USER GUIDE

UG016 | Thermally Conductive Insulator Pad – WE-TINS

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1. INTRODUCTION TO WE-TINS

The WE-TINS is a thermal interface material designed to provide a robust thermal interface capable of withstanding significant compression forces while ensuring electrical insulation between contact surfaces. This makes it an ideal thermal solution where both electrical insulation and high compression force are required.

The pad's contact surfaces are composed of dry silicone rubber, which is both soft and conformable. This combination allows the pad to effectively interface with rough or uneven surfaces, ensuring thermal conductivity.

Additionally, the material's reworkable nature provides flexibility during assembly and maintenance, allowing for adjustments and repositioning without compromising performance.

The WE-TINS pad is engineered to maintain its properties under varying environmental conditions, including high temperatures and mechanical stress. This durability ensures long-term reliability and efficiency in demanding applications such as power electronics, consumer electronics, and industrial machinery.

2. MATERIAL SPECIFICATIONS

The thermally conductive insulator pad has two main components, shown in Figure 1:

- **Filled silicone rubber:**
  It provides the pad with a conformable surface that fills moderately rough contact surfaces. Due to its rubber characteristics, the contact surfaces are dry and the pads can be reworked and repositioned as needed during assembly and maintenance.
- **Fiberglass mesh:**
  The mesh gives the part mechanical stability under high compression forces.

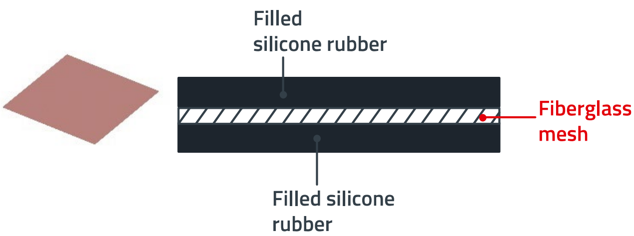

Figure 1: WE-TINS cross-section

The properties of the WE-TINS thermally conductive insulator pads can be grouped into three categories, shown in Table 1, Table 2, and Table 3:

Material Properties		
Bulk Thermal Conductivity	1.6 W/m·K	3.5 W/m·K
Color	Pink	White
Thickness	0.23 mm	0.25 mm
Specific Gravity	2.5 g/cm^3	1.5 g/cm^3
Hardness	85 Shore A	70 Shore A
Operating Temperature	-60 up to 180 °C	-60 up to 200 °C

Table 1: Material properties of WE-TINS

Thermal Properties (17.25 N/cm² Compression)		
Bulk Thermal Conductivity	1.6 W/m·K	3.5 W/m·K
Thermal Impedance	4.84 K·cm^2/W	1.94 K·cm^2/W

Table 2: Thermal properties of WE-TINS

Electrical Properties		
Bulk Thermal Conductivity	1.6 W/m·K	3.5 W/m·K
Breakdown Voltage	5.5 kV	4 kV
Volume Resistivity	10^{14} Ω·cm	10^{14} Ω·cm

Table 3: Electrical properties of WE-TINS

3. DESIGN CONSIDERATIONS

When interfacing a transistor with a cooling assembly, the most popular solutions are the use of mica for its electrically insulating properties and thermal greases that wet-out hard contact surfaces. This approach presents long term reliability issues stem from the materials themselves.

Mica is an excellent electrical insulator, however one of its main disadvantages is it is naturally brittle. This can result in total interfacial failure in designs that have to withstand vibrations and/or are susceptible to large temperature fluctuations.

Thermal pastes and greases, while providing a thin bond line thickness, suffer from the pump-out effect. Solid contact surfaces which are heating up and cooling down suffer constant expansion and contraction; over time, this pushes the interface out of the gap and degrade significantly the thermal performance of the system.

Thermally conductive insulating pads can provide a reliable alternative to the use of mica and greases.

How to design-in the WE-TINS

Let's consider a scenario where we are interfacing a TO-220 transistor with a heatsink, as shown in Figure 2, where we want to evaluate and decide between two thermal interface strategies:

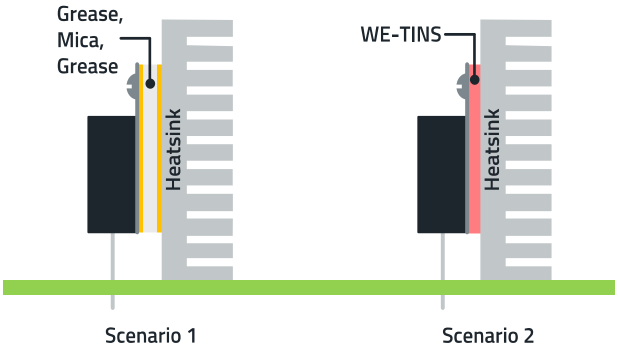

Figure 2: Design-in of WE-TINS

For this purpose, we will use thermal resistance formula:

$$R = \frac{L}{\lambda \cdot A} \qquad (1)$$

Where:

