Modules with preapplied thermal interface material

About this Document

Scope and purpose

To optimize the thermal transfer between power semiconductor and heat sink it is mandatory to apply a thermal interface material filling microscopic gaps and unevennesses accordingly. The material chosen, as well as the process of application, has a major influence on the thermal results. In addition, the lifetime expectations of the application have to be met.

To achieve the best possible result, module, local distribution of thermal interface material and process of application have to be considered to be an inseparable unit.

The present application note deals with the topics of handling power modules with preapplied thermal interface material – TIM.

Targeted audience

This application note is for all users involved in handling power electronic devices. It is intended to be a guide for technicians and assembly workers to achieve proper usage of the module technologies described.

Contents

1 Features and Properties

The thermal interface used by Infineon Technologies consists of a material that changes its appearance if heated up. At about 45°C it changes from solid state to thixotropic state. Below this temperature, solid refers to a consistency similar to candle wax which is the base for the unique mechanical features and thermal abilities of the material.
The material is applied using a screen printing process. The resulting honeycomb shapes and the dedicated areas without material applied are characteristic features of the solution.

The approach's highlights include

- High thermal conductivity in the system
- Non-conductive and silicone free
- Long-term stable at base plate temperatures up to 125°C
- Resistent towards bleeding, pumping and capillary effect
- Non toxic
- Simplified mounting and cleaning

1.1 Storage and Transport

The rules given in the documentation TR14_Storage_of_IFX_Proodcts define how to store and handle devices manufactured by Infineon Technologies. All these rules also apply for modules with pre-applied TIM. Storing modules with TIM applied can be done under atmospheric conditions at up to 70°C for 24 months. A horizontal storage position is to be preferred but not mandatory. At temperature levels beyond the phase transition temperature, mechanical contact to the thermally active layer has to be prevented. This is for technical reasons as well as personal safety.

The viscosity of the material in its thixotropic state is adjusted to ensure that even in vertical position the material will not start flowing or even dripping off its initial position. As described in the TR14 rules, shock and heavy vibration during transportation have to be avoided.

1.2 Cleaning prior to mounting

The TIM layer applied has to be regarded as a functional surface. Care has to be taken that this layer is not contaminated for example by dust or dirt particles. In contrast to common thermal greases there is however the limited possibility to remove contaminations from the layer without destroying it. Using a soft brush or a soft dry cloth, particles or crumbs can carefully be removed from the thermally active layer. It has to be observed that no TIM is removed during the process. Larger particles can carefully be removed using a pincer. Scratching and heavily rubbing the TIM-layer has to be prevented. Cleaning has to be done with the necessary precaution.

1.3 Packaging

To protect the TIM-layer, the modules are packed in blister boxes. The package is designed to support the modules on areas not covered with TIM. The box as displayed in Figure 1 can be opened on either side allowing access to the base plate or the top-side of the module as desired during manufacturing:

Figure 1: Blister and cardboard box for EconoPACK™ +

During handling the modules, the rules regarding ESD-protection have to be obeyed as for any semiconductor and electrostatically sensitive device.

1.4 Optical Appearance

TIM is applied using a stencil printing process to locally adjust the volume applied to the module. Prior to mounting it is advisable to check that the print is undamaged and complete, a valid example is depicted in Figure 2:

Figure 2: Module with TIM applied, EconoPACK™ + as an example

2 Mounting to a heat sink

In case a module needs to be replaced, the heat sink has to be cleaned and remaining left-overs have to be removed. In cold conditions, cleaning is not demanding special care regarding personal safety. Cleaning can be done without wearing gloves. Larger particles can be removed using a squeegee or scraper. Care hast o be taken that the heat sink's surface is not scratched or damaged otherwise. It is therefore advised to use a plastic scraper for this step. Further cleaning can be done using a dry cloth. The use of liquid solvents or cleaners is not recommended. Figure 3 shows a possible cleaning sequence.

