Pre-Applied phase change Thermal Interface Material 2.0

About this document

Scope and purpose

For a large share of its broad power module portfolio Infineon offers a new pre-applied phase-change thermal interface material (TIM 2.0) to optimize heat transfer between power module and heat sink. This material option allows to improve performance, reliability, as well as efficiency. This application note highlights benefits and applications of TIM 2.0 and serves as a guideline for handling power modules with TIM2.0.

Intended audience

The intended audiences for this document are design engineers, technicians, and developers of electronic systems.

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1 General information

The increasing demand on power density in the power electronics pose growing challenges for the thermal interface between the power semiconductor modules and the heat sink. Different types of Thermal Interface Materials (TIM), such as Phase-Change-Materials (PCM), are used to ensure an efficient heat transfer at the interface between the power module and the heat sink. In this case, any voids and irregularities between the mating surfaces can be filled with this material.

TIM contributes up to 60% of the total thermal resistance. Therefore, the selection of the appropriate material plays a fundamental role and becomes a critical challenge for the user, particularly when long-term stability is required for the application.

In this context, Infineon offers a TIM (TIM 2.0) that meets these requirements for a wide range of applications. It exhibits outstanding wetting properties, making it suitable for application demanding higher performance and offers a significant value adder to customer products.

However, to fully exploit the advantages of TIM 2.0, it is of vital importance to follow the corresponding handling instructions within the respective portfolio. In the following chapter usage and handling of power modules with the pre-applied TIM is described.

1.1 Nomenclature and portfolio of the pre-applied TIM 2.0

TIM 2.0 is available for a wide range of Infineon power modules. The portfolio includes EasyPACK™, EasyPIM™, and EasyDUAL™ products as well as XHP™ 2, PrimePack™, and IHM. Furthermore, TIM 2.0 is the standard PCM for all future power modules.

Due to its special characteristics, it is pre-applied using a stencil printing process. This eliminates the need for customers to apply it by themselves simplifying the assembly process, reducing production time, and minimizing process risk on customer side.

TIM 1.0 remains the standard for many released products. For new product introductions, TIM 2.0 will be the default pre-applied material. For released products, TIM 2.0 may be offered upon customer request or as a standard variant, depending on the specific product lifecycle stage. This transition ensures that customers benefit from optimal thermal management solutions, providing improved performance, reliability, and efficiency across the entire portfolio over time.

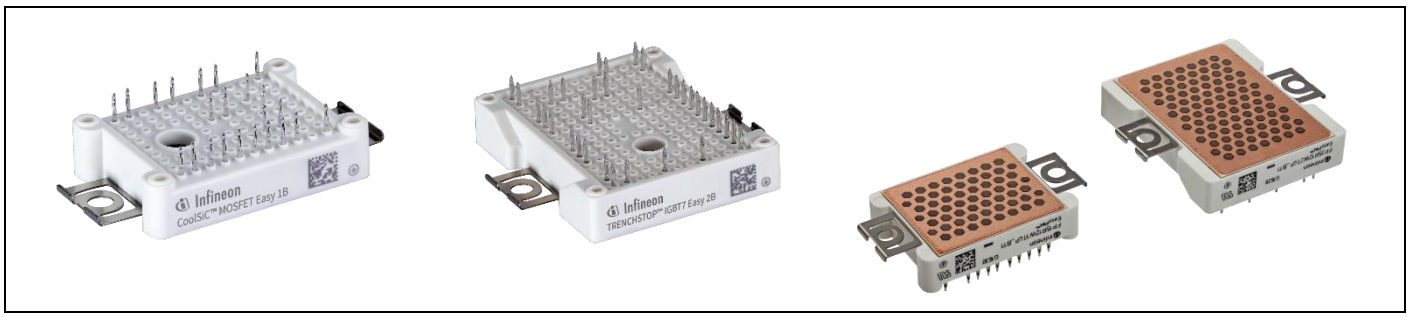

Figure 1 EasyPACK™ B series

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Figure 2 XHP™ 2, PrimePack™ 3+, IHM series

To facilitate easy identification of products featuring TIM 2.0 technology, Infineon has introduced the label “Q” in the product names. This notation allows customers to quickly identify which products feature the pre-applied TIM 2.0 version, making it easier for them to select the right product for their specific application requirements. This application note covers all products bearing the respective label in their product designation. In the following example, the labeling for TIM modules are explained:

