Solving thermal management challenges in a minimum space

Electronic equipment needs an efficient means of managing and dispersing heat as systems continue to shrink in size.

Heat is a killer for electronic systems. As applications get thinner and lighter, this statement has never been more true, yet space and weight restrictions – especially in portable mobile devices – mean that conventional solutions may not be feasible. But it's not just consumer products such as smartphones, tablets and cameras that are at risk. Communications infrastructure equipment cram more and more complex electronics systems into a small space; electric (Eco) and hybrid cars require long-lasting, lightweight batteries; the advent of the smart factory (Industry 4.0) calls for greater levels of monitoring and control; solar panels (ironically) need to be able to cope with constant exposure to the sun; modern medical devices must be able to be worn comfortably.

All these examples require heat to be transferred or dispersed effectively, using a minimum amount of space. Pyrolytic Graphite Sheet (PGS) is a new, ultra-light graphite interface film material, developed by Panasonic, which has a thermal conductivity up to five times greater than copper. It is pliable enough to be cut and folded into complex three dimensional shapes then simply stuck onto the heat source to diffuse the heat or provide a path for heat to flow to a cold wall.

What is PGS?

Pyrolytic Highly Oriented Graphite Sheet is made of graphite with a structure that is close to a single crystal. It is produced from polymeric film using a heat de-composition process. The hexagonal crystal structure of graphite is arranged uniformly in a horizontal 2D structure see figure 1 (PPT slide 6).

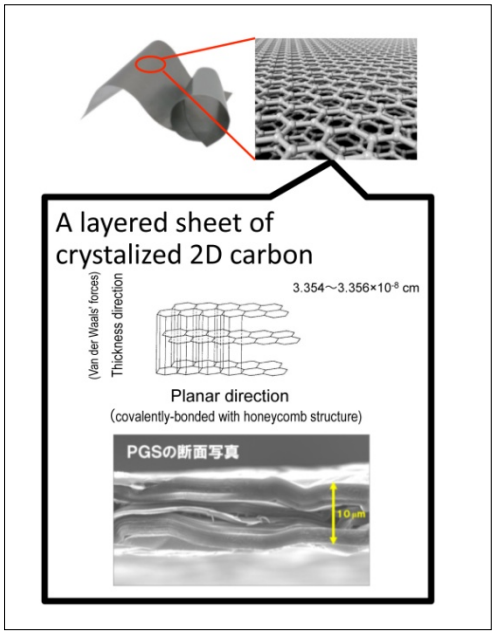


Fig 1.

Features

PGS has a number of features which make it highly suitable as an easy-to-use, space-saving, thermal management solution:

● it is very thin – available in a range of thicknesses from 100µm down to 10µm – and has excellent thermal conductivity from 700 to 1950W/m.K which is two to five times higher than copper and up to seven times better than aluminium (see fig 2)

