

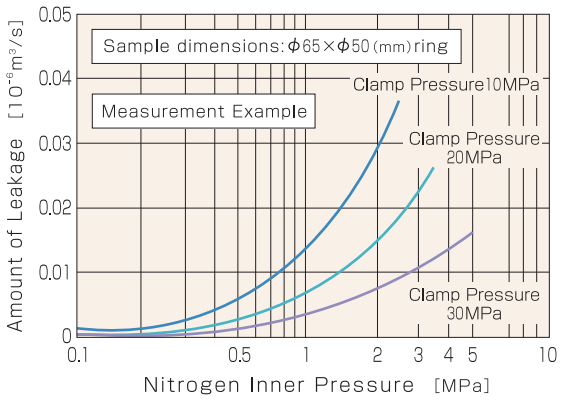
Property Data

The Relationship Between Density and Compression stress during Compression and Release (PF-50)



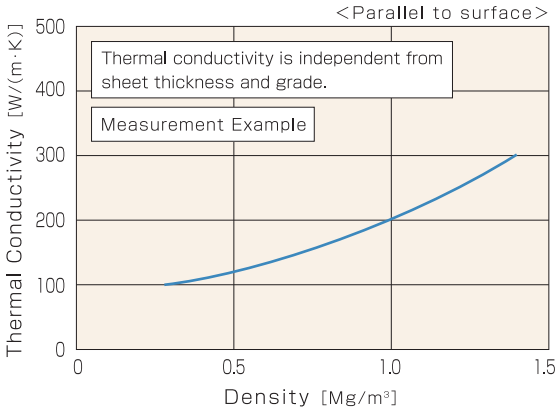
Excellent compressibility/recovery

The Relationship Between Clamp Pressure and Amount of Leakage (PF-50)

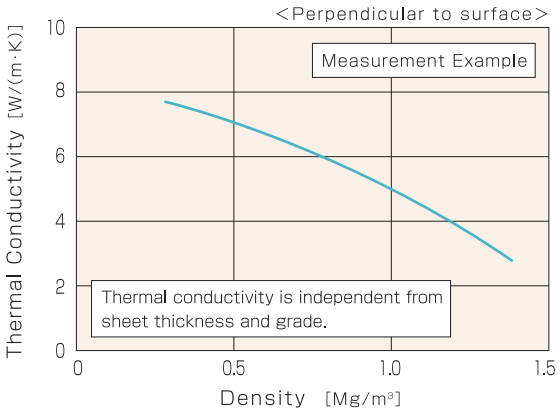


High sealing properties

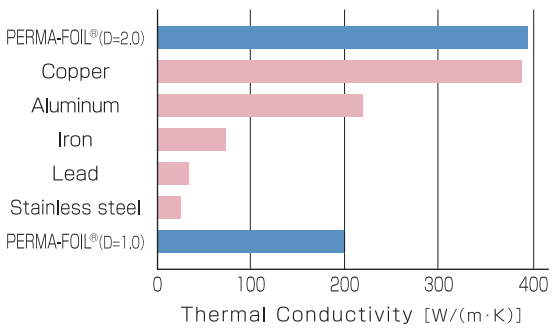
The Relationship Between Density and Thermal Conductivity (25℃)



The thermal conductivity parallet to surface is excellent.

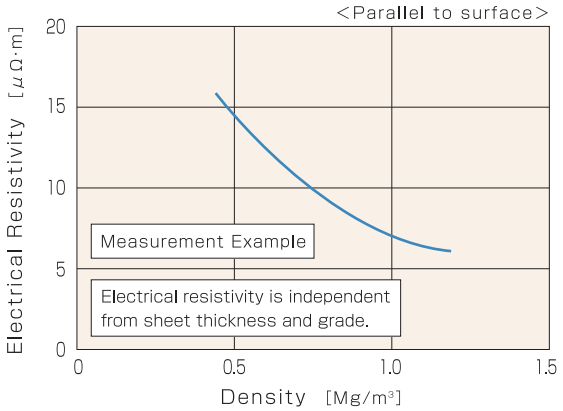


The insulating properties perpendicular to surface is excellent.

