Thermal Conductive Sheet Containing Vertically Oriented Graphite Fillers "TC-BWP01" for FCBGA TIM1 Applications

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1 Abstract

As the performance of semi-conductor packages becomes higher and their size becomes smaller, the need to control heat through a thermal interface material (TIM) has become increasingly important. To meet the demand for a thermally conductive, flexible material, Hitachi Chemical has worked to develop and commercialize a high performance solution. By orienting graphite fillers vertically within an acrylic rubber based matrix, Hitachi Chemical's TIM provides both high thermal conductivity and flexibility.

Part of a TIM application depends on the cooling design of the electrical device. In TIM1 applications, where the TIM is applied directly to IC chips, the TIM must not only provide high thermal conductivity, the TIM must also be able to handle warpage of IC chips under lower pressure assembly, with high reliability.

In this report, we will discuss our developed TIM, which can handle the warpage of IC chips and provides high reliability in TIM1 applications.

2 Characteristics of the Developed Product

・Adoption of soft and highly adhesive resin for the sheet enables the handling of the warpage of IC chips.
・Adoption of thermally stability and moisture resistant resin ensures adhesion after a severe reliability test.

3 Background of the Development

Hitachi Chemical has developed and commercialized "TC-001", a vertically oriented graphite thermal conductive sheet in which graphite fillers are vertically oriented by creating a composite material consisting of graphite fillers and soft acryl rubber and by controlling the structure based on our unique technology. **Figure 1** shows a cross-sectional image of "TC-001". On "TC-001", graphite fillers with a large grain size are vertically oriented to penetrate through the sheet. Thermal conductivity of 90 W/m･K was achieved in the vertical direction.

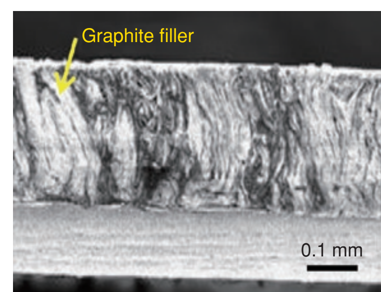

Figure 1 Cross sectional image of "TC-001"

TIM (thermal interface material) caught between the heat source and the heat dissipation material is used to improve heat transfer efficiency. In the TIM1 application in which TIM is used between IC chips as the heat source and the heat spreader, TIM must be able to handle the warpage of IC chips and to have high reliability capable of securing adhesion after reliability test.

In addition, market trends promote the use of IoT (Internet of Things) and require servers with high performance. A problem related to these trends is that general-use grease may have insufficient thermal conductivity.

With this as background, we attempted to develop a technology that provides warpage handling and high reliability while securing the high thermal conductivity of vertically oriented graphite sheets.

4 Technical Details

(1) Design concept for providing warpage handling ability and high durability

Figure 2 shows an outline of a TIM1 application, and **Table 1** shows the general properties of the "TC-BWP01", which has a conventional vertically graphite oriented structure and achieves (i) high thermal conductivity, (ii) flexibility and adhesion capable of handling the large warpage of IC chips, and (iii) reliability capable of maintaining adhesion with IC chips and a heat spreader after an reliability test by using soft, highly adhesive, thermally stability and moisture-resistant resin.

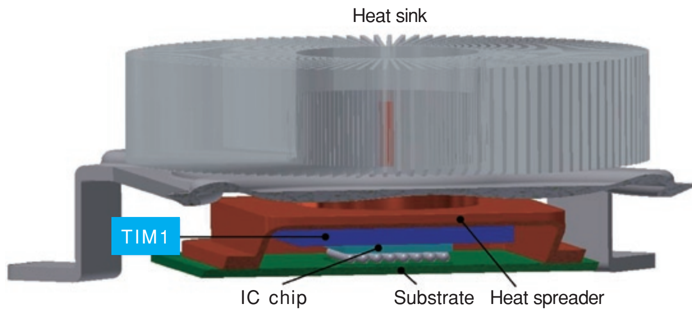

Figure 2 Outline of a TIM1 application

Table 1 General properties of "TC-BWP01"

Item	Unit	TC-001 thickness 0.3 mm	TC-BWP01 thickness 0.3 mm
Thermal resistance	K・cm^2/W	0.14	0.15
Adhesive force	N・mm	4.0	7.6
Stiffness	N/mm	1050	966
Tensile strength	MPa	0.3	0.4

(2) Evaluation of warpage handling

Figure 3 shows the warpage in the IC chip area of a test package. **Figure 4** shows the adhesion performance of "TC-BWP01". When assembling a test package with a substrate size of 45 × 45 mm and an IC chip size of 20 × 20 mm, the warpage at the IC chip area was approximately 70 μm. In addition, it was confirmed that "TC-BWP01" adheres to the IC chip and the heat spreader without de-lamination after the assembly.

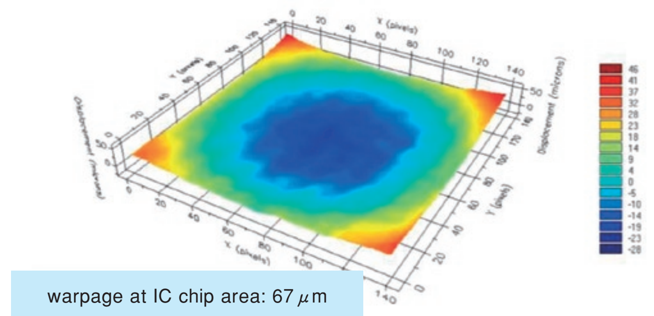

Figure 3 Warpage of an IC chip area

Item	"TC-BWP01" thickness 0.3 mm			
	After assembly	Reliability test		
		(a) HTSL (150℃ 1000 h)	(b) Heat cycle (−55⇔125℃ 1000 cycles)	(c) HAST (130℃ 85%RH 192 h)
Image of Scanning Acoustic Tomograph	IC chip area			
Coverage (%)	99	99	99	99

Figure 4 Coverage of a "TC-BWP01"

(3) Evaluation of durability

The endurance test for a test package was performed under three conditions: (a) HTSL (High Temperature Storage Test) 150°C 1000 h, (b) Heat cycle −55°C ⇔ 125°C 1000 cycles, and (c) HAST (High Accelerated Stress Test) 130°C 85% RH 192 h to recognize that adhesion similar to that after the assembly was secured.

"TC-BWP01" is capable of handling the large warpage of IC chips and has high reliability. Therefore, we expect FCBGA TIM1 to be applied to semiconductors, including applications to servers.

5 Future Business Development

・Expand the application of FCBGA TIM1 in Japan and overseas.
・Continuously improve adhesion by taking into consideration the increase of warpage associated with enlarged IC chip size.

[References]

1) Hitachi Chemical Technical Report No. 53, (October 2009)