Precautions when using Shunt Resistors

Method of Suppressing Increase in Surface Temperature of Shunt Resistors

● Summary

Shunt resistors are widely used for current sensing in automotive and industrial applications. In the automotive sector, as vehicles become more complex and the number of motors and ECUs grows, applications need to be configured in a limited space.
As a result, components are being mounted more intensively and customers require shunt resistors—one of the components mounted on vehicles—that are more power efficient and compact.
Accordingly, the thermal design of products and circuit boards has become an important issue.

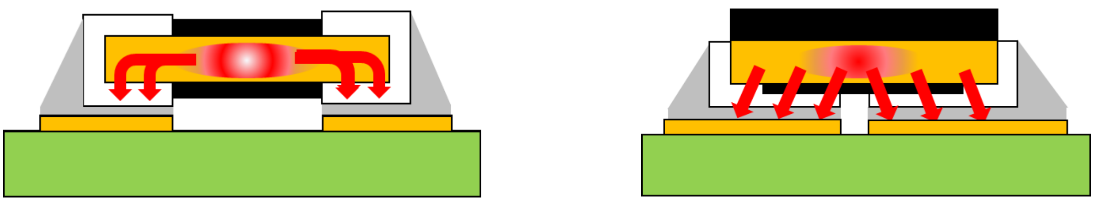
● Method of Suppressing Increase in Temperature of Shunt Resistors

In order to suppress the increase in temperature of shunt resistors, the heat dissipation design of both the product and the mounting board are important.
Even if the product is designed to suppress temperature increase, the temperature can rise unexpectedly if the mounting board is not adequately designed to dissipate heat.
Conversely, even if the mounting board is designed to dissipate heat, the actual temperature rise may be larger depending on the heat dissipation design of the product.

[Suppressing temperature rise through product heat dissipation design]

If the heat generated is not efficiently dissipated by the mounting board, it will be trapped in the product and a large temperature rise will occur.
When designing the thermal characteristics of the product, it is necessary to ensure a heat dissipation path from the resistive element to the board.
A typical example is shown below.

Figure 1 shows the heat dissipation to board paths of a standard product and the GMR Series.
Compared to standard products, the GMR Series is designed to dissipate the heat generated by the resistive element more efficiently and to dissipate it directly to the board.
As a result, the GMR Series has a lower surface temperature rise than standard products of the same size.
This reduced surface temperature rise means that more power can be applied and therefore a higher power guarantee is possible.



Heat dissipation path of a standard product　　Heat dissipation path of the GMR Series

Figure 1. Heat dissipation paths to board of different products

No. 64AN091E Rev.001
Oct 2021

Figure 2 shows a thermal image of the surface temperature of a standard product of size 5025 and the GMR50 with 2 W applied.

The same board is used to mount each product and a resistance value of 5 mΩ is used for both products.

The results show that the hot spot *1) temperature of the resistive element of the GMR50 is lower than the temperature of the standard product.

On the other hand, the temperature at the terminals of both products is the same level.

This means that the difference in temperature rise between the products is due to the difference in thermal resistance *2) from the resistive element hot spot to the terminals.

To suppress heat generation, you must choose a product with low thermal resistance (between the resistive element and the terminals).

- Thermal resistance of 5025 size standard product: 31.0ºC/W (117ºC-55ºC/2W)
- Thermal resistance of GMR50: 9.5ºC/W (75ºC-56ºC/2W)

