

Application Note

„Application of thermal paste for Power Modules without base plate“ Version 1.0

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1. Introduction

With the introduction of power modules without base plate, the application of thermal paste becomes an even more important step in the assembly process. The following paper gives a brief introduction on the necessity of thermal paste itself, which thickness is recommended by SEMIKRON for different module types, how paste should be applied and how the quality of a paste layer can be rated.

This paper is only an application support. The responsibility for the correct assembly remains with the customer. SEMIKRON takes no responsibility for incorrect assembly and results thereof.

2. Necessity of thermal paste

A semiconductor power module is not an ideal switch and power losses occur during operation. It is therefore necessary to mount the module onto a heat sink in order to dissipate the generated heat.

Due to unevenness, there is an air gap between the module base and heat sink. This gap greatly affects the dissipation of the power losses, so that in worst cases overheating and therewith destruction of the whole module may occur (Fig. 1).

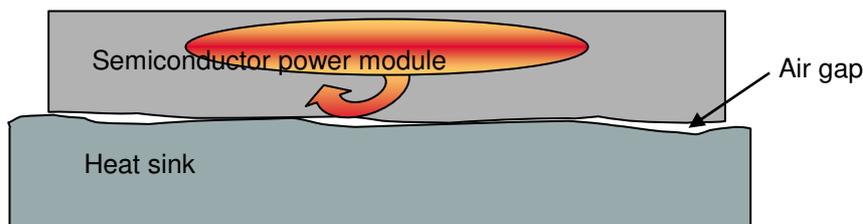


Fig. 1: Power module on heat sink without thermal conductive layer

Therefore all air (specific thermal conductivity $\lambda_{\text{air}} \approx 0,03 \text{ W} / (\text{m}\cdot\text{K})$) must be properly displaced by thermal paste ($\lambda_{\text{paste}} \approx 1,0 \text{ W} / (\text{m}\cdot\text{K})$). Although thermal paste is more effective for transferring heat than air, it is less effective than metal components (e.g. copper $\lambda_{\text{copper}} \approx 400 \text{ W} / (\text{m}\cdot\text{K})$). The optimum layer thickness is as shown in fig. 2. displacing all air, but allowing metal to metal contact.

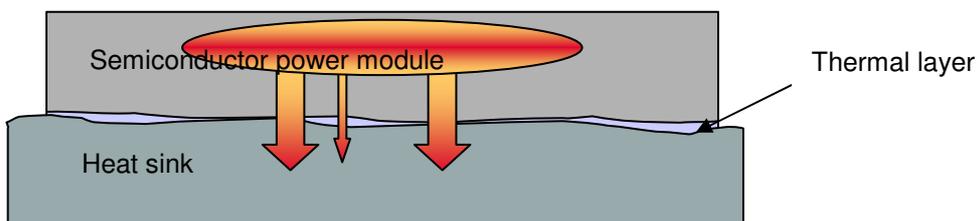


Fig. 2: Power module on heat sink with optimal thermal paste layer

Summary:

- Deposit as little thermal paste as possible, to allow metal to metal contact.
- Deposit enough thermal paste to displace all air between module and heat sink.

3. Recommendations for paste layers

Fig. 3 shows how the thermal resistance depends on the thickness of paste layer. Before the optimum thickness is reached, thermal resistance is rather high, due to remaining voids underneath the module. Above the optimum thickness, thermal resistance increases again, because of the of thermal paste's poor conduction value.

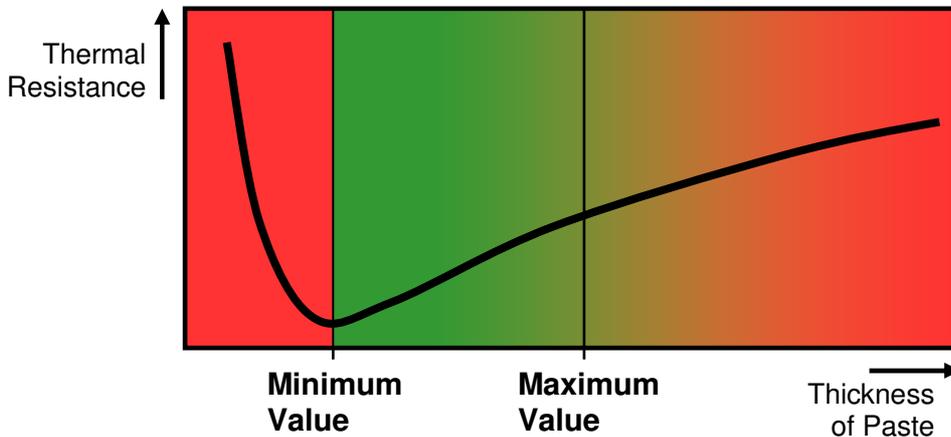


Fig. 3: Thermal resistance's dependence on paste layer thickness

The following table 1 gives thickness values of the paste layer for SEMIKRONs power modules without base plate. These values are experimentally determined and only valid for "Silicone Paste P12" by "WACKER Chemie" in accordance with the mounting instructions for the respective device:

