Isotropic Conductive Film "IC-01A" for Low Temperature Connection and High Dimensional Stability

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1 Abstract

In recent years, smartphones and the like have become smaller, thinner, and multifunctional, and are mounted with various electronic components. Solder has been mainly used to connect these electrodes, but it is not suitable for