- FP15R12W1T4 → without TIM
- FP15R12W1T4P → TIM 1.0
- FP15R12W1T4Q → TIM 2.0

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2 Technical information

2.1 Thermal Interface Material (TIM) 2.0

TIM 2.0, originally known as Honeywell PTM6000HV-SP, is a PCM with a polymer structure, which undergoes a phase change from solid to soft as soon as the respective phase-change temperature of about 45°C is exceeded. Below this melting temperature it maintains wax-like consistency. In order to ensure a complete phase change within the entire material, Infineon recommends to ensure TIM reaches temperatures of 60°C once after assembly.

A key benefit of this material lies in its enhanced thermal performance, achieved through to the high thermal bulk conductivity and excellent wetting properties. These characteristics optimally reduce the thermal contact resistance. Despite the high thermal conductivity, it has a high resistance with respect pump-out, even when the power modules are mounted vertically. This high stable performance was validated by reliability tests, which will be discussed in the subsequent sections.

The main important characteristics of TIM2.0 are listed in following Table 1. For more details, please contact your Infineon sales partner.

Parameter	Value	Unit
Thermal conductivity	5.2	$W/m \cdot K$
Specific gravity	2.6	g/cm^3
Volume resistivity	2.1x10^{14}	$\Omega \cdot cm$
Phase-change temperature	> 45	°C
Continuous operating temperature limit	150	°C
Viscosity above phase-change temperature	Thixotropic	
Color	Gray	

Table 1 Properties of TIM2.0

2.2 Storage of TIM 2.0 modules

TIM 2.0 products are delivered in special protective packing. To avoid impacting the performance and lifespan of these products, they shall be stored in the original packing according to the conditions in Table 2. Mechanical contact with pre-applied PCM shall be avoided.

Parameter	Value	Unit
Temperature	5 < T < 40	$°C$
Relative humidity	10 < rh < 65	%
max storage time	24	$months$

Table 2 Storage conditions of the products with pre-applied TIM 2.0

In case the maximum storage time is exceeded, it is recommended that TIM 2.0 is removed from the module and replaced with a new thermal grease before is installed and used in an application. For more information regarding the removal process, please refer to the following Application Notes:

- Application Note AN 2012-07 “Mounting to a heat sink” for the cleaning process [1]
- Application Note AN 2006-02 “Application of thermal compound” for the application process [2]

Note: The application process described in AN 2006-02 is based on EconoPACK™ 3 but is also valid for modules without base plate. Please follow the specified processes to ensure proper removal of TIM 2.0 and application of an alternate grease.

2.3 Reliability tests for TIM2.0

Infineon conducts a series of reliability tests to ensure the reliability of the modules and to verify its performance under various environmental conditions. In the following, the reliability tests to ensure the reliability of the TIM 2.0 with our modules are considered and listed below:

- **Power cycling test (PC)** [3]: Via PC tests reliability and service life of the pre-applied TIM 2.0 was evaluated under repeated current cycles. Power cycling is also explained in [10]. The aim is to emulate the loads that occur under real conditions and to determine any noticeable material deterioration, such as pumping out.
- **High-temperature reverse bias** [4]: In this HTRB test, limit sample modules with TIM 2.0 are examined. After baking out, solvent is released from TIM. The test checks whether the components of the module are affected by high temperatures or an increased proportion of solvent. If there is no impairment, the module passes.
- **Humidity test** [5]: This humidity test was conducted to evaluate the ability of the TIM 2.0 to withstand high humidity without affecting the material properties. The TIM 2.0 was exposed to controlled high humidity to simulate the effects on the Rth and components.
- **Vibration test** [6]: The purpose of this vibration test is to evaluate the resistance of the TIM 2.0 to mechanical vibrations that are common in many applications. The TIM 2.0 was subjected to a controlled vibration profile to determine that the TIM does not leak.

- **Temperature shock test–(TST)** [7]: The aim of this TST was to determine the resistance of TIM 2.0 to thermomechanical shocks that occur in many applications. In this test, the TIM 2.0 was subjected to a controlled shock profile to see whether a pump-out of the TIM and a ceramic crack could occur. If there is no pump-out and no ceramic crack during the test, then the test is passed.
- **Life-cycle test**: This test was specially developed to emulate the entire lifetime of TIM 2.0 and to evaluate its reliability and performance over a longer period of time. In this specially developed test, modules featuring TIM 2.0 are stored at high temperature and then run in continuous operation to accelerate aging process. Modules are then thermally cycled to be able to assess the lifetime based on the Rth. This test emulates field operation of module featuring TIM 2.0.

