Development of a Novel Insulated NTC Thermistor for Power Module Applications

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Introduction

Power semiconductor devices degrade under high-temperature operation and thermal cycling, making accurate junction temperature (JT) monitoring essential for system reliability. Electrical sensing based on thermo-sensitive electrical parameters (TSEPs) has become the mainstream method, but on-chip sensors in SiC devices face yield and process issues, while conventional glass-encapsulated NTC thermistors require dedicated copper pads, limiting placement near bare dies and reducing accuracy [1–3]. This work proposes a novel electrically insulated NTC thermistor integrated into power modules, enabling flexible substrate design, improved thermal responsiveness, and enhanced sensing accuracy while maintaining insulation and mechanical reliability.

Thermistor Structure

The insulated thermistor shown in Fig. 1(a) presents a perspective view of the internal structure, where a chip-type NTC element is encapsulated in a rectangular epoxy resin body. As illustrated in Figs. 1(b) and 1(c), copper plates are attached to the top and bottom surfaces for electrical connection and substrate bonding, respectively. The top copper plate enables voltage sensing via wire bonding, eliminating the need for dedicated mounting space on the substrate side. This structure allows flexible and reliable placement near switching devices.

Results and Discussion

Three-dimensional FEM simulations were conducted to evaluate the thermal response of the proposed thermistor in SiC power modules under 100 W dissipation per die. The proposed device exhibited faster temperature tracking of bare dies compared with a conventional thermistor. Thermal time constant analysis showed 2.356 s for the proposed sensor, reduced by 0.235 s relative to the conventional one, clearly demonstrating improved responsiveness. This improvement indicates that the proposed design can provide more reliable junction temperature monitoring under realistic operating conditions.

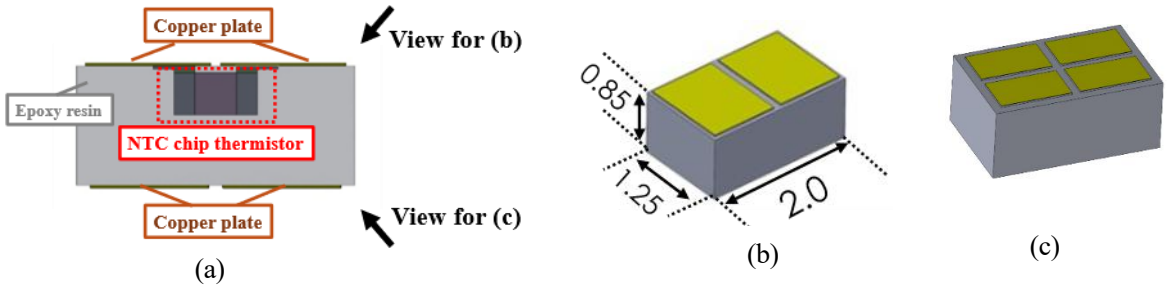

Figure 1: Structure of the proposed NTC thermistor. (a) Internal structure. (b) Top view. (c) Bottom view.

References

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