

Power Modules with Phase-Change Material

Handling of Power Modules with Pre-Applied Phase-Change Material

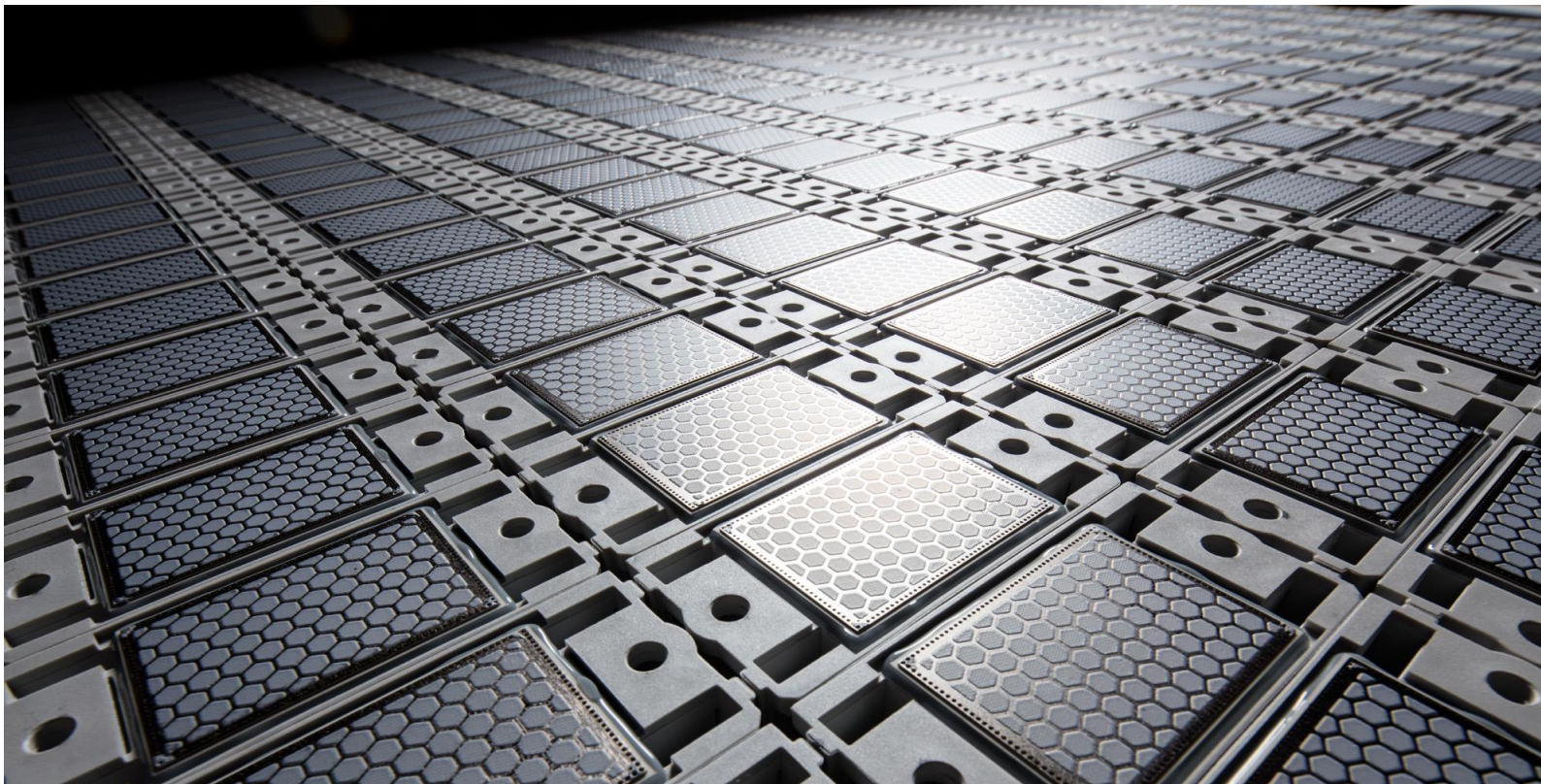


Table of Contents

1	Abstract	4
2	Introduction	4
3	The Phase-change Material	5
4	Vincotech Modules with Pre-applied PCM	6
5	Damaged PCM Layer / Allowed Deviations	8
6	Mounting / Assembly.....	9
7	Operation	10
8	Disassembly / Reuse	11
9	Labeling and Marking	12
10	Conclusion	13

