Thermal Design

Precautions for Thermal Resistance of Insulation Sheet

If a non-isolated package with an exposed metal pad (thermal pad) for heat dissipation on the back surface, such as TO (Transistor Outlines) packages, is installed on a heatsink, it is necessary to isolate the heatsink from the metal pad using an insulation sheet because a high voltage is applied to the heatsink via the metal pad. Thermal estimation using inappropriate values of the thermal resistance of the insulation sheet leads to incorrect results. Therefore, this application note provides precautions for the thermal resistance of the insulation sheet.

As an example of the TO packages, Figure 1 shows the appearance of the TO-247 package. A metal pad for heat dissipation is exposed on the back surface. For MOSFET, since this pad is electrically connected with the drain of the die (semiconductor chip) inside the case, a high voltage is applied to the metal pad in many circuits. If this package is installed on a heatsink, it is necessary to insert an insulating heat dissipation sheet between the heatsink and the metal pad as shown in Figure 2.

To adhere the heatsink and the TO package, pressure is applied with an attachment mechanism such as screws and clips. The pressure compresses the insulation sheet and changes its thermal resistance. The change in the thermal resistance can be attributed to change in the contact thermal resistance due to the applied pressure.

Obtaining the thermal resistance of insulation sheet

Depending on the manufacturer, some specifications of insulation sheets published in catalogs and on websites may include the contact thermal resistance while others may not. There are also cases where it is provided using the pressure as a parameter. The contact thermal resistance is an important parameter because it affects the heat dissipation performance of the sets. Even if the contact thermal resistance is included in the values, it is necessary to consider change in the contact thermal resistance due to the types of material and surface roughness on both sides of the sheet.

In some cases, only the thermal conductivity may be provided. The thermal conductivity is a value unique to each material. It indicates how easily heat can be transferred inside the material. It is independent of the thickness, and may be underestimated if the contact thermal resistance is not known.

Therefore, it is necessary to obtain the thermal resistance data corresponding to the actual operating pressure from the manufacturer and perform the thermal estimation. Figures 3 and 4 show an example of the sheet with low and high hardness, respectively. Since the thickness of the low hardness sheet is decreased by the applied pressure, the thermal resistance of the sheet itself is decreased. Although the thickness of the high hardness sheet is not significantly changed by the applied pressure, the thermal resistance is decreased. This shows that applying pressure decreases the contact thermal resistance. Since the contact thermal resistance of a high hardness insulation sheet is increased due to the types of material and surface roughness on both sides of the sheet, it is more susceptible to pressure.

