Halogen Free, High Elasticity and Low CTE Multilayer Material「MCL-E-700G(R)」

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1 Summary

Currently, the thickness of materials in semiconductor packages is becoming thinner due to the progressive miniaturization of high-performance electronic equipment. However, thinner substrate may cause poor connection reliability due to warpage increased at soldering process. To solve this problem, new thermosetting resins having low coefficient of thermal expansion (CTE), high modulus and high glass transition temperature were investigated. As a result, we developed a novel material for substrate named "MCL-E-700G(R)" that is expected to be applicable to high heat-resistant thin packages having a build-up structure with low warpage.

2 Features of MCL-E-700G (R)

- Because its coefficient of thermal expansion in X, Y directions is low and its modulus of elasticity is high, it can reduce warpage drastically.
- It has outstanding drilling workability, so it can reduce processing cost.
- The product is environment-friendly. It meets flammability standard UL94V-0 without using halogen flame retardant, antimony or red phosphorus.

3 History of Development

Through simulations analyzing factors of the warpage of package substrates, we have discovered that warpage can be reduced by lowering CTE and increasing the modulus of elasticity of substrate material.[2)] A method to decrease CTE and increase the modulus of elasticity is to load a large amount of inorganic filler. However, this method causes many problems at drilling process because of overloading on drill bits. Thus we sought to develop substrate materials that have greater elasticity and lower thermal expansion compared to conventional materials by using new thermosetting resins. Compared to conventional thermosetting resin, the developed resin has greater elasticity and lower thermal expansion.

Thermosetting resins based on ring structure containing nitrogen show high elasticity, low thermal expansion and high incombustibility. However, these resins face many problems when used as materials for circuit boards, including lack of solubility to solvent and requiring a high temperature at thermosetting process. Thus we developed the package substrate material MCL-E-700G (R). It resolves the problems above by introducing substituent for solubility and reactive group that is hardened at relatively low temperature.

4 Content of Technology

(1) Features of MCL-E-700G (R)

The properties of package substrate MCL-E-700G (R) and MCL-E-700G (RL), which uses S glass in the substrate, are shown in **Table 1**. Compared to conventional substrate materials, E-700G (R) and E-700G (RL) have high modulus of elasticity, high glass transition temperature and low CTE. With high decomposition temperature, they also have superior heat resistance. They can be applied to build-up structures by semi-additive process, and can support narrow and high density wiring.

(2) Warpage properties of TEG substrate

We created a TEG substrate, which has three-dimensional PoP (Package on Package) structure, and measured the amount of warpage after reflow soldering. The results are shown in **Figure 1**. For both the top package and the bottom package, the amount of warpage was greatly reduced when E-700G (R) and E-700G (RL) were used as the substrate material. This is due to the effects of E-700G (R) and E-700G (RL)'s low CTE and high elasticity.

Table 1 Properties of MCL-E-700G(R) and E-700G(RL)

Property		Condition	Unit	E-700G(R)	E-700G(RL)	High Tg FR-4
Glass transition temperature		TMA(tensile)	℃	250-270	250-270	165-175
		TMA (compression)		220-240	220-240	165-175
		DMA		295-305	295-305	200-220
Thermal decomposition temperature		TGA(Td5)	℃	400-420	400-420	340-360
Coefficient of thermal expansion	X, Y	α1(tensile)	ppm/℃	7-9	5-7	13-15
		α2(tensile)		5-7	5-7	10-12
		α1(compression)		10-12	8-10	13-15
		α2(compression)		4-6	3-5	10-12
	Z	α1(compression)		15-25	15-25	23-33
		α2(compression)		90-120	90-120	140-170
Copper foil peel strength		12 μm(Std)	kN/m	0.9-1.1	0.9-1.1	0.8-1.0
Modulus of elasticity		A	GPa	32-34	34-36	23-28
Heat resistance	T-288	TMA	min	>60	>60	>60
Heat resistance of the package		260℃ reflow	cycle	>20	>20	>10

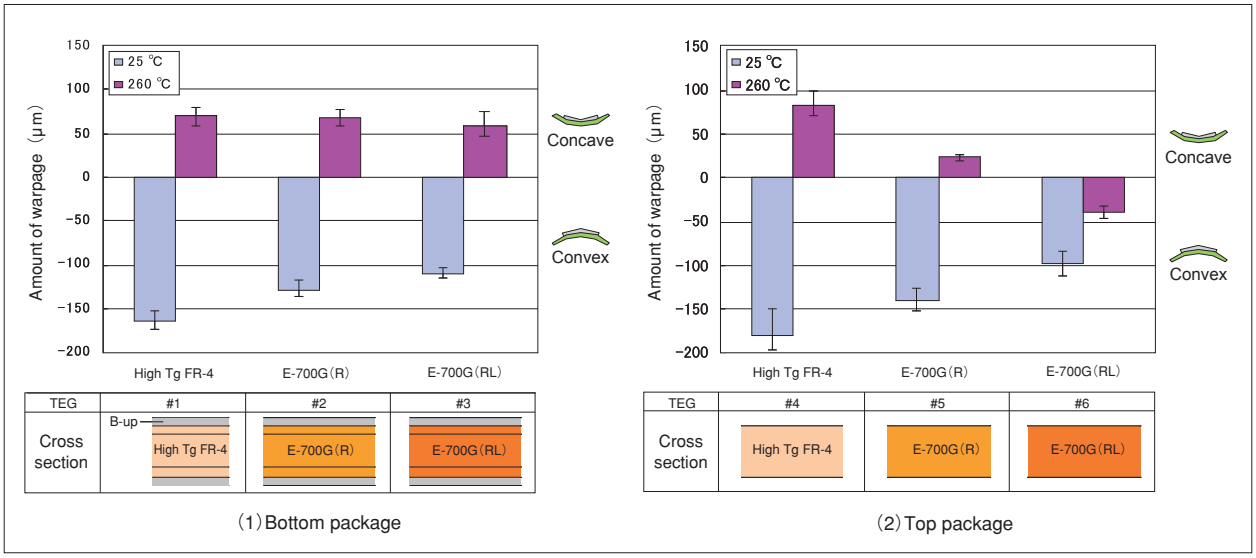

Figure 1 Measuremental results for test element group

5 Future Developments

・Investigation of supporting miniaturization by applying highly adhesive profile-free foil.
・Development of materials supporting new generation (CTE: 3-5 ppm/°C, modulus of elasticity: 35-40 GPa)

【References】

1) Kasuga, Ryo: Package Technological Trends, Journal of the Japan Institute of Electronics Packaging, No.5, pp. 353 – 357 (2007)
2) Morita, Koji: Hitachi Chemical Technical Report, No. 51, pp. 29 – 32 (2008)