Revision History

Date	Revision Level	Description	Page Number(s)
Nov. 2017	3	Added allowed PCM layer damages section	13 pages
April 2016	2	Added module constructions	12 pages
July 2012	1	First release	9 pages

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1 Abstract

There are several advantages to using phase-change material (PCM) rather than conventional thermal grease as the thermal interface material (TIM) between the power module and heatsink. Vincotech offers modules with a layer of pre-applied PCM. The thermal interface material is applied in a layer with uniform thickness by a screen-printing process. This document describes the benefits of this phase-change material and provides tips on handling modules.

2 Introduction

Heat has to be transferred from the module to the heatsink and thermal interface material is a necessary evil that gets the job done. However, thermal resistance increases if the layer is too thin or thick. Vincotech has addressed this issue by supporting modules with a pre-applied layer of phase-change material. The module's size and technology determines the layer's thickness.

The phase-change material is solid at room temperature, so it requires no special care during transportation, handling and application. Because of its thixotropic consistency, the material softens but does not flow when heated during soldering. The surface needs protection only if the power module's phase-change material comes into contact with other objects during or directly after soldering, for example, the soldering oven's carpet. The screen-printing process is precise, thereby maximizing heat-transfer capability.

The customer is spared the task of applying thermal interface material, thereby saving time and reducing the failure risk.

3 The Phase-change Material

Vincotech uses Loctite PSX-Pm phase-change material. It has the advantage that it can be applied by screen or stencil printing. It is fluid during the application and dries out over time and temperature. Once the phase-change material solidifies, the module may be handled like any conventional module. Key benefits include:

- Faster, easier module mounting
- Optimum thickness of the thermal interface material
- Improved R_{th} and reduced risk of DBC cracking
- Streamlined production; no need for screen-printing facilities
- Automated screen printing for utmost reliability
- No risk of smearing thermal paste; material is solid at room temperature
- Standard solder profile applicable (e.g. J-STD-001, J-STD-003)
- Compatible with Press-fit pins

The table below lists the phase-change material's physical and thermal properties. Please refer to the manufacturer's datasheet for more details.

Parameter	Value	Unit
Specific gravity	2	g/cm ²
Thermal conductivity	3.4	W/m*K
Phase-change temperature	45	°C
Viscosity above phase-change temperature	Thixotropic	
Color	Grey	

Table 1: Physical and thermal properties of the phase-change material

4 Vincotech Modules with Pre-applied PCM

Vincotech offers modules with a pre-applied layer of phase-change material as indicated in **Error! Reference source not found.** All modules are UL-listed; therefore modules with phase-change material are also UL-approved. They come in a standard blister box with a protective lid.

