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Panasonic G-TIM: Graphite Thermal Interface Material

24.02.2022

Agenda

- Graphite Thermal Interface Material Overview
- Increased thermal performance with G-TIM
- Reliability Benefits of G-TIM
- Assembly with Graphite Sheet
- Where G-TIM Makes Sense
- Conclusion

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Overview of Panasonic Graphite Sheets

Material:

Pyrolytic Graphite Sheet (PGS)

Standard PGS:

Standard graphite sheet

- Thickness: 70µm, 100µm
- Compressibility: little to not compressible
- Thermal conductivity: 700-1000 W/(m*K)
- Suitable for: plane (module) surfaces

Compressible PGS:

G-TIM (Graphite Thermal Interface Material) or "**GraphiteTIM**"

-Thickness: 200µm, 250µm, 350µm
-Compressibility: up to 60% (350µm)
-Thermal conductivity in x-y: 200-400W/(m*K)
-Thermal conductivity in z: 28 W/(m*K)
-Suitable for: bended (module) surfaces

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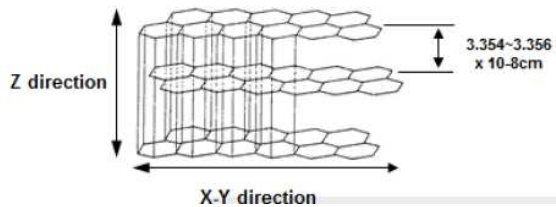
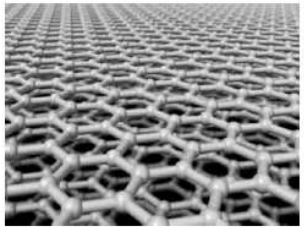
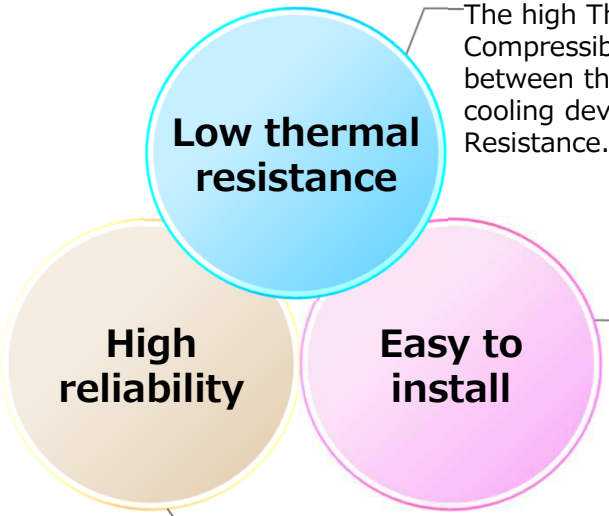
Overview of Panasonic G-TIM

PGS Crystal Structure





Further evolution of PGS
Released G-TIM



The high Thermal Conductivity and high Compressibility effectively fill the voids between the heating device and the cooling device to achieve low Thermal Resistance.

Easy to handle and install because of Sheet Type. (Inventory Control, Repair and Processing)

Chemically very stable for a long period compared to Grease because of its Property of hardly changing Thermal Resistance.

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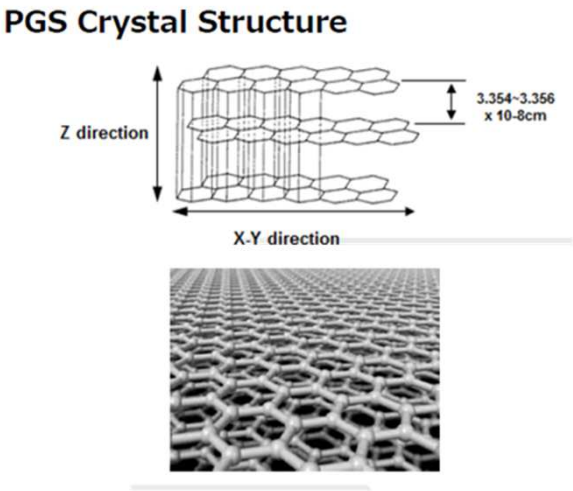
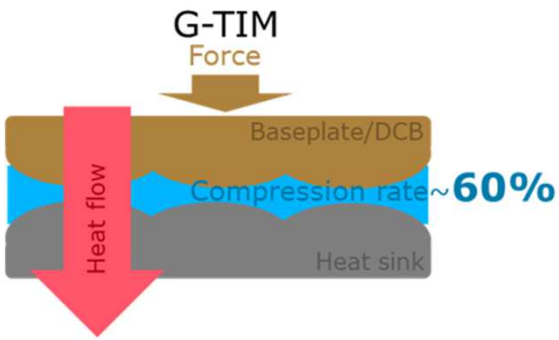
Overview of Panasonic G-TIM





