Thermally Conductive Metal Substrate

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1 Summary

Due to the strong demand for saving energy, the light-emitting diode (LED) market is growing rapidly.[1)] High-power LED devices especially are strongly needed. To disperse the heat from LED devices, thermally conductive metal based printed wiring board is also strongly needed. By applying our novel thermally conductive epoxy resin technology, a thermally conductive adhesive sheet "HT-5100S" and a metal substrate "HT-5100M" were developed. HT-5100S can be treated as a sheet because it has high flexibility. HT-5100M has not only an excellent heat dissipation property but also an excellent insulation property and adhesion strength.

2 Features

- HT-5100S has higher thermal conductivity (5 W/m·K) compared to the conventional thermally conductive insulating sheets (1 - 3 W/m·K).
- HT-5100S has high flexibility at a half-hardened condition (B-stage) and shows excellent properties at bending and punch-out process.
- HT-5100M has great insulation performance, high adhesion strength and high breakdown voltage, so it is superior in long-term insulation reliability.

3 History of Development

Previously, thermally conductive sheets were made by high density loading of thermally conductive ceramic filler into resin. According to Kaneshiro's experimental formula[2)], in order to increase thermal conductivity of composite, increasing the thermal conductivity of resin and increasing the loading rate of fillers are effective, though increasing the thermal conductivity of fillers is less effective. (**Figure 1**). However, adhesion strength and insulation properties of the composite are degraded by the loading rate of the fillers. We have begun to develop insulating sheets and metal substrates with high thermal conductivity by using thermally conductive epoxy resin with mesogen structures[3)], and by investigating methods to disperse thermally conductive fillers into the resin we developed.

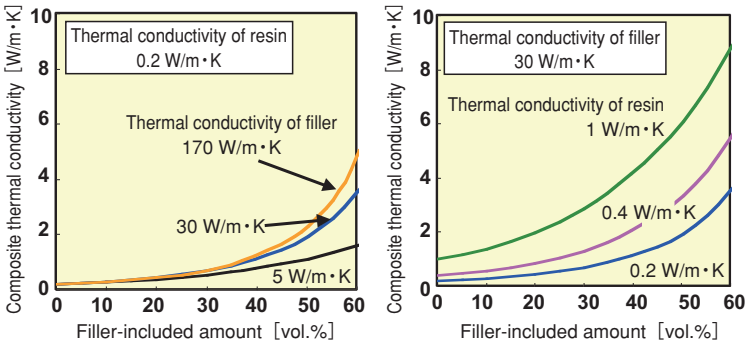


Figure 1 Dependence of composite thermal conductivity on filler content.

4 Content of Technology

The thermal conductivity of composites including general-purpose resin and thermally conductive fillers is about 3 W/m·K. However, the thermal conductivity of HT-5100S, which uses our proprietary thermally conductive resin as composites, reaches 5 W/m·K. Also, because conventional resin with high thermal conductivity is highly crystallized, it is easy for B-stage sheets to become fragile. By combining with the phenol resin we developed, the crystallization of the composites is controlled and thermal conductivity and flexibility both could be achieved. As a result, HT-5100S shows high flexibility (**Figure 2**), and it has outstanding handling capability in B-stage.

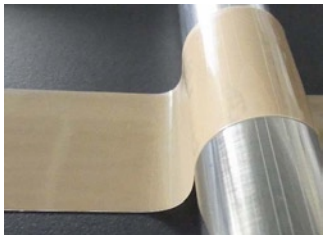


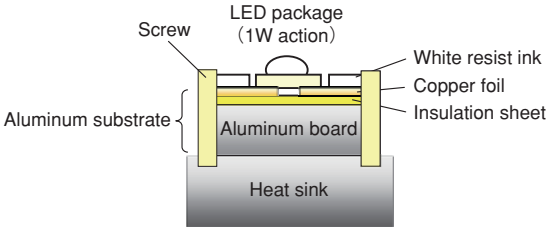
Figure 2 Flexibility of HT-5100S (B-stage).

Table 1 Properties of HT-5100M

Property	Measurement condition	Unit	HT-5100M
Thermal conductivity	Xe flash method	W/m·K	5.4
Copper foil peel strength	25 ℃	kN/m	1.5
Thermal resistance	300 ℃	s	>120
Volume resistivity	25 ℃	Ω・cm	$>1.0\times10^{15}$
Breakdown voltage	Normal state	kV	>3.0
Tg	DMA (tan δ) 1.5 Hz	℃	165

The general properties of the metal substrate HT-5100M, which uses HT-5100S as the insulation layer, is shown in **Table 1**. HT-5100M exhibits not only high thermal conductivity but also superior insulation and adhesion strength. Also, because it has excellent heat resistance, it can be applied not only to LED but also to power modules and automobile circuit boards.

We implemented LED using HT-5100M and measured its temperature when it is lit (**Figure 3**). Compared with conventional 2 W/m·K substrate, HT-5100M could lower the temperature of LED by 7 °C. From calculations using the Arrhenius equation, HT-5100M is estimated to improve the lifespan of LED by about 1.5 times.



Property	Unit	Insulation sheet	
		Conventional product	HT-5100S
Thermal conductivity	W/m·K	2	5
Package temperature	℃	86.1	78.7

Figure 3 Result of LED heating test

5 Future Developments

・Sales of metal substrates, insulating sheets, and metal foil-attached insulating sheets in various configurations
・Extend technology to substrates mounted on power modules and other areas

【References】

1) Tamura, Yoshio: Display Search Report (2010)
2) Kanenari, Katsuhiko: Macromolecules, 26, pp. 557-561 (1977)
3) Takezawa, Yoshitaka: Macromolecules, 59, pp. 81-84 (2010)