

Technical Explanation

Thermal Interface Materials (TIM)

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1. Introduction

SEMIKRON offers a broad range of pre-applied Thermal Interface Materials (TIM) for a wide product range. The TIM materials are applied to the power modules by SEMIKRON's automated screen and stencil printing process prior to delivery to the customer.

Silicone and silicone-free as well as phase-changing Thermal Interface Materials are available. TIM materials with best-in-class thermal performance are High Performance Phase Change Material (HP-PCM) for baseplate modules (silicone-free) and the High Performance Thermal Paste (HPTP) for baseplate-less modules (silicone-based). These two TIM materials are highly recommended to achieve the maximum module performance.

The major advantages of using modules with pre-applied TIM are:

- Best possible heat dissipation, i.e. low thermal resistance thanks to position-dependent optimized TIM layer pattern
- Easy and fast assembly of the module
- Increased productivity due to reduced handling costs and logistics
- Outsourcing of a "dirty" manufacturing process
- Optimized and reproduceable thickness of thermal paste layer, which drastically reduces the risk of damaging the DBC while providing the lowest thermal resistance at the same time
- Excellent long-term stability thanks to the use of well proven TIM materials

2. Technical Details

The modules with pre-applied Thermal Interface Material are printed in a clean environment on an automated and SPC controlled silk screen or stencil printing manufacturing line. The amount of TIM printed on the module surface can be found in the datasheets entitled "typical thickness" or "typical weight". The value for the thickness is valid after the module is mounted and the thermal paste has been distributed evenly across the entire bottom surface of the module. If the weight is stated in the datasheet, an inhomogeneous pattern is applied to the module. For these patterns, it is not applicable to define the amount of TIM material by a thickness as the calculated resulting thickness is not constant over the printed surface.

The thermal resistance values $R_{th(j-s)}$ for baseplate-less and $R_{th(c-s)}$ for baseplate modules specified in the module data sheets are valid for the standard thermal paste material WACKER® P12 (thermal conductivity $\lambda=0.81 \text{ K/(W*m)}$). If a module is applied with HP-PCM (High Performance Phase Change Material, $\lambda=8.5 \text{ W/(m*K)}$) or HPTP (High Performance Thermal Paste, $\lambda=2.5 \text{ W/(m*K)}$), the thermal resistance $R_{th(c-s)}$ or $R_{th(j-s)}$ will be lowered. Therefore, a second lower R_{th} value is specified in the datasheet.

Moreover, for heatsink rated modules without baseplate like MiniSKiiP, SKiM and SEMITOP the output current I_c is directly dependent on the thermal resistance $R_{th(j-s)}$ which includes the TIM layer. In consequence, also for the output current I_c two values are given. One value for the standard material WACKER® P12 and one for HPTP. It is worth mentioning that the thermal conductivity λ or the name of the TIM material is used to differentiate between the two values for the thermal resistance and/or for the output current.

2.1 TIM Materials

Phase Change Material	Thermal Paste
Available TIM types: – HALA P8 – HALA HT – HP-PCM Characteristics: – aluminum particles as thermal conductive filling material – wax or wax-resin as carrier matrix – solvent for the processability Phase Change Material are typically offered for baseplate modules only. One exception is SEMITOP E1/E2 where both options, thermal pastes and phase change materials are offered. Phase change material compounds consist of substances mentioned above and are pasty prior to the application. The material is applied via screen or stencil printing process followed by a heating process which ensures that all solvents are evaporated. After the processing onto the power module the material is stiff like candle wax at room temperature but exhibits a low viscosity at temperatures above 40-50°C. At these higher temperatures, the material begins to flow under pressure and wets the contact surface between the heat sink and the baseplate. The benefit of phase change materials is their rigid consistency during handling, where accidental contact does not necessarily damage the printed design.	Available TIM types: – P12 – HPTP Characteristics: – metal oxide particles as filling material – silicone as carrier matrix – no solvents Thermal pastes are typically offered for baseplate-less modules only. The materials are applied via screen or stencil printing process. An additional heating process is not required. The main advantage of using a thermal paste instead of a phase change material is the reduced mechanical stress during the assembly process. For some module types, such as the MiniSKiiP and the SKiM modules, the use of a thermal paste instead of a phase change material is essential due to the increased risk of DCB fractures with phase change materials during mounting. In addition, baseplate-less modules often require very low thermal paste layer thicknesses of less than 20µm. Only a thermal paste can be pressed with moderate force into a very thin, homogeneous layer right at the module assembly.

2.2 Print pattern tolerances

The application of TIM materials is subject to a process-related variation in the amount of material applied. The resulting upper and lower limits are checked as part of the qualification and release tests.

The type of attachment process also entails a variation in print positioning, but this has no influence on the assembly process or the subsequent thermal properties.

In addition, slight errors in the print structure may occur during the printing process, which are acceptable. The maximum permissible deviation in the size of the honeycomb structure is $\sim 10\ldots 15\%$.

A slight sub-surface migration of thermal interface material may occur on the stencil. Consequently, there may be an optical change in the printed pattern, which, however, has no technically relevant influence on the thermal properties of the module.

For more information about good and bad parts, please refer to chapter 10.

