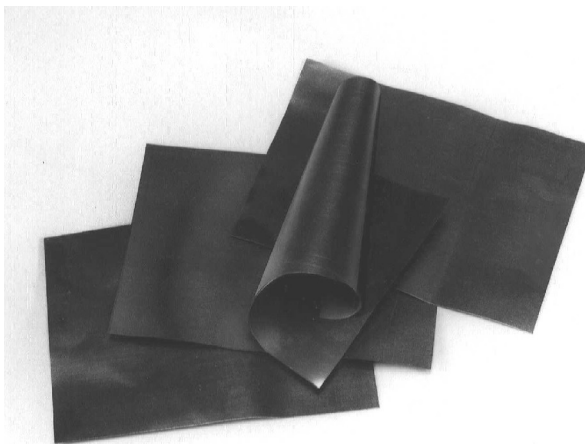


Basic Properties and Application Examples of PGS Graphite Sheet

PGS Graphite Sheet



- 1. Basic properties of PGS Graphite sheet**
- 2. Functions of PGS Graphite sheet**
- 3. Application Examples Presentation**

[Sales Liaison]

Panasonic Electronic Devices Co., Ltd.

Capacitor Business Unit PM Group Goods Team

PGS Contact Direct Line (0774)31-7366

[For inquiries of technology issues]

Panasonic Electronic Devices Japan Co., Ltd.

Ceramic Division Engineering Team4

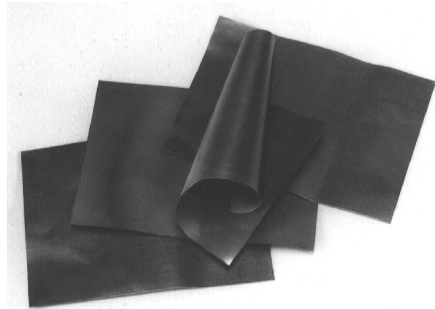
PGS Contact Direct Line (0123)23-8149

PGS Graphite Sheet

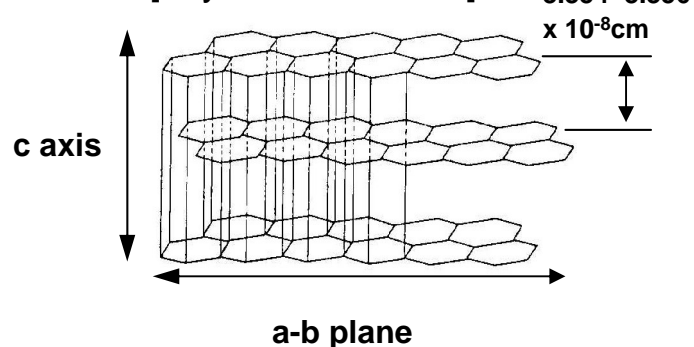
PGS Graphite Sheet

PGS (Pyrolytic Highly Oriented Graphite Sheet) is made of graphite with a structure that is close to a single crystal, which is achieved by the heat decomposition of polymeric film. PGS is a competitive conductive sheet with high thermal conductivity and high flexibility.

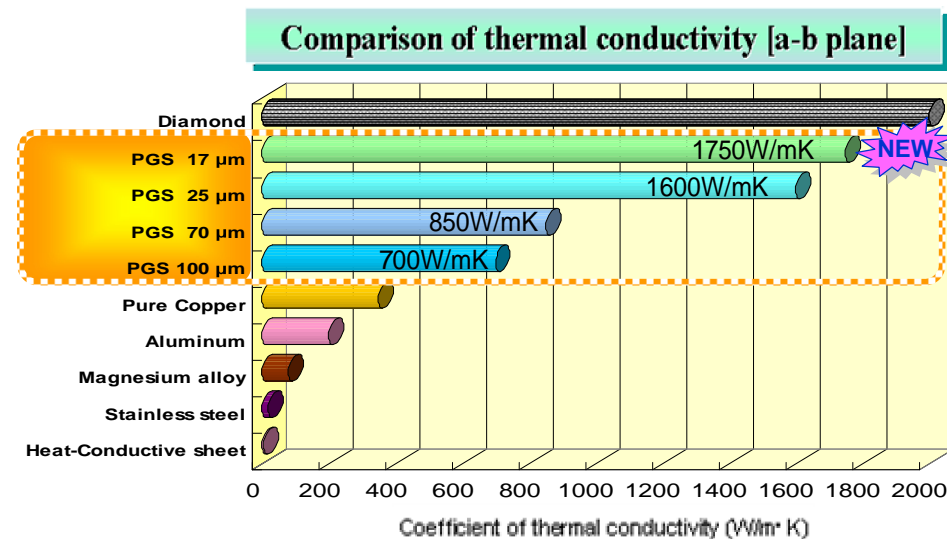
PGS Graphite Sheet: C99.9% or more



[Layered Structure]



High heat conductivity: Each material has high heat conductivity.

