Low Transmission Loss/Low CTE Multilayer Material, "MCL-HS100"

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1 Abstract

Semiconductor packages for smartphones and other electronic devices are becoming smaller, thinner and denser. Lowering of rigidity due to the thinning of the package substrate increases the warpage and interconnection failures of the package. To reduce this warpage, lower CTE substrate is effective. Meanwhile, with recent advances in high-capacity, high-speed communications, electrical signals used for information communication equipment tend to be higher frequencies each year. However, the higher the signal frequencies are, the more electrical signals are converted into heat in the circuits, and transmission loss is increasing. These issues have led to the demand for substrate materials with low Dk and low Df. So, focusing on the developments of package substrate materials with low CTE, and high-speed network substrate materials with low Dk and low Df, we have developed MCL-HS100.

2 Characteristics of MCL-HS100

- Very low transmission loss and low warpage.
- High heat resistance and high glass transition temperature (Tg) (general characteristics).
- Environmentally friendly material that uses halogen-free flame retardant.

3 Background of the Development

Since the advent of mobile electronic devices (such as smartphones), the size and thickness of semiconductor packages has been decreasing, while the density of semiconductor packages has been increasing. At the same time, rigidity and the thickness of the substrate has been decreasing. This causes increased warpage of the package substrate at mounting, leading to mounting problems. To address these mounting problems, it is effective to reduce the difference in the coefficient of thermal expansion between the chip and the package substrate by reducing the thermal expansion of the substrate. In addition, the higher performance of electronic devices and the dramatic progress in network technology led to a rapid increase in data transmission capacity and speed. The signal frequencies that can be handled by electronic devices have been steadily increasing each year. As a result, the substrate must respond to higher speeds and there is increasing demand for low transmission loss materials.

In light of this, our company has been developing the low thermal expansion material MCL-E-705G, the next-generation package materials characterized by MCL-E-770G, and the next-generation high speed network materials characterized by the low transmission loss material MCL-LW-900G. Using the results of this material development, we successfully developed the material MCL-HS100, which has the properties of both low thermal expansion material and low transmission loss material.

4 Technical Details

1. Design concept of MCL-HS100

Generally, the reduction in the coefficient of thermal expansion of the substrate material can reduce the warpage of the thin-type package substrate. Low thermal expansion is achieved by providing the base resin of the MCL-HS100 with the plane stack structure of the aromatic ring and by introducing hard segments with a strong intermolecular force between the stacks. In addition, low thermal expansion is realized by introducing a low elastic soft segment to allow resin to easily follow the thermal behavior of glass cloth (**Figure 1**). Furthermore, resin that is low dielectric and has high heat resistance was applied to the base resin (a high heat resistant resin), using our unique technology for polymer alloying. Moreover, using a similar resin,

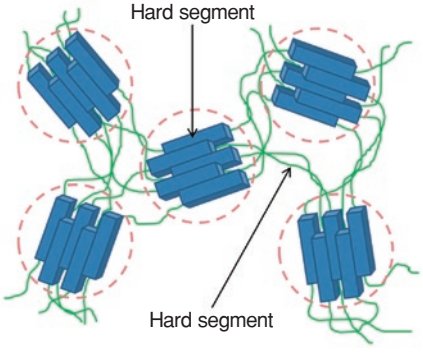


Figure 1 Resin design model of MCL-HS100

we also developed MCL-HS100 (E), for which low dielectric glass is used as the glass cloth.

2. General Characteristics of MCL-HS100

General properties of the MCL-HS100 and MCL-HS100 (E) when using E-glass and low dielectric glass are shown in **Table 1**. The coefficient of thermal expansion of the MCL-HS100 is 7 ppm/°C, which is lower than that of the low transmission loss material MCL-LW-900G. In addition, the MCL-HS100 has dielectric characteristics of Dk = 4.0 and Df = 0.0055 at 10 GHz. These characteristics are lower than those of the low thermal expansion material MCL-E-705G. Thus, it was verified that MCL-HS100 has a lower thermal expansion property than MCL-LW-900G and has a lower dielectric property than MCL-E-705G. Furthermore, since Tg was found to be 230°C using the TMA method and T-288 indicates 60 minutes or more, MCL-HS100 was recognized to have excellent heat resistance.