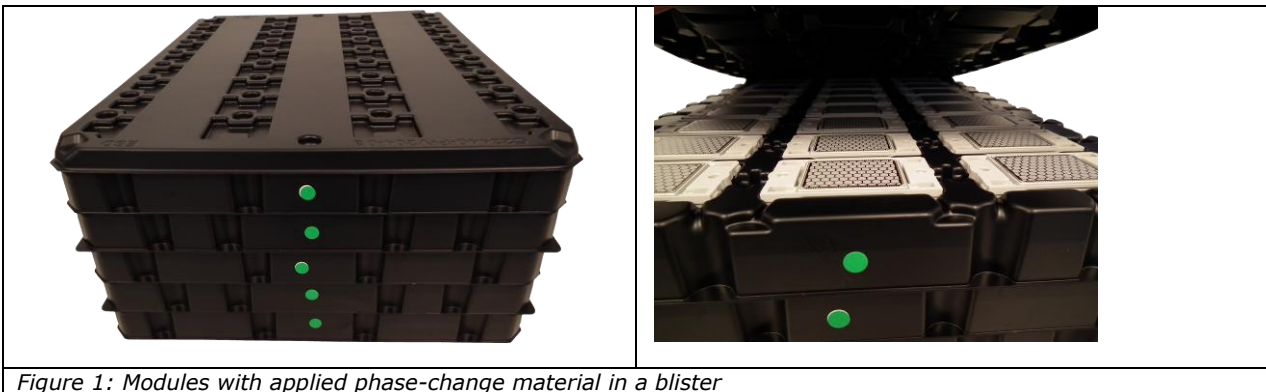


Figure 1: Modules with applied phase-change material in a blister

Modules must be stored in blister boxes under the following conditions:

- Temperature: $-25\text{ °C} < T < 60\text{ °C}$
- Relative humidity: $10\% < rH < 95\%$

No aging effect is known.

This compound was subjected to a battery of tests to verify its reliability.

Test	Conditions
High temperature storage	2 x 500 h @ 85 °C
High humidity and high temperature	2 x 500 h @ 85 % rH and 85 °C
Thermal shock test	100 x (30 min. @ 125 °C / 30 min. @ -40 °C)

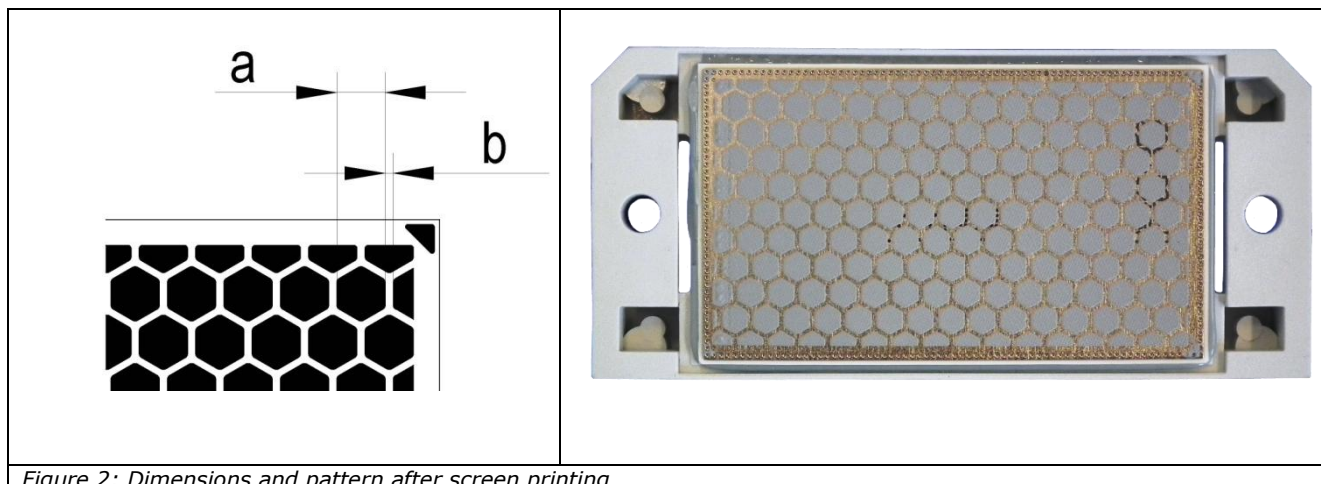
Table 2: Phase-change material reliability tests

All modules had phase-change material applied and were mounted vertically to an aluminum heatsink for these tests.

The following table and figures show the pattern, thickness and dimensions of the applied phase-change material at the back of the module after screen printing.