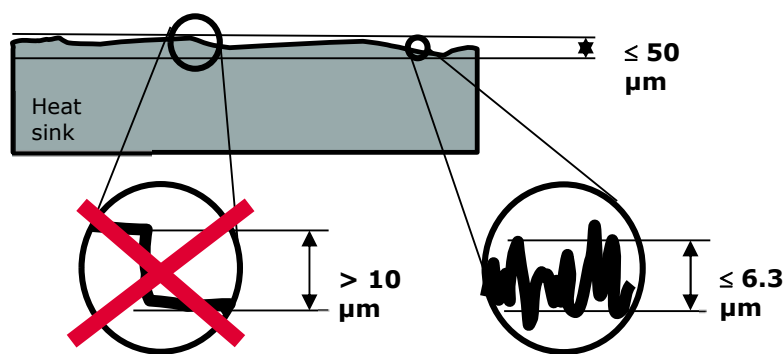
2.3 Surface specification for the heat sink

To achieve a good thermal connection between the module and the heat sink and to support optimal heat transfer, the heat sink must meet the following specifications (see Figure 1).

It is recommended that the cooler is milled by a carbide indexable insert. This tooling method delivers the best result with a typical surface roughness of $\sim 1\text{--}3\mu\text{m}$.

- Heat sink must be free from residues, particles or dust
- Evenness $\leq 50\mu\text{m}$ on 100mm (DIN EN ISO 1101)
- Roughness $R_z: \leq 6.3\mu\text{m}$ (DIN EN ISO 4287)
- No steps $> 10\mu\text{m}$

Figure 1: Surface specification



3. Qualification Tests

The qualification process of a TIM material is a complex and lengthy process to minimize premature ageing, pump-out effects and other risks. Good thermal conductivity alone is not a sufficient quality indicator.

Thermal Interface Materials are applied to different qualification tests to quantify the max. shelf life during storage and transport of modules inside the blister packaging and to prove the reliability of assembled modules in the application. The TIMs are tested according to IEC 60068-2-xx for environmental conditions (like high and low temperature storage, according to IEC 60721-3-1 for minimum 12 Month in a shelf-life test and according to IEC 60749-49 in power cycle tests.

3.1 Typical qualification tests for shelf life of pre-printed modules inside blister

Tests	Tests		Standard
	P12	P8, HT, HPTP, HP-PCM	
High-Temperature Storage	✓	✓	IEC 60068-2-2 Bb
Low-Temperature Storage	✓	✓	IEC 60068-2-1 Ab
Climatic Change	Not applied	✓	Close to IEC 60068-2-38
Pass Criteria	R _{th} measurement after test within spec, mounting according to mounting instruction ok		Close to IEC 60747-9
Shelf Life	18 months inside blister, conditions: -25°C...+60°C, 5...95% r.h.	24 months inside blister, conditions: P8: 5°C...+40°C, 5...85% r.h. HT: -25°C...+60°C, 5...85% r.h. HP-PCM: -25°C...+60°C, 5...85% r.h. 12 months inside blister, conditions: HPTP: 5°C...+40°C, 5...85% r.h.	IEC 60721-3-1

3.2 Typical qualification tests for reliability (module mounted on heat sink)

Tests	Tests	Standard
	P12, P8, HT, HPTP, HP-PCM	
High-Temperature Storage	✓	IEC 60068-2-2 Bb
Low Temperature Storage	✓	IEC 60068-2-1 Ab
High Humidity, High Temperature Storage	✓	IEC 60068-2-67
Climatic Change	✓	Close to IEC 60068-2-38
Power Cycling Test	✓	IEC 60749-34
Temperature Cycling Test	✓	IEC 60068-2-14 Na
Pass Criteria	R _{th} measurement before and after storage test/thermal cycling criteria: variation of thermal resistance within spec, For Power Cycling EOL reached at R _{th} +20%	Close to IEC 60747-9

4. Operation, Storage and Transportation conditions

TIM	P12	HPTP	HT	P8	HP-PCM
Shelf life conditions	18 month inside blister conditions: -25°C...+60°C, 5...95% r.h.	12 month inside blister 1K2 conditions: 5°C...+40°C, 5...85% r.h.	24 month inside blister 1K2 conditions*: -25°C...+60°C, 5...85% r.h.	24 month inside blister 1K2 conditions: 5°C...+40°C, 5...85% r.h.	24 month inside blister 1K2 conditions*: -25°C...+60°C, 5...85% r.h.
Max. storage or transport temperature **	+55°C	+55°C	+55°C	+55°C	+55°C
Max. operation temperature T _{op} tested in assembled state and according to standard test conditions ***	+125°C****	+125°C****	+125°C	+105°C	+125°C

* shelf life conditions according to climatic class 1K2 but with extended temperature range

** limited by the blister packaging

*** for baseplate-less modules: T_{op} to be measured on heatsink, for baseplate modules: T_{op} to be measured on baseplate

**** max. temperature used in test, silicone-based pastes like **P12** and **HPTP** can handle temperatures of **180...200°C**

It is generally recommended that modules with pre-applied Thermal Interface Material are stored at room temperatures with low humidity (air conditioned if necessary).

