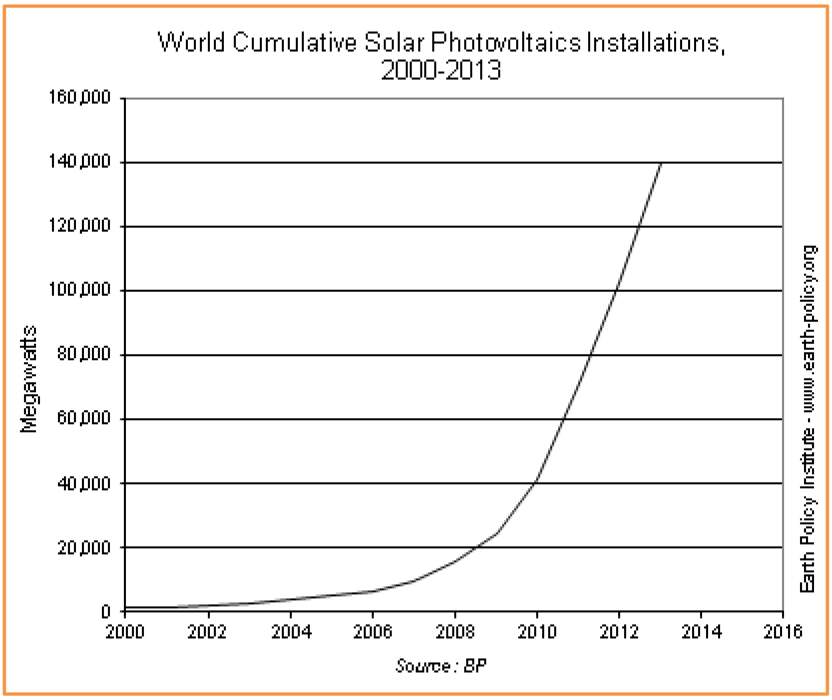
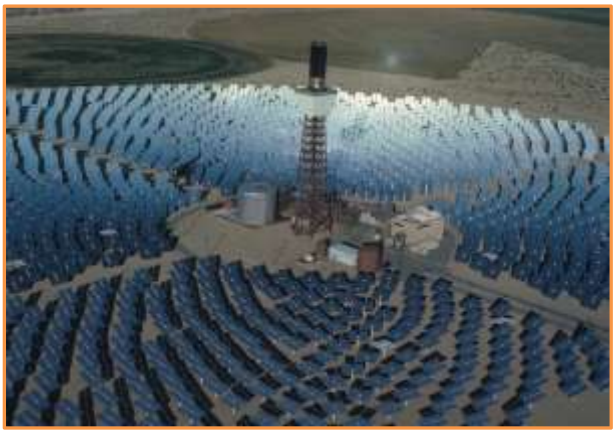
THERMAL MANAGEMENT ON SOLAR PANELS

Solar energy is the plentiful energy source on Earth. Besides being renewable and "free" we can find it in much higher quantities than needed. The power intercepted by the Earth is about 173,000 TW which is a tiny percentage of what Sun is emitting, however, this power is 10,000 times bigger than all the energy the humanity needs.



In order to use this huge amount of energy, the focus on solar cells as a source of photovoltaic energy is rapidly increasing nowadays. In fact, the photovoltaic market has been increasing by more than 20% annually since 2002.

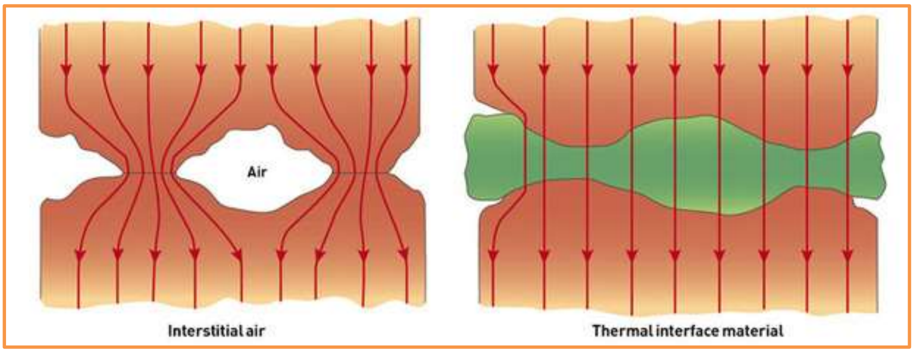
Solar cells manufactured in 2011 are capable of converting about 15% of its absorbed light energy into output electricity. Meanwhile Solar cells panels that employ optical concentrators can convert up to 30% of absorbed light into electricity. Regrettably, the remaining 70% of absorbed energy is turned into heat inside the solar cell. The continuous decrease in solar cells size coupled with the increase in their energy absorption generates more heat inside the solar cells and raise their temperature.