- L – bond line thickness
- λ – thermal conductivity of the material
- A – area of contact surface

Scenario 1

Since we are simply evaluating the thermal resistance of the interface, we can focus only on the physical and thermal properties:

Material	Thickness	Area	Thermal Conductivity
Mica	0.5 mm	289 mm²	0.45 W/m·K
Thermal Grease	0.1 mm	289 mm²	5 W/m·K

Table 4: Physical and thermal properties of Mica and Thermal Grease.

Thermal resistance of the grease:

$$R_{paste} = \frac{1 \cdot 10^{-4}\ \mathrm{m}}{5\ \frac{W}{mK} \cdot 2.89 \cdot 10^{-4}\ \mathrm{m}^2} = 0.07\ \frac{K}{W} \qquad (2)$$

Thermal resistance of the mica:

$$R_{mica} = \frac{5 \cdot 10^{-4}\ \mathrm{m}}{0.45\ \frac{W}{mK} \cdot 2.89 \cdot 10^{-4}\ \mathrm{m}^2} = 3.84\ \frac{K}{W} \qquad (3)$$

To calculate the total thermal resistance of the interface, we must take into consideration both layers of thermal grease as well as the mica. This will give us the total thermal resistance of the interface:

$$R_{scenario\ 1} = 2 \cdot R_{paste} + R_{mica}$$
$$= 2 \cdot 0.07\ \frac{K}{W} + 3.84\ \frac{K}{W} = 3.98\ \frac{K}{W} \qquad (4)$$

Scenario 2

As with the previous scenario, we can focus on the physical and thermal properties of the WE-TINS insulator pad:

Material	Thickness	Area	Thermal Conductivity
WE-TINS 1.6	0.23 mm	289 mm²	1.6 W/m·K
WE-TINS 3.5	0.25 mm	289 mm²	3.5 W/m·K

Table 5: Physical and thermal properties of WE-TINS insulator pad

Thermal resistance of the WE-TINS 1.6 W/m·K:

$$R_{\text{TINS 1.6}} = \frac{2.3 \cdot 10^{-4}\ \text{m}}{1.6\ \frac{\text{W}}{\text{m·K}} \cdot 2.89 \cdot 10^{-4}\ \text{m}^2} = 0.49\ \frac{\text{K}}{\text{W}} \qquad (5)$$

Thermal resistance of the WE-TINS 3.5 W/m·K:

$$R_{\text{TINS 3.5}} = \frac{2.5 \cdot 10^{-4}\ \text{m}}{3.5\ \frac{\text{W}}{\text{mK}} \cdot 2.89 \cdot 10^{-4}\ \text{m}^2} = 0.25\ \frac{\text{K}}{\text{W}} \qquad (6)$$

Since the lower performing 1.6 W/m·K thermally conductive insulator pad already has a lower thermal resistance than that of the first scenario, we assume:

$$R_{\text{scenario 2}} = 0.49\ \frac{\text{K}}{\text{W}} \qquad (7)$$

Conclusion

Now that we have performed a preliminary assessment of both scenarios, we can conclude that a WE-TINS will have a similar, if not better, thermal performance than a combined mica and thermal grease interface. It also simplifies the assembly as the handling of pads is easier than the other interfacial solutions explored.

4. THERMAL PERFORMANCE

The added value that thermally conductive insulator pads bring when compared to elastomeric pads is that they can withstand higher compressive pressure. As with any gap filling thermal interface, the higher the compression, the lower the thermal resistance of the pad.

This is due to two factors:

- Reduction in bond line thickness
- Increase in contact area due to adaptation of surface roughness

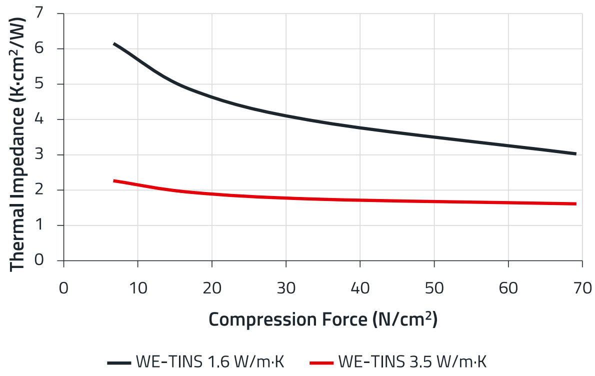

Figure 3: Thermal impedance as a function of the compression force.