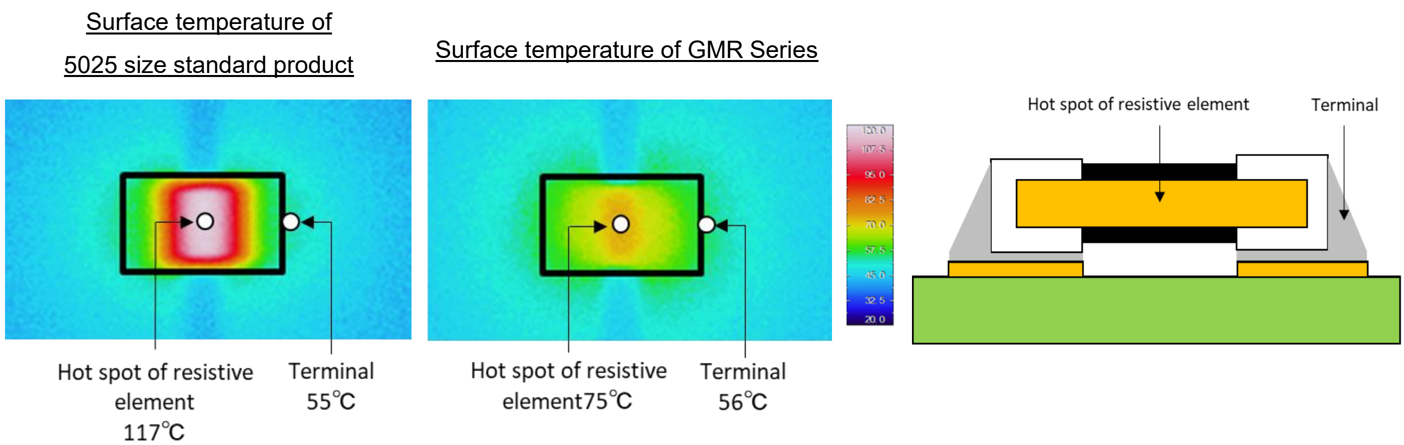


Figure 2. Comparison of heat generated with 2 W applied

[Board heat dissipation design]

When considering the heat dissipation design of a board, the following items are important:

- The copper foil thickness (multilayer boards)
- The copper foil area

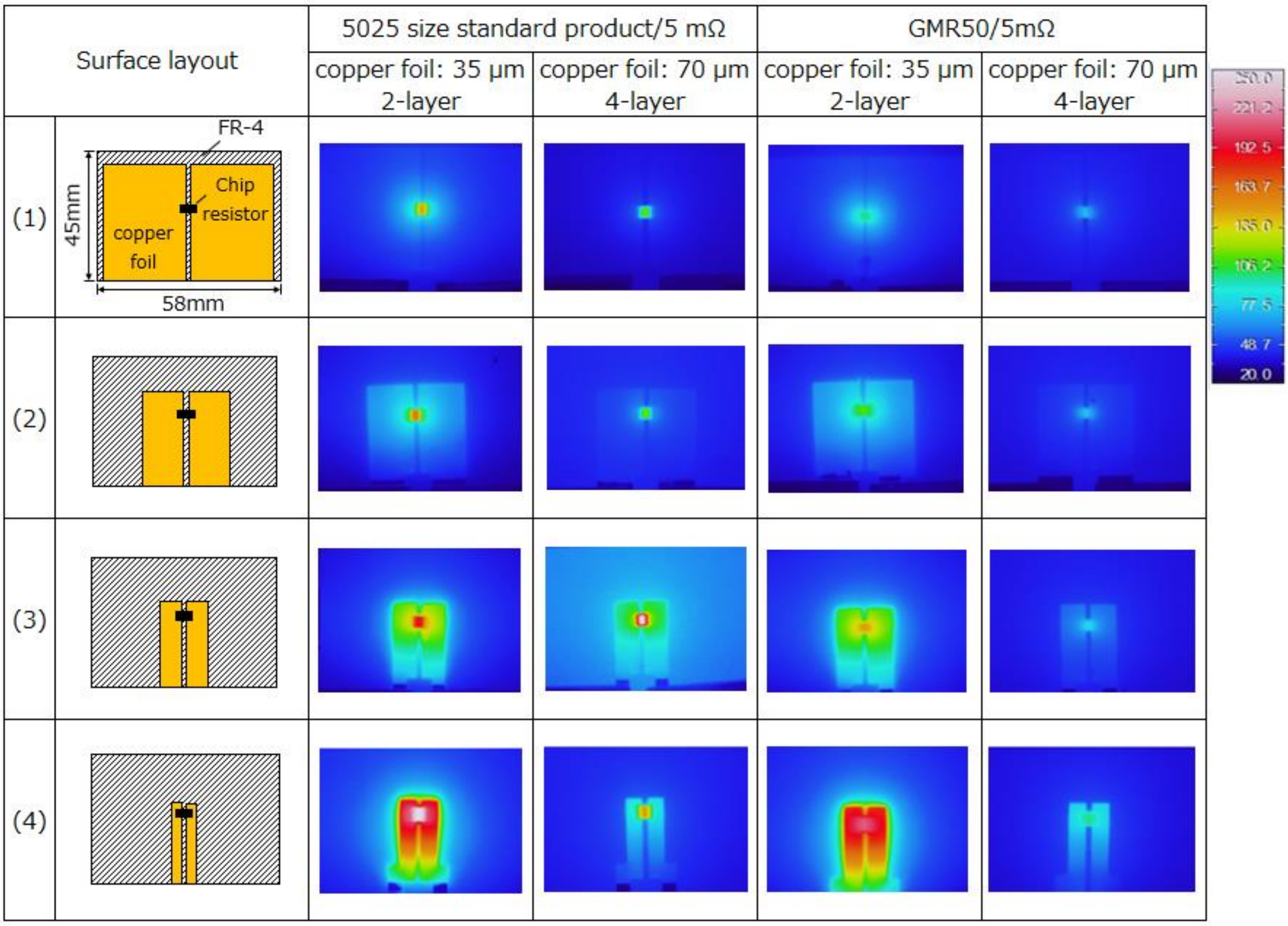
Figure 3 shows a comparison of the heat generated on a two-layer board with a copper foil thickness of 35 μm and a four-layer board with a copper foil thickness of 75 μm for four types of board with different copper foil areas on the surface layer. The copper foil on top of the surface layer was laid out covering the board size. The products used were a GMR50 and a 5025 size standard product of 5 mΩ.

