Application Method and Evaluation of Thermal Grease

1. Purpose

An appropriate thermal interface is an essential matter to be considered in mounting a power module on a heat-sink. Thermal grease is widely used as thermal interface material to reduce thermal resistance between a power module and a heat-sink. The realization of appropriate thermal interface requires correct application of grease. If grease is incorrectly applied, it may cause overheating of the chips. In this document, a correct application method and evaluation results of thermal grease are mentioned.

2. Application method

In this section, an application method which was confirmed by MPSD for mounting an IGBT module on a heat-sink, is presented. However, an optimum mounting method varies according to the shape of a heat sink. Therefore the method is just an example and is not intended to guarantee the mounting condition. Fig.1 shows the work flow of the method. The steps of the work flow are as follows.

Step 1 – Set a stencil:

Clean the surface of the base-plate by removing all foreign materials and then set a stencil on the base-plate as shown in Fig.1 (a).

Step 2 – Place grease:

Place enough grease on the edge of the stencil for spreading all over the surface of the base-plate as shown in Fig.1 (b).

Step 3 – Squeeze the grease:

Squeeze the grease into the stencil by a squeegee as shown in Fig.1 (c). Fig.1 (d) shows the state of the grease after squeezing.

Step 4 – Remove the stencil:

Remove the stencil after squeezing as shown in Fig.1 (e).

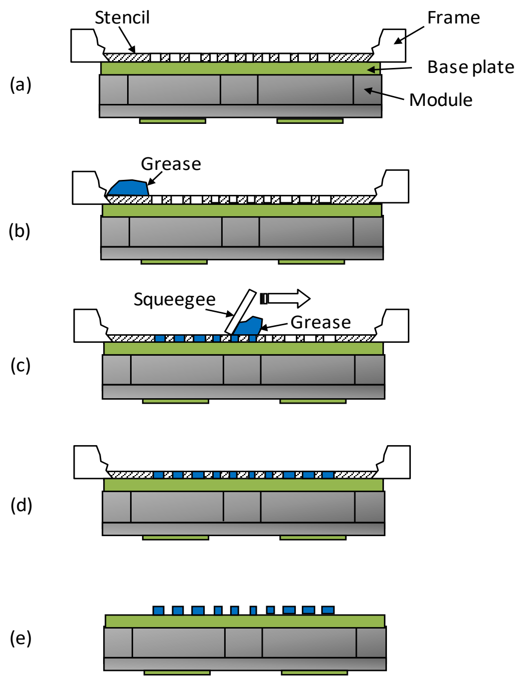

Fig.1 Work flow of grease application

3. Evaluation

3.1 Thermal resistance

(a) Evaluated grease: Grease type G747 and newer types released by Shin-Etsu Chemical Co., Ltd. were evaluated. Table 1 is the list of the catalog data for G747 and the other types.

Table 1 Characteristics of evaluated grease

Grease type *1)	Appearance	Viscosity (Pa·s) 25°C	Specific Gravity 25°C	Volatile Content (%) 150°C/24hr	Thermal conductivity (W/m·K)
G747	White	50	2.65	0.06*2)	0.9
G750	Gray	300	2.77	0.28	3.5
G775	White	500	3.4	0.26	3.6
G776	White	58	2.9	3.10	1.3*3)
G777	White	172	3.4	0.10	3.1

*1) Released by Shin-Etsu Chemical Co., Ltd.
*2) 120°C/24hr
*3) Value after evaporation of solvent

(b) IGBT module: The appearance of an IGBT module used for measuring the thermal resistance of grease is shown in Fig. 2. The size of the module is 140mm x 190mm.

Fig.2 IGBT module used for measuring thermal resistance

(c) Stencil: Fig. 3 shows the perforated pattern of a test stencil used for thermal resistance measurement. Generally, practical thickness of metal type stencil is from 100μm to 150μm. This time the thickness 150μm was selected for evaluation.

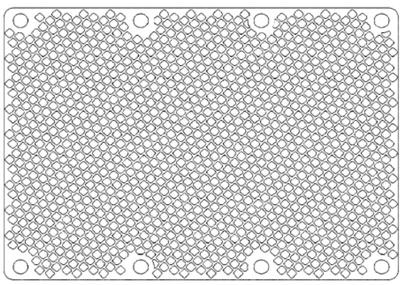

Fig.3 Perforated pattern of test stencil

(d) Measuring and results: Case temperature Tc and heat-sink temperature Th is defined as shown in Fig. 4. According to the definition, Tc and Th were measured just under the center of IGBT chip and then thermal resistance Rth(c-h) was calculated by the following equation:

$$Rth(c\text{-}h) = (Tc - Th)/P \quad \text{------ (1)}$$

where P is power applied to the IGBT chip.