The increasing in the solar cell temperature negatively affects its power conversion efficiency and can damage it. Therefore, it is important to control the solar cell temperature and effectively remove the unwanted heat.

In fact, we can observe that only a fraction of absorbed solar radiation energy is turned into useful output, meanwhile the rest is converted to heat inside the cell. This heat can be removed by two main approaches, passive cooling and active cooling.

The most popular cooling systems utilize passive cooling technologies, where a basic heat sink can reduce the solar cell temperature by about 15°C, which increases the output power by 6%.



When a heat sink is attached to a solar cell, a thermal resistance between the two interfaces can limit the amount of heat transferred between the solar cell and heat sink. This resistance is a result of the small air gaps in between the joined surfaces and caused by the surfaces imperfections. Since air is a poor thermal conductor, we need to fill these gaps with a material that has better thermal conductivity. Here is where the **T**hermal **I**nterface **M**aterial**s** (TIMs) enter the game to improve the interfacial contact by decreasing the thermal resistance.

As said before, when two adjoining surfaces such as the solar cell back panel and a heat panel are joined together to transfer heat, air gaps caused by defects in the two surfaces can cause thermal contact resistance between the two surfaces.

Thermal interface materials, generally in the form of paste, are used to fill these air gaps and provide a better thermal contact between the two surfaces.

T-Global Technology can offer a variety of TIMs in the form of paste like the S606 family, with features of good thermal conductivity, high stability and with the property of not hardening with time. We can find its properties on the following table:

Property	**S606**	**S606B**	**S606C**	**Unit**	**Test Method**
Colour	White	White	Grey	-	Visual
Thermal Conductivity	3.6	1.8	5	W/mK	ASTM D5470
Weigth Loss	<0.5	<0.5	<0.5	%	ASTM E595
Specific Gravity	2.3	2.3	2.3	g/cm^3	ASTM D792
Working Temperature	-40 to 180	-40 to 180	-40 to 180	°C	-
Volumen resistance	$>10^{12}$	$>10^{12}$	$>10^{12}$	Ohm-cm	ASTM D257
Standard Package	1kg	1kg	1kg	Kg/pot	-

Another option could be the TG-NSP-60 or TG-NSP-35

Property	**TG-NSP-60**	**Unit**	**Test Method**
Colour	Grey	-	Visual
Thermal Conductivity	5.9	W/mK	ASTM D5470
Weight Loss	<0.5	%	ASTM E595
Working Temperature	-55 to 200	°C	-
Volume Resistivity	$2.15\text{x}10^{15}$	Ohm-cm	ASTM D-257
D4-10	0	PPM	GC/MS

The most important parameter when talking about the thermal interface material performance it's the thermal conductivity of the material. The higher thermal conductivity for the TIM the better thermal contact between the two surfaces.

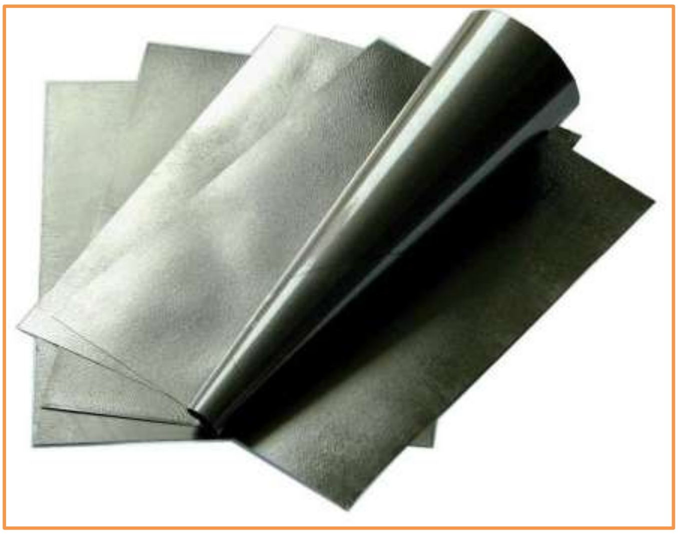
Thermal interface materials must also be designed to spread effectively under surfaces pressure. A TIM that has better spreading characteristics can enhance the interfacial thermal contact by eliminating more air pockets between the two surfaces.

Another important feature to consider in choosing thermal interface materials is its durability. Performance stability and reliability of TIMs over long operating times is important and TIMs with higher viscosities are used for this.