In the case of the two-layer board with a copper foil thickness of 35 μm, heat dissipation is less in the board thickness direction and greater in the horizontal direction, so when the surface copper foil area is reduced, the product temperature increases significantly.

On the other hand, in the case of the four-layer board with a copper foil thickness of 75 μm, heat is dissipated in the direction of the board thickness, so the temperature rise of the product remains relatively low even when the surface copper foil area is reduced. If the mounting area of the shunt resistor on the surface of the board cannot be made larger, the temperature rise of the product can be suppressed by making the copper foil thicker or by using a multilayer board to create a heat dissipation path for the heat generated by the product.

In addition, as mentioned above, even if the product has a good heat dissipation design, the temperature rise can vary greatly depending on the design of the mounting board.

When selecting a shunt resistor, it is important to consider the thermal resistance of the product and the heat dissipation of the board on which the product will be used.



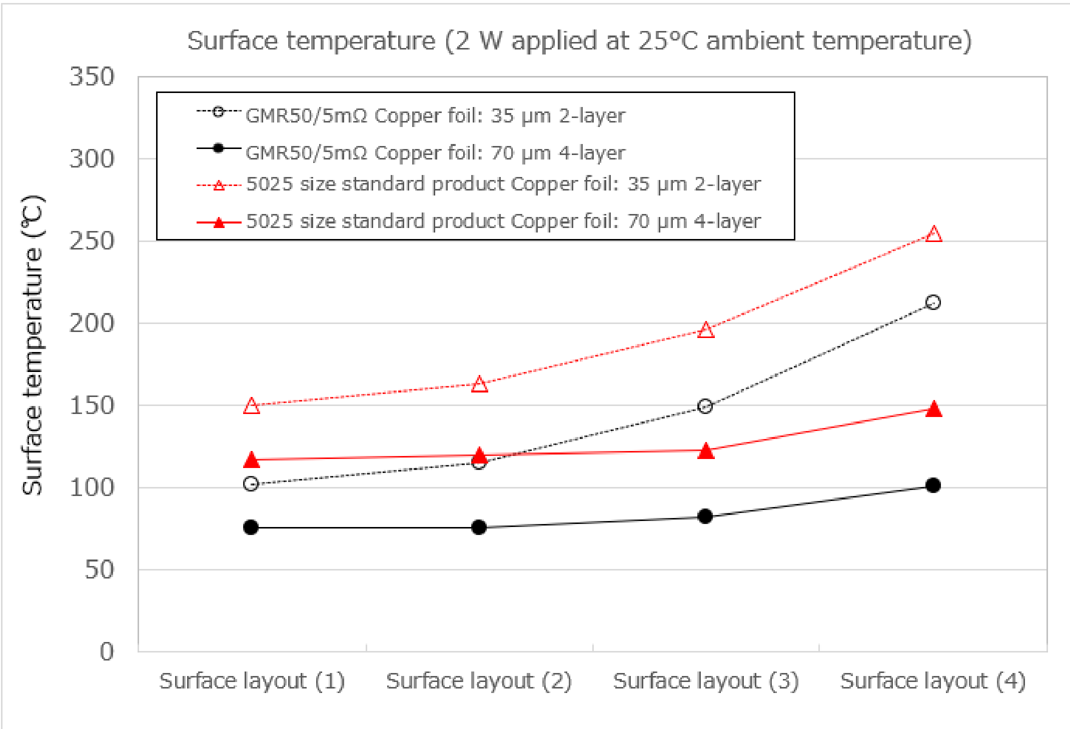


Figure 3. Comparison of surface temperature for different layouts of copper foil on a board

Also, in actual use, shunt resistors are surrounded by other components on the board, and both the heat radiated by these components and the effect of heat on them must also be taken into account.

ROHM can simulate not only resistors but also surrounding components such as ICs and power semiconductors as part of its design support for countermeasures against heat.

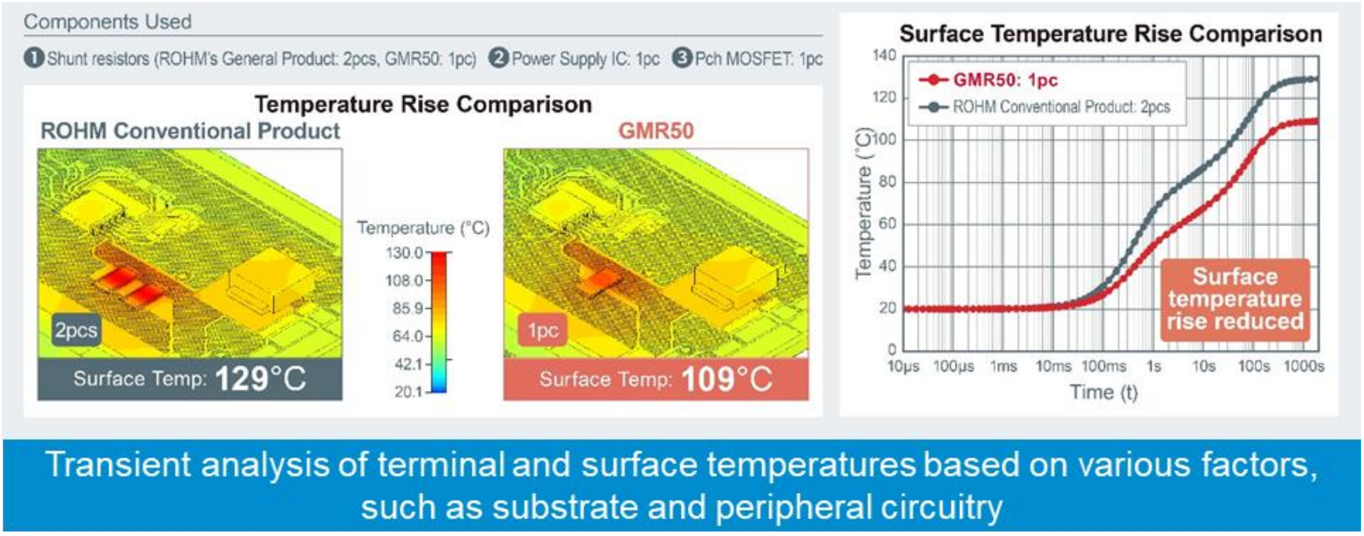


Figure 4. Example of thermal simulation

<Term descriptions>

*1) Hot spot

The highest point of surface temperature, where the concentration of heat in a resistor is highest.

*2) Thermal resistance

A quantification of how difficult it is for heat to be conducted. Thermal resistance is calculated by dividing the temperature difference between two given points by the heat flow (applied power).

The unit is ºC/W (K/W). This means that the higher the thermal resistance, the more difficult it is for heat to be conducted, and vice versa.

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