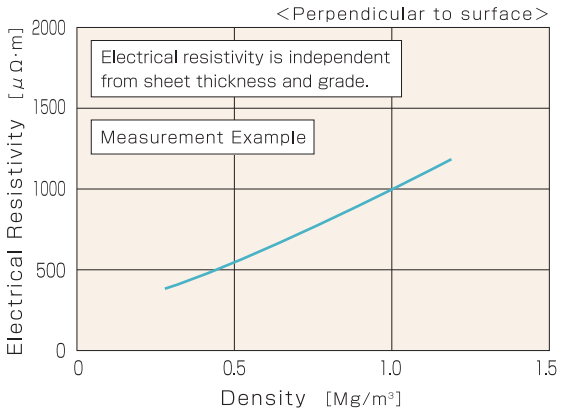


High density products have an extremely high thermal conductivity.

The Relationship Between Density and Electrical Resistivity (25℃)

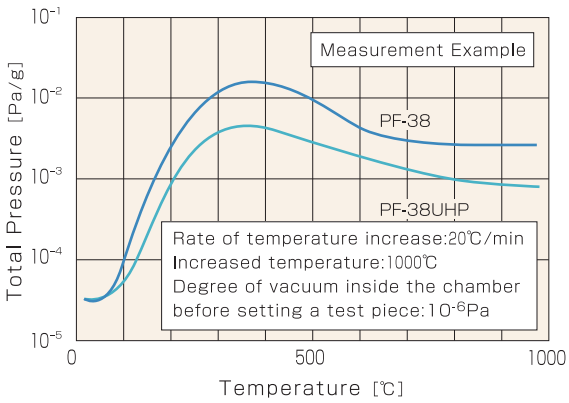


The electrical resistivity parallel to surface is low.



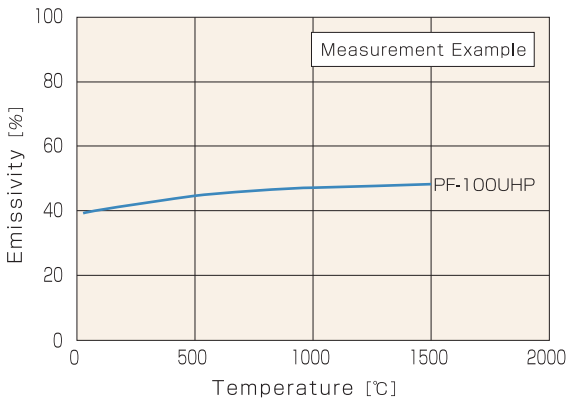
The electrical resistivity perpendicular to surface is high.

■ Thermal Desorption Spectrum (TDS)



Have an extremely low emitted gas amount.

■ Emissivity

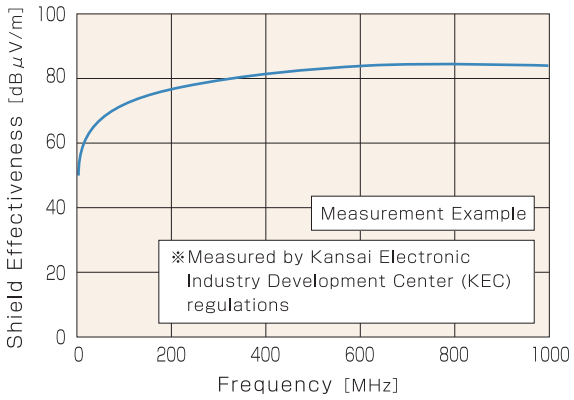


■ Chemical Resistance

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

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

■ Electromagnetic Shield Characteristics (PF-50)



High electromagnetic shield characteristics.