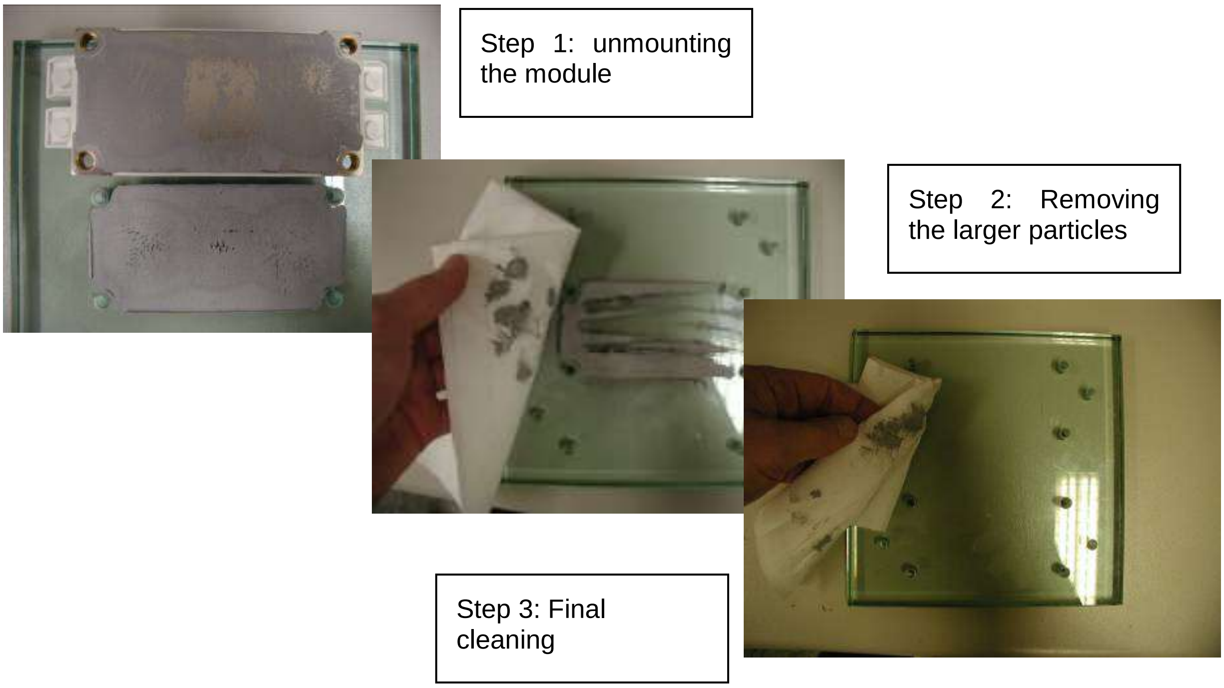


Figure 3: Cleaning the mounting area prior to assembling a new module

Inside the microscopic surface structure, tiny particles will remain. This is not a detrimental effect for the repairs in case the module used for the repair features Infineon's pre-applied TIM as well. During the first phase transition, the thermal interface will form an interconnection again, leading to excellent thermal transfer.

If a module with pre-applied TIM is mounted in a position that was covered with different thermal grease before, thorough cleaning acc. to the grease manufacturer's given procedures is mandatory.

In case a formerly TIM-covered module has to be re-mounted, thorough cleaning and applying a new thermal interface layer is necessary.

3 Handling during Assembly

If the module is delivered to the assembly line without the blister packaging, care hast o be taken regarding the handling. In any case, the TIM-layer has to be considered a functional area and should be protected from mechanical contact, scratching and touching. Contamination by dirt, dust, moisture, oil or grease has to be prevented.
The stencil design features areas not covered with TIM along the edges of the module. These areas can be used to carry the module in proper carriers.

As can be seen in Figure 4, the areas chosen are those that do not contribute to the thermal transfer or provide direct metal-to-metal contact; there is no detrimental influence towards the thermal capabilities.