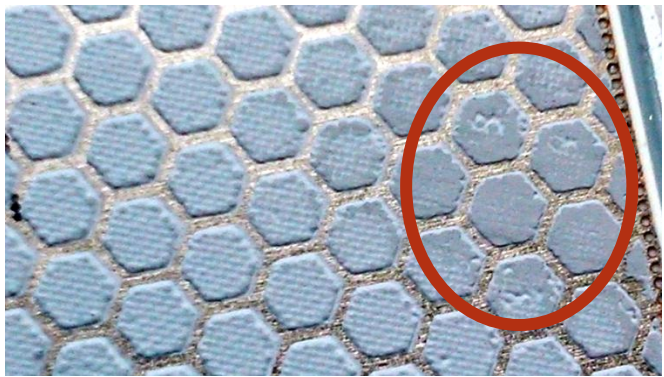
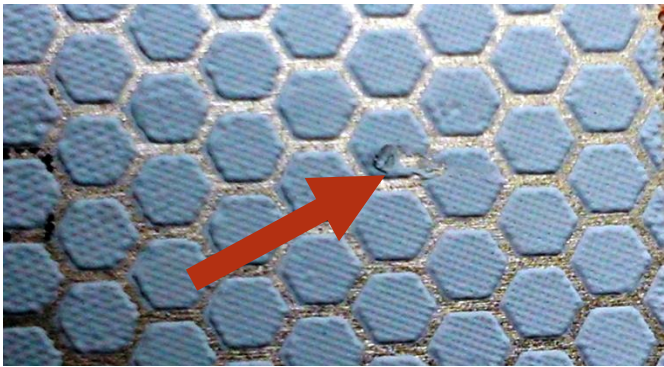
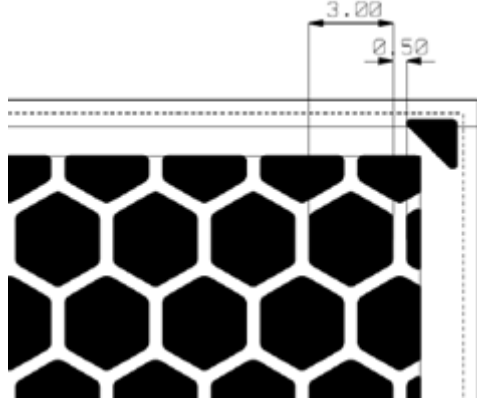
Type	Thickness				Cell size		
	Min.	Typ.	Max.	Unit	a	b	Unit
<i>flow 0</i> Al ₂ O ₃ DBC	30	55	80	µm	3	0,5	mm
<i>flow 1</i> Al ₂ O ₃ DBC	30	50	70		3	0,5	
<i>flow 1B</i> Al ₂ O ₃	70	90	110		3	0,5	
<i>flow90 0</i> Al ₂ O ₃ DBC	35	60	85		3	0,5	
<i>flow90 1</i> Al ₂ O ₃ DBC	45	70	95		3	0,5	
<i>flow 2</i>	80	110	140		2,1	0,5	
<i>flowSCREW 4w</i>	120	140	160		2,1	0,5	

Table 3: Dimensions after screen-printing



The small triangle at the top right of the printed phase-change pattern is one of four corner markers used to align the press-in tool for modules with Press-fit pins.

5 Damaged PCM Layer / Allowed Deviations

<p>Local discoloration or tiny scratches on top of the Phase-Change Material (PCM) layer has no negative influence on the thermal performance or the expected lifetime of the material and module.</p>	 <p><i>Figure 1: Local discoloration and tiny scratches</i></p>
<p>However large scratches where a portion of the material is dislocated can only be tolerated if;</p> <ol style="list-style-type: none"> 1) the width of one scratch does not exceed the distance of the honeycombs (0.5 mm for all flow modules) 2) and the total percentage of material dislocations is below the values given in Table 1. in proportion to the total surface covered with the PCM. 	 <p><i>Figure 2: Large scratch with material dislocation</i></p>
<p>In any case the PCM is damaged beyond specification there is no proper way to repair it. The module should be returned to Vincotech and a new layer of PCM has to be applied.</p>	 <p><i>Figure 3: Dimensions of the honeycomb pattern</i></p>