PGS Crystal Structure

- Basis for all graphite TIM

G-TIM Introduction

- Latest evolution of PGS TIM
- Developed by Panasonic

Benefits Compared to Standard PGS

- Low thermal resistance thanks to increased compressibility

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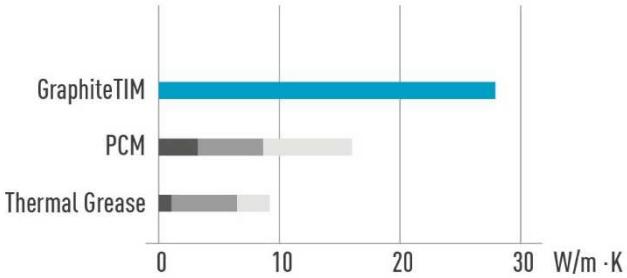
Features of Panasonic G-TIM

Added Value

High Compressibility reduces Thermal Contact Resistance by filling gaps between uneven surfaces

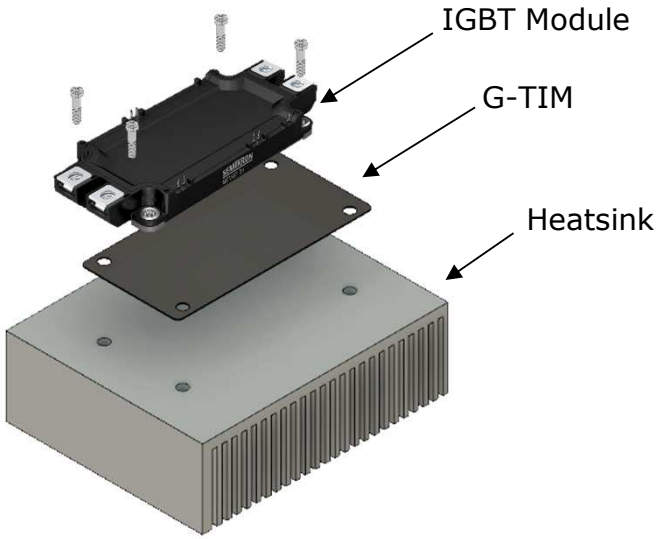
TIM Material with

- Excellent Workability
- High and long time Reliability compared to Conventional TIM Materials
- Thermal Conductivity (through thickness)



Practicability

Specifically designed as TIM for IGBT Modules



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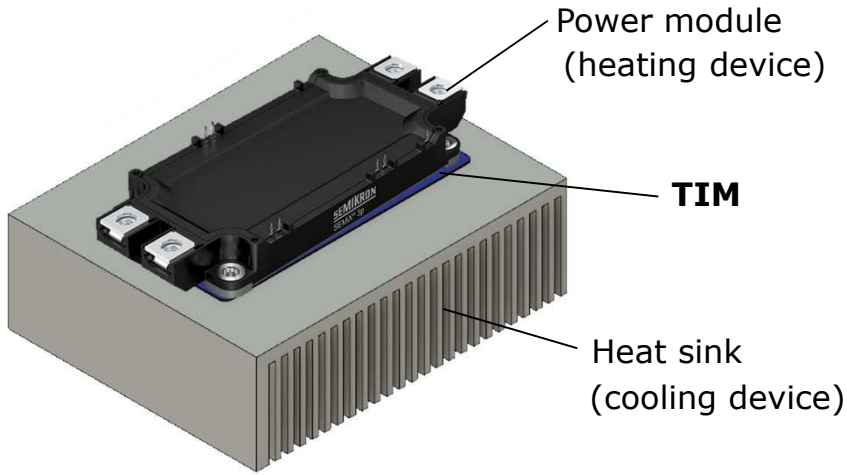
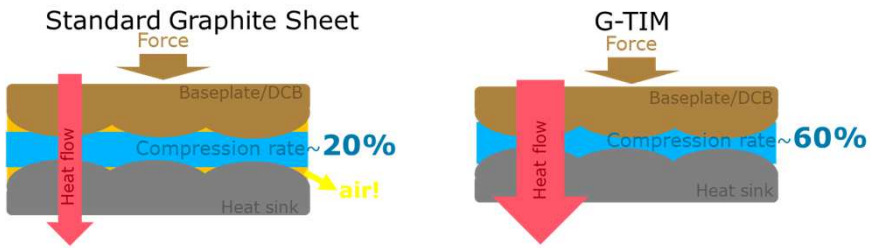
Panasonic G-TIM Offers Best Compressibility