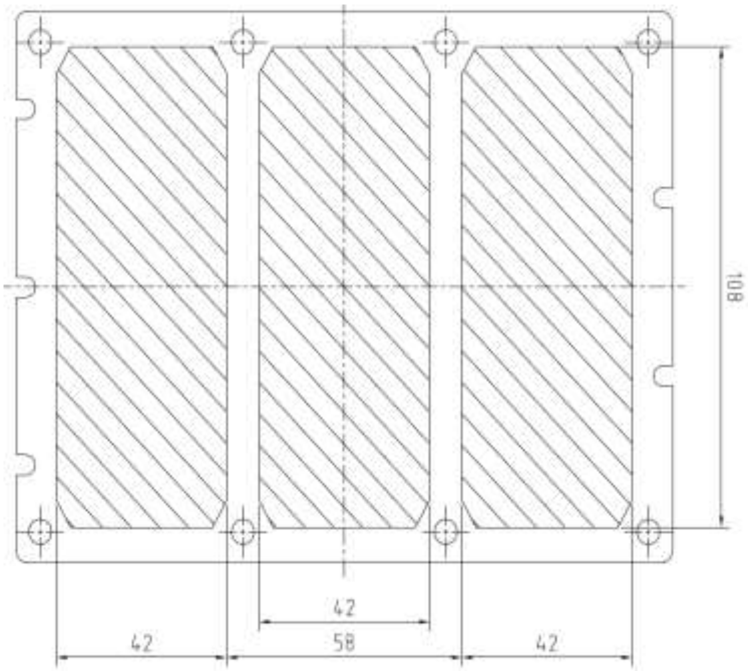


Figure 4: EconoPACK™ + and the positions of the areas not covered by TIM. All around the hatched areas, the module can be contacted without damaging the TIM-layer

A further possibility is given, consisting of a carrier that supports the module at the base plate's screw holes to protect the TIM-layer.

3.1 Mounting the Module to PCB

This step depends on the contact technology featured by the module. The following sections give hints on either using a soldering process or PressFIT connections as a non-soldering alternative.

3.1.1 Wave Soldering Process

In this process, the module is placed into its PCB-position upside down. In wave soldering machinery, a first step usually is pre-heating to reduce the effects of thermal capacitances in larger components. This is necessary to prevent so-called cold soldering spots and achieve a proper wetting of the metal pins, thus forming reliable solder joints.

During this step, TIM is heated up to levels beyond the phase transition temperature. In case the different soldering chambers are separated using curtains, there would be the risk of destroying the TIM-layer or contaminate the oven with TIM particles; both has to be prevented.

For this reason, it is necessary that the module's base plate is not mechanically contacted during the soldering process. Simple counter measures therefore have to be installed. Covering the module with a simple metal cage, that features large gaps to prevent mechanical contact while allowing radiation to heat up the base plate, is sufficient.
If the TIM-layer crosses the transition temperature, its optical appearance can change slightly. The dots printed to the base plate may show less sharp edges than before. This however is of no influence to the thermal qualities of the material. The wave soldering process tested was based on the JEDEC-Profile used for common FR4 SMD soldering. Figure 5 includes a photo of an EconoPACK™ 3 module after wave soldering is done.