5. Production Handling

Phase Change Material	Thermal Paste
Phase Change Materials applied on a baseplate of a power module are solid at room temperature and only change to a paste-like consistency when the module is heated to above 40-50 °C (e.g., during burn-in or initial operation). Contamination with dust or particles can easily be removed from the solid layer. Please use a brush tool to remove any contaminations. Damage to the printed phase change material pattern by e.g., accidental touching or moving over the heatsink is not likely to occur, unless a force is applied.	Power modules without base plates that have been provided with thermal paste must be handled carefully because of the pasty TIM layer. Accidental touch will smudge the printed pattern and may impact the performance. A contamination with particles can be removed by using a tweezer tool.

To avoid contamination of the printed TIM surface with particles and dust, the blister packaging should be opened at the earliest at the time of module assembly. To open the blister pack, please follow the instructions in chapter 4.3.

5.1 Packaging units

Following table shows the packaging unit size for each module family and housing size:

Module	Quantity per packaging blister	Module	Quantity per packaging blister
Mini II 0	66	SEMITOP E1	28
Mini II 1	40	SEMITOP E2	20
Mini II 2	24	SEMITRANS 2	10
Mini II 3	16	SEMITRANS 3	6
Mini II 2GB	24	SEMITRANS 10	2
Mini II 3GB	16	SEMITRANS 20	1
Mini I 8 small	15	SEMiPACK 2	10
Mini I 8 big	12	SEMiX 1s	8
SKiM 63	4	SEMiX 2s	6
SKiM 93	4	SEMiX 3s	6
SKiM 4	4	SEMiX 13	4
SKiM 5	2	SEMiX 33	2
Semitop 2	56	SEMiX 3p	6
Semitop 3	35	SEMiX 5p	4
Semitop 4	20	SEMiX 6p	6

5.2 Surface cleaning

Before mounting the module on the heat sink, make sure that the heat sink surface is free from contamination, foreign particles or dust. A lint-free cloth with isopropanol is recommended for cleaning the surface. In case of module replacement, any residues of thermal paste or phase change material on the contact surfaces should also be removed with isopropanol and lint-free cloths before mounting the replacement part.

5.3 Opening blister packaging

- The surrounding environment must be clean and free of dust.
- The blister should remain closed during production stops to avoid contamination.
- The TIM pattern should be free of contamination and the print pattern should not be damaged.
- Larger sized particles which are visible to the naked eye can be removed by using tweezers.

All parts are subjected to a final optical inspection. In case of contamination with particles or damage to the print image, please refer to the catalogue to find out which parts must be sorted out. (see chapter 9).

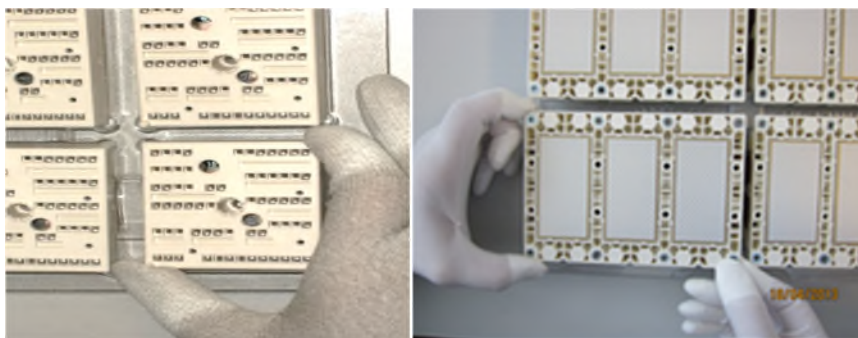
5.4 Removing modules from the blister packaging

All ESD regulations for electronic components (IEC 61340-5) must be observed when removing the modules from the blister packaging as well as for further handling steps. ESD gloves must be worn when handling the modules. Contamination of the modules with thermal paste or hand perspiration must be always avoided. For easier removal of the modules from the blister packaging it is recommended for MiniSKiiP® that the package is turned before removal so that the spring pins (upper side of modules) are visible (see Fig. 2 and 3). For SKiM®63/93 it is recommended to turn the package so that the printed DBC is visible. Then the blister package can be opened, and the module can be taken out.

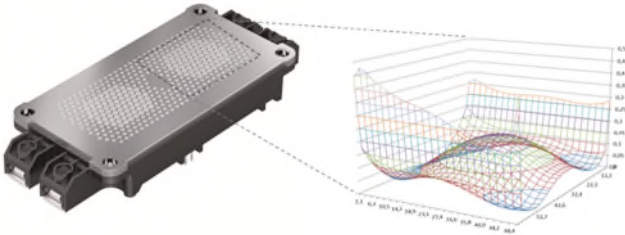
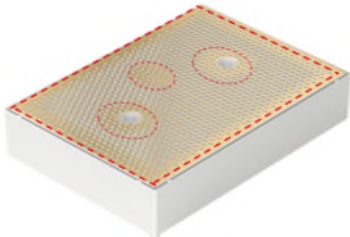
Figure 2: MiniSKiiP and SKiM63/93