- High Compressibility fills voids, increasing thermal conductivity
- Standard Graphite TIM has typical compression rate of 20%
- G-TIM offers compression rates up to 60%
- To achieve this high compression, **pressure must be >800 kPa**





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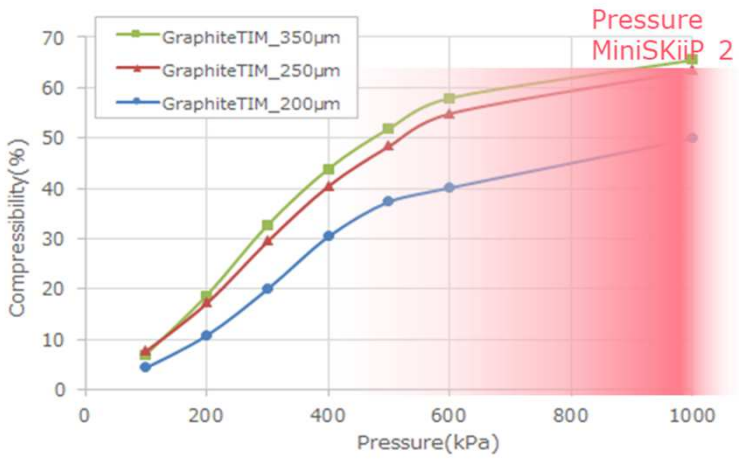
Applied module pressure to compress the G-TIM

	Minimum (kPa)	Maximum (kPa)
MiniSKiiP	900	4000
SEMIX	1800	3700
SEMITRANS	1400	4700



Applied pressure depends on:

- Module area/construction
- Number of mounting points
- Mounting torque
- Screw diameter

Resulting <u>theoretical</u> applied pressure for various modules shown in chart.

Based on minimum, this all works based on:

- Minimum torque (higher = better)
- High compression achieved only at pressure **>800 kPa**

All modules apparently have sufficient pressure to implement G-TIM

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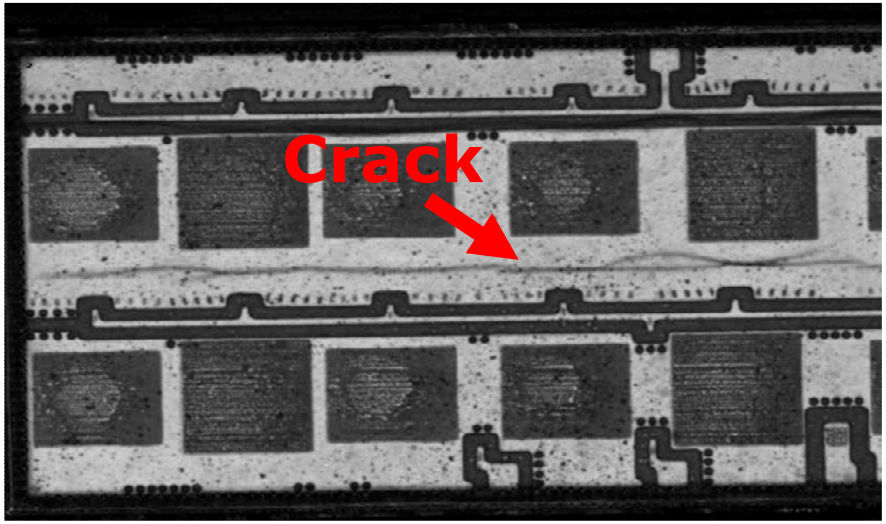
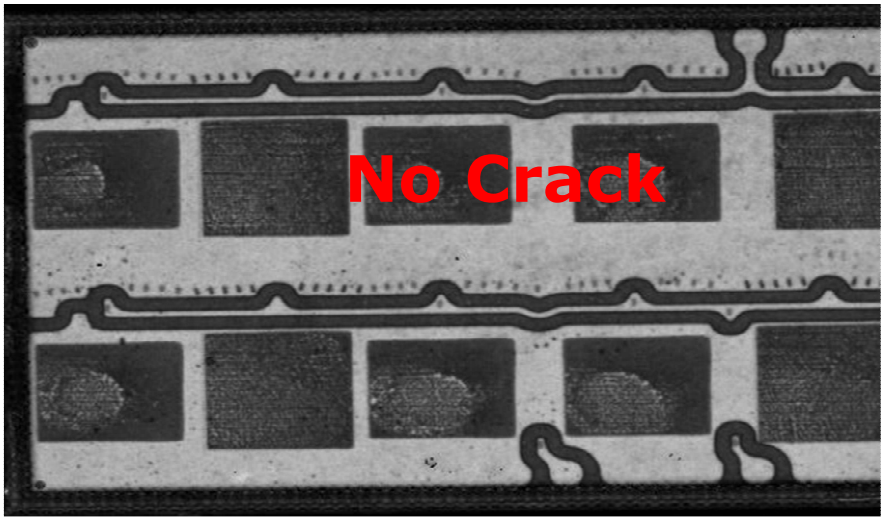
Limitations of G-TIM