Module Type	Recommended paste thickness
SEMITOP 1	20 µm - 30 µm
SEMITOP 2	30 µm - 40 µm
SEMITOP 3	50 µm - 60 µm
MiniSKiiP 1	20 µm - 50 µm
MiniSKiiP 2	30 µm - 50 µm
MiniSKiiP 3	40 µm - 50 µm
MiniSKiiP 8	70 µm - 80 µm
SKiM 4	40 µm - 60 µm
SKiM 5	40 µm - 60 µm
SEMIPONT 5	70 µm - 80 µm
SEMIPONT 6	70 µm - 80 µm



Tab. 1: Thickness values of thermal paste layers

To achieve the given values (table 1), the heat sink surface has to meet the following quality requirements (refer to Fig. 4):

- For SEMITOP and MiniSKiiP, the flatness over the whole mounting area must be $\leq 20 \mu\text{m}$.
For SKiM, the flatness of the mounting area must be $\leq 50 \mu\text{m}$ based on a length of 100 mm.
- No steps $> 10 \mu\text{m}$
- Roughness $R_z \leq 6.3 \mu\text{m}$
- Free from grease
- Free from particles

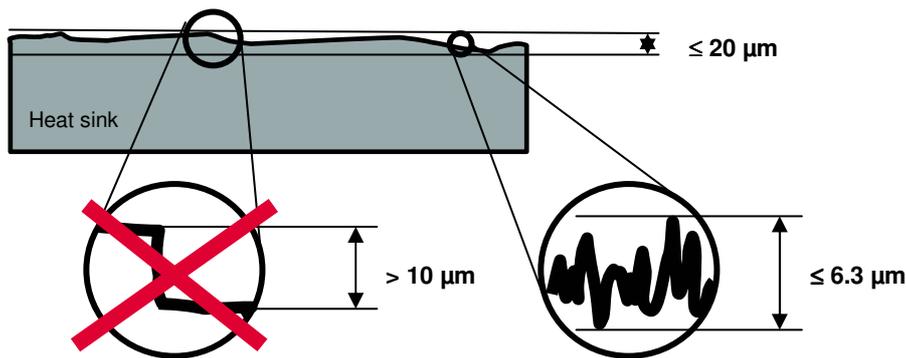


Fig. 4: Requirements on the surface quality of heat sinks

4. Application of paste

For modules without base plate it is necessary to achieve an even, homogeneous and reproducible paste layer. Uneven paste layers leading to uneven stress distribution in ceramic substrate and destruction can occur. Furthermore the procedure must fit into high volume production lines. Taking all these aspects into account SEMIKRON recommends screen printing as application procedure for thermal paste. This is described below in detail.

A second possible option for application of thermal paste is a hard rubber roller, specially for field repair or low volume production. In this case, it is recommended to follow the following steps:

- a) Apply the paste with a hard roller
- b) Remove excessive paste with a clean roller
- c) Check thickness

Sometimes a brush or a spatula is used. Since these procedures lead to layers with inhomogeneous and not reproducible thicknesses, they are not recommended under any circumstances!

4.1. Screen Printing

4.1.1. Equipment

SEMIKRON did several tests on screen printing with “Monolen-PET” meshes. In Table 2 the experimentally determined results of these investigations are given. The values are valid for thermal paste “Silicone Paste P12” by “WACKER Chemie”. A scraper made of polyurethane with hardness 75 Shore was used (Fig. 5).