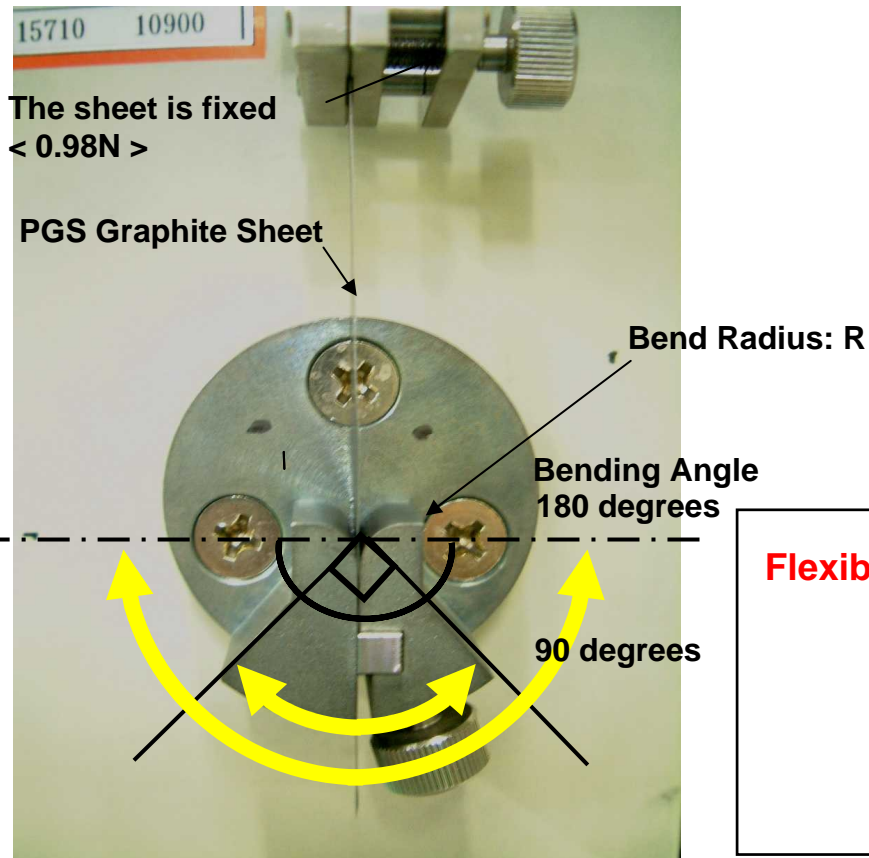


Flexibility: PGS is bending-resistant due to its flexibility. PGS can be used for areas such as curved surfaces and corners because its heat conductivity will remain unchanged in the absence of folds in PGS.

Flexibility of PGS Graphite Sheet

PGS Graphite Sheet

[Bending Test]




[Bending Limitation]

Bending Angle	Bending Radius(R)	
	R =2(mm)	R =5(mm)
90 degrees	10,000 cycls or more	100,000 cycls or more
180 degrees	3,000 cycls or more	30,000 cycls or more

Flexibility: PGS is bending-resistant due to its flexibility. PGS can be used for areas such as curved surfaces and corners because its heat conductivity will remain unchanged in the absence of folds in PGS.

Material Characteristics of Graphite Sheets

PGS Graphite Sheet

		 17 μm	25 μm	70 μm	100 μm
Thickness (mm)		0.017±0.005	0.025±0.010	0.070±0.015	0.100±0.030
Thermal Conductivity (W/(mK))	X,Ydirection	1700 to 1800	1500 to 1700	750 to 950	600 to 800
	Z direction	15	15	15	15
Thermal diffusivity(cm ² /s)		9 to 10 (0.0009 ~ 0.001 m ² /s)	9 to 10 (0.0009 ~ 0.001 m ² /s)	9 to 10 (0.0009 ~ 0.001 m ² /s)	9 to 10 (0.0009 ~ 0.001 m ² /s)
Density (g/cm ³)		2.17 (2170 kg/m ³)	2.10 (2100 kg/m ³)	1.10 (1100 kg/m ³)	0.85 (850 kg/m ³)
Specific Heat (50 °C)(J/gK)		0.85 (850 J/kgK)	0.85 (850 J/kgK)	0.85 (850 J/kgK)	0.85 (850 J/kgK)
Heat resistance (°C)		400	400	400	400
Extensional strength (MPa)	X,Ydirection	40	30	22	19.6
	Z direction	0.1	0.1	0.4	0.4
Bending test (times) (R5/180°)		30,000 or more	30,000 or more	30,000 or more	30,000 or more
Electric Conductivity (S/cm)		20000 (2.0×10 ⁶ S/m)	20000 (2.0×10 ⁶ S/m)	10000 (1.0×10 ⁶ S/m)	10000 (1.0×10 ⁶ S/m)

Applications of PGS Graphite Sheet (two functions)

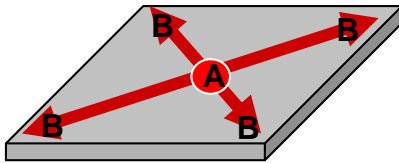
PGS Graphite Sheet

1) Thermal Transfer

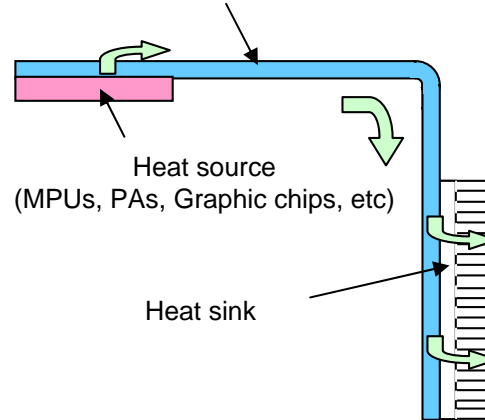
Carrying the heat



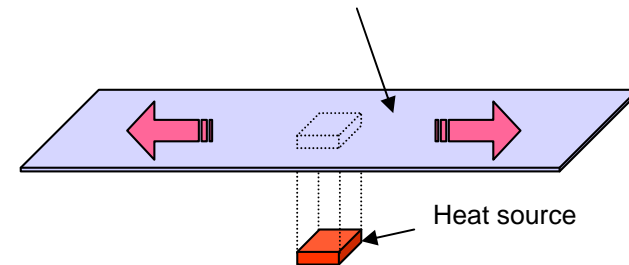
Diffusing the heat



PGS Graphite sheet

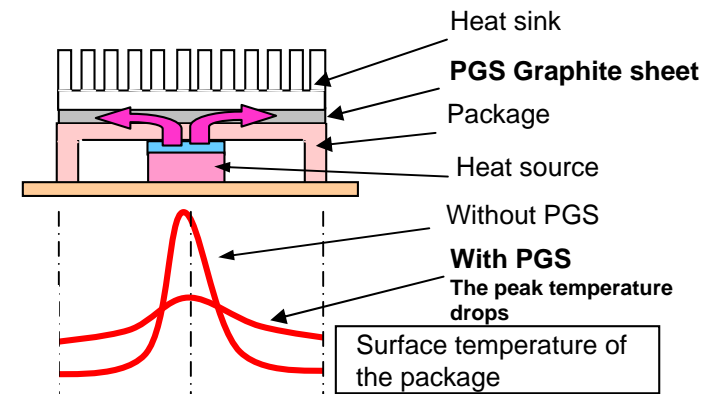
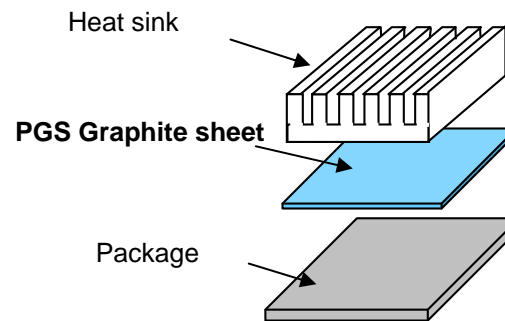
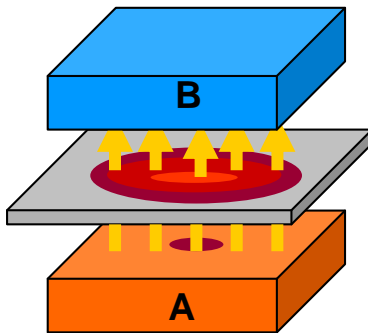