Package	flow0	flow1	flow2	P95x	P34x	flow90	flow90 0
max. damage ratio	9,1 %	8,0 %	5,5 %	4,4 %	6,7 %	7,1 %	8,3 %
max. damaged area	93 mm ²	150 mm ²	250 mm ²	72 mm ²	99 mm ²	94 mm ²	86 mm ²

Table 1: allowable damage

6 Mounting / Assembly

The module can be mounted to the heatsink after it has been soldered or pressed in. The procedure is the same as the standard mounting process described in the housing specifications or handling instructions, apart from one major difference: Screws to the heatsink can be fastened and tightened in a single step. The phase-change material is solid at room temperature, so screws can be tightened immediately without having to give the material any relaxation time.

Pictured below is a module with melted phase-change material assembled to an inspection block.

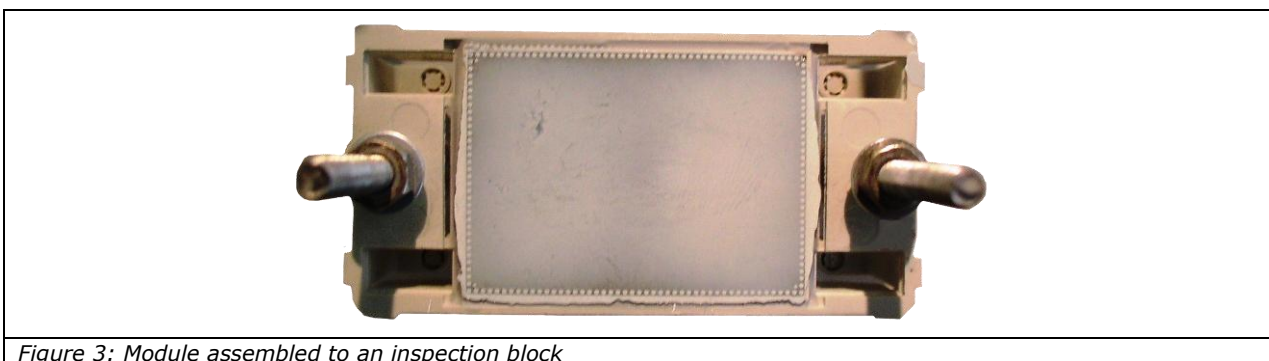


Figure 3: Module assembled to an inspection block

Please refer to each module's handling instructions to learn more about the heatsink properties, mounting and handling.

7 Operation

Upon initial start-up, the R_{th} between the junction and the heatsink of a system without soft material will be 10 % to 15 % higher than that of an operating system; that is, a system where the module is operating a temperature higher than 45 °C and the phase-change material has attained its ultimate thickness. The higher R_{th} is not a problem because the heatsink temperature is below 45 °C to 50 °C, a state at which chips cannot overheat. Time-to-melt is a function of temperature and the speed of temperature change. The material will not flow unless heat and force are applied.