It is crucial to apply TIMs appropriately. Excess amounts can have negative results and amounts that are too low can result smaller spreading than required. The TIM must also be easily removed when replacement is required.

Other factors to consider in TIMs include cost and corrosion resistance. Additionally, TIMs must not cause long time corrosions to surfaces where they're applied.

GRAPHENE SHEETS



Graphene is a sheet of single-layered carbon atoms packed densely into a honeycomb crystal lattice. Graphene is characterized by its high intrinsic thermal conductivity ranging from 3 - 5.3 KW/m K, high electron mobility, and low resistivity. The superior thermal and electrical properties of graphene make it an excellent material for thermal management, low noise transistors, and electrical interconnects. A report of 500% increase in thermal conductivity of the TIM was observed with the addition of small graphene volume loading fraction of $f \sim 5\%$. This significant improvement in the TIM thermal conductivity is largely owed by the superb intrinsic thermal conductivity of graphene and the strong graphene coupling to matrix materials.

T-Global Technology in partnership with Digi-Key can offer its T69 product which is a highly oriented pyrolytic graphite sheet with high thermal conductivity. A heat source can reduce temperature by spreading heat over the T69. It is flexible and has features of ultra-thin and high EMI shielding effect.

Property		Test Methods
Thickness (μm)		Micrometer
Thermal conductivity (W/m.K)	XY axis	AC calorimeter
	Z axis	Laser flash
Thermal Diffusivity (cm^2/S)		AC calorimeter
Density (g/cm^3)		Archimedes law
Electrical conductivity (S/cm)		JISK7194
Flexibility		MIT

Property		**T69-17**	**T69-25**	**T69-40**	**T69-50**	**T69-70**	**T69-100**
Thickness (mm)		17 µm	25 µm	40 µm	50 µm	70 µm	100 µm
		0.017 ±0.005	0.025 ±0.010	0.040 ±0.012	0.050 ±0.015	0.070 ±0.017	0.100 ±0.019
Available size (mm)		305x305	305x305	295x295	295x295	295x295	295x295
Thermal conductivity (W/m.K)	XY axis	1750	1500	1350	1300	1000	700
	Z axis	11	18	20	20	20	26
Thermal Diffusivity (cm^2/S)		10 – 11 (0.001 – 0.0011 m^2/S)	9 – 10 (0.0009 – 0.001 m^2/S)	9 – 10 (0.0009 – 0.001 m^2/S)	8 – 10 (0.0008– 0.001 m^2/S)	8 – 10 (0.0008 – 0.001 m^2/S)	8 – 10 (0.0008 – 0.001 m^2/S)
Density (g/cm^3)		2.1 (2100 kg/m^3)	1.92 (1920 kg/m^3)	1.8 (1800 kg/m^3)	1.7 (1700 kg/m^3)	1.2 (1200 kg/m^3)	0.85 (850 kg/m^3)
Specific Heat (at 50°C) (J/kgk)		0.85 (850 J/kgk)	0.85 (850 J/kgk)	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	400	400
Extensional Strength (Mpa)	X-Y Direction	40	30	25	20	20	20
	Z Direction	0.1	0.1	0.4	0.4	0.4	0.4
Expansion Coefficient (1/K)	X-Y Direction	9.3 x 10^{-7}	9.3 x 10^{-7}	9.3 x 10^{-7}	9.3 x 10^{-7}	9.3 x 10^{-7}	9.3 x 10^{-7}
	Z Direction	3.2 x 10^{-5}	3.2 x 10^{-5}	3.2 x 10^{-5}	3.2 x 10^{-5}	3.2 x 10^{-5}	3.2 x 10^{-5}
Bending Test (R5/180°C) (Times)	20000 or more	20000 or more	20000 or more	20000 or more	20000 or more	20000 or more	20000 or more
Electric Conductivity (S/cm)	20000	20000	20000	20000	20000	20000	20000

Another option T-Global Technology can offer is our T62 product. On the following table you can find its amazing properties:

Property	T62 Graphite	T62-1Graphite + Adhesive	T62-2PET + Graphite + Adhesive	Unit
Colour	Black	Black	Black	-
Thickness	0.13	0.16	0.2	Mm
	0.005	0.0063	0.0079	Inch
Thermal Conductivity	X,Y, 400 Z, 5	X,Y, 400 Z, 15	X,Y, 400 Z, 5	W/mK
Flammability Rating	V-0	V-0	V-0	UL94
Specific Gravity	1.5 - 1.8	1.5 - 1.8	1.5 - 1.8	g/cm^3
Graphite Contained	> 98	> 98	> 98	%
Hardness	80	80	> 80	Shore A
● REACH Compliant		● RoHS Compliant		