Problem

- Baseplate-less devices are sensitive to cracks
- SAM analysis visualize cracks
- High risk with thick(e.g.350µm) G-TIM on baseplate-less device

Solution

- New G-TIM (<200um) under development for baseplate-less module.
- This new type will reduce the possibility of cracking

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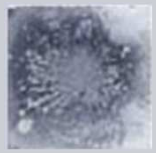
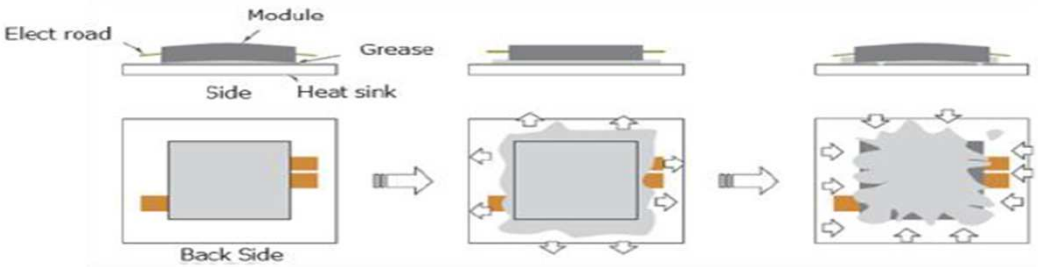
Benefit of Panasonic G-TIM Related to Reliability

Reduced thermal stress, durable & robust

Pump out Test (Temperature Cycles T=-40°…+100°C)

Product	Initial	120 times
GREASE		 Pump OUT !
G-TIM		PERFECT!



G-TIM⇒ “High Reliable Material”

Characteristic **NO CHANGE**

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Power cycling - SEMiX603GB12E4p with Panasonic G-TIM

Test equipment: Mentor Graphics “MicRed PwT”

IGBT:

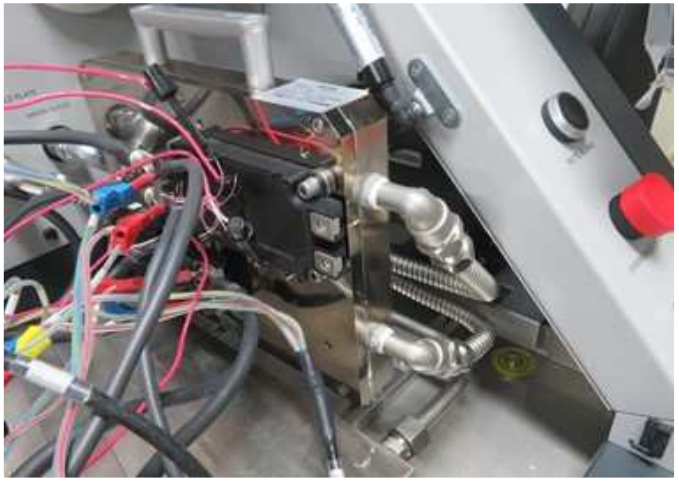
SEMiX603GB12E4p

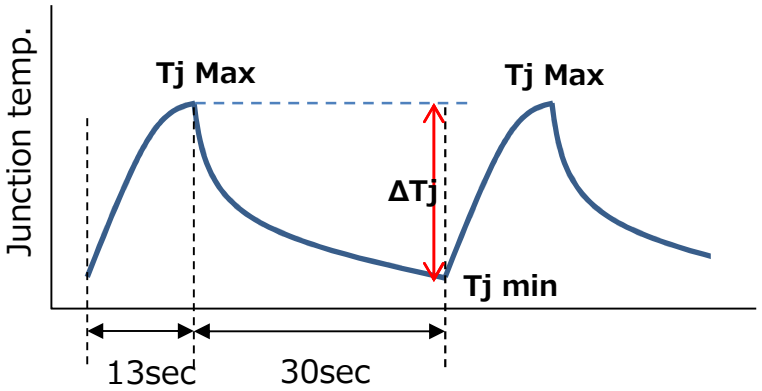
TIM:

Pre-applied TIM HALA P8

Panasonic G-TIM P/N : EYGR0612ZRWF*

*initial thickness:350μm





<u>Test condition</u>

Ic=460A(Pre-applied TIM HALA P8)

Ic=450A(G-TIM 350μm)

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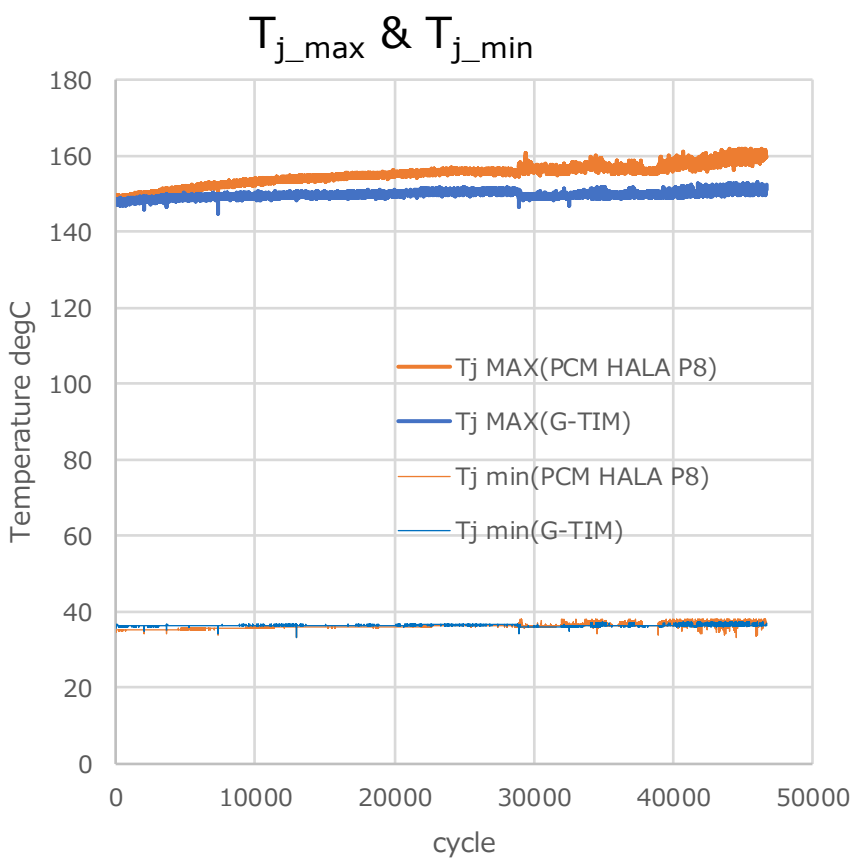
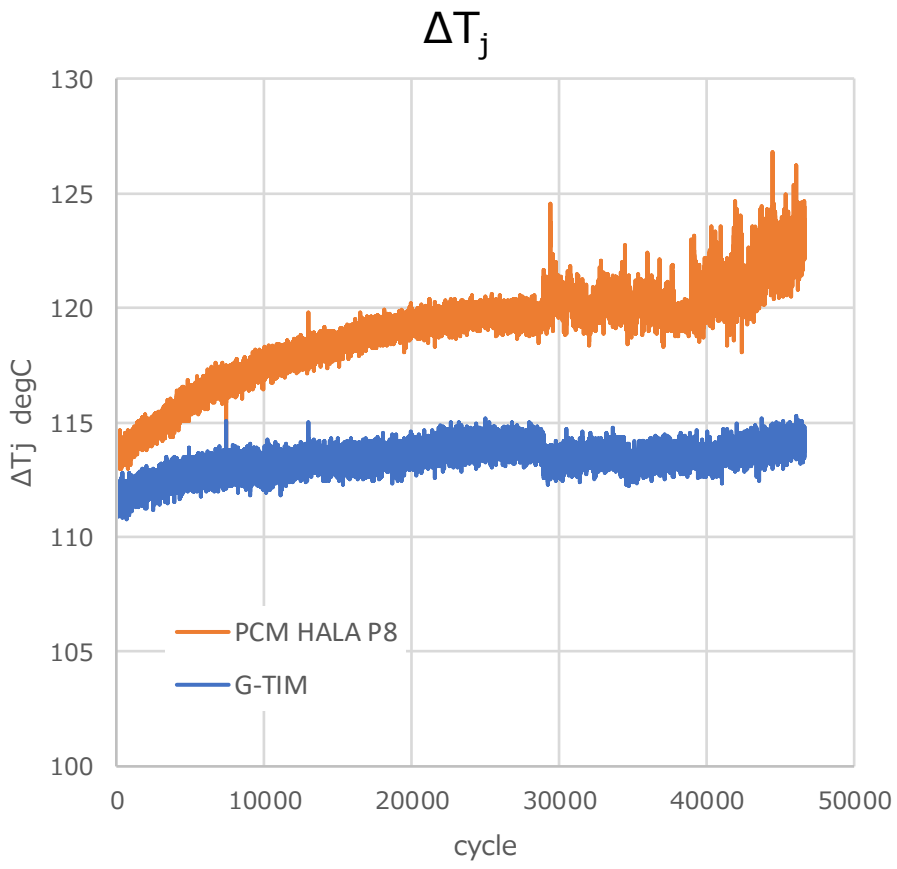
Power cycling - SEMiX603GB12E4p with Panasonic G-TIM