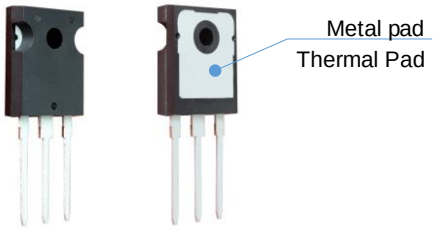

Figure 1. Appearance of the TO-247 package

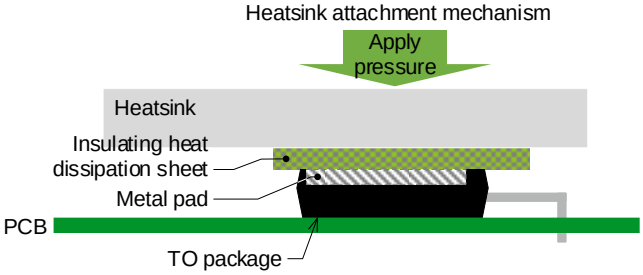

Figure 2. Isolation between the metal pad of the TO package and the heatsink

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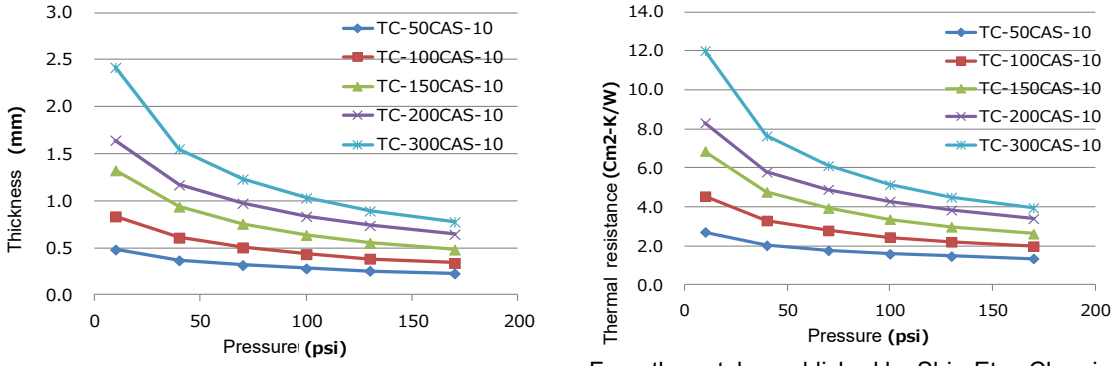
Low hardness heat dissipation silicone pad TC-CAS-10 Series



From the catalog published by Shin-Etsu Chemical Co., Ltd.

Figure 3. Thermal resistance characteristics of low hardness sheet with varied pressure

High hardness heat dissipation insulating silicone rubber product TC-TAG-3 Series

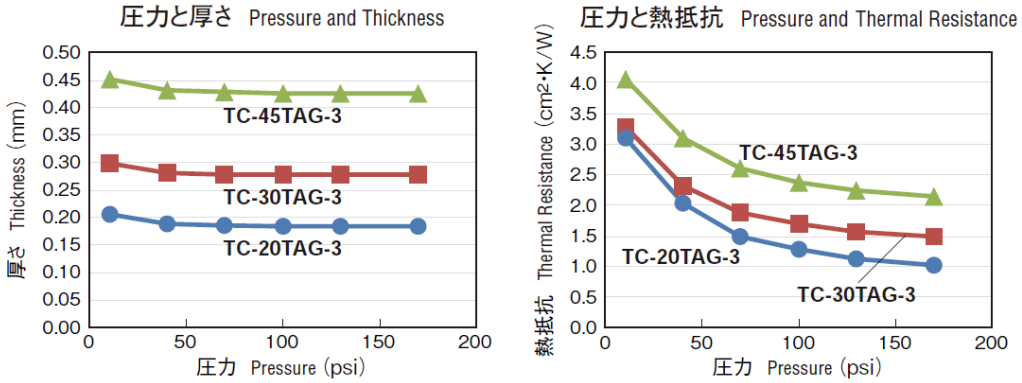


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Figure 4. Thermal resistance characteristics of high hardness sheet with varied pressure

Next, we will explain the difference in the estimated results for the junction temperature with and without consideration of the contact thermal resistance. The results shown here are based on simulations of the model in Figure 2. Consumption power P_C of the device is 30 W. Ambient temperature T_A is 65°C.

Estimation without consideration of the contact thermal resistance:

- 1.5°C/W is used for θ_{JA}.
- $T_J = \theta_{JA} \times P_C + T_A$

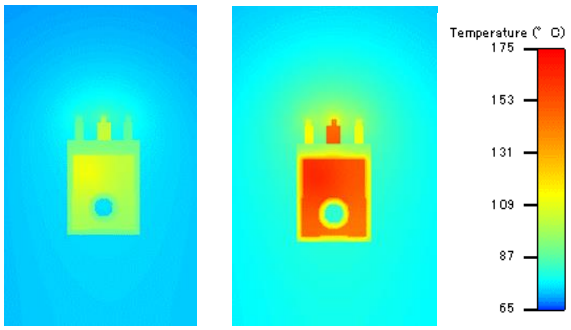
  $= 1.5°C/W \times 30\ W + 65°C = 110°C$

Estimation with consideration of the contact thermal resistance:

- With the contact thermal resistance added, 3°C/W is used for θ_{JA}.
- $T_J = \theta_{JA} \times P_C + T_A$

  $= 3°C/W \times 30\ W + 65°C = 155°C$

In this example, the estimation of the junction temperature without consideration of the contact thermal resistance leads to an acceptable result within the rating. However, the actual result exceeds the absolute maximum rating because the contact thermal resistance is added. Thus, caution should be exercised because incorrect results may be obtained if the contact thermal resistance is not considered in applications with a high power consumption.



Without contact thermal resistance

With contact thermal resistance

Figure 5. Temperature difference between cases with and without consideration of the contact thermal resistance

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