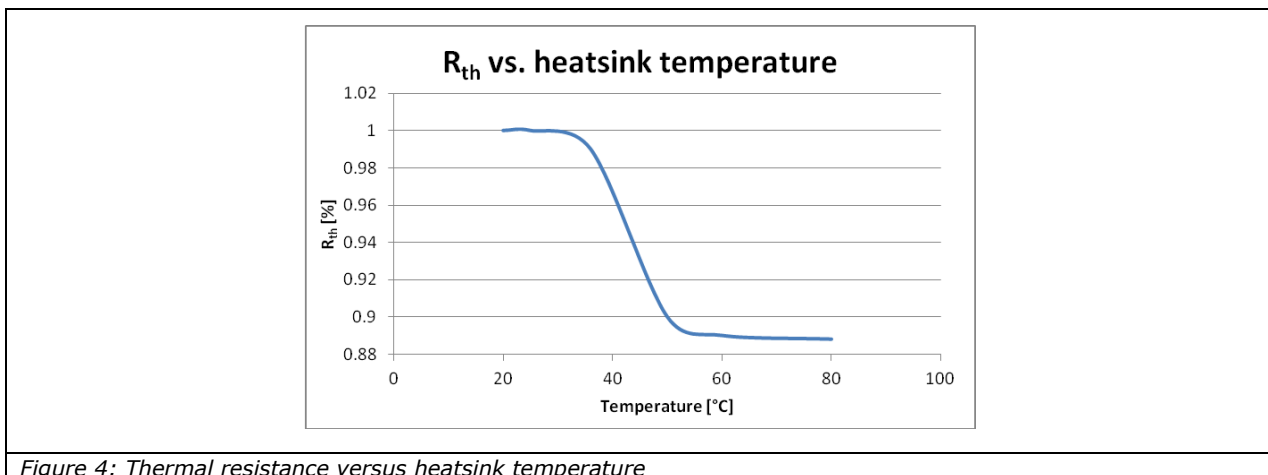


Figure 4: Thermal resistance versus heatsink temperature

Once the module has been mounted, the system should be heated up (e.g. during the system's burn-in test) while leaving enough time for the phase-change material to melt. If the temperature of the PCM exceeds 45 °C, the material will melt, fill gaps and after a short time provide an optimal thermal connection between the module and heatsink. Screws do not have to be tightened again.

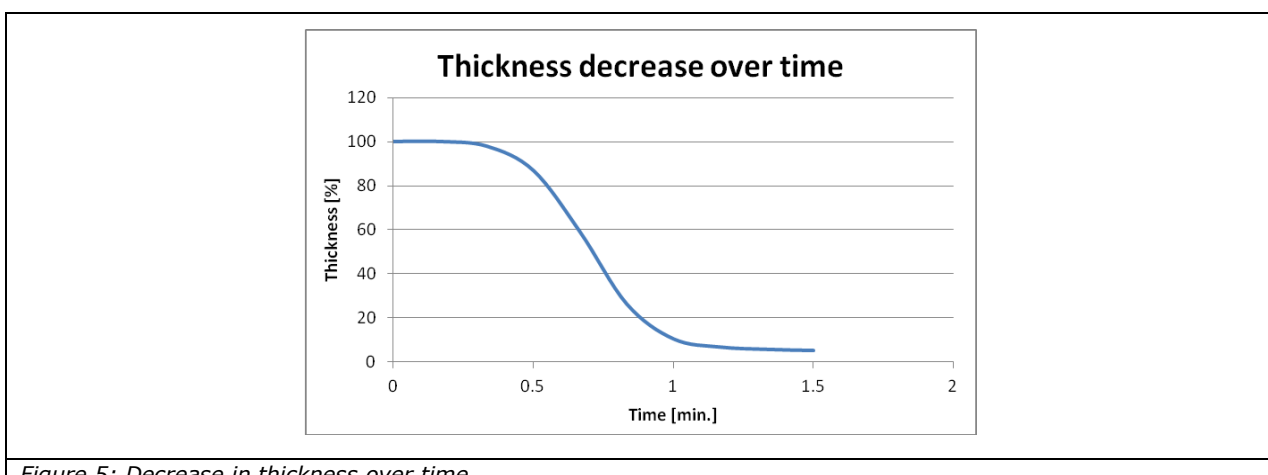


Figure 5: Decrease in thickness over time

The above curve shows how thickness decreases as the heatsink temperature increases at a rate of 15 K/min. with the temperature starting at 35 °C. The force applied to the phase-change material was around 100 kPa, which is below the *flow* modules' pressure handling capability and therefore leaves a margin for safety.

The phase-change material returns to its solid state when the temperature drops below 45 °C. This means the material's phase changes every time it reaches 45 °C.

8 Disassembly / Reuse

No special care has to be taken when removing the module from the heatsink. Simply loosen the screws and use a knife to lift the module from the heatsink. Standard isopropyl or other alcohol with similar properties may be used to clean the back of the module and the heatsink. A non-woven antistatic microfiber cloth is best for this purpose. It is not advisable to reuse the module without cleaning it first.