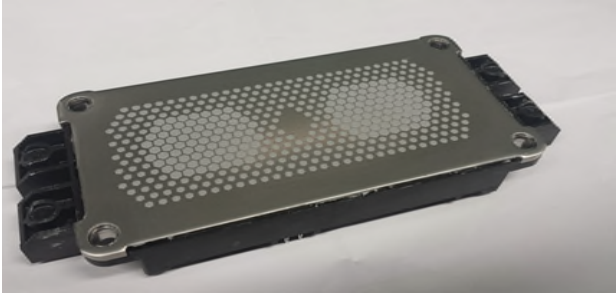
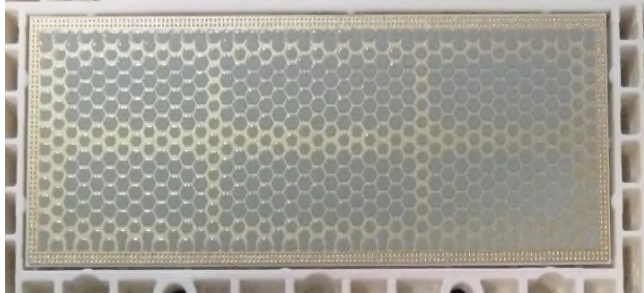
Figure 3: Removal of MiniSKiiP and SKiM63/93



6. Mounting

Phase Change Material	Thermal Paste
Phase change materials are typically applied on baseplate modules only. For each module baseplate a certain print pattern layout is developed according to the baseplate bending (see Fig.4). This layout ensures a direct metal-to-metal contact of the module baseplate and heat sink. Only the air gaps created by the bending of the modules and the roughness are filled with thermal interface material. This approach leads to two main advantages: - Thermal resistance $R_{th(j-s)}$ is optimized - No need to retighten the screws after melting the phase change material  Fig.4: Print pattern according to baseplate bending For each module family (e.g. SEMITRANS, SEMiX) mounting instructions are given. These mounting instructions with prescribed values for mounting torque and speed will not change when the modules have been applied with phase change material. After mounting the module on the heat sink and initial heating, the phase change material melts above a module baseplate temperature of 40-50°C and fills the bend and roughness. Result: -Mounting according to existing Mounting Instructions -Even if the material is melted and spread, the fastening screws of the module do not have to be retightened at any time.	Thermal Pastes are typically applied on baseplate-less modules only. For standard thermal pastes like WACKER® P12 a homogeneous honeycomb pattern is applied underneath the DBC (see Fig.5). Target is to gain a well distributed TIM layer between DBC and cooler without any air voids.  Fig.5: MiniSKiiP3 – homogeneous print layout – STANDARD TIM The module must be mounted according to the given module specific mounting instructions. After the module assembly the thermal paste distributes and fills out the roughness and the bending of the module. The High Performance Thermal Paste (HPTP) has a higher viscosity compared to standard pastes like WACKER® P12. To reduce mechanical stress during the assembly process the print pattern has been adapted by applying less material on the pressure areas of the module (see Fig.6)  Fig.6: – Optimized print layout – High Performance Thermal paste (HPTP) Result: -Mounting according to existing Mounting Instructions -The optimized print pattern allows to apply always the same mounting procedure independent from the thermal paste type

7. Evaluation of imprint pattern

Phase Change Material	Thermal Paste
The pictures below show the <u>typical appearance</u> of baseplate modules applied with phase change materials: - Fig.7 before mounting - Fig.8,9,10 after mounting and thermal cycling  Fig.7: Typical baseplate module+TIM before mounting Mounting and heat-up procedure: - Mount the module according to mounting instructions on the heat sink - Perform 3 thermal cycles 20/90°C: <u>Option 1:</u> Put the heat sink with the mounted module e.g. on a heating plate and increase the temperature as fast as possible up to 90°C. As soon as the upper temperature has been reached it can be removed from the heating plate and should be cooled down as fast as possible back to ~20°C. Repeat this procedure at minimum 2 times. <u>Option 2:</u> Apply approx. 50-80% of the nominal module DC current that the baseplate can heat up to a temperature of 90°C. Then cool down after down to a baseplate temperature of ~20°C. Both options give the material the opportunity to melt, spread out and evenly distribute. Evaluation of print pattern: - Dismount the module and lift it carefully off the heat sink - For baseplate modules it is not mandatory that the TIM material is completely spread out over the whole baseplate area. Only in the central area of the module it should be ensured that the honeycombs have disappeared, and the material is well distributed. (Fig.8) - Especially the area around the mounting holes and the module edges are free of TIM material that metal-metal contacts can be established. This approach results in optimal thermal resistance and no need for retightening.	The pictures below show the <u>typical appearance</u> of baseplate-less modules applied with thermal paste: - Fig.11 before mounting - Fig.12,13,14 after mounting and thermal cycling  Fig.11: Typical baseplate-less module+TIM before mounting Mounting and heat-up procedure: - Mount the module according to mounting instructions on a heat sink - Perform 3 thermal cycles 20/90°C: <u>Option 1:</u> Put the heat sink with the mounted module e.g. on a heating plate and increase the temperature as fast as possible up to 90°C. As soon as the upper temperature has been reached it can be removed from the heating plate and should be cooled down as fast as possible to ~20°C. Repeat this procedure at minimum 2 times. <u>Option 2:</u> Apply approx. 50-80% of the nominal module DC current that the heat sink can heat up to a temperature of 90°C. Then cool down to a heat sink temperature of ~20°C. Both options give the material the possibility to spread out and evenly distribute. Evaluation of print pattern: - Dismount the module (unscrew, wait 24 hours till the module can be taken off easily without separation of the DBC and the module housing) - it is mandatory that <u>the predominant part of the DBC surface</u> (except the DBC edges with the dimples) <u>and the cooler area</u> is wetted with TIM material. All honeycombs should have touched the heat sink surface or better completely disappeared. - An optimal imprint pattern is given if the honeycombs have disappeared, and the thermal paste has spread evenly and without air voids (Fig. 12). Significant air voids increase the thermal resistance and lead to an increase in chip

