Power Module

Optimized heat sink assembly method for effective heat dissipation

Power modules are widely used in inverter and motor drive applications. Inside the module the semiconductor devices dissipate heat from conductive loss and switching loss. Therefore, it is necessary to consider in the design the heat dissipation mechanism. This application note shows the optimized assembly of power modules to heatsinks and presents the effect of optimized mounting on effective dissipation of heat from the module to the heat sink.

Power module structure

As shown in Figure 1, the power module consists of chips, a base plate, and an isolation substrate between them. Ideally, the base plate should be flat to achieve a good thermal contact to the heatsink. However, in reality it is warped due to mechanical stress between the different materials inside that remains after the manufacturing process. A measurement of the flatness of a base plate surface is shown in Figure 2. The height differences reach around 40μm. This induces gaps at the interface of module base plate and heat sink, deteriorating the heat dissipation, and as a result, the chip temperatures may exceed maximal allowed chip temperature.

About thermal grease

A thermal sheet or thermal grease is used commonly to fill the gap between the base plate and heat sink surface. This would be necessary, even if there were no gap at room temperature, as the baseplate shape changes with the temperature.

Although, in principle, it is easy to use a thermal sheet because of its solid shape, the required torque for installation is larger than the power module's torque rating. In the case of thermal grease, the required torque is smaller than power module's rating due to its liquidity. However, it is difficult to control the thickness of grease and the shape will be easily changed due to temperature changes during operation (pump-out). Please pay close attention to material selection. The assembly method and effects of thermal grease are shown as below.

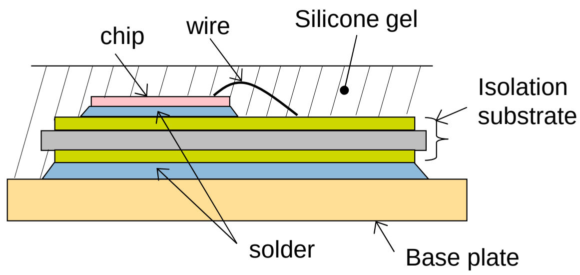
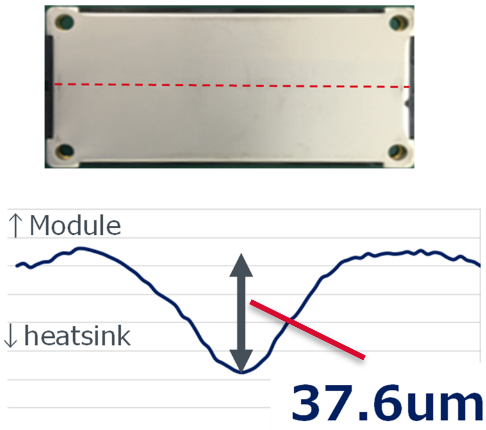


Figure 1. Power module structure



Sample:BSM300D12P2E001

Figure 2. Warped shape of power module base plate at room temperature

Application of Thermal greases.

The gap size between heat sink and module base plate depends on power module. Please choose a suitable thickness for thermal grease. Too thin or too thick thermal grease would increase the thermal resistance. It is recommended to control the thickness of thermal grease in the range of 50-100μm. Using a metal mask and a squeegee, is strongly recommended, instead of roller or spatula, to uniformly paint grease on module base plate surface.