PGS Graphite sheet



2) Thermal Interface

Decreasing the thermal resistance and diffusing the heat



Application Example of PGS Graphite Sheet (Transfer)

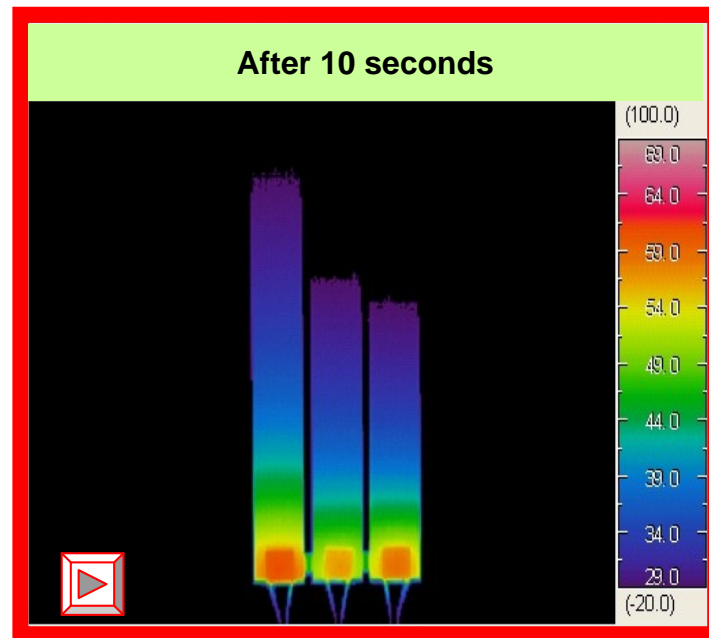
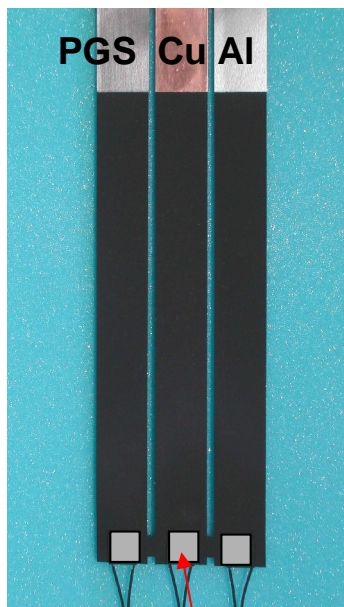
PGS Graphite Sheet

■ Inspection 1

The heat transfer was monitored with thermograph after the heater was attached to the lower part of PGS, Copper and Aluminum.

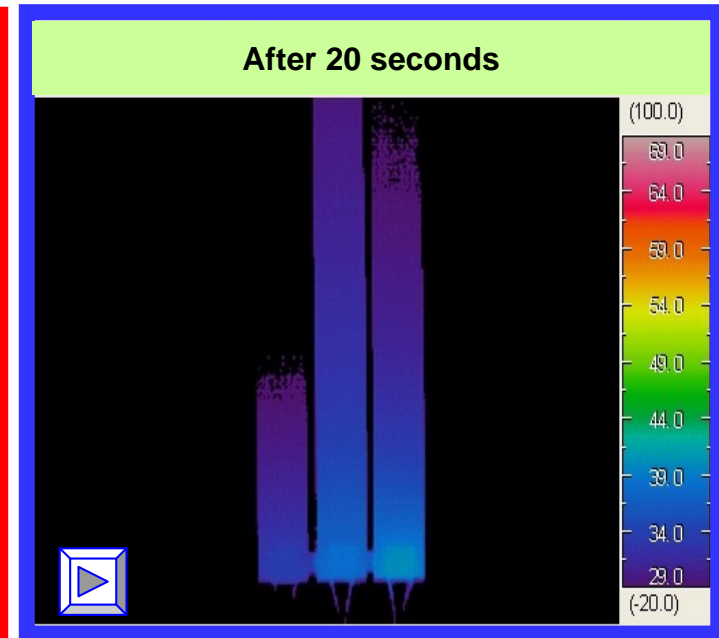
«Heat conductivity when the heater was on.» «Cooling state when the heater was turned on during the heat balance state»

Size;18x180x0.1mm



PGS Cu Al

-PGS Graphite Sheet carries the heat rapidly due to high heat conductivity



PGS Cu Al

-PGS Graphite sheet has high cooling effect .

Resistance heater 10x10mm
Applied voltage 8V (approx.12W)

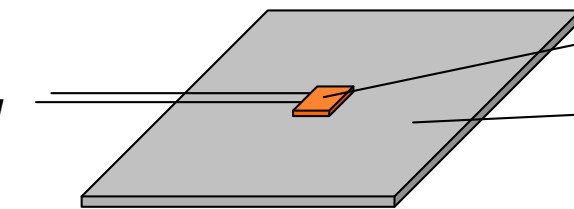
Application of PGS Graphite Sheet (Transfer)

PGS Graphite Sheet

- **Inspection 2** The heat transfer was monitored with thermograph after the heater was attached to the center part of PGS, Copper and Aluminum.

[Measuring method]

Resistance Heater
Electric power 12W



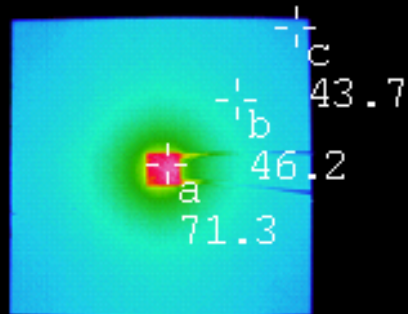
Heater size 10×10mm

Sample size(heat sink)
90×90×0.3mm

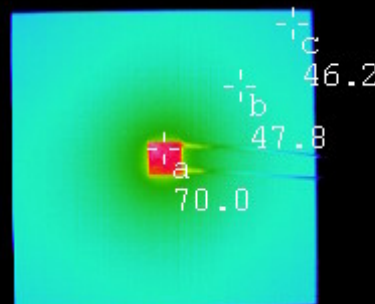
Ambient Temperature:25 deg.C

*The surface of the samples and the heater was subjected to black oxide treatment.