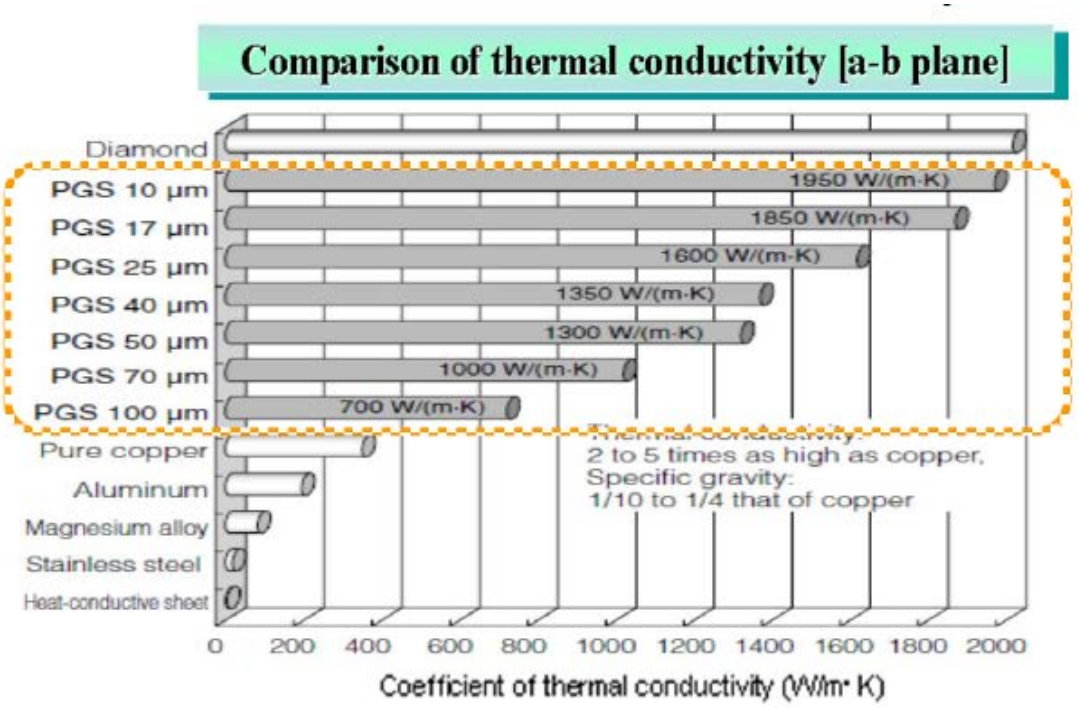


Fig 2.

● it is flexible and pliable so it can be easily cut and folded into a complex shape. With a bend radius or 2mm, sheets can be bent through 180 degrees more than 3000 times, and its thermal conductivity is unaffected if sharp folds are avoided;

● the material is very stable so it is resistant to environmental effects and shows no deterioration with age;

● PGS can provide some shielding to electromagnetic noise, providing a simultaneous EMI and thermal solution (see fig 3).

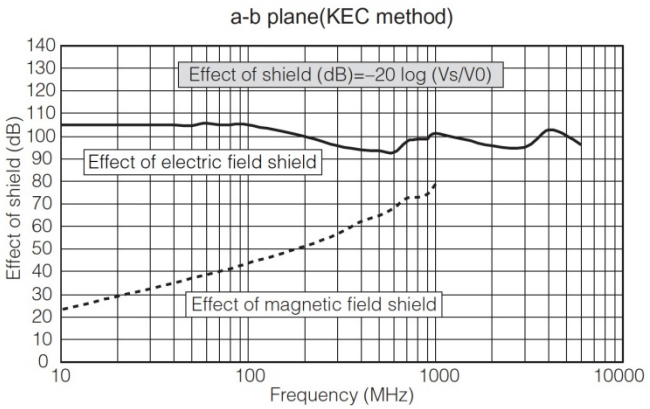


Fig 3.

Usage and Results

PGS film is used to transfer heat away from a heat source, or to diffuse or spread heat away from a hot spot (A>B) as shown in figure 4.

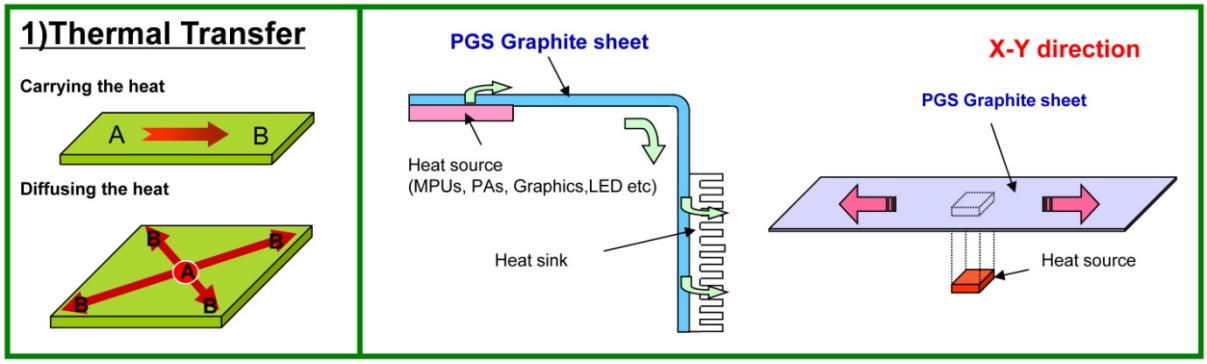


Fig 4.

It can also be used as a highly-efficient thermal interface material as in figure 5.