Figure 3. shows the flow of grease painting on module surface

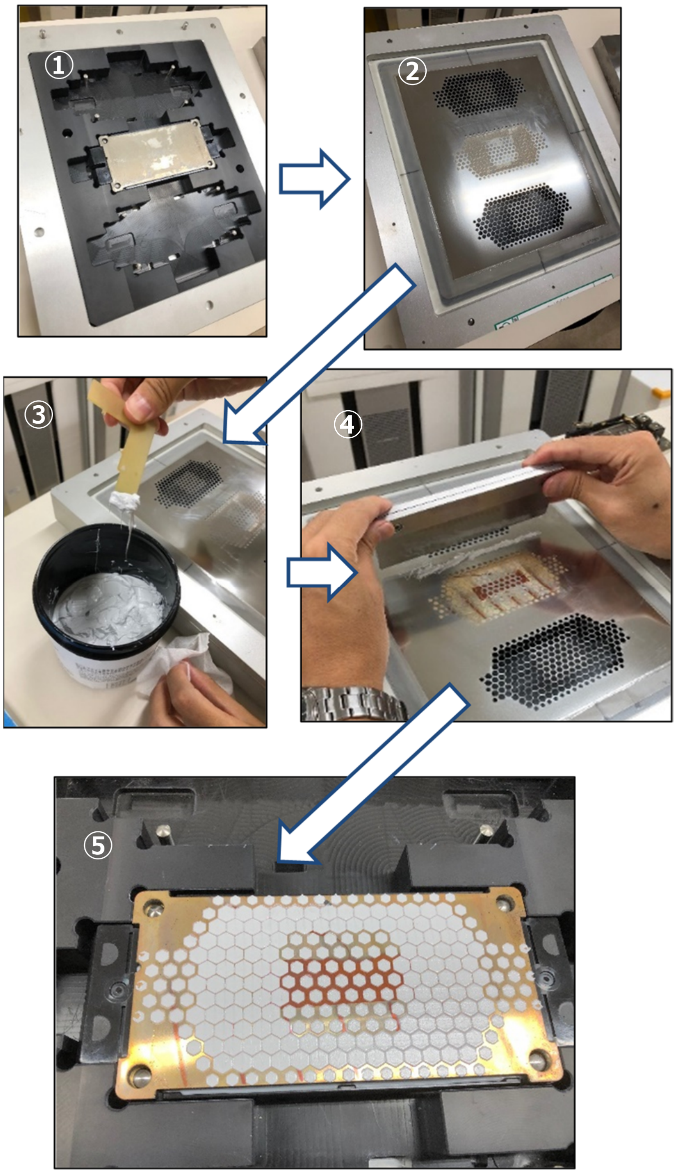


Figure 3. Thermal grease painting using metal mask

① Attach the power module to the mold
※ Wipe module base plate surface

② Stack metal mask on the power module
※ Wipe the metal mask

③ Paint grease on the metal mask

④ Spread the thermal grease on the base plate's surface using the squeegee.
-Hold the squeegee with a 60° angle to the surface and move it at the speed of 2-3 cm/s. Do it several times until thermal grease is uniformly distributed.

⑤ The Base state surface after painted with grease.

Please contact ROHM through to the following URL if you need the metal mask schematic.
(https://www.rohm.co.jp/contactus)

The interface of the heat sink and the module (shown in Figure 4.) should meet the following requirements:

- Flatness of heatsink of 30 μm or less.
- Surface roughness of heatsink of 10μm or less

Otherwise, the isolation substrate inside the power module can be destroyed.

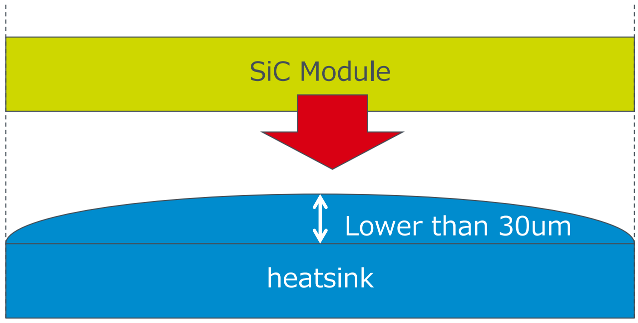


Figure 4. Heat sink and module interface

The thermal grease will be spread out by the pressure from assembly torque. Increase the torque gradually for more uniform distribution of the grease. The sequence of tightening the screws to fix the module to the heatsink is shown in Figure 5. The torque in step ② should be bigger than in step ①. Be sure that the torque applied is within the specification range of the power module rating, to prevent isolation damage of the substrate inside.

