Particle-Aligned Anisotropic Conductive Film (PAL-ACF) for Fine Pitch Interconnection

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1 Abstract

In recent years, flat panel displays used in smart Phones, tablet PCS, etc. have a larger size and higher image quality. Following this trend, technical solutions for enabling fine-pitch interconnections are required for anisotropic conductive film (ACF) used in the Chip-on Glass (COG) modules of these applications. Hitachi Chemical has developed particle-aligned anisotropic conductive film (PAL-ACF) for fine pitch interconnection utilizing core technologies for designing advanced performance resins and particle dispersion process technology.

2 Characteristics of the New Product

- Enables collective fine-pitch interconnections.
- Enables both conductivity and insulation in fine-pitch interconnections.

3 Background of the Development

In the global market for flat panel displays, the demand for mobile products, such as smartphones and tablet PCs, is rapidly growing. As their built-in panel displays, such products use liquid crystal displays and organic EL displays that use the COG bonding system. In recent years, as liquid crystal displays are rapidly developed to support larger image size and higher image quality, the number of electrode terminals of driver IC chips is steadily increasing and electrode circuits are becoming more fine-pitch interconnected.

In light of this, there is an increasing need for the ACF for the COG bonding system that is used to respond to fine-pitch interconnection.To this end, a function-separated bilayer construction ACF1) was adopted, the conductive particle size was reduced, and the number of conductive particles was increased. However, the following problems arose: these methods have limitations in insulation between the adjacent circuits, and the variation in the number of conductive particles captured between the counter circuits increased. To solve these problems, we started to develop an ACF for fine-pitch COG bonding system using resin design technology and conductive particle dispersion technology, two of our fundamental technologies.

4 Technical Details

During the development of this product, resin design technology was enhanced to further improve the functionality of the separated bilayer construction ACF1).The layers include the anisotropic conductive film layer with dispersed conductive particles (ACF layer) and the non-anisotropic conductive particle film layer with adhesives only (NCF layer). For this type of ACF, the fluidity of the adhesive of the ACF layer at bonding was less than that of the NCF layer for restricting the flow of the ACF layer generated by the flow of the NCF layer at bonding. As a result, the efficiency of capturing conductive particles between the counter electrodes was improved. In the ACF we developed, we were improved the ability to capture conductive particles and reduced variation by increasing the difference in the resin flow between the ACF layer and NCF layer by 7.6 times in comparison with the conventional product. The resin flow characteristics of conventional and developed products are shown in **Figure 1**.

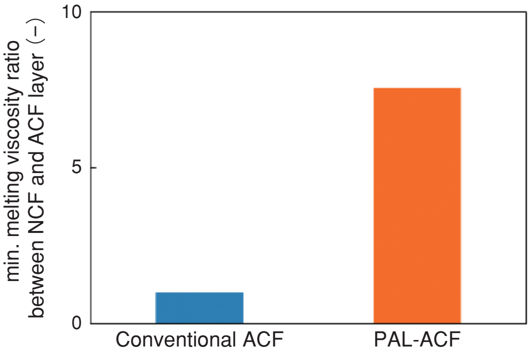
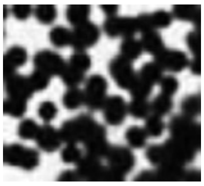
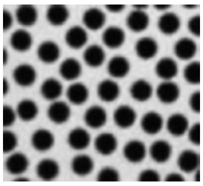
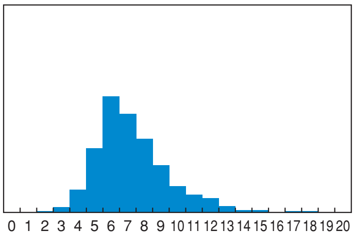
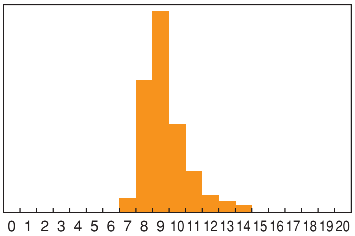
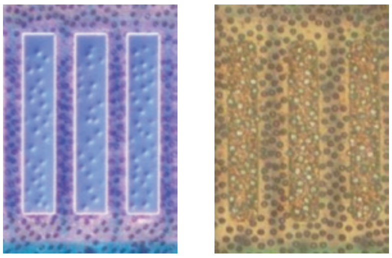


Figure 1 Melting viscosity ratio between NCF and ACF layer

A comparison of the structures and characteristics of the conventional and developed products is shown in **Table 1**. During development, we improved the conductive particle dispersion technology to create technology for monodispersion where the conductive particle exists as monodispersed particle without coagulation (a phenomenon that was difficult to achieve with conventional products).

The developed ACF can capture conductive particles efficiently while maintaining the conductive particle monodispersion state before bonding, and without allowing the conductive particles to flow between the counter circuits even after bonding. As a result, we could capture a large number of particles and achieve high insulation resistance while limiting variation in the number of captured conductive particles, thus making possible the fine-pitch interconnection that was difficult to achieve for conventional products.

Table 1 Properties of ACF

Item		Conventional ACF	PAL-ACF
Conductive particle arrangement			
Product structure (cross-sectional schematic diagram)			
Monodisperse ratio of conductive particle (%)		Unmeasurable	≧ 75
Smallest connection circuit	Area[*1] (μm^2)	500	400
	Space[*2] (μm)	12 / 5	10 / 5
Frequency in number of conductive particles captured [particles] (Connection area: 400 μm^2)			
Photo of bonded area[*3] Left : Differential interference microscope image Right : Optical microscope image (Connection area: 1,200 μm^2)			
Insulation resistance (Ω)[*4]		8.6E+10	1.7E+14

[*1] Actual and minimum bump to bump space / Bump to pad space after bonding.

[*2] Effective bonding area between bump and electrode on glass after bonding. Calculated value using Hitachi's TEG. Ave-3σ ≧ 5 pcs.

[*3] Bonding conditions: 150℃/5 seconds/60 MPa
IC chip: 0.9 mm × 20 mm × 0.2 mm t, Au bump, IC bump area size: 12 μm × 100 μm (1,200 μm^2),
Glass substrate: Thickness: 0.2mm, ITO electrode/ITO-Metal electrode

[*4] Bonding conditions: 150℃/5 seconds/60 MPa
IC chip: 0.9 mm × 20 mm × 0.2 mm t, Au bump, IC bump area size: 12 μm × 100 μm (1,200 μm^2),
Glass substrate: Thickness: 0.2 mm, ITO electrode, Bump-pad distance: 5 um
Reliability test: High Temperature and Humidity Test (85℃/85%RH, 500 hrs.)

5 Future Business Development

- Sales promotion of the developed product
- Finding new ways to apply the product

【Reference】

1) Nozomu Takano, Tohru Fujinawa, and Toshihiko Kato: Hitachi Chemical Technical Report, No. 55, pp. 21-23 (2013)