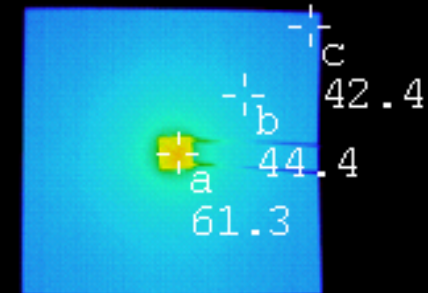
After 30 minutes



Aluminum



Copper



PGS Graphite Sheet

- The temperature of the heater reveals that PGS Graphite Sheet carried the heat, keeping the heat temperature lowest among the three materials.
- The low temperature of PGS surface shows that PGS has high heat dissipation.

Thermal Resistance of PGS Graphite Sheet (Interface)

Thermal resistance property

PGS Graphite Sheet

Thermal resistance represents the degree of non-conductivity of the heat. Materials with lower thermal resistance are a more efficient conductor of heat (Thermal resistance depends on hardness of, and surface condition of material as well as heat conductivity.)

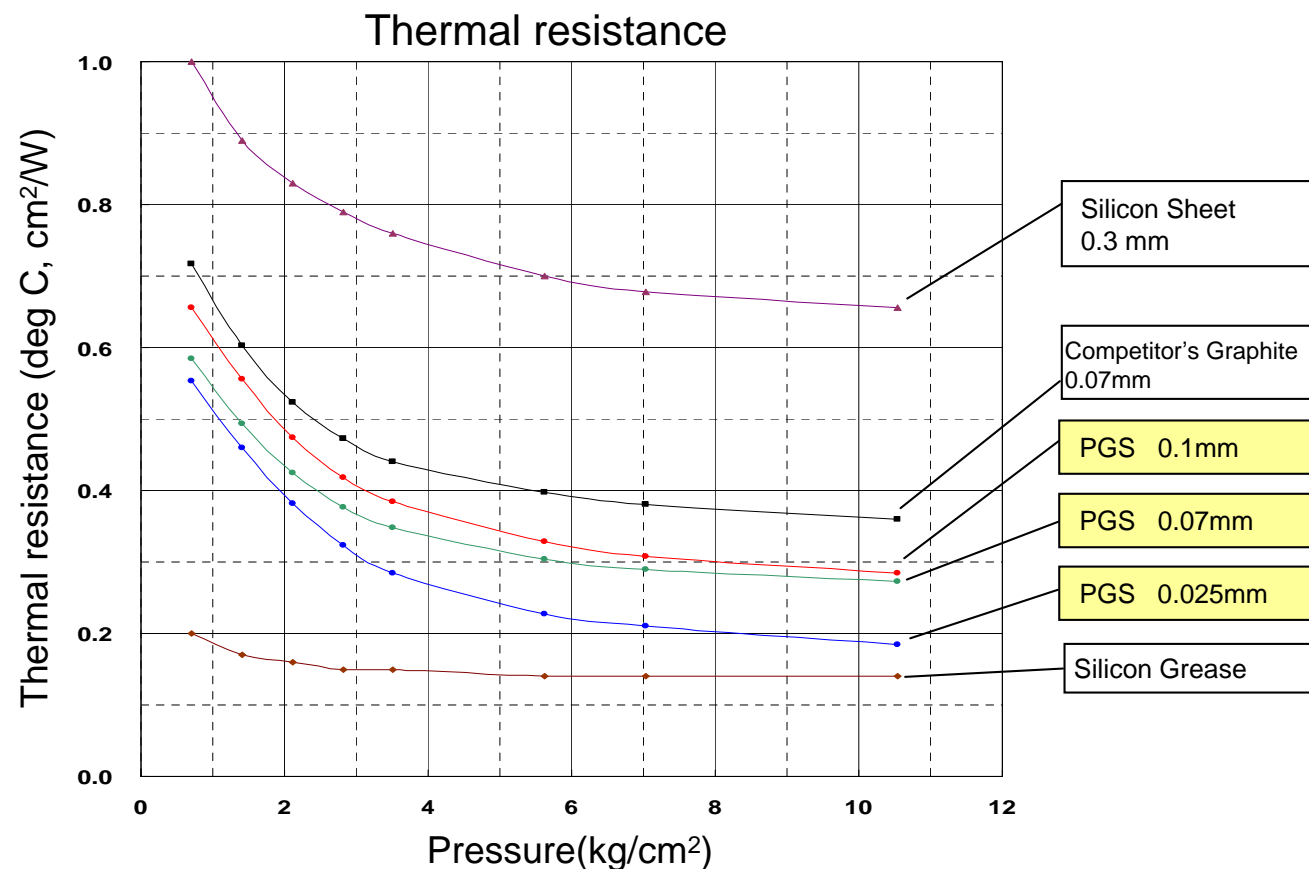
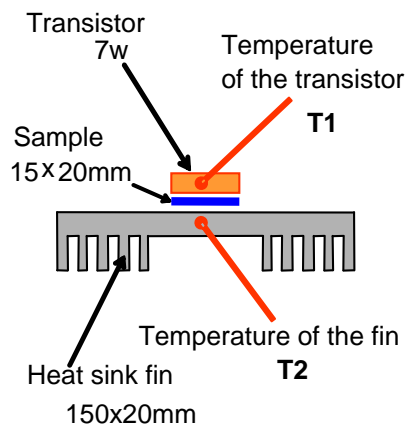
[Measuring Method]

The sample is placed and fixed between the transistor and the fin to measure temperature difference, from which the thermal resistance is calculated.

