New Material for Fine Patterning Package Substrates by Semi-additive Process“PF-EL”

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1 Abstract

The demand for miniaturization of electronic components and thinning has become stronger to achieve the miniaturization of high-performance electronic devices such as smartphone and tablet PC. Thus, the high-end package substrate is demanded to have higher stiffness and wiring density. We have developed new materials composed of the primer having high adhesion property with electrolessly plated copper and glass-fabric prepreg. It is PF-EL. Combining newly developed materials with glass-fabric prepreg, we finally obtained the build-up material for the higher wiring density and stiffness for the package substrate. The obtained build-up material may expand the capability of the next generation packaging.

2 PF-EL Features

- Fine line formation is possible in semi-additive process (SAP) using a roughened copper foil.
- High adhesion with copper plating is achieved.
- It can be used with prepreg to produce highly stiff, fine patterning substrates.

3 Background of Development

As recent electronic equipment becomes more functional and smaller, package substrates need to be denser and thinner. When the proportion of film materials used for build-up layer on these fine patterning package substrates increases, the coefficient of thermal expansion (CTE) tends to rise and stiffness is likely to decrease due to a thinner core layer. Accordingly, warpage increases, and chip cracks and other packaging defects are prone to occur. Finer line formation and stiffer structures are required for both core and build-up layers[1].

Hence, we estimated that both fine line formation and high stiffness could be achieved by using an ultra-thin primer layer on the surface of low thermal expansion and ultra-thin glass-fabric prepreg, in place of the film material on the build-up layer, as shown in **Figure 1**. For starters, we developed copper foils coated with several μm of primer on which SAP is applicable.

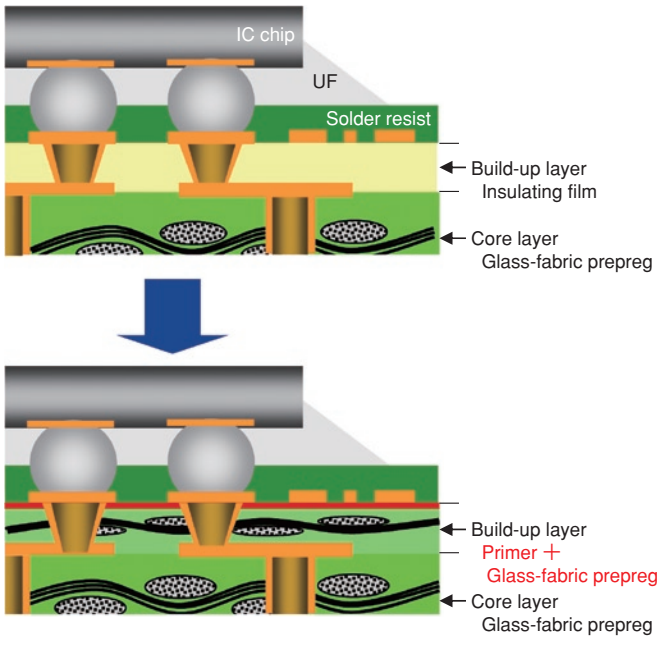

Figure 1 Package substrate using PF-EL

4 Details of Technology

1. PF-EL design concept

PF-EL is basically designed with glass-fabric prepreg coated with several μm of primer on which a roughened copper foil is transferred. The primer targets high adhesion with copper plating through the physical anchor effects of the primer surface, on which a roughened ultra-low profile copper foil is transferred, and the inclusion of a functional group, having high chemical interaction with copper, into the resin. With this primer, a fine line formation in SAP using a stable and microscopic roughened form (surface roughness Ra: 0.40 μm or less) by transferring roughened copper foil, and high peel strength against copper plating are achieved.

Sample		A	B	C	D	E
Primer		None	Used	Used	Used	Used
Desmear	Swelling	—	—	80℃/ 2 min	80℃/ 5 min	80℃/10 min
	Micro-etching	—	—	80℃/ 3 min	80℃/ 8 min	80℃/15 min
	Neutralization	—	—	40℃/ 5 min	40℃/ 5 min	40℃/ 5 min

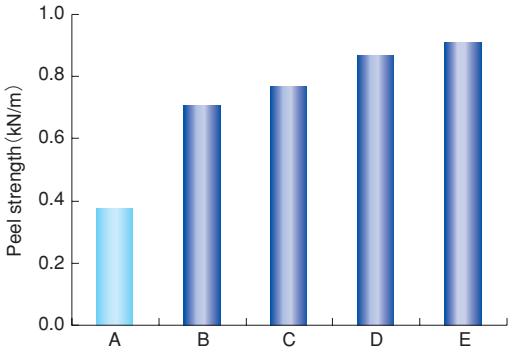

Figure 2 Peel strength between PF-EL and copper plating

2. Adhesion between PF-EL and copper plating

Figure 2 shows the peel strength measurements of copper-plated PF-EL. The peel strength is 0.4 kN/m or less without primer, but increases to 0.7 kN/m or more and stabilizes after primer is applied. It was confirmed that the plating peel strength is improved by adding a more microscopic roughened form produced in the desmear process. Hence, it is proved that the physical and chemical interactions between the primer and copper plating can effectively improve and stabilize adhesion.

3. Fine line formation of PF-EL

Figure 3 shows the fine line formation of PF-EL in SAP. We confirmed the fine line formation of a line/space = 10/10 μm level. **Figure 4** shows the results of highly accelerated life tests. A potential decrease in the reliability of interconnection insulation of PF-EL due to the migration of copper between narrow pitched wirings was a concern, but the insulating resistance did not deteriorate, even after 300 hours, proving that PF-EL has good insulation reliability.

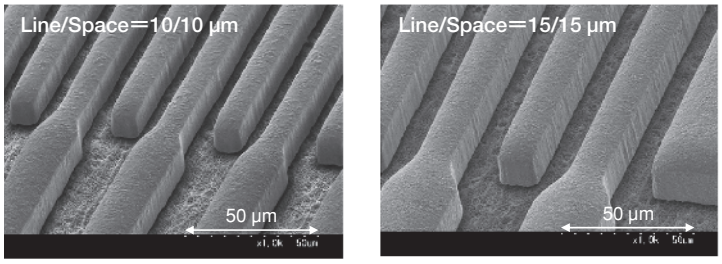

Figure 3 SEM image of fine line formation on PF-EL

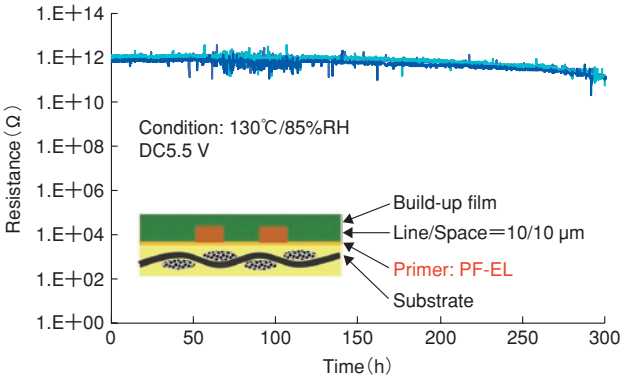

Figure 4 Result of HAST of PF-EL

5 Future Prospects

- Development of semi-additive fine line formation materials for next-generation equipment (development of Airfoil)
- R&D of the application of ultra-low roughened copper foil (Ra: 0.2 μm or less) and improvements in adhesion with copper plating

【References】

1) D. Fujimoto et al., "New Fine Line Fabrication Technology on Glass-cloth Prepreg", 61st Electronic Components and Technology Conference, pp. 387-391, 2011