- Figure 9 shows a suboptimal imprint pattern after disassembly, where the TIM material has not fully spread after three thermal cycles. But the largest baseplate bend under the chips is filled with TIM material and all honeycombs have touched the heat sink surface. It is likely that the distribution of TIM material will continue to improve with further heat or power cycles.
- Figure 10 shows an unacceptable imprint pattern after disassembly. Even though 3 thermal cycles were performed the TIM material has filled out the baseplate bending insufficiently. Most of the combs are still visible.
- It should also be noted that the imprint patterns are strongly dependent on the TIM materials used. A HALA P8 and a HP-PCM already distribute after one or two temperature cycles, while a HALA HT requires far more cycles for a comparable distribution. Pictures below show modules with HALA P8.

Imprint pattern:

Typically Good:

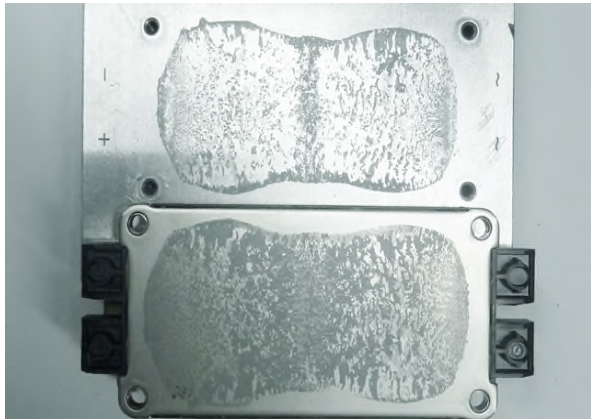


Fig.8: After 3 thermal cycles 20°C/90°C and disassembly

- temperature during operation. Figure 13 shows a still acceptable but not optimal imprint pattern. Some areas with honeycombs are still visible but all of them have already touched the heat sink. It can be supposed that during the next 10 power cycles these air voids will fully disappear.
- Picture 14 shows an unacceptable imprint pattern. Large areas of honeycombs have even not touched the cooler. It is not expected that any load cycles will close these air voids.

Please note: On baseplate-less modules, a well and homogeneous distribution of the TIM material is of greater relevance compared to baseplate modules. The reason for this is that there is no copper plate available for thermal spreading and any air inclusion can lead to a thermal overload of the component.

Imprint pattern:

Typically Good:



Fig.12: After 3 thermal cycles 20°C/90°C and disassembly

Typically not optimum but still acceptable:

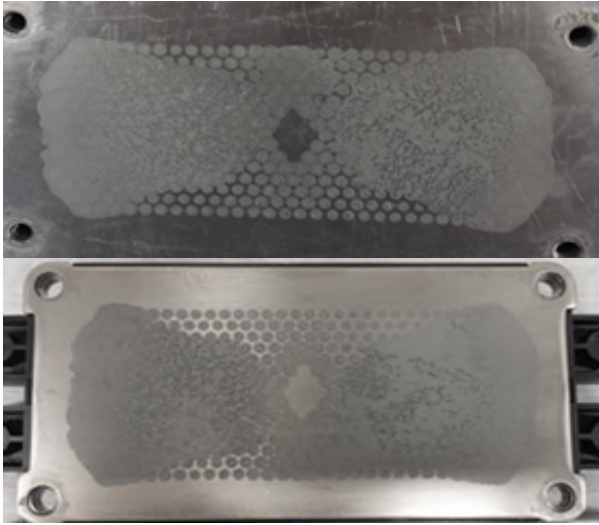


Fig.9: After 3 thermal cycles 20°C/90°C and disassembly

Typically not optimum but still acceptable:

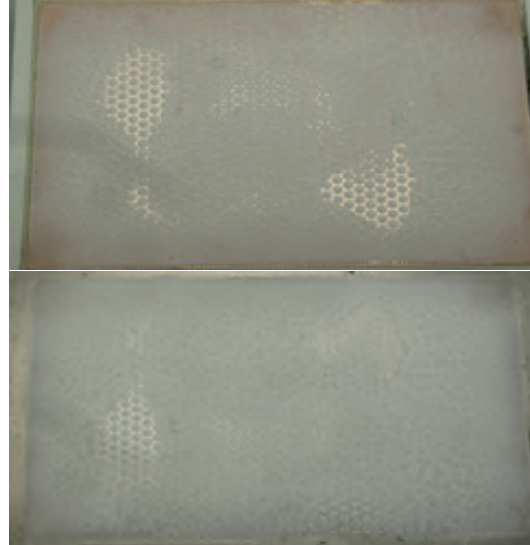
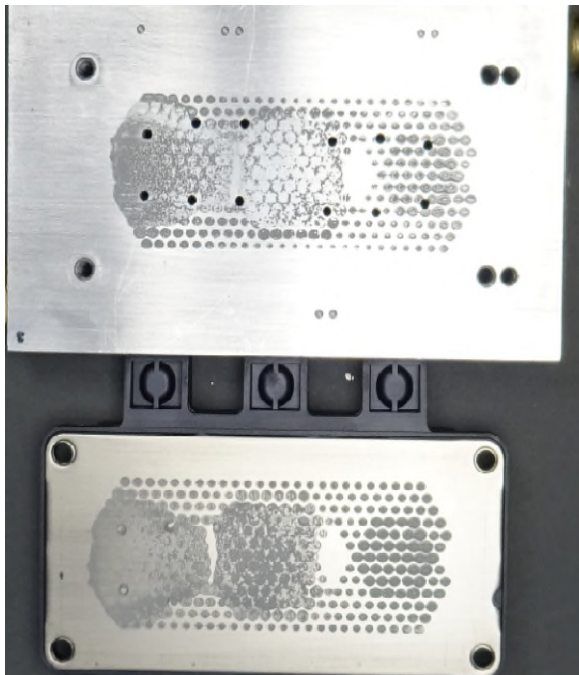