5. THERMAL MEASUREMENT SETUP

All thermal parameters mentioned in this guideline have been performed in-house following ASTM D5470 - Standard Test Method for Thermal Transmission Properties of Thermally Conductive Electrical Insulation Materials, as seen in Figure 4. The standard focuses on steady-state heat transfer conditions.

During testing, a constant heat source is applied to one side of the TIM (thermal interface material) specimen, while a cooling assembly ensures a temperature difference to create a heat flow through the material under test. This setup allows for the measurement of thermal conductivity and impedance under different temperature and mechanical conditions.

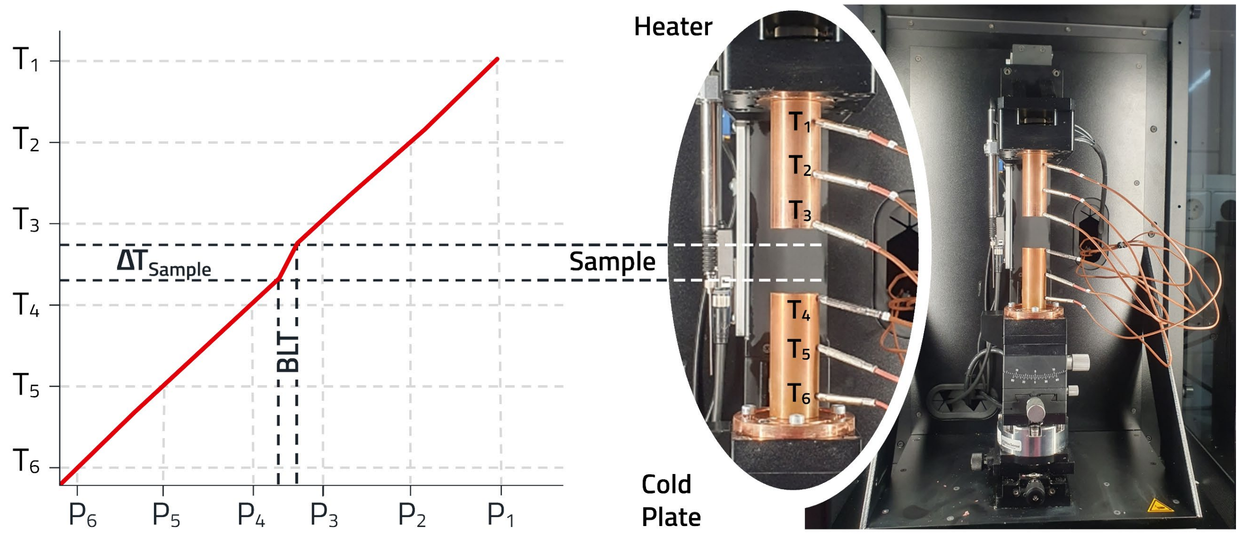

Figure 4: ASTM D5470 testing setup

6. INSTALLATION AND HANDLING

The correct installation of TIM is crucial for ensuring optimal thermal performance and long-term reliability of electronic devices. During installation, it is essential that the pads are clean, free from contaminants, and properly aligned with the components they are intended to cool. Proper alignment guarantees maximum surface contact, minimizing thermal resistance. Applying an appropriate amount of pressure while installing the pads is vital. Adequate pressure helps in squeezing out air pockets and ensures a tight bond between the pad, the electronic component, and the heatsink.

In order to ensure correct application, the following steps are recommended:

1. The surface of the component and cooling assemblies must be clean and dry. It is recommended to use isopropyl alcohol applied with a lint-free wipe or swab to remove any particles on contact surfaces.
2. Place the pad on one of the contact surfaces and hold it in place.
3. Position the rest of the assembly and ensure that the pad is aligned with the profile.
4. Apply the recommended compression.

Cutting

The WE-TINS can be cut into shape with any sharp object. Laser cutting is discouraged because it can harden the edges and decrease thermal performance of the pad by increasing its hardness around the cut.

Reworking

If the pads are not damaged upon installation, they can be removed and used again for repositioning during assembly as long as the contact surfaces remain clean and free of any foreign particles.

7. MODIFICATION AND PROTOTYPING SERVICE

Würth Elektronik provides a shape modification service that accompanies you from prototyping to manufacturing, offering no MOQ or tooling costs. The goal of this service is to support you from prototyping to manufacturing.

Modified shapes are performed by die-less cutting. This technique allows a knife to cut a standard sheet into any desired shape within the machine's tolerances. The parts will be delivered in bulk or on a sheet if a pressure sensitive adhesive is required.

Reach out to your Würth Elektronik representative with the following information, and they will get back to you with a personalized quotation:

- Base material
- Number of parts needed
- Technical drawing of desired part
- Any special requests you may have

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