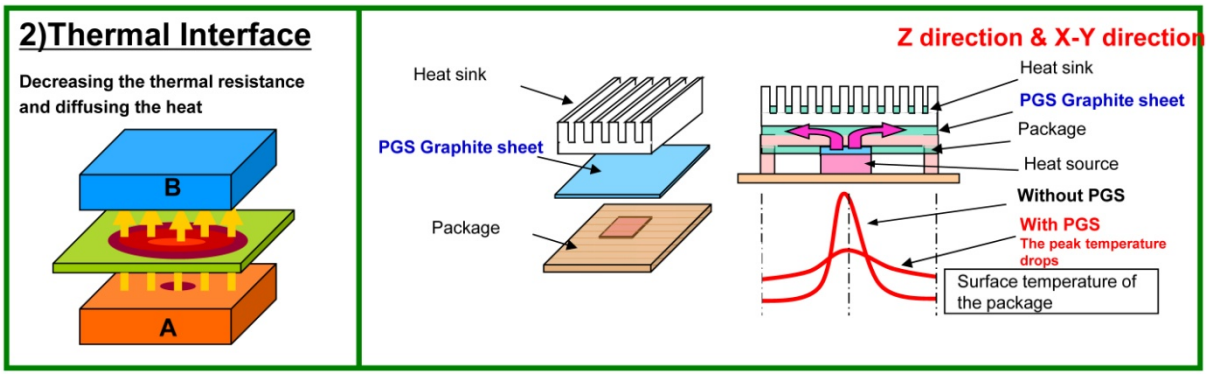


Fig 5.

The efficacy of PGS in reducing IC hot spot temperatures is demonstrated in figure. The temperatures at the ABS (Acrylnitril-Butadien-Styrol)surface, the IC and the PCB are shown for two different 70 µm thick PGS sheet sizes.

Application Example of PGS (Simulation with heat)

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

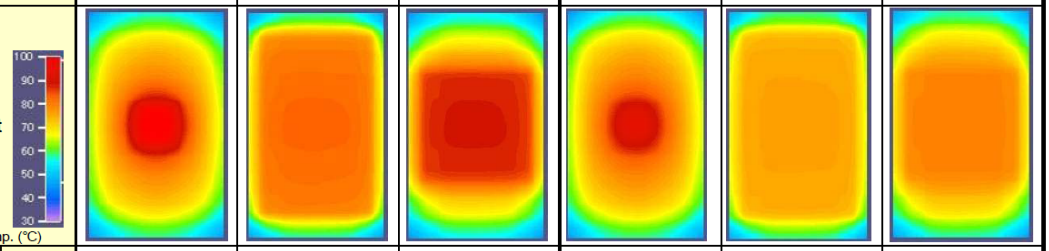
		Type A	Type A-1	Type A-2	Type B	Type B-1	Type B-2
Model		ABS / Silicon / IC / PWB	PGS, Insulated film	PGS		PGS	PGS
PGS size (mm)		without	25×40×0.07 (Large)	25×25×0.07 (Small)	without	25×40×0.07 (Large)	25×25×0.07 (Small)
Silicon		with	with	with	without	without	without
Result							
Temp. (°C)	Surface	99.85	83.84	89.08	93.65	77.17	80.86
	IC	101.9	88.89 (-13.0)	93.26 (-8.6)	103.2	99.76	100.96
	PWB	96.25	85.31	89.06	97.26	94.19	95.31

Fig 6.

Applications

Two examples show how PGS film can be used.

Figure 7 demonstrates how heat can be transferred away from an IC (LED) to the casing in a camera design, reducing the heat sinking that is required.

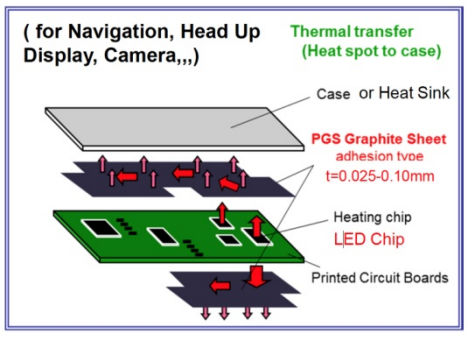


Fig 7.

Figure 8 shows how when applied in a IGBT or switching FET module, PGS acts as a thermal interface, reducing the thermal contact resistance and thermal soaking required.

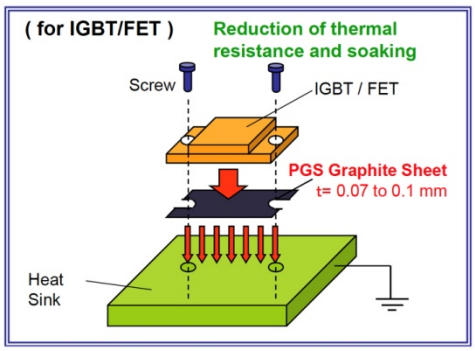


Fig 9.