Fig. 5 shows the results, where the value of Rth(c-h) is indicated as a relative value based on the value of G747 indicated as 1. Rth(c-h) corresponds well to the thermal conductivity of each grease, i.e. G747, G776, G750, G775, G777.

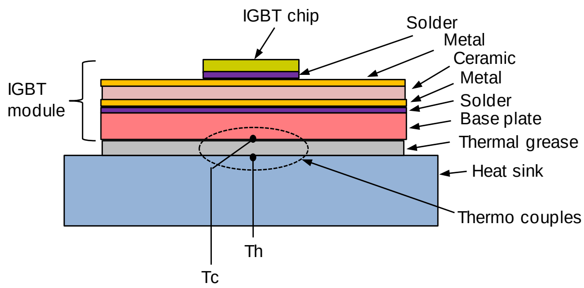

Fig.4 Definition of Tc and Th

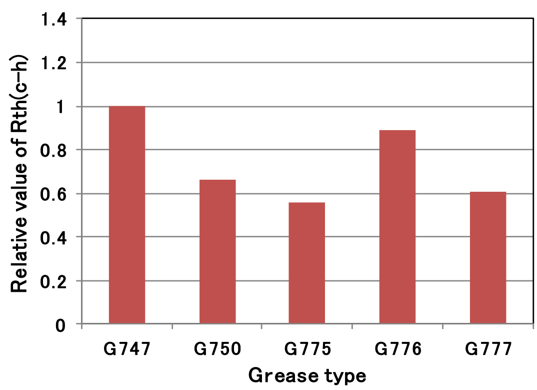

Fig.5 Thermal resistance comparison among grease types

3.2 Power cycling

For the purpose of comparing the durability against thermal stress among the different types of grease, power cycling test were conducted. Fig. 6 shows the test results. In case of G747, ΔTj is increased according to the test cycles. Same tendency is observed for G750, but the increase level is smaller than G747. In case of G775, G776, G777, ΔTj is stable up to 50000 cycle. From these test results, G775, G776, G777 are estimated as more stable than G747.

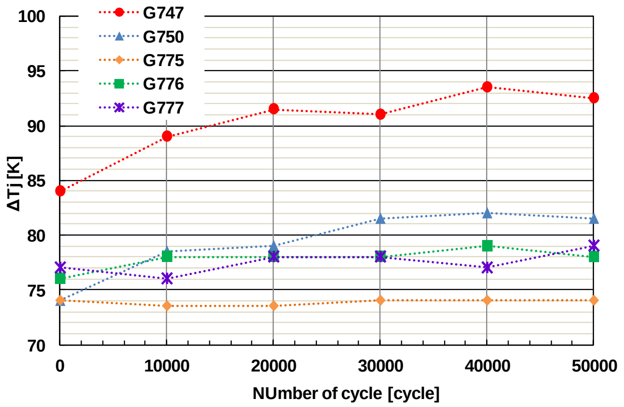

Fig.6 ΔTj change with power cycle

3.3 Summary of the test results

(1) Tendency of Rth(c-h) measurement results correspond to the thermal conductivity of each grease type. And G750, G775, G777 show lower thermal resistance than the others.

(2) G750, G775, G776, and G777 are expected to be more stable than G747 as a result of ΔTj change through the power cycling test.

These results may change according to test conditions, therefore, please refer to as an example.

4. Example of Practical perforated pattern

In applying thermal grease on a base-plate, the following item (1) and (2) are needed to be considered.

(1) To perfectly fill the thermal interface area under IGBT-chips and diode-chips with grease when an IGBT module is fixed to a heat-sink by screws.

(2) To reduce the amount of extruded grease from the thermal interface area of a base-plate when an IGBT module is fixed to a heat sink by screws.

Fig. 7 shows an example of practical perforated pattern. In the area under IGBT-chips and diode-chips, large size holes are clustered together in order to increase the amount of grease to the application area. In the other areas, especially near to the mounting holes of the IGBT to the heat-sink, there are small size holes in order to decrease the total amount, especially extruded grease. The pattern of Fig. 7 is a suggested example and is not intended to guarantee the effectiveness of the pattern. Verification with the actual heat-sink is recommended.

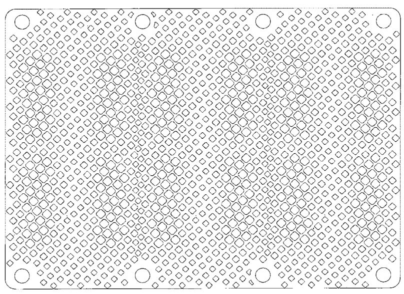

Fig.7 Example of perforated pattern of stencil