Thermal resistance
 $R_{th} = (T1 - T2) / W$
 (deg.C/W)

Transistor

1.5x2cm=3cm²
 P =approx. 7W

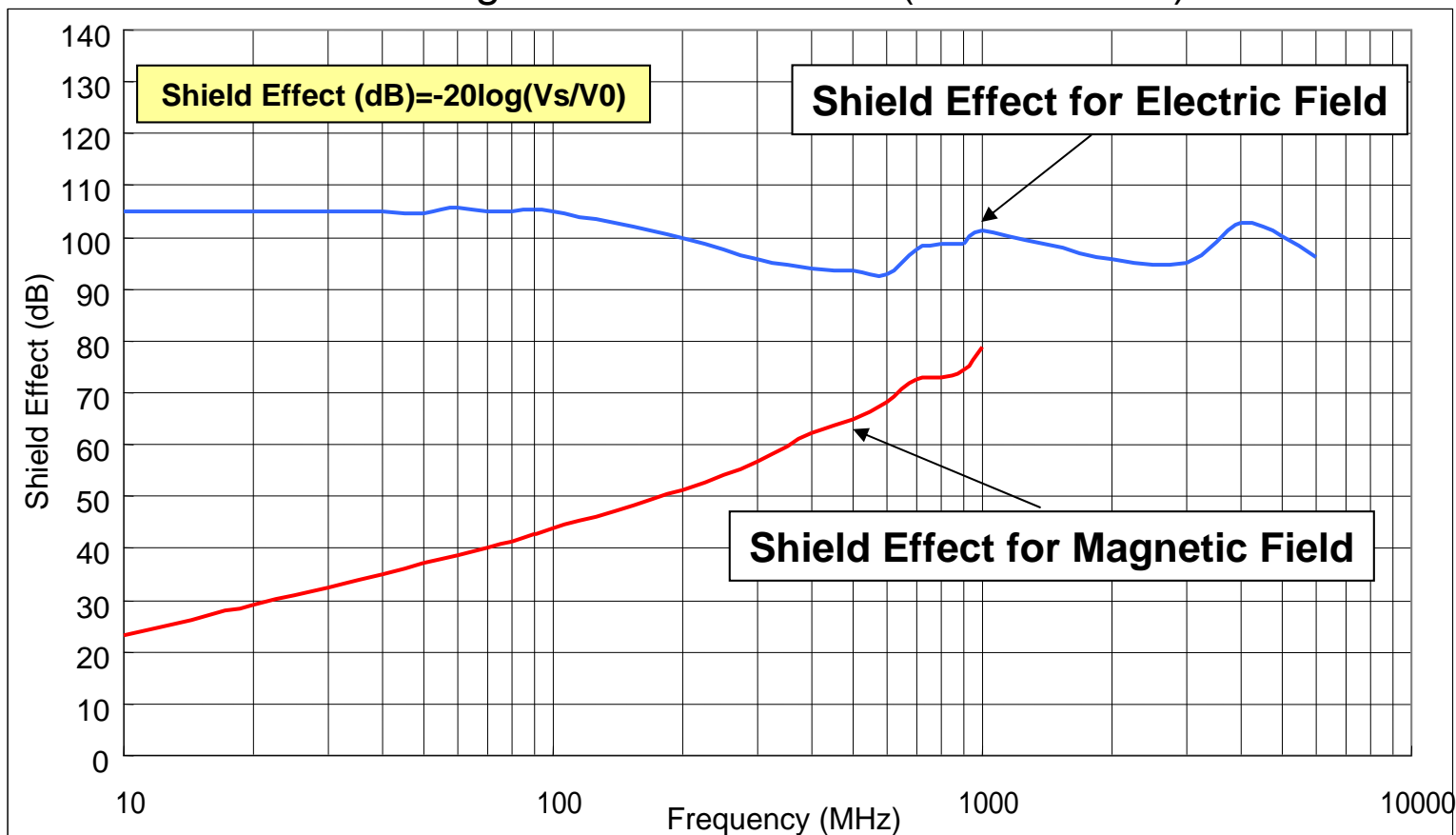


PGS has low thermal resistance due to its high conductivity and flexibility.

Shield Effect of PGS Graphite Sheet

PGS Graphite Sheet

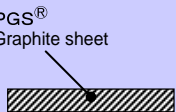
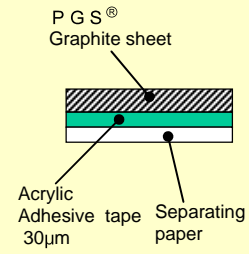
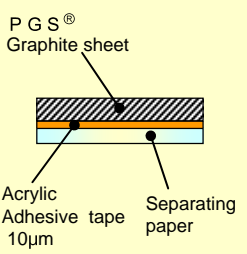
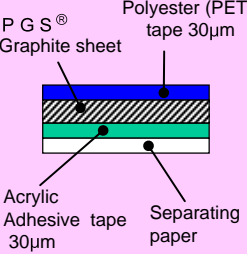
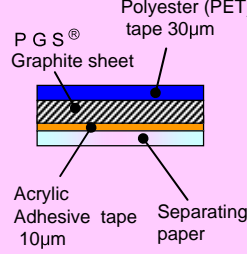
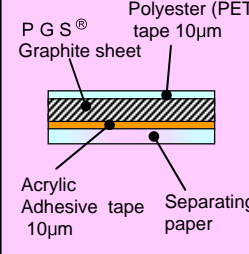
Shielding Effectiveness Test (KEC Method)



PGS Graphite Sheet Application Development (Standard series)

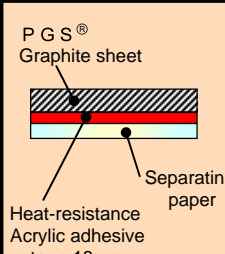
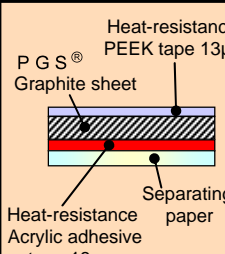
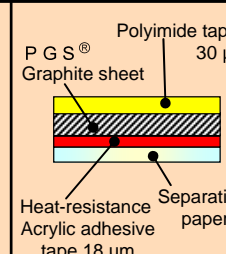
■ Standard series (PGS 100, 70, 25 μm)