Mesh designation	77 - 55	43 - 80	27 - 140
Threads / cm ²	77	43	27
Thread diameter "T"	55 µm	80 µm	140 µm
resulting layer thickness	20 µm - 30 µm	40 µm - 50 µm	70 µm - 80 µm



Tab. 2: Experimentally determined layer thickness values for screen printing of thermal paste

Fig. 5 Polyurethane scraper

4.1.2. Procedure

At SEMIKRON thermal paste is applied onto the heat sink by screen printing. It is also applicable to print the paste onto the bottom side of the modules. The procedure is divided into the following steps:

1. Step: Positioning heat sink in the printing tool.
2. Step: Cleaning heat sink with isopropyl , as its surface must be grease free and free from particles (Fig. 6).
3. Step: Filling the mesh with paste. In this step, the mesh does not touch the surface of the heat sink. The distance between screen and heat sink is about 5 ... 15 mm (Fig. 7).
4. Step: Printing the image onto the surface. Now the screen is pressed partially to the heat sink by the scraper (Fig. 8).
5. Step: Finished (Fig. 9).

It is useful to work out a proper screen printing process together with a local supplier of screen printing equipment, as they have experience and can give helpful information.



Fig. 6: Cleaning the heat sink



Fig. 7: Filling the mesh with paste



Fig. 8: Printing the image

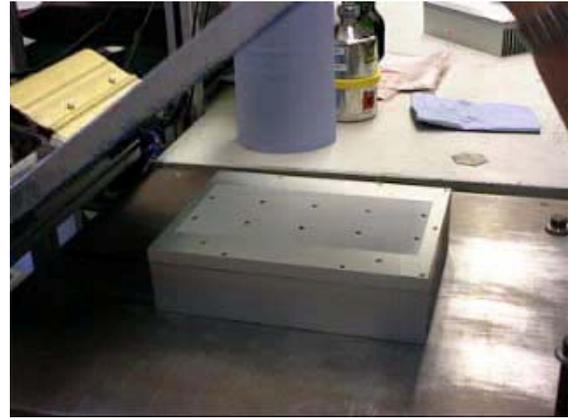


Fig. 9: Finished

4.2. Measurement of paste layer thickness

The measurement of the paste layer thickness can be done by a „measurement comb“ or “Wet Film Comb” as shown in figure 13 (in German: „Sechseck-Kamm 5 ... 150 µm“)

Handling as shown in figure 14:

- Keep the comb vertically
- Place it with two of the six edges onto the surface of the heat sink.
- Then scrape the comb slowly over the surface through the thermal paste layer.

Evaluation (Fig. 15):

- After the comb has been pulled over the surface and through the thermal paste, two or three of the measurement tines should be coated by the paste. If not, the next scale size of the comb must be used.
- The value of the paste layer thickness lies approximately between the covered and uncovered tine.