After 45000 cycles, G-TIM has smaller change in Tj MAX and ΔTj.

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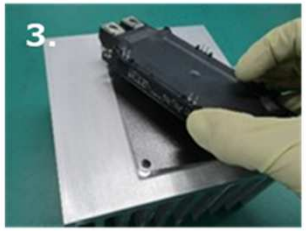
Handling & Mounting instructions

1. Take out G-TIM from plastic bag gently. Don‘t pinch strongly.

2. Clean heat sink surface and put G-TIM on it by fitting the holes with threaded position. (it doesn‘t matter to place top or back side of G-TIM)



3. Put Power device on G-TIM carefully.

4. Assure that the holes of G-TIM fit with the threaded position. If not, once putting off the power device, reposition the G-TIM.

5. Place screws.

6. Tighten the screws in accordance to the mounting instructions of the certain device.

Notes:

- do not handle with bare hands, use gloves instead
- don’t rub or touch with rough materials to avoid scratching
- do not use pointed or sharp objects such as tweezers for handling, as these can damage the G-TIM

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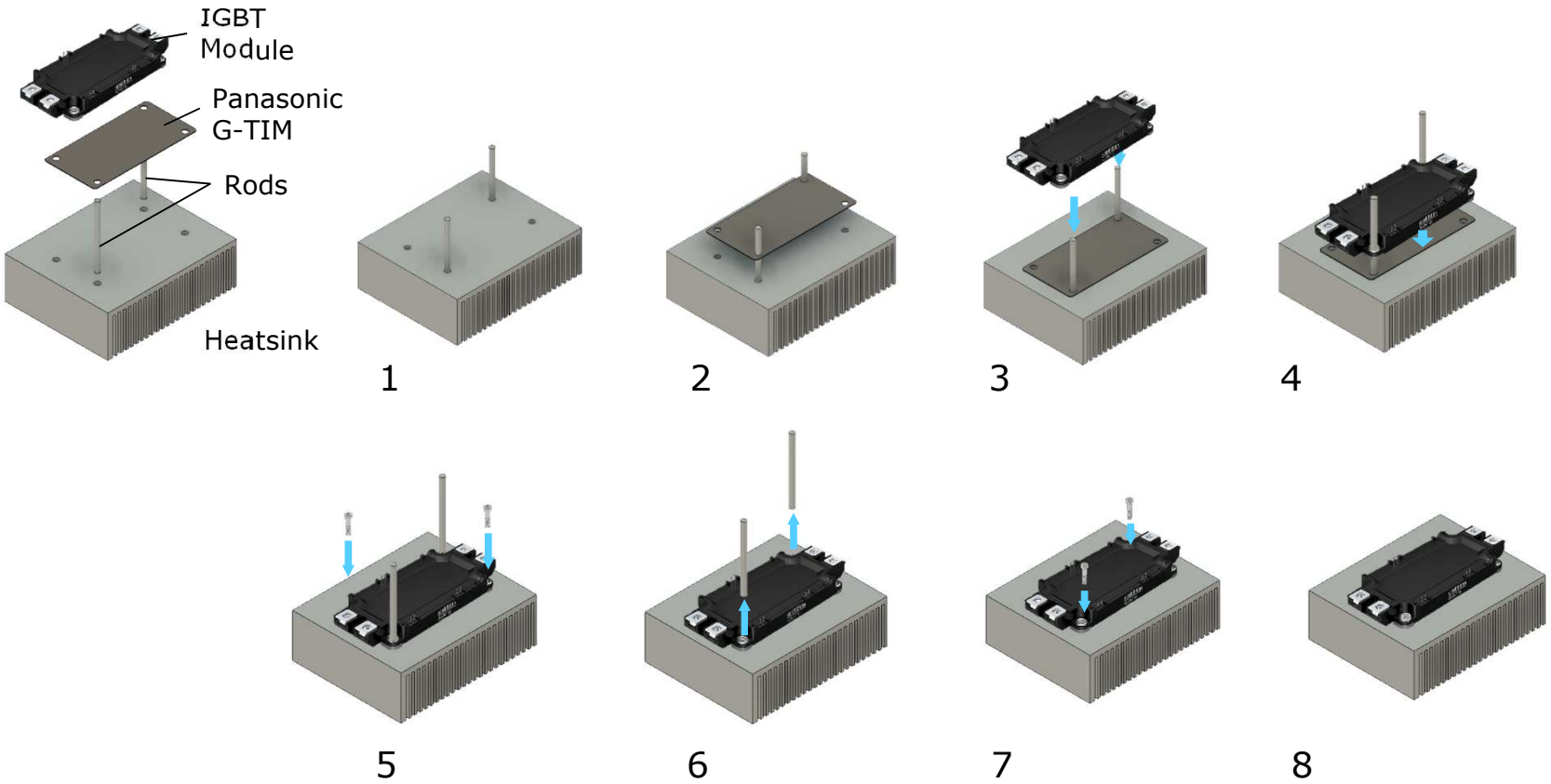
Handling & Mounting instructions

Working example using a rod for the IGBT module.



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Comparison Pre-applied PCM/Grease vs. G-TIM