All reliability testing verified that TIM 2.0 meets the required reliability standards for use in various applications.

2.4 Handling instruction for TIM 2.0

When working with TIM 2.0, it is important that the user follows the handling instructions correctly. TIM 2.0 is sensitive to environmental influences such as temperature, humidity, and mechanical stress. In case TIM is not handled correctly, this may lead to a deterioration in its performance, which in turn leads to increased component temperatures and possibly to system failure. Damage to the material can be avoided by correct handling, such as:

- Wearing clean, dry gloves when handling TIM 2.0 to prevent contamination.
- Avoiding external contact to the TIM 2.0 surface so that any contamination from e.g. skin does not affect its performance.
- Using a soft, dry brush to remove any dirt or dust from the surface of TIM 2.0.
- Avoiding exposing TIM 2.0 to direct sunlight or high temperature.
- It is recommended using a protective cover to the surface of the TIM 2.0 paste, so that contamination or scratches during the press-in process can be prevented.

Following these guidelines will ensure that the performance of TIM 2.0 is not compromised.

2.5 Solder, press-in, and press-out processes

Press-in and press-out processes are crucial steps in handling og TIM 2.0 modules. They require careful handling to achieve the optimal results. It is important to utilize the correct tooling and follow the recommended procedure to prevent damage, ensure proper alignment, and maintain the integrity of the TIM 2.0 material.

2.5.1 Solder

Soldering tools required for assembly of EasyPACK™ modules are described in detail in [8]. This application note contains step-by-step instructions for the soldering process for mounting modules in a printed circuit board (PCB). These processes can also be used for modules with TIM. Care must be taken to ensure that the TIM material is not damaged. Moreover, it is recommended that the temperature of the material does not exceed 45°C. Otherwise, higher thermal resistance ($R_{th,j\text{-}h}$) values may occur during operation, increasing the risk of failure.

2.5.2 Press-in

Press-in tools required for the assembly of EasyPACK™ modules with TIM are comprehensively detailed in [9]. This Application Note provides step-by-step guidance on the press-in process for mounting modules with TIM into a printed circuit board (PCB) in the section “Press-in process of a module with thermal interface material (TIM)”.

2.5.3 Press-out

The press-out process, using appropriate tools, is crucial to prevent any damage to the PCB and the module. Detailed information on the correct tools and procedure for safely removing the module from the PCB is available in [9]. In case that the module has previously been detached from a heat sink, the used TIM must be removed and a fresh thermal grease applied so that the module can be reused.

Note: Handling and assembly instructions for modules with baseplate such as XHP™ 2, PrimePack™ 3 or IHM can be found in the corresponding application notes [11], [12], and [13] respectively.

2.6 First commissioning of TIM 2.0

The first commissioning of the modules featuring TIM 2.0 is a crucial step to ensure the reliable operation of the thermal management system. During this process, TIM undergoes a controlled temperature profile to activate its thermal interface properties. Adhering to the recommended procedures is essential to prevent damage to the material. By carefully controlling the temperature profile, TIM can be optimized for maximum performance, ensuring effective thermal management and reliable operation of the system.

TIM 2.0 changes its state from solid to liquid form at a phase change temperature of about 45°C. Via this process thermal resistance is optimized while wetting is maximized. Phase change and spreading out is only induced if heat as well as external force are applied.

Therefore, it is recommended to perform the final test of the equipment in such a way that a smooth and complete phase transition from solid to liquid is achieved. For this purpose, it is recommended that the temperature of TIM between module and heat sink should exceed a temperature of about 60°C for a duration of at least 2minutes. This allows the TIM material to fully wet the area between module and heatsink ad hence optimize thermal contact.
Figure 3 shows R_{th} change over time based on a dedicated measurement setup. Here, R_{th} of a baseplate-less module was tracked while $T_{vj,max}$ was controlled at a pre-set temperature of 80°C. Assembly forces were in the typical range for EasyPACK™ modules, i.e. 40 kPa. In this setup R_{th} changes significantly at the beginning and saturates after 2 Minutes.