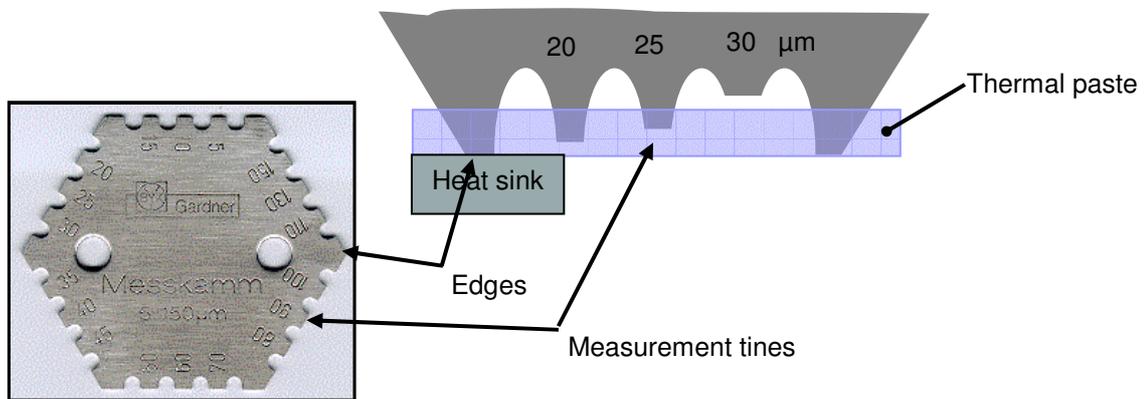


Fig. 13: Measurement comb

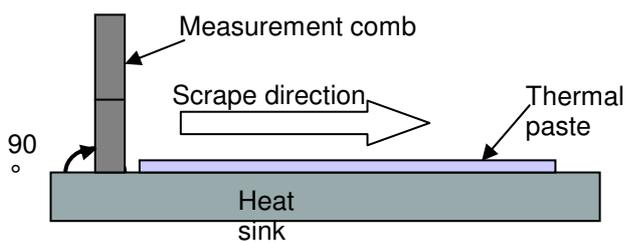


Fig. 14: How to handle the comb

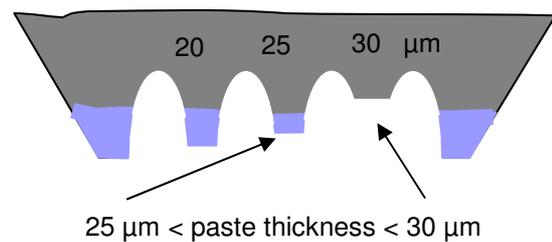


Fig. 15: How to evaluate the thickness

4.3. Quality Controlling

When controlling the quality of thermal paste printing, it is useful to measure the thickness regularly. When the thickness falls under the minimum value, the mesh has to be cleaned or displaced. A quality control sheet like shown in fig. 10 is a helpful tool in this case.

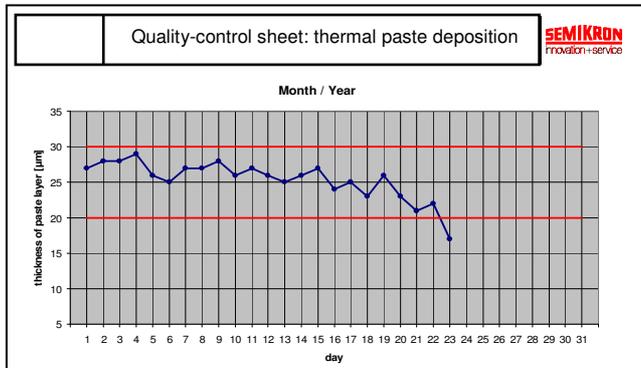


Fig. 10: Quality control sheet for paste deposition

5. Paste deposition qualification

For qualification of paste deposition, the transfer of paste from heat sink to module must be evaluated.

Procedure: Assemble the power module in the usual way: deposit thermal paste, position and mount the module with the nominal torque as given in the corresponding datasheet. Give the paste a chance to move and fill remaining voids, by waiting for some hours or performing a few temperature cycles. Then unscrew module. Lift it carefully without turning it and evaluate the transferred paste:

- **When the whole area is coated, the thickness of the layer is either good or too thick.**
In figure 11, a well done paste application can be seen: The whole area of the bottom side is coated. The thickness of thermal paste layer is satisfactory. If an amount of squeezed out paste is visible at the edges, the paste layer is too thick.
- **When dry areas are visible, the layer is obviously too thin.**
A non-coated area can be seen in figure 12. The thickness of thermal paste is inadequate.

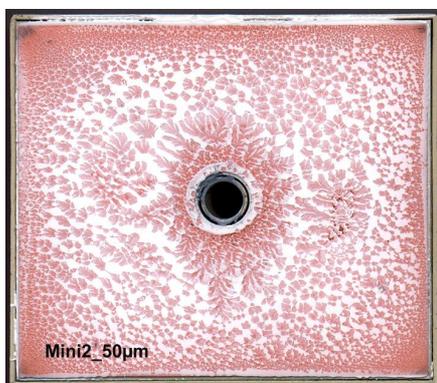


Fig. 11: Bottom view with satisfactory thickness of paste layer

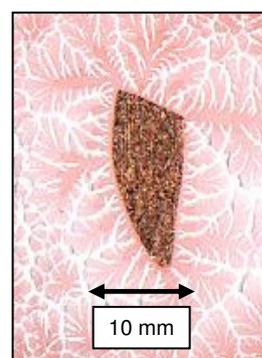


Fig. 12: Dry area: The paste layer was inadequate.

6. Supplier list

Thermal Paste

Silicone Info-Service
Wacker-Chemie GmbH
Hanns-Seidel-Platz 4
D-81737 München
Germany
Tel.: +49-(0) 800 - 62 79 - 8000
FAX: +49-(0) 89 - 62 79 - 2888
e-mail: silicones@wacker.com
internet: <http://www.wacker.com>

Screen Printing Equipment

Schlee Siebdruckhandelsgesellschaft mbH
Vacher Straße 274
D-90768 Fürth
Germany
Tel.: +49-(0) 9 11 - 97 33 - 0
Fax: +49-(0) 9 11 - 97 33 - 233

Measurement Comb / Wet Film Comb

ELCOMETER Instruments GmbH
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D-73434 Aalen
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Tel.: +49-(0) 73 66 - 91 92 83
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