Pre-applied Phase Change Material (PCM)/Grease	Feature	Panasonic G-TIM
+++	Production Handling	+
+++	Cost	+
+++	Rth	++
++	Pump Out	+++
++	Shelf life	+++
+	Service/maintenance	+++
++	Max. operation temperature	+++

* The higher number of "+" denotes increased performance

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Thermal Comparison: PCM, HPTP and G-TIM

		(PCM) Phase Change Material HALA P8	HPTP (High Performance Thermal Paste)	Panasonic G-TIM		
				200um	250um	350um
Compressibility @600kPa	% (ASTM D5470)	>80% (after melting)	>80%	40%	55%	55%
		Thin layer improve Rth				
Density	gr/cm³	2	4.2	0.36	0.34	0.28
Thermal Conductivity	W/mK	3.4(x-y, z)	2.8 (x-y, z)	400 (x-y) 28 (z)	250 (x-y) 28 (z)	200 (x-y) 28 (z)
Operation Temperature	°C	-40…+105	-40…+180	**-55…+400** **High Operation Temperature**		
Typical Thickness	µm	baseplate: **50**…100 baseplate-less: **10**…50 **Thin layer improve Rth**		200	250	350

The data above are representative values, not guaranteed values

Even though Graphite typically has higher thermal conductivity, thickness also increased, increasing overall thermal resistance.

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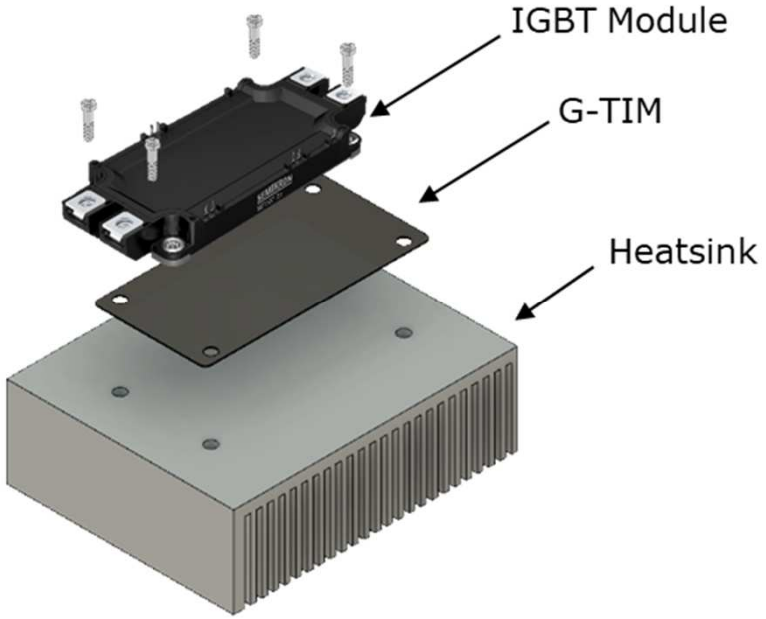
Summary