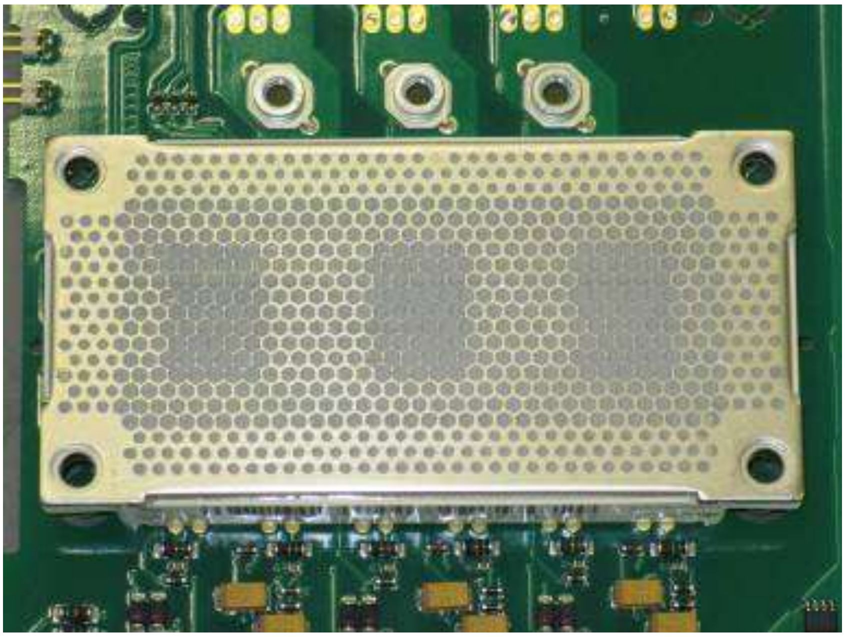


Figure 5: Module with TIM-Layer after crossing the wave soldering oven

For safety reasons and due to the thermal capacitances of the module, touching the material immediately after soldering is not advisable. It is strongly advised to first allow cool down prior to further handling steps.

If the following handling steps include re-packaging of the PCB with the module soldered to it, mechanical contact to the TIM-layer has to be prevented throughout all processes. Care has to be taken that no scratches occur within the TIM layer as a consequence of handling the material. Especially moving the material on rough surfaces has to be omitted.

Modules that feature solder connectors can also be mounted to the heat sink in a first step and do selective soldering afterwards. In this case, there is no difference between common modules and those with TIM applied.

3.1.2 Mounting a PressFIT-Module

PressFIT pins require a lever press or similar machinery to connect the module to the PCB. Detailed descriptions of the necessary tools can be found within the according application notes.

To handle modules with pre-applied TIM only a slight change of the press is needed. This refers to a frame that supports the module at the areas not covered with TIM. As the press-in forces are generated in exactly these areas, the remaining process does not differ from the one used for standard modules without TIM.

To generate the distance needed between tools and TIM, the thickness of a proper frame has to be in the range of 150-200µm.
A possible frame to press in an EconoDUAL™ 3 or EconoPACK™ 3 is sketched in Figure 6:

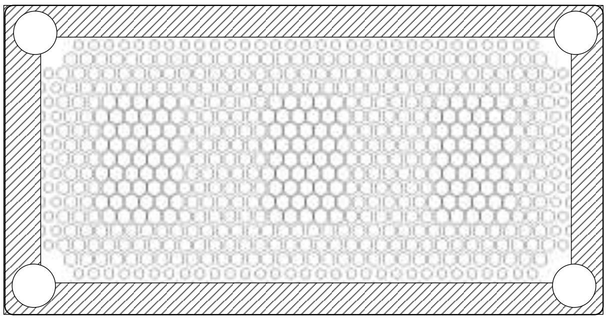


Figure 6: Schematic drawing of a frame to safely press in Econo-Type modules. Contact is given in the hatched areas while the honeycomb shape symbolizes the TIM-Layer.

It is also possible to use a set of mounting tools dedicated to modules that feature TIM. These tools consist of a stamp and a counterholder. Shape and size of the stamp as well as its geometry have to chosen according to the shape of the TIM-Layer. The rendered pictures in Figures 7 and 8 only hint out one possible solution. The according 3D CAD-files are available from Infineon on request.

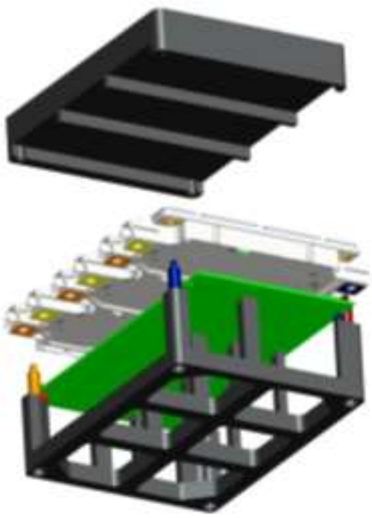


Figure 7: Possible press-in tools for EconoPACK™ + modules, view from bottom side

