

Low Elastic Prepreg for Automotive Application “TD-002”, to Inhibit Solder Crack

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1 Abstract

In recent years, hybrid vehicles and electric vehicles, which are applying advanced electronic controls, are increasing. As the ECU came to be mounted in the engine compartment, the solder crack issue comes from the stress due to the mismatching CTE between electronic components and PWB. Low elastic modulus material “TD-002” was developed as a material to solve this issue.

TD-002 has low elastic modulus and high elongation, and also has high reliability properties in CAF and heat resistance. TD-002 applied to the surface of PWBs of standard FR-4 material inhibits solder cracking, absorbing the soldering stress.

2 Functional characteristics of TD-002

- It has low elasticity and high extensibility.
- When applied to the surface of PWB, it absorbs stress applied on solder and inhibits cracking of the solder layer.
- It can inhibit solder cracking when used in combination with conventional materials, not necessarily requiring high functional materials (such as materials with low CTE)

3 Background of the Development

In recent years, the number of automobiles equipped with an electronic control unit (ECU), which are represented by fuel efficient hybrid cars and electric vehicles, has been increasing.

Accordingly, with expected rapid increase in quantity and high densification of mounted ECU, the trend of installing ECU in the limited space and high temperature environment such as engine room is getting stronger. In such a high-temperature environment, stress distribution is concentrated in solder joints created by the difference between the coefficients of thermal expansion (CTE) of mounted components and the substrate resulting in solder cracks and electrical connection problems (Figure 1a). One approach to this problem can be to use insulating layer materials with low modulus of elasticity and high extensibility to release the stress generated by the difference between the coefficients of thermal expansion (CTE) of mounted components and the substrate (Figure 1b).

Based on this concept, we developed low elastic modulus and highly extensible material for PCB, “TD-002” for automotive applications to inhibit solder cracks.

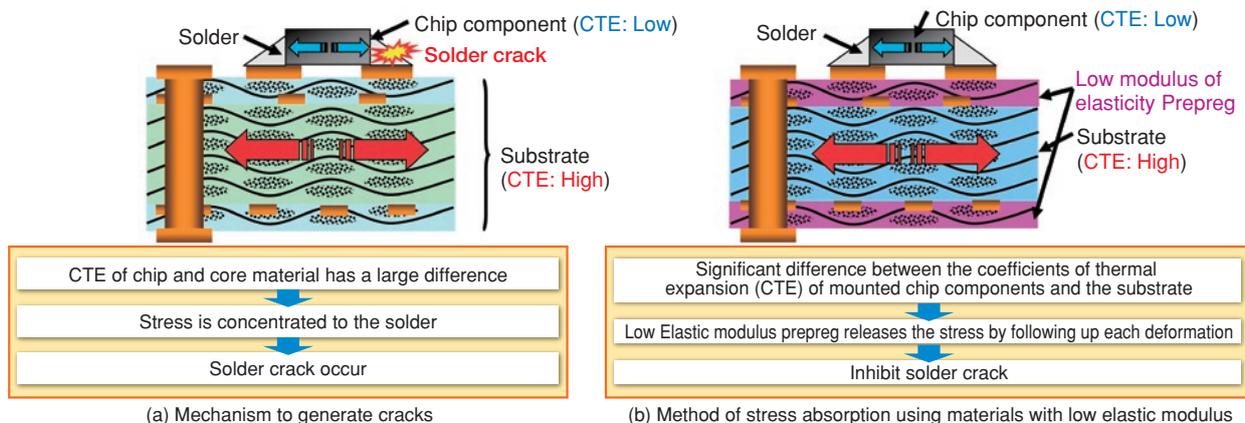


Figure 1 Mechanism of solder crack and stress absorption by low elastic modulus material

4 Technical details

1. Design concept of TD-002

TD-002 should have both low modulus elasticity and high extensibility to inhibit solder cracks, and high level of reliability required for PCB including insulation reliability and high temperature resistance. To achieve this, we designed a material that

can provide both functions using our own proprietary polymer technology for blending low elastic modulus and high extensible flexible resin with high temperature resistant thermosetting resin.

Product of TD-002 is in the form of prepreg, which can be multi-layered in combination with core materials, and does not require expensive low CTE substrate, resulting in total cost reduction to manufacture substrates.

2. Solder crack inhibition effect of TD-002

To confirm solder crack inhibition effect of TD-002, we prepared substrates for evaluation, which mounted components on either an FR-4 single component board or a multilayered substrate where TD-002 was laminated onto FR-4 core material and evaluated them by measuring solder crack growth rate after thermal shock test¹⁾. Evaluation results are shown in **Figure 2**. These evaluation results showed lower solder cracking rates for each surface mounted component using TD-002 than for that using FR-4 single component substrate; thus, it was confirmed that TD-002 was effective in inhibiting solder cracks.