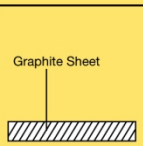
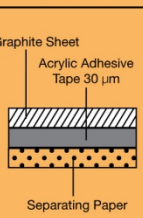
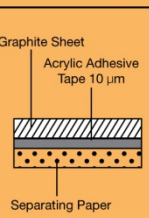
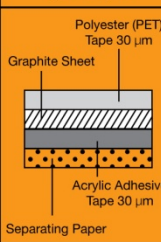
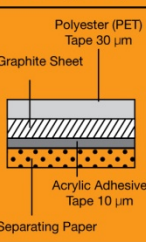
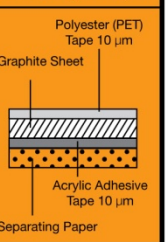
Alternative solutions.

PGS has a lower thermal resistance than silicon sheet material and graphite products from other manufacturers. Silicone grease has a lower thermal resistance, but it has the disadvantage of drying up over time and losing effectiveness. Also it is less easy to apply uniformly so results can be variable.

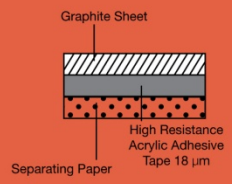
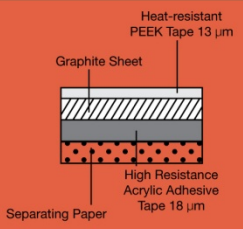
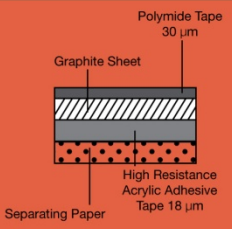
Product overview

PGS is available as sheet only, or in combination with a number of standard and high heat resistance adhesive options. Additionally, for higher isolation requirements PET tape is available.

Standard PGS Types

Type	PGS Only	Adhesive Types		Laminated Types (Insulation + Adhesive)		
	S Type	**A-A Type**	**A-M Type**	**A-PA Type**	**A-PM Type**	**A-DM Type**
Front Face	—	—	—	Polyester Tape Standard Type 30 µm	Polyester Tape Standard Type 30 µm	Polyester Tape Thin Type 10 µm
Rear Face	—	Insulative Adhesion Type: 30 µm	Insulative Thin Adhesion Type: 10 µm	Insulative Adhesion Type: 30 µm	Insulative Thin Adhesion Type: 10 µm	Insulative Thin Adhesion Type: 10 µm
Structure						
Features	- High Thermal Conductivity - High Flexibility - Low Thermal Resistance - Available Up to 400°C - Conductive Material	- With Insulation Material on One Side - With Strong Adhesive Tape for Putting Chassis - Withstanding Voltage: 2 kV	- With Insulation Material on One Side - Low Thermal Resistance Comparison with A-A Type - Withstanding Voltage: 1 kV	- With Insulation Material on Both Sides - Withstanding Voltage: PET Tape: 4 kV Adhesive Tape: 2 kV	- With Insulation Material on Both Sides - Withstanding Voltage: PET Tape: 4 kV Adhesive Tape: 1 kV	- With Insulation Material on Both Sides - Withstanding Voltage: PET Tape: 1 kV Adhesive Tape: 1 kV
Withstand Temperature	400°C	100°C	100°C	100°C	100°C	100°C
Standard Size	115 x 180 mm	90 x 115 mm	90 x 115 mm	90 x 115 mm	90 x 115 mm	90 x 115 mm
Maximum Size	180 x 230 mm 150 x 180 mm (25µm)	115 x 180 mm	115 x 180 mm	115 x 180 mm	115 x 180 mm	115 x 180 mm

High Heat Resistance PGS Types

Type	A-V Type	A-RV Type	A-KV Type
Front Face	—	High Heat Resistance and Insulation Type 13 µm	High Heat Resistance and Insulation Type 30 µm
Rear Face	High Heat Resistance and Insulation Adhesive Type: 18 µm	High Heat Resistance and Insulation Adhesive Type: 18 µm	High Heat Resistance and Insulation Adhesive Type: 18 µm
Structure			
Features	- With High Heat resistance and Insulation Tape on One Side - Withstanding Voltage Adhesive Tape: 2 kV	- With High Heat resistance and Insulation Tape on Both Sides - Withstanding Voltage PEEK Tape: 2 kV Adhesive tape: 2 kV	- With High Heat resistance and More Insulated Tape on Both Sides - Withstanding Voltage PI Tape: 5 kV Adhesive tape: 2 kV
Withstand Temperature	150°C	150°C	150°C (Polymide: 180°C)
Standard Size	90 x 115 mm	90 x 115 mm	90 x 115 mm
Maximum Size	115 x 180 mm	115 x 180 mm	115 x 180 mm