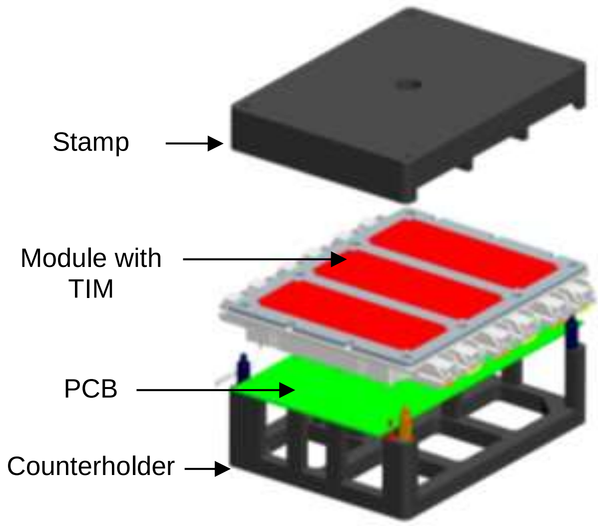


Figure 8: Possible press-in tools for EconoPACK™ + modules, view from top side

For PressFIT modules too, there is the possibility to first mount the device to the according heat sink and press it into the PCB in a second step. In this procedure, there is no difference between modules that feature TIM or those without.

4 Evaluating the thermal properties of a given design

Most often, thermal simulations are the basis to evaluate the thermal properties of a new power electronic design. Care has to be taken to verify these simulated results by in-situ tests of the final hardware under conditions as close as possible to the real application.

Power semiconductors suffer from the thermal situation under load, which can be categorized in temperature swing and temperature level. Both values can be measured directly. A determination using a thermal model as a detour or a secondary parameter is not recommended.

4.1 Comparative measurements using an IR-Camera

This method of measurement has the highest level of confidence. It generates the most accurate impression about thermal spreading and temperature levels inside a power module. This method needs an open, blackened module with no gel inside and a proper IR-camera. Operating the module at high voltages is not an option as the isolating gel is not present. A power source is mandatory that can provide high currents in the range of of the module's rated current at very low voltages. Per series-connected IGBT, the source has to deliver at least 2-3 Volts. The photo in Figure 9 gives an insight about a laboratory setup consisting of heat sink, fan, controller and timer.

Figure 9: Test bench for IR-measurement done with an EconoPACK™ +

The IR-camera allows for an accurate observation of temperature distribution and maximum temperature reached inside the module.

Figure 10 is a picture taken with an IR-camera. All IGBTs inside the module are operating; the air flow in this experiment is from left to right.

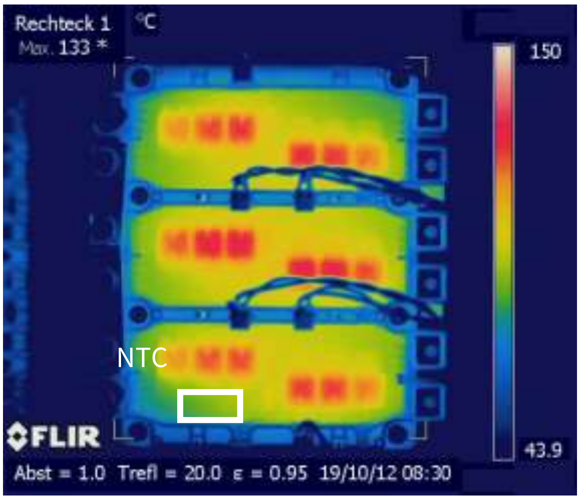


Figure 10: IR-picture of a module under load. DUT: FS450R17OE4P

The measurement in the example provides about 95200 measurements inside the module. It easily provides the maximum temperature reached. It is clearly visible, that the temperature in the NTC's position is below the chip temperature. In the measurement done, the NTC-temperature is about 105°C while the hot spot at the IGBT was 133°C.

4.2 Evaluating the TIM-Imprint

In the past it was often tried to derive a correlation between the imprint of certain thermal grease and its thermal qualities. This approach lead to massive misjudgments and is therefore not recommended.