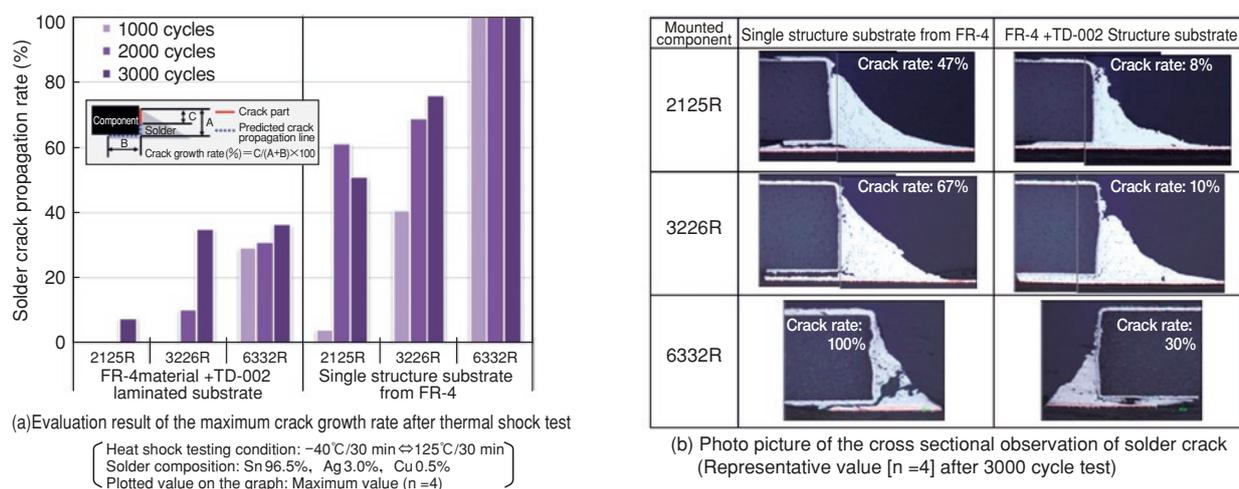


Figure 2 Reduction effect of solder crack by using TD-002

3. General properties of TD-002

General properties of TD-002 are shown in **Table 1**. TD-002 has one fourth (1/4) of FR-4 elastic modulus and about 4 times of FR-4 tensile elongation, and shows high deformation follow up property. Due to these properties, the stress caused by the difference between CTE of mounted components and the substrate during the heat shock test can be released (**Figure 1b**).

Also, other functional performance levels of TD-002 are on the same level as FR-4, indicating that TD-002 meets the high level reliability requirements for PCB.

Table 1 General properties of TD-002 (Thickness 0.4mm)

Item	Condition	Unit	TD-002	High Tg Halogen Free FR-4	
Solder Heat Resistance	260°C Float	s	> 300	> 300	
Tg ^{*1}	TMA	°C	155-170	155-170	
CTE ^{*1}	X	TMA [<Tg]	6-9	12-15	
	Y		6-9	14-17	
	Z		80-130	30-40	
Elongation ^{*2}	Resin only	Tensile 25°C	%	5.1	1.3
Elastic Modulus ^{*2}	Resin only	Tensile DVE 25°C	GPa	0.8-1.2	4.8-5.2
Flexural Modulus	Lengthwise		GPa	5-8	25-29
Dielectric Constant ^{*3}	1 GHz	—	3.6-3.8	4.4-4.6	
Dissipation Factor ^{*3}	1 GHz	—	0.011-0.013	0.014-0.016	
Volume Resistivity	C-96/20/65 + C-96/40/90	Ω · cm	1×10 ¹⁵ -1×10 ¹⁶	1×10 ¹⁵ -1×10 ¹⁶	
Surface Resistance	C-96/20/65 + C-96/40/90	Ω	1×10 ¹⁴ -1×10 ¹⁵	1×10 ¹⁴ -1×10 ¹⁵	
Insulation Resistance	C-96/20/65 + D-2/100	Ω	1×10 ¹⁴ -1×10 ¹⁵	1×10 ¹⁴ -1×10 ¹⁵	
Water Absorption	E-24/50 + D-24/23	%	0.10-0.30	0.08-0.12	
Copper Peel Strength	35 μm	kN/m	0.8-1.0	1.2-1.4	
Flammability	UL-94	—	V-0	V-0	
CAF properties ^{*4}	85°C/85%RH, DC100 V	h	> 2000	> 2000	

*1 Heating Rate: 10°C/min
 *2 Resin only, Thickness: t0.1 mm
 *3 Measured by cavity resonator.
 *4 Laminate thickness: t1.6 mm, Drill bit: Φ0.4 mm, T/H wall distance: 0.3 mm, Pre-condition: Reflow x 2 (Max 250°C)

5 Future Business Development

- Development of the next generation halogen-free substrate to inhibit solder cracks

[Reference]

- 1) Takayo Kitajima: JPCA Preliminary draft prepared for presentation at the Show 2015 NPI: Low Elastic Prepreg for Automotive Application “TD-002”, to Inhibit Solder Cracks