Fig.13: After 3 thermal cycles 20°C/90°C and disassembly



Typically not acceptable:

Fig.10:After 3 thermal cycles 20°C/90°C and disassembly

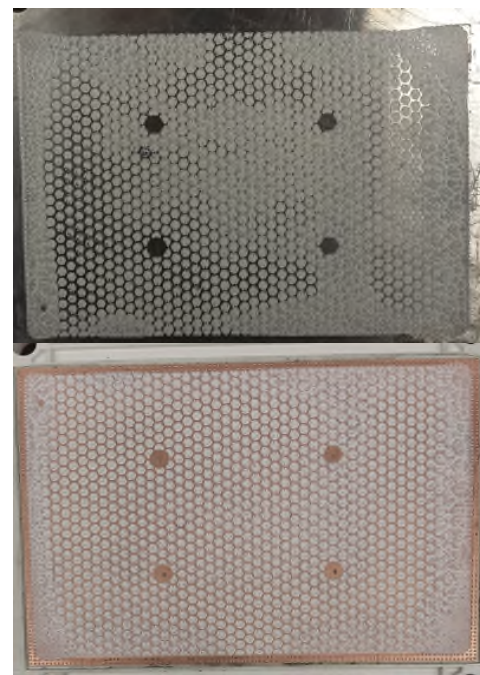
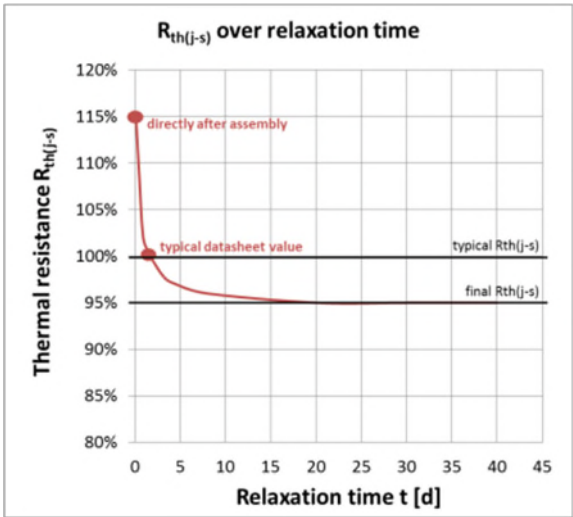


Fig.14: After 3 thermal cycles 20°C/90°C and disassembly

If assembly tests have been carried out and the imprint pattern after disassembly shows a poor connection between module and heat sink, as shown in Figs. 10 and 14, this is usually due to a deviation of the cooler surface from the specification (See chapter 2.3).

To verify a proper thermal connection, it is recommended to determine the thermal resistance between module and heat sink $R_{th(j-s)}$.

8. First time of operation

Phase Change Material	Thermal Paste
After the power module has been mounted to the heat sink according to the Mounting Instructions, it can be put directly into operation with nominal current. The $R_{th(j-s)}$ of the module is higher directly after assembly than after melting and distribution of the phase change material. The melting process already starts at a temperature of $T_c=40-50^{\circ}\text{C}$, so $R_{th(j-s)}$ drops very quickly and does not cause the junction temperature to exceed the desired steady-state value under nominal load conditions. Nevertheless, thanks to relaxation and distribution effects, the $R_{th(j-s)}$ will slightly improve during the first heat up/cool down phases. The final $R_{th(j-s)}$ is typically reached after the first 50-100 power cycles. In consequence, a certain load pattern or burn-in process is not required if the power module is not exposed to a high overload condition during the first time of operation.	After the module has been mounted to the heat sink according to the Mounting Instructions, it can be put into operation. After the assembly of a baseplate-less module, the thermal paste starts to spread out and distributes evenly. In this stage, the initial thermal resistance $R_{th(j-s)}$ is approx. 15-20% above the final $R_{th(j-s)}$. Thanks to a "settling process" this R_{th} improves significantly with an exponential curve progression over time until the final $R_{th(j-s)}$ is obtained after several days (see Fig.15). Thermal pumping effects induced e.g. by thermal cycles or active power cycles will accelerate this settling process. Subsequently, it is recommended to wait 1 to 2 days before applying full load to the power module which is typically the case between production and commissioning. Alternatively, the same result can be achieved by a burn-in with about 75% of the full load in the beginning and 3...5 temperature cycles. For reference: The data sheet values for $R_{th(j-s)}$ is measured after 3 thermal cycles at a liquid cooled heatsink from 20°C to 90°C. This corresponds to a relaxation time of approx. 2 to 5 days.  Fig.15: Typical thermal resistance over relaxation time

