Thermally Conductive Flexible Substrate with Heat-resistant Adhesive Layer

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1 Summary

Due to the strong demand to save energy, incandescent lamps and fluorescent lights are being substituted by LED light bulbs. Such high power devices are mounted on metal-based printed wiring board (PWB). The metal-based PWB has excellent thermal conductivity, but its rigidity and thickness are disadvantageous. If thermally conductive and flexible PWB were developed, it would be very effective for developing smaller mobile equipment, thinner TVs, and sophisticated light equipment. We developed novel flexible-PWB material with low thermal resistance and a heat-resistant adhesive layer to attach the PWB onto chassis easily.

2 Features of Thermally Conductive Flexible Substrate with Heat-resistant Adhesive Layer

- The insulating film is thinned down to 10 μm while maintaining insulation property. Thermal resistance decreases to 40% of conventional film with thickness of 25 μm.
- Because it has metal separators with a heat-resistant resin layer, the substrate can handle in PWB fabrication process and mounting process with its heat-resistant adhesive layer laminated.
- Because the heat-resistant adhesive layer is laminated beforehand, the PWB can be fixed after mounting by simply peeling off the separator.

3 History of Research

Hitachi Chemical entered the market for ultra-thin multilayered printed wiring board (PWB) substrates with the MCF-5000I series, capable of numerous multilayers. Though the thickness of insulating layer of MCF-5000I is very thin (10 um), its heat resistance and insulation properties are excellent because the imidization rate of polyimides is high. Thus the product excels in dimensional stability, and shows stability of dielectric properties in GHz band. Also, because flexible structures and stiff structures are arranged in a suitable balance in the PI, MCF-5000I exhibits high peel strength even for unroughened copper foil (see **Table 1**). Because MCF-5000I excels in thermal resistance – 40% of conventional flexible PWB – it is useful for the purpose of spreading heat, and we have tried to apply it to those applications.

Table 1 Properties of MCF-5000ID (Cu foil/insulator (10 μm)/Cu foil)

Property	Thermal resistance	Peel strength for unroughened coper foil	Heat resistance	Volume resistivity	Breakdown voltage
	0.3 ℃cm²/W	1 kN/m	>5 min at 300 ℃	2×10^{15} Ω・cm	2.7 kV

4 Content of Technology

Conventional metal PWB substrates are rigid and thick, and are mounted onto the chassis with screws. In contrast, PWBs using MCF-5000I cannot be securely attached to the chassis with screws because it is bent easily, though it has the advantage of being light and thin. We tried to use thermal interface materials (TIM) instead of screws to fix PWBs to chassis, but problems such as change of the shape of PWBs by the laminating pressure occurred. Also we tried to mount LEDs after laminating MCF-5000I and TIM, but problems of contracting or melting of separators by soldering process occurred. To resolve these problems, we have developed a new heat-resistant and chemical-resistant TIM, which can withstand PWB fabrication and reflow processes. We brought to market HT-9000ITM, an ultra-thin PWB material consisting of MCF-