PGS Graphite Sheet

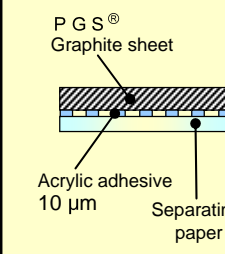
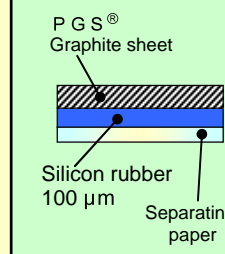
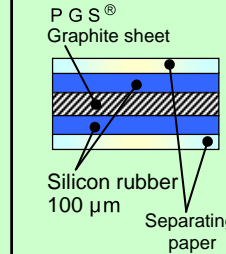
Type	PGS Only	Adhesive Type		Laminated type (Insulation & Adhesive)			
	S type	A - A type	A - M type	A - PA type	A - PM type	A - SM type	
Front face	-----	-----	-----	Polyester tape standard type 30μm	Polyester tape standard type 30μm	Polyester tape thin type 10μm	
Rear face	-----	Insulative adhesion type 30μm	Insulative thin adhesion type 10μm	Insulative adhesion type 30μm	Insulative thin adhesion type 10μm	Insulative thin adhesion type 10μm	
Structure							
Features	<ul style="list-style-type: none"> ➢ High Thermal Conductivity ➢ High Flexibility ➢ Low Thermal Resistance ➢ Available up to 400°C ➢ Conductive Material 	<ul style="list-style-type: none"> ➢ With insulation material on one side ➢ With strong adhesive tape for putting chassis ➢ Withstanding Voltage : 2 kV 	<ul style="list-style-type: none"> ➢ With insulation material on one side ➢ Low thermal resistance comparison with A-A type ➢ Withstanding Voltage : 1 kV 	<ul style="list-style-type: none"> ➢ With insulation material on both side ➢ Withstanding Voltage PET tape : 4 kV ➢ Adhesive Tape : 2 kV 	<ul style="list-style-type: none"> ➢ With insulation material on both side ➢ Withstanding Voltage PET tape : 4 kV ➢ Adhesive Tape : 1 kV 	<ul style="list-style-type: none"> ➢ With insulation material on both side ➢ Withstanding Voltage PET Tape : 1 kV ➢ Adhesive Tape : 1kV 	
Withstand temp	400 °C	100 °C	100 °C	100 °C	100 °C	100 °C	
Standard Size	115×180 mm	90×115 mm	90×115 mm	90×115 mm	90×115 mm	90×115 mm	
Max. Size	180×230 mm 115×180 mm (25μm)	115×180 mm	115×180 mm	115×180 mm	115×180 mm	115×180 mm	
100 μm	Part No.	EYGS121810	-----	-----	-----	-----	
	Thickness	100 μm	-----	-----	-----	-----	
70 μm	Part No.	EYGS121807	EYGA091207A	EYGA091207M	EYGA091207PA	EYGA091207PM	EYGA091207SM
	Thickness	70 μm	100 μm	80 μm	130 μm	110 μm	90 μm
25 μm	Part No.	EYGS121803	EYGA091203A	EYGA091203M	EYGA091203PA	EYGA091203PM	EYGA091203SM
	Thickness	25 μm	55 μm	35 μm	85 μm	65 μm	45 μm

PGS Graphite Sheet Application Development (High heat resistance series , Special processing series)

■ High heat resistance series (PGS 70, 25 μm)

Type		high heat resistance type		
		A – V type	A – RV type	A – KV type
Front face		-----	high heat resistance and insulation type 13μm	high heat resistance and insulation type 30μm
Rear face		High heat resistance and insulation adhesion type 18μm	High heat resistance and insulation adhesion type 18μm	High heat resistance and insulation adhesion type 18μm
Structure				
Features		<ul style="list-style-type: none"> With high heat resistance and insulation tape on one side Withstanding Voltage Adhesive tape : 2 kV 	<ul style="list-style-type: none"> With high heat resistance and insulation tape on both side Withstanding Voltage PEEK tape : 2 kV Adhesive tape : 2 kV 	<ul style="list-style-type: none"> With high heat resistance and more insulated tape on both side Withstanding Voltage PI tape : 5 kV Adhesive tape : 2 kV
Withstand temp		150 °C	150 °C	150 °C (Polyimide : 180 °C)
Standard Size		90x115 mm	90x115 mm	90x115 mm
Max. Size		115x180 mm	115x180 mm	115x180 mm
70 μm	Part No.	EYGA091207V	EYGA091207RV	EYGA091207KV
	Thickness	88 μm	101 μm	118 μm
25 μm	Part No.	EYGA091203V	EYGA091203RV	EYGA091203KV
	Thickness	43 μm	56 μm	73 μm

■ Special processing (PGS 100μm)

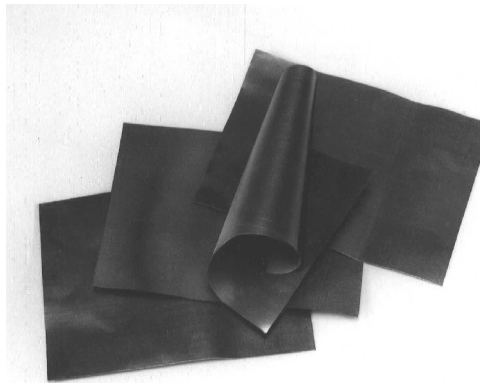
Type	Adhesive Type	Multilayered type	
	C – C type ※	M – SS type ※	M – SW type ※
Front face	-----	-----	Printing Silicon rubber
Rear face	Printing Acrylic adhesive	Printing Silicon rubber	Printing Silicon rubber
Structure			
Features	<ul style="list-style-type: none"> With pin point adhesive on one side due to the high thermal conductivity Non – insulation 	<ul style="list-style-type: none"> With silicon rubber on one side to increase contact area with heat source and reduce thermal resistance Minute cohesiveness High heat resistance Non – insulation 	<ul style="list-style-type: none"> With silicon rubber on both side to increase contact area with heat source and reduce thermal resistance Minute cohesiveness High heat resistance Non – insulation
Withstand temp	100 °C	180 °C	180 °C
Standard Size	90x115 mm	90x115 mm	90x115 mm
Max. Size	115x180 mm	115x180 mm	115x180 mm
Part No.	EYGC091210C	EYGM091210SS	EYGM091210SW
Thickness	110 μm	200 μm	300 μm

※ C – C , M – SS , M – SW It becomes a production on orders about each type.