9. Labelling

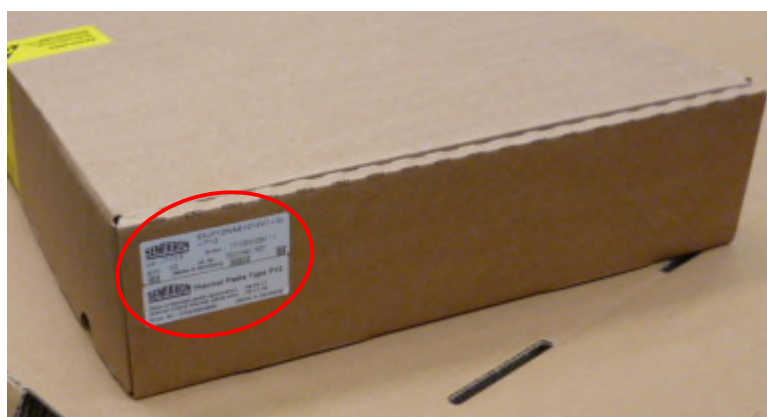
9.1 Labelling on delivery packaging

At least one module label with the module designation is affixed to each delivery packaging. (Fig. 16)
As soon as the modules are delivered with pre-applied TIM, a variant code within the module label (Fig. 17, 1.) and an additional label for the TIM material indicate this.

Following the variant codes for the TIM materials (first digit identifies accessories, **second digit** identifies the TIM material):

- M01 – WACKER® P12
- M04 – HALA P8
- M05 – High Performance Thermal Paste (HPTP)
- M06 – HALA HT
- M07 – High Performance Phase Change Material (HP-PCM)

Figure 16: Position of type label on delivery boxes



The 2 labels contain the following items:

Figure 17: Type label on paper box



Part No: **1. 25230650 | M25**
 Part Name: **2. SKiiP 38NAB066V1**
 Quantity: **3. 48** Unit: PCE
 1. Batch: DE231100 **4.**
 Order Code: 2211DE009450 **5.**
6.

SEMIKRON

Date Code:
23110
Made in
Germany

Label for the
module

SEMIKRON

7. Thermal Paste HPTP

Date of thermal paste application : 20.03.2023 **8.**
 Advice! Check thermal paste after : 20.03.2024 **9.**
 Storage conditions: 1K2 (+5°C...+40°C, 5%...85% r.H.) **10.**
 Prod.-No. : 22DE05610210 **11.**



12.

Label for the
TIM material

Module label:

1. Part number and variant code
2. Product type designation
3. Quantity on modules inside the card box
4. Module Production Batch number - 8 digits: DEYYWWLL (DE=country of manufacturing, YY=Year, WW=Week, LL=Lot of same type per week)
5. Order Confirmation number / Item on Order Confirmation
6. Barcode contain all information which are listed under 1. -5.

TIM Label:

7. Type of pre-applied TIM Material
8. TIM Material application date
9. Shelf-life expiry date
10. Recommended storage conditions
11. TIM Production Batch number
12. Barcode contain TIM Production Batch number

Bar Code in compliance with:

- Standard: EEC 200
- Format: 19/9

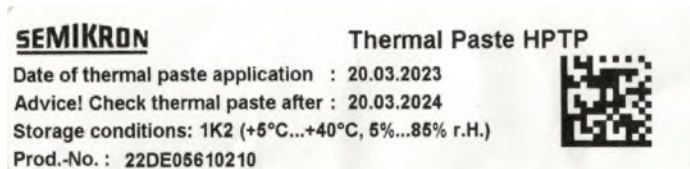
9.2 Labelling on blister packaging

If the modules come with a pre-applied TIM material, there will be a second same label for the TIM material on the blister itself in addition to the labels on the outer box.

The label gives information about the date of application and the date of expiry (Fig. 18).

An additional sealing label warns against opening the blister too soon before use (Fig.19). Both are fixed to the blister packaging (Fig. 20).

Figure 18: Label with date of expiry



Type of TIM Material:

P12:	WACKER® P12	(Shelf life: 18 month)
P8:	HALA P8	(Shelf life: 24 month)
HPTP:	High Performance Thermal Paste	(Shelf life: 12 month)
HT:	HALA HT	(Shelf life: 24 month)
HP-PCM:	High Performance Phase Change Material	(Shelf life: 24 month)

The specified shelf life represents a guaranteed minimum shelf life of the pre-applied TIM material, under the assumption that the storage conditions have been complied with.

After the date of expiry, the TIM material is not necessarily unusable. Depending on the storage conditions (preferably dry and cool), the modules with the pre-applied TIM material could still be used. For this purpose, it is recommended to evaluate the print pattern as shown in "chapter 7."