① 1→2→3→4 with fasten torque of 0.5 N.m

② 1→2→3→4 with fasten torque of 3.0 N.m

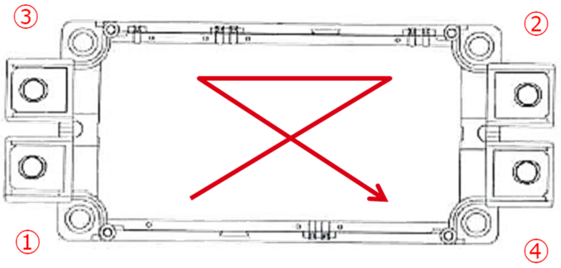


Figure 5. The sequence of tightening the screws.

Chip temperature measurement

Figure 6. shows measurement of the chips' temperature in case either the thermal grease or thermal sheet is used. Details on the sheet and grease are shown in Table 1. A thermographic camera was used to measure the chips' temperature during operation. The measurement conditions are shown in Table 2 below. The mounting torque applied to the screws is the same as conditions described previously.

Table 1. Material information

	Sheet	Grease
Heat conductivity (W/mK)	25~45	≒3
Thickness after mounted(μm)	≒200	≒50

Table 2. Temperatures measurement conditions

Item	Parameter
Sample	BSM300D12P2E001
DC Current(A)	225
Duration(s)	60
Chiller Temp(℃)	50

The temperature profile across the line of chips is plotted in Figure 7. and the measurement results are shown in Table 3. In case of using thermal grease, the temperature difference between chips is less than 5℃, which confirms the effective heat dissipation in this case. In case of using the thermal sheet, the chip temperature in the middle area is remarkably high and the temperature difference between chips reaches up to around 20℃. This result shows that heat was not effectively dissipated in this case. Larger torque is needed for thermal sheet, especially when sheet is slacked or with scratches. If torque is not large enough, gap will be induced, deteriorating the heat dissipation. However, a too high torque would exceed the module specifications, 3.5 N.m. We advise against using thermal sheets. Instead, we recommend to use a thermal grease between heatsink and power module.

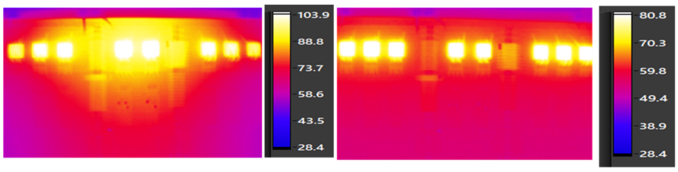


Figure 6. Chip temperature measured by thermographic camera

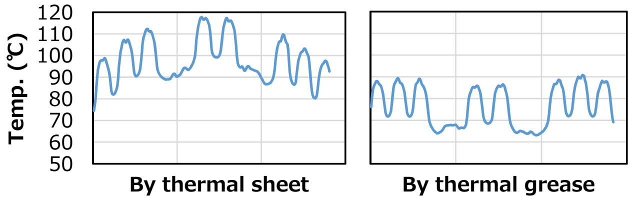


Figure 7. Chip temperature profile

Table 3. Measurement result

	max(℃)	min(℃)	ave(℃)
Sheet	117.8	97.6	108
Grease	90.8	86	87.8

Summary

Using thermal grease with thickness control by metal mask is recommended for good heat dissipation. Please take care about thermal grease viscosity, because this influences grease spread. The result of several types is shown in Table 4. and grease with too large viscosity could not be performed in good heat dissipation. The grease viscosity is about 160 Pa.s in this application note.

Table 4. Result of heat dissipation by grease

Heat Conductivity (W/mK)	Specific Gravity (g/cm3)	Viscosity (Pa・s)	Heat dissipation
0.9	2.65	50	Good
3.0	3.2	160	Good
1.3	2.9	60	Good
4.5	2.5	420	Bad

If grease viscosity is extremely high, too high force would be applied to the module, inducing damage to the isolation substrate inside. Hopefully, this application note can help you to handle SiC power modules in your application well.

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