PGS Graphite Sheet Application Method

PGS Graphite Sheet

- 1.Application Example of PGS through simulation**
- 2.General Thermal Design Model**

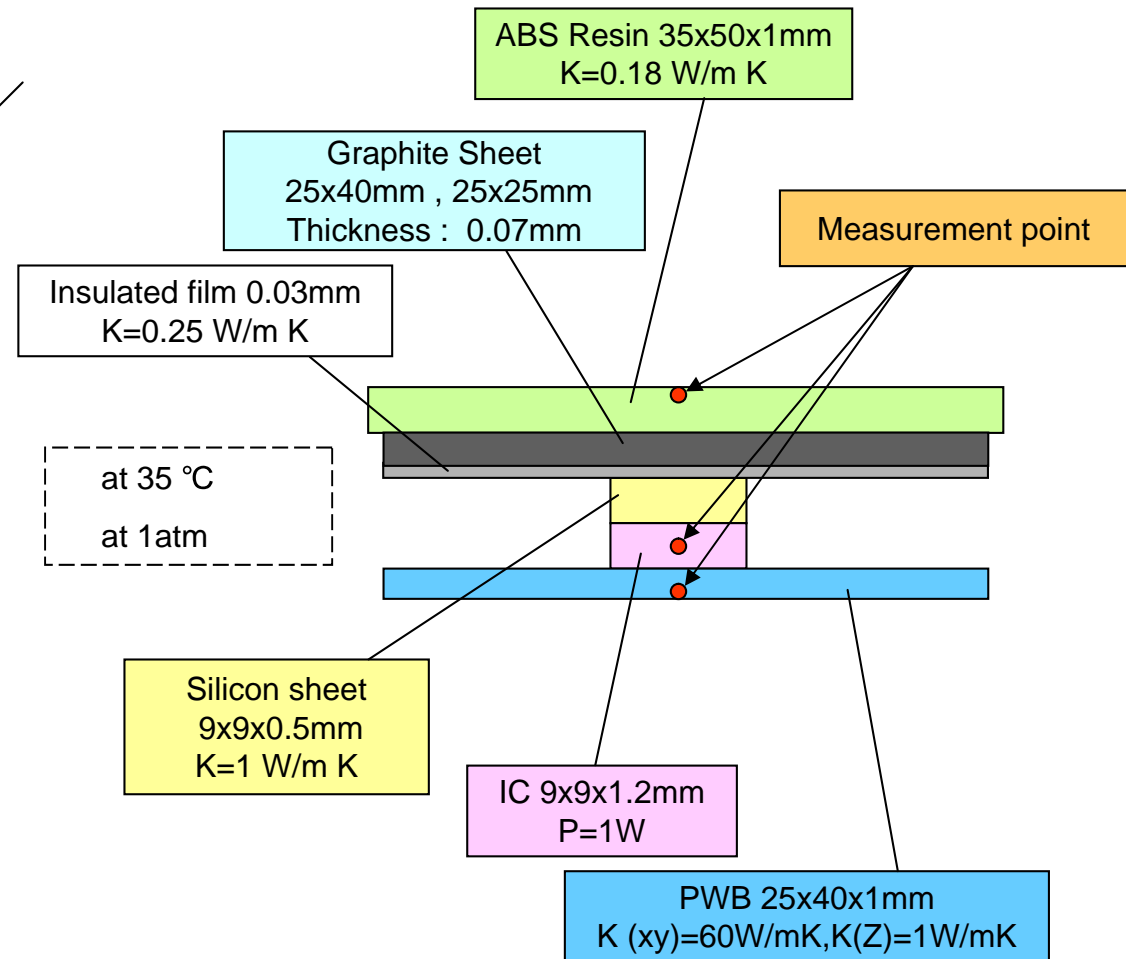
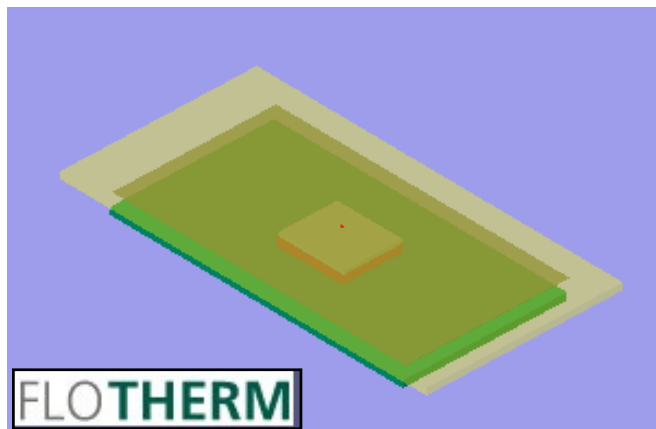
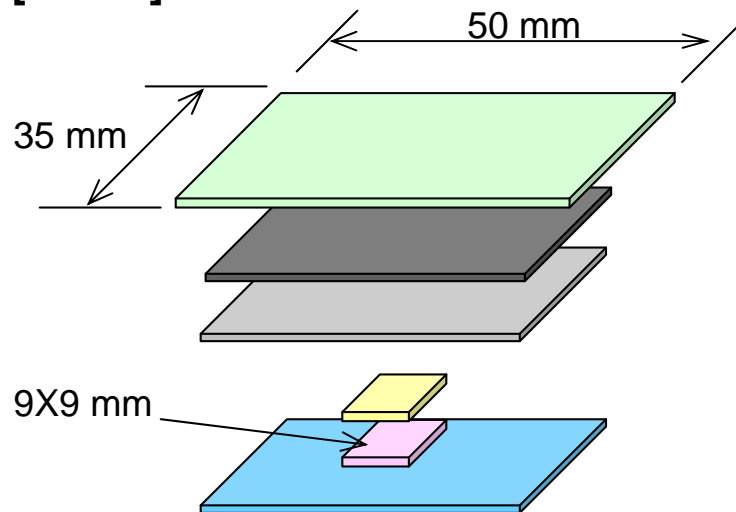


1.Application Example of PGS (Simulation with heat)

PGS Graphite Sheet

- ◆ In this simulation test, thermal diffusivity will be measured by analyzing heat spot of a layered sample mainly consisting of PWB, IC (heating element), PGS and a case face (ABS Resin).