The picture below shows a disassembled module that had been in operation and its heatsink print.

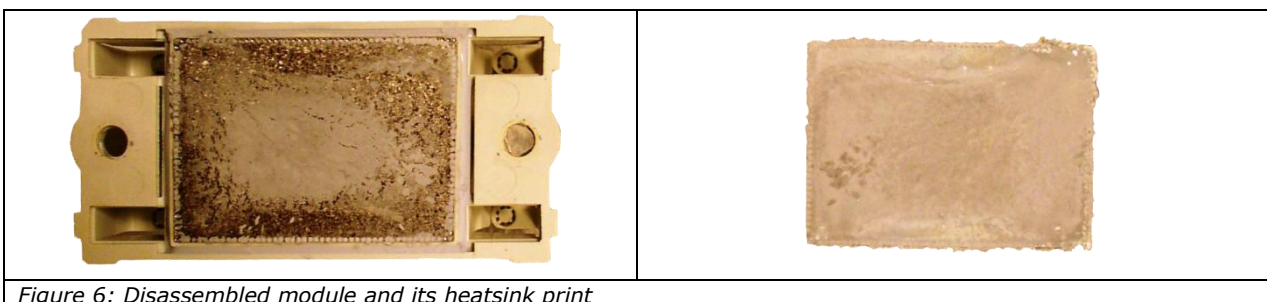


Figure 6: Disassembled module and its heatsink print

Standard thermal grease or the Loctite phase-change material described above can be applied before the module is remounted.

9 Labeling and Marking

All Vincotech modules come in a carton. The suffixes *-/3/* indicate that it contains modules with pre-applied phase-change material.



Figure 7: Label on carton

The part number printed on the module does not indicate that these modules come with phase-change material pre-applied.

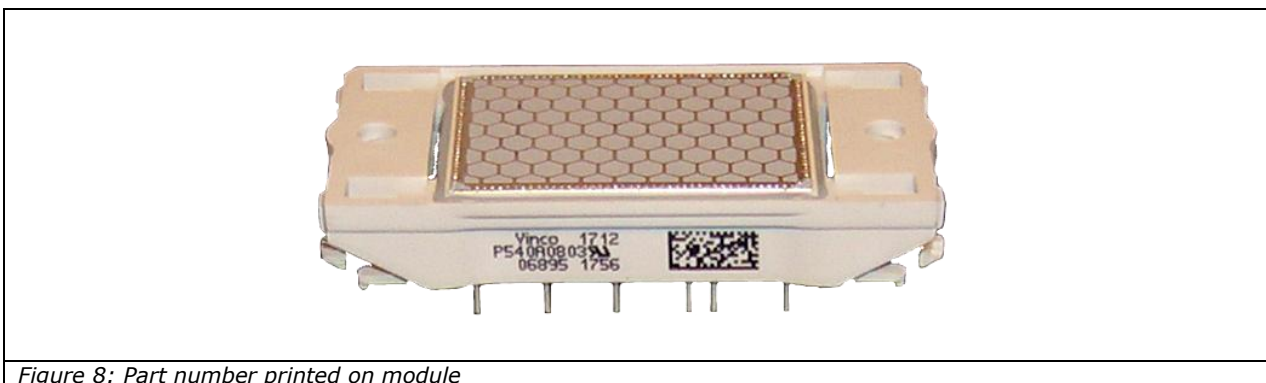


Figure 8: Part number printed on module

The "03" prefix to the RoHS indicates that this module is in revision status 03, and has no bearing on whether or not it comes with pre-applied phase-change material.

10 Conclusion

Vincotech offers modules with pre-applied phase-change material. This PCM is applied in a screen printing process that leaves an optimum and always consistent layer thickness. This phase-change material is thixotropic and therefore will not flow without the application of pressure. Standard soldering profiles may be used. A lid or a foil can prevent the phase-change material's surface from coming into contact with the soldering oven's carpet.

Power modules with Press-fit pins and phase-change material are compatible. Please refer to the module's handling instructions to learn more about this.