Figure 11 and Figure 12 can be taken as an example:

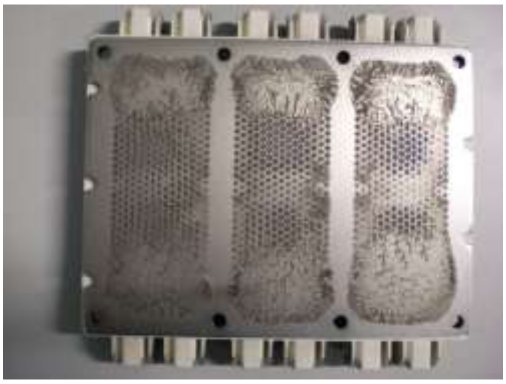


Figure 11: Optical appearance of a TIM-Layer after cycling. View to the base plate

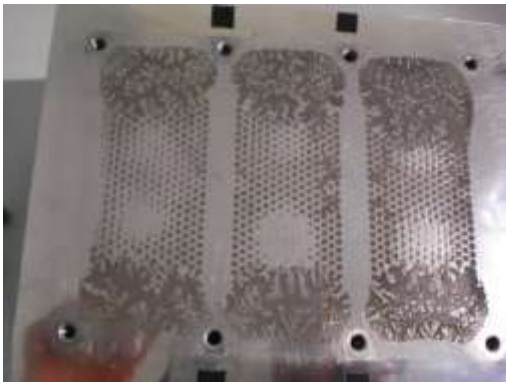


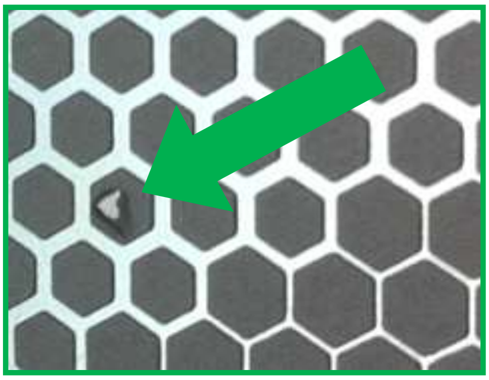
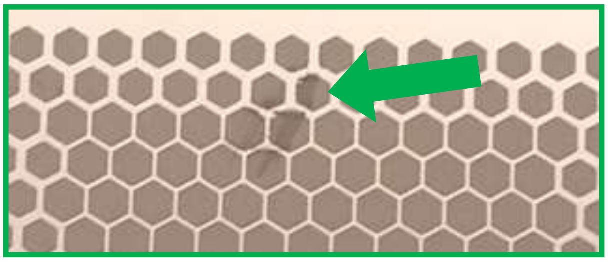
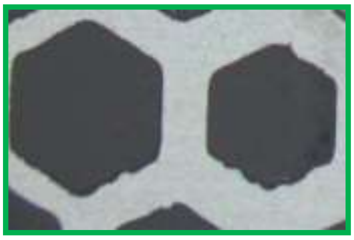
Figure 12: Optical appearance of a TIM-Layer after cycling. View to the heat sink

Despite the fact that the printing pattern is still visible, the thermal performance of the setup turned out to be excellent. Temperature levels and -distribution can be seen in Figure 10.

5 Good parts - Overview

Despite intense control and monitoring of the printing process and highest standards in handling the materials, tiny deviations regarding the TIM-layer can occur. These have no negative influence to the thermal performance or the expected lifetime of the material.

This section hints out some of these deviations, all of them considered noncritical.

Tolerable deviation: Single honeycombs show discolorations or small amounts of TIM at the edges.	
Tolerable deviation: Outside the areas with the highest printing density, a small portion of material is dislocated.	
Tolerable deviation: Local discoloration or tiny scratches on top of the TIM-layer	
Tolerable deviation: Diffuse edges of single honeycombs	
Tolerable deviation: Small amounts of material between two honeycombs	
In all cases displayed, the automated inspection system has verified, that the proper amount of material was applied to the module.	

6 Further Infomation

A collection of further information regarding thermal interface material and its application in form of scientific articles and whitepapers can be found at www.infineon.com/TIM.

Revision History

Changes towards former versions

Page or Reference	Changes done
Rev. 1.0	First release in 2012
Rev. 1.1	Sept. 2015: Migration to new template, German version discontinued, additional information regarding maximum case temperature of 125°C

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