[Model]



1.Application Example of PGS (Simulation with heat)

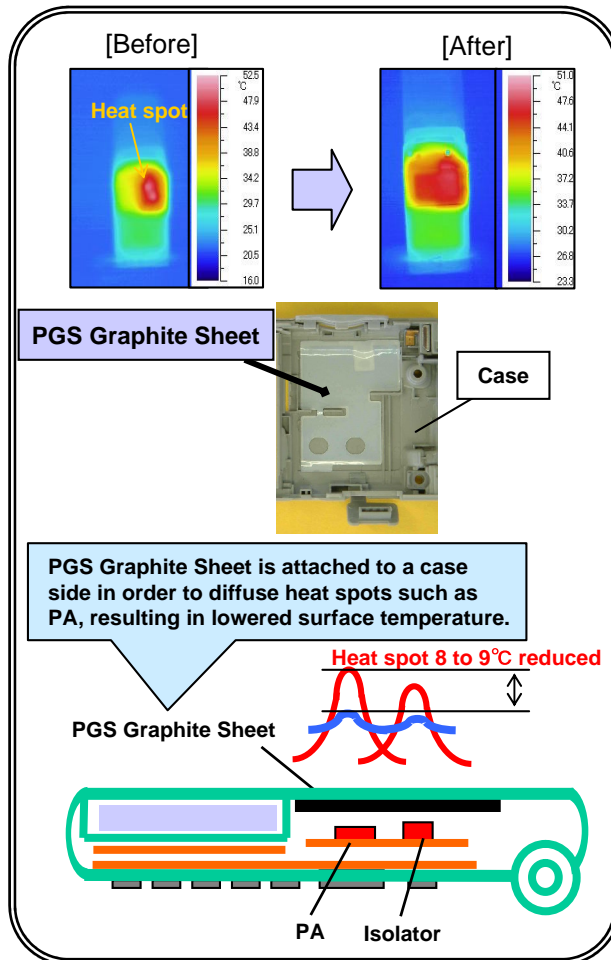
◆Heat distribution of the ABS surface with PGS70μ: Diffused the heat and broke the heat spot.

		Type A	Type A-1	Type A-2	Type B	Type B-1	Type B-2
Model	ABS						
	Silicon						
PGS size (mm)		without	25×40×0.07 (Large)	25×25×0.07 (Small)	without	25×40×0.07 (Large)	25×25×0.07 (Small)
Silicon		with	with	with	without	without	without
Result							
	Temp. (°C)						
Temp. (°C)	Surface	99.85	83.84	89.08	93.65	77.17	80.86
	IC	101.9	88.89	93.26	103.2	99.76	100.96
	PWB	96.25	85.31	89.06	97.26	94.19	95.31

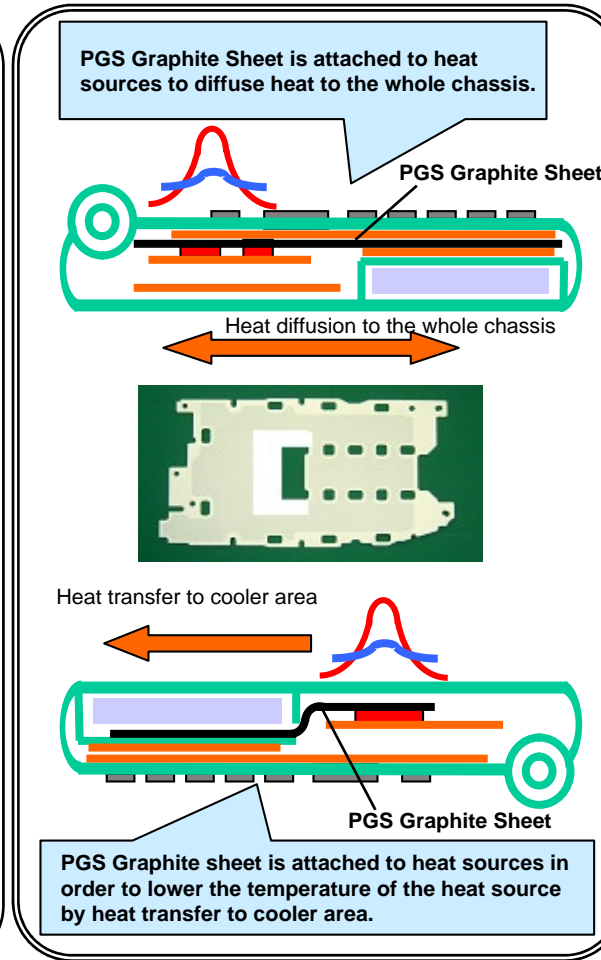
You can choose whichever application you think is suitable for your purposes-whether to lower the temperature of heat source or to lower the surface temperature.

2. Typical Thermal Design with PGS Graphite Sheet

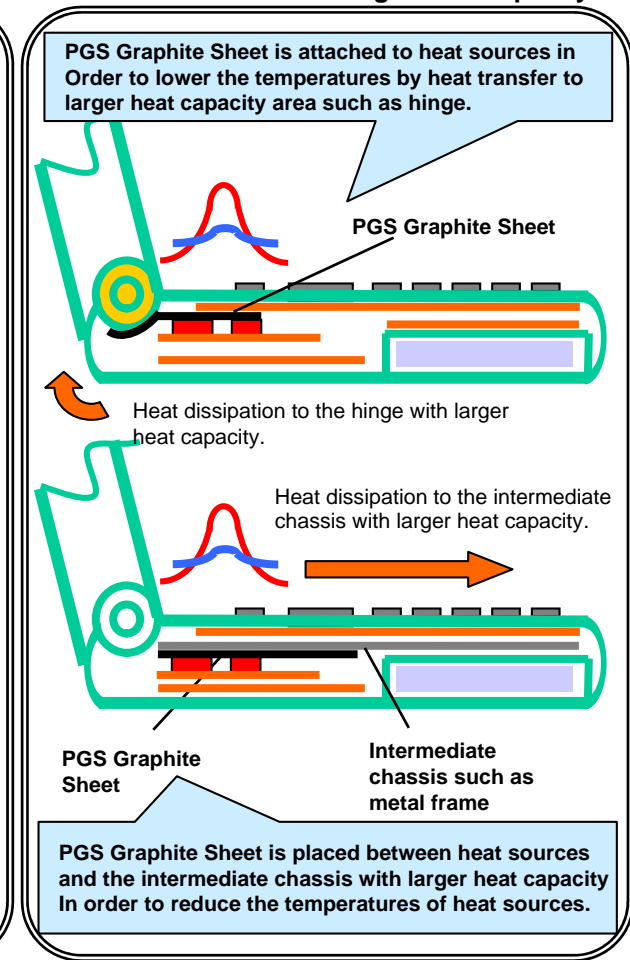
<Blocking and Sealing of Heat Source>



<Heat diffusion to the whole chassis>



PGS Graphite Sheet <Heat transfer to the chassis with larger heat capacity>



PGS Graphite Sheet, an excellent heat transfer material, meets thermal design for various devices with various structures.