Graphite TIM thermal performance depends on:

- Compressibility
- Thickness
- Pressure applied by the module

G-TIM with 350µm thickness:

- Slightly higher thermal resistance for baseplate modules compared to PCM HALA P8
- Maintains reduced temperature and ΔT in power cycle test compared to PCM HALA P8
- Can have lifetime advantages over conventional TIM, while HPTP and PCM offer increased thermal performance



Assembly with G-TIM

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Graphite Sheet Thickness Recommendation

- Baseplate modules require a TIM thickness of 50-100µm.
  Therefor G-TIM 250µm (137µm compressed) and 350µm (190µm) are recommended

- Too thick G-TIM could lead to cracks during assembly of baseplate-less modules

- Baseplate-less modules require a TIM thickness of ~10-50µm, so a new thinner G-TIM with a high compressibility is necessary.

- New G-TIM (<200um) under development for baseplate-less modules.

- Respective mounting instructions still valid for all modules.

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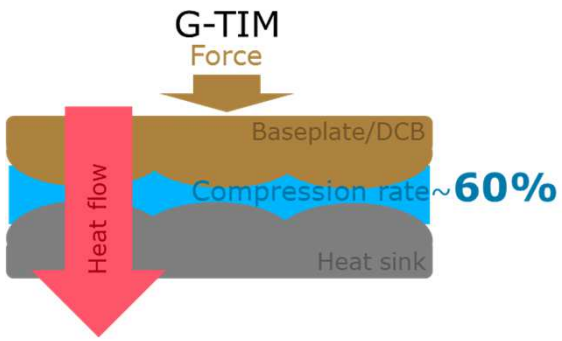
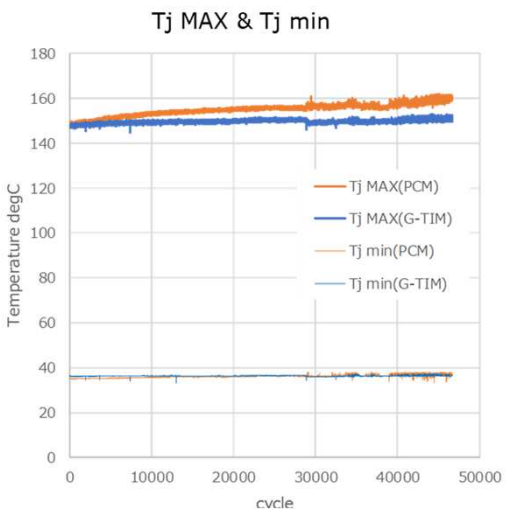
Conclusion





Thermal Performance

- With increased compression, G-TIM offers lower thermal resistance compared to standard graphite

Reliability Increase

- No TIM pump out with G-TIM
- Lower temperature swings with G-TIM vs. conventional TIM

Increased Cost

- Higher material cost than conventional TIM
- Increased handling effort

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Samples and Pairing with SEMIKRON Product

1	2	3	4	5	6	7	8	9	10	11	12
E	Y	G	S	0	9	1	8	Z	L	X	2

Suffix

Product Code
PGS Graphite Sheet

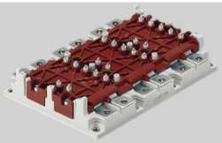
Style	
S	Standard type
R	High compressible type

Dimension	
0909	90 mm × 90 mm
0918	90 mm × 180 mm
1818	180 mm × 180 mm

Thickness of GraphiteTIM	
ZL	200 μm
	250 μm
ZR	350 μm

* Please contact us for custom-made products.

- Graphite TIM (G-TIM) is not offered by SEMIKRON
- Requests should be directly addressed to Panasonic
- Graphite Sheets are available for:

MiniSKiiP	SKiM	SEMITOP	SEMITRANS	SEMIX
				

- See: https://industrial.panasonic.com/ww/soft-pgs-cross

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