Please note that the actual process time may vary depending on the set operation and cooling conditions due to the specific thermal capacity of the heat sink. R_{th} exceeding the saturated value for heat sink temperatures below 50°C is uncritical since chip temperatures are low in such a case. With rising chip temperature, heat sink temperature also rises and the resulting phase change of TIM2.0 reduces thermal resistance.

During field operation R_{th} may continue to vary over time due to thermal cycling. Since the material gradually changes its state from liquid to solid back, once the heat sink temperature is lower than 45°C, it is resistant to pump out, even in vertical state conditions.

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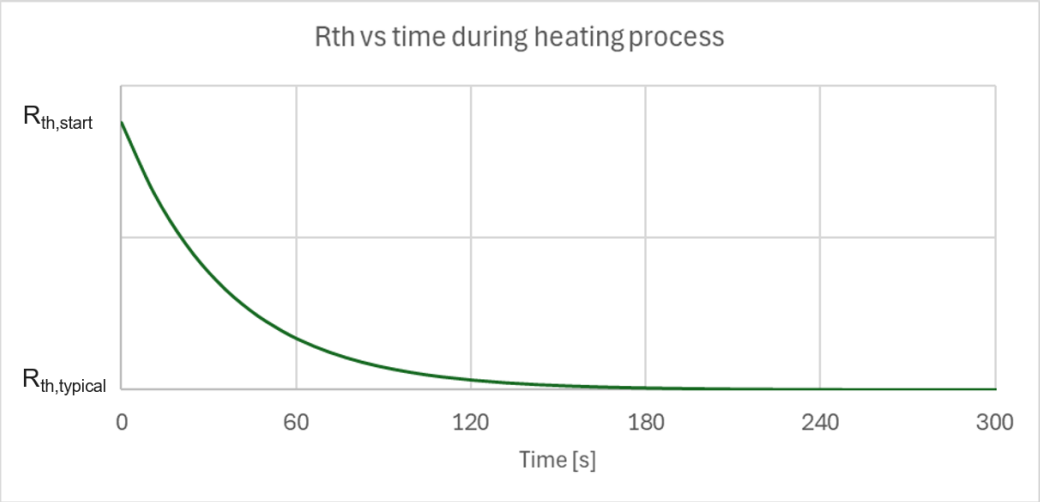


Figure 3 Thermal resistance versus time during dedicated heating test

3 Minor process variations of TIM application process

The standards for controlling and monitoring the application process of TIM onto modules are very high in Infineon's production. Minor variations in the TIM imprint do not influence product performance and are thus tolerated. For example, individual honeycombs may show discoloration or small amounts of TIM on the edges. Figure 3 depicts typical process variations in the print image without performance impact.

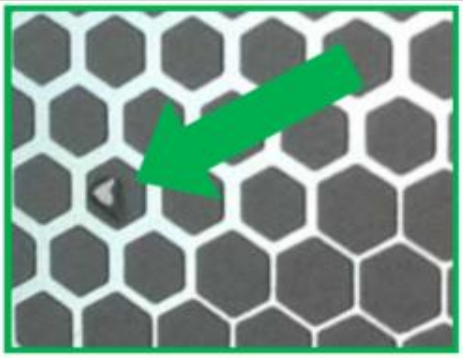
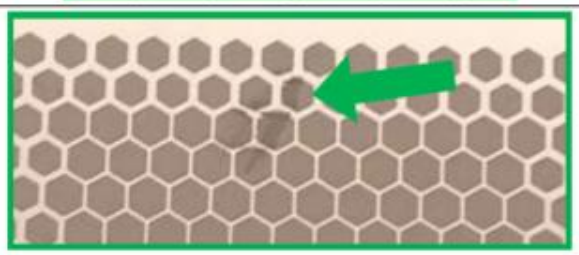
Tolerable deviation: Single honeycombs show discolorations or small amounts of TIM at the edges.	
Tolerable deviation: Outside the areas with the highest printing density, a small portion of material is dislocated.	
Tolerable deviation: Local discoloration or tiny scratches on top of the TIM-layer	
Tolerable 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.	

Figure 4 Example of typical process variations without performance impact

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Revision history

Document revision	Date	Description of changes
Revision 1.0	2025-03-21	Initial version
Revision 1.1	2026-06-01	Update including extended TIM portfolio

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