Figure 19: Advice label on blister packaging



Figure 20: Position of labels on blister packaging

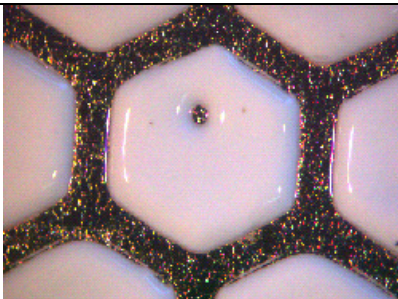
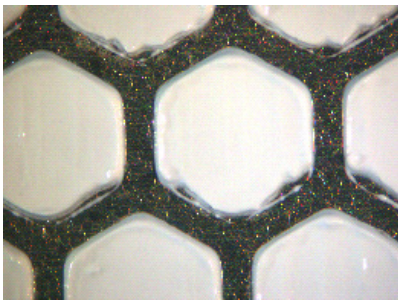
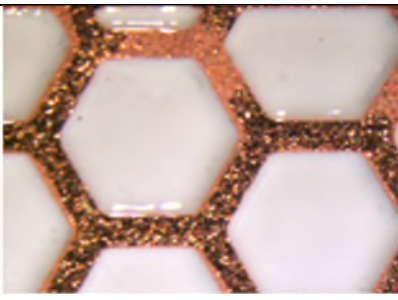


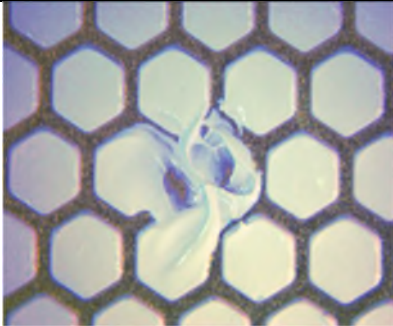
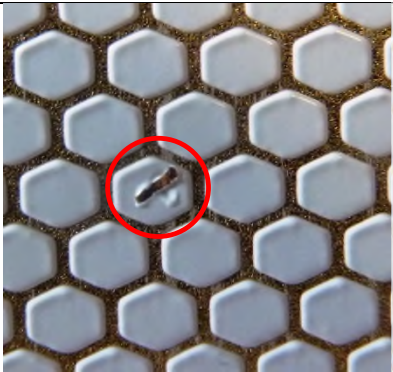
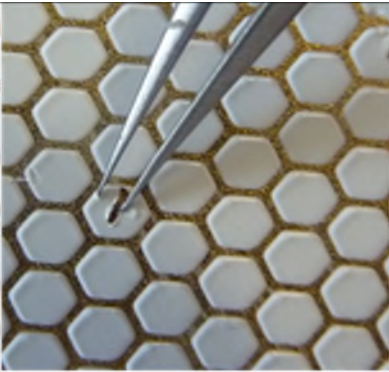
10. Catalogue acceptable / non-acceptable parts

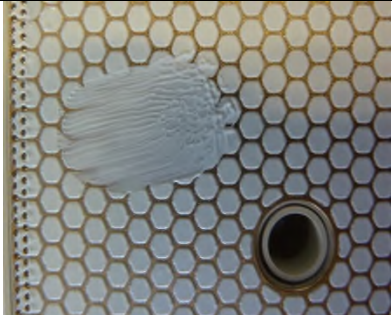
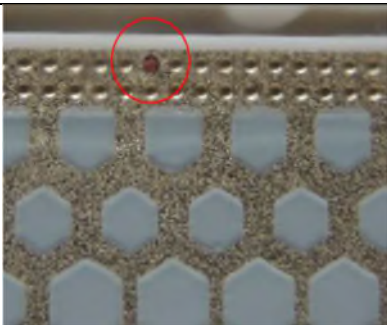
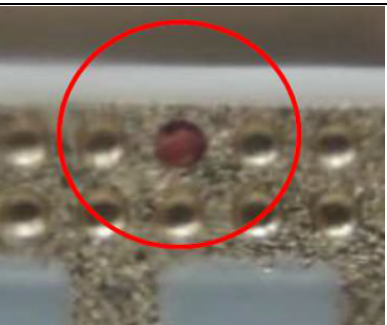
The TIM application process is done in a separated, controlled environment and the printing process is subjected to an automated process control which ensures a consistent and reproducible printing quality. **Despite all precautions a minor deviation or contamination of the printing pattern cannot completely avoided and therefore does not constitute a cause for complaints.**

The modules should be visually checked and any contamination with particles, fibers that are **visible to the naked eye** needs to be removed prior to the assembly by using a tweezer.

In this case the pattern must be evaluated as shown in the table below.

Deviation due to the stencil or screen printing process		
Defect description	Mechanical defect picture	Quality acceptance
Slight defects in printing pattern (small voids)		OK
Deformed honeycomb edges		OK
Slight sub-surface migration		OK
Few dots contain a plateau		OK

Defects caused by handling or assembly process		
Defect description	Mechanical defect picture	Quality acceptance
Only a few dots are blurred		OK
Formation of shades caused by removed residues		OK
Contamination with particles e.g. hairs, fibers	  (removable with tweezers)	OK only when removed prior to the assembly
	  (removable with tweezers)	OK only when removed prior to the assembly

			OK only when removed prior to the assembly
Many dots or whole printed sub-areas are blurred or smeared	  (The application of a new TIM layer is recommended)		NOT OK
Surface discolouration	 		ok

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