3. Warpage Characteristics of MCL-HS100

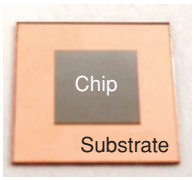
Samples of MCL-HS100 (E) using low dielectric glass were created for the purpose of measuring warpage using the shadow moiré method. **Figure 2** shows the results of warpage measurement. We found that the warpage of the package substrate of MCL-HS100 (E) was less than that of the low transmission loss material MCL-LW-910G. It was also lower than that of the low thermal expansion materials MCL-E-700G and MCL-E-705G.

4. Transmission Loss of MCL-HS100

A three-layer printed circuit board was created to perform the measurement of transmission loss in a strip line structure, the results of which are shown in **Figure 3**. It was found that MCL-HS100 (E) shows less transmission loss than the low thermal expansion materials MCL-E-705G and MCL-E-770G.

Table 1 General properties of MCL-HS100 (thickness 0.8mm)

Item		Unit	MCL-HS100	MCL-HS100(E)	MCL-E-705G	MCL-LW-900G	MCL-LW-910G
Glass type		—	E-glass	Low Dk-glass	E-glass	E-glass	Low Dk-glass
Tg	TMA	℃	230	230	260	198	198
CTE	X < Tg	ppm/℃	7	7	6	13	13
	Z < Tg	ppm/℃	25	25	13	40	40
Flexural Modulus		GPa	25	25	33	19	19
Dk(10 GHz)		—	4.0	3.5	4.4	3.5	3.3
Df(10 GHz)		—	0.0055	0.0035	0.0080	0.0045	0.0030
T-288 (Without copper)	TMA	min.	> 60	> 60	> 60	> 60	> 60



- Substrate : Coreless-5Layer
- Package size : 14 x 14 mm
- Chip size : 7.3 x 7.3 mm
- Chip thickness : 150 μm
- Underfill thickness : 50 μm (CEL-C-3730-4)
- L1,5: 12 μm Cu 100%, L2, 3, 4: No copper, SR:-
- PPG construction
  - HS100(E) : (1078, R.C.: 63%) x 4ply
  - E-700G(R) : (1078, R.C.: 66%) x 4ply
  - E-705G : (1078, R.C.: 65%) x 4ply
  - LW-910G : (1078, R.C.: 61%) x 4ply

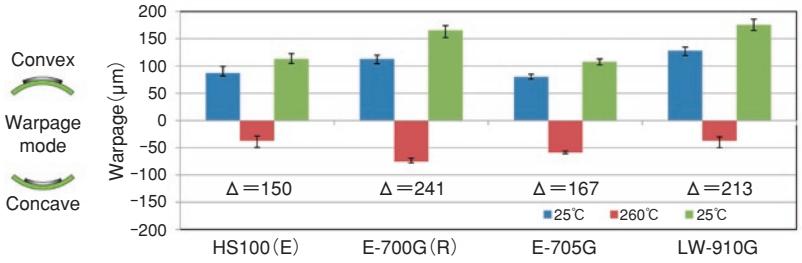
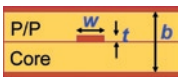


Figure 2 Warpage evaluation result of MCL-HS100

〈Measurement conditions〉
Evaluation PWB: Strip-line
Temperature & Humidity: 25℃/60%RH
Characteristic impedance: Approx. 50Ω
Proofreading method: TRL



- Trace width(w) : 0.12-0.14 mm
- Dielectric thickness(b) : 0.23-0.26 mm
- Trace thickness(t) : 18 μm

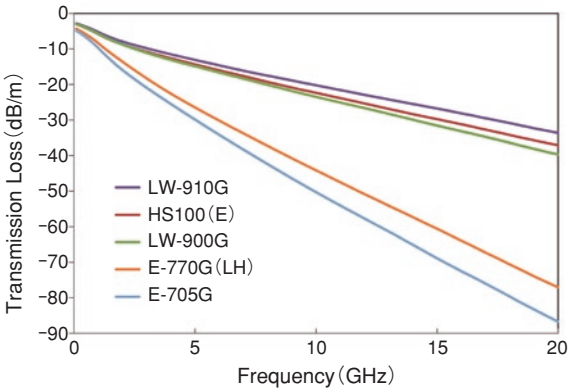


Figure 3 Transmission Loss of MCL-HS100

5 Future Business Development

- Development of next-generation materials that qualify as both low transmission loss materials and low thermal expansion materials, and that are suitable for high frequency

【Reference】

1) Tomokazu Shimada: JPCA Show 2016 NPI Presentation Proceedings pp. 47-49