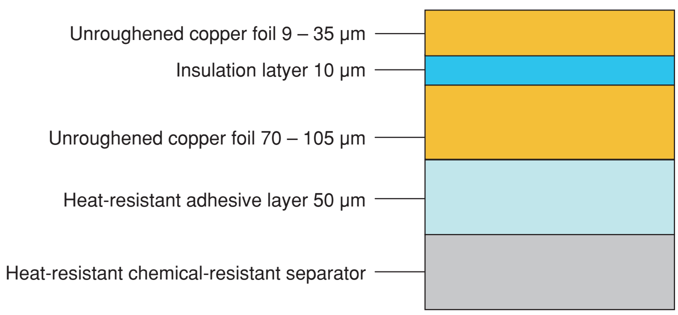

Figure 1 Cross-section of HT-9000ITM

5000I laminated with the newly developed TIM (see **Figure 1**). Specifically, we resolved the above problems by using 1) heat-resistant resin layer combining our proprietary heat-resistant polymer and thermally conductive inorganic filler and 2) separator with outstanding alkaline-resistant, acid-resistant, and heat-resistant properties. As for the properties of the adhesive layer, our newly developed TIM exhibits thermal resistance at the same level as conventional TIM (2.5°C cm^2/W, 0.7 kN/m) and peel strength of more than twice of conventional TIM (see **Table 2**). Also, because the adhesive layer is highly durable against heat, the temperature difference between HT-9000ITM PWB mounted with heat-generating elements (resistance) and a heat sink after high-temperature testing (150 °C 1000 h) remained constant (see **Figure 2**). Furthermore, because HT-9000ITM can be attached to cylindrical or bent chassis after LED mounting, it can contribute to a wide range of illumination intensity and design forms (see **Figure 3**). Because HT-9000ITM can be cut by knife and arranged on PWB without leaving gaps between products, it is effective to increase the number of PWBs and reduce the amount of waste (see **Figure 4**). Furthermore, because HT-9000ITM is 1/6 of the thickness of conventional metal PWBs, it can also contribute to making electronics like TV thinner.

Table 2 Properties of heat-resistant adhesive layer of HT-9000ITM

Property	Thermal resistance	Peel strength (against Al)			Volume electrical resistivity	
		Before test (after 72 hours by pasting)	−50 ℃⇔125 ℃ After 1000 cycles	85 ℃85 %RH After 1000 h	Before test	−50 ℃⇔125 ℃ After 1000 cycles
	2.5 ℃cm^2/W	1.6 kN/m	2.0 kN/m	2.5 kN/m	2×10^{13} Ω・cm	6×10^{12} Ω・cm

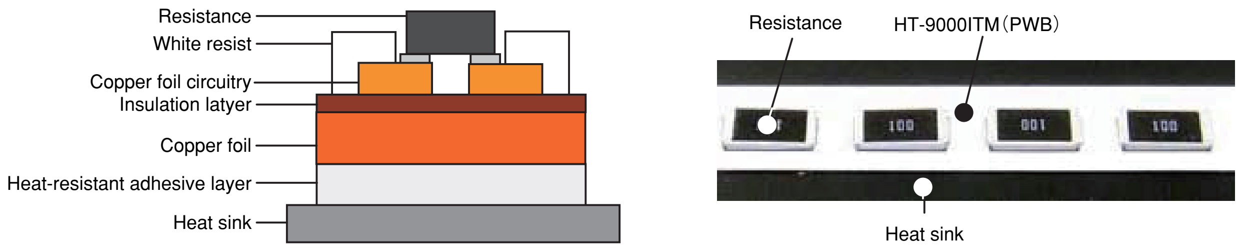

Figure 2 Sample for measuring difference in temperature between PWB and heat sink

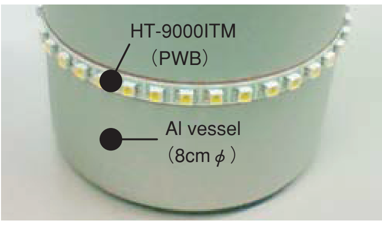

Figure 3 Flexible-LED light bar using HT-9000ITM on an Al vessel

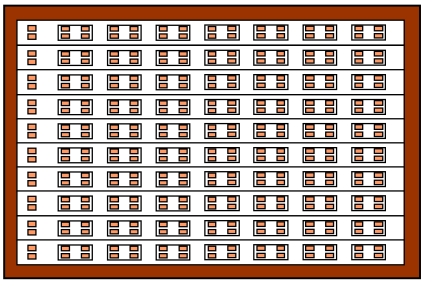

Figure 4 Arrangement of PWB in HT-9000ITM without causing the blank to split

5 Future Developments

・Producing samples for LED backlight units and LED lighting applications.

【References】

・For introduction of MCF-5000I series products, see Hitachi Chemical Technical Report No. 51, p. 33 (2008).