■ Initial Reaction Temperatures With Various Substances

※Extracted from other publications

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

■ Impurity Analysis Example

Units: mass ppm

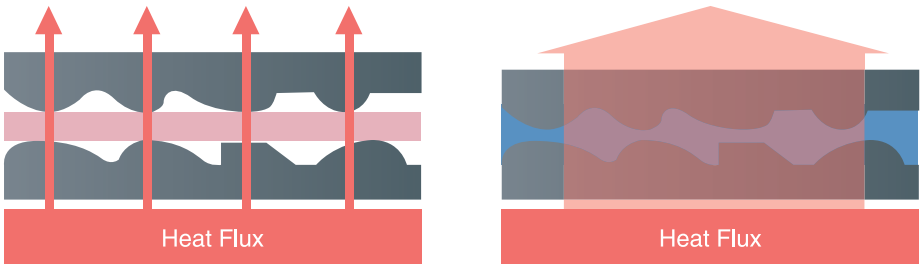
Element	Element	
	Regular Products	High Purified Products
Li	<0.01	<0.01
Na	46	<0.05
K	1.9	<0.1
Cu	1.0	<0.08
Be	<0.02	<0.02
Mg	0.7	<0.02
Ca	40	<0.04
Zn	<0.1	<0.1
Al	90	<0.08
V	0.7	<0.07
S	1000	<1.0
Fe	160	<0.04
Ni	<0.1	<0.1

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

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

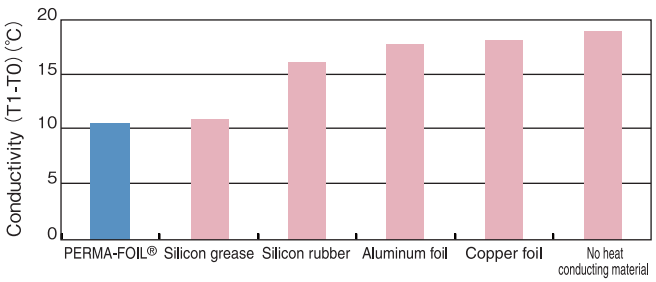
Heat conduction effects

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



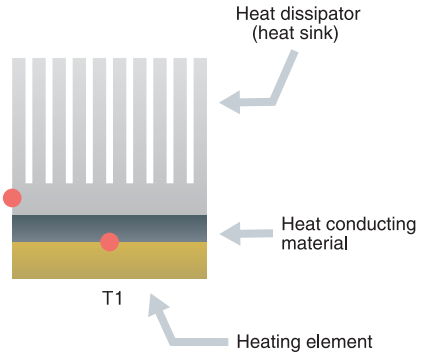
Copper or Alminium foil　　PERMA-FOIL®

Comparison of heat conductivity



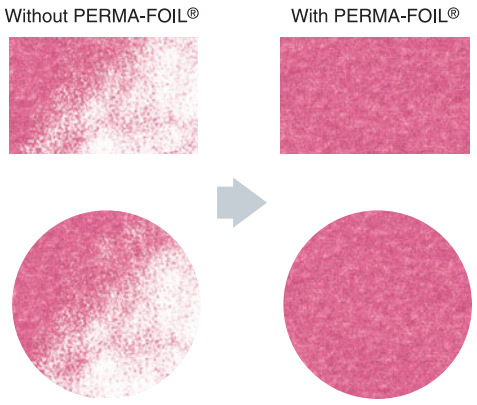
Heat conducting material

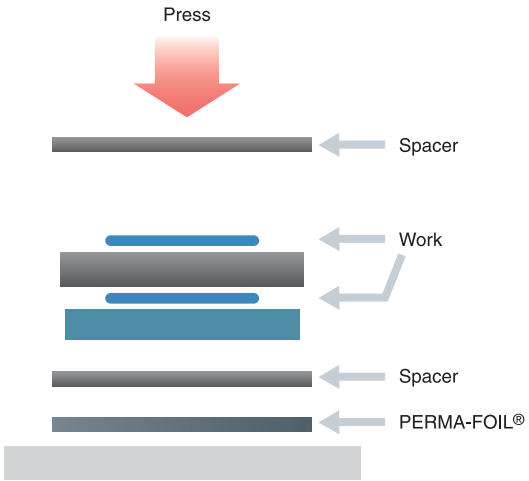
Temperature measurement results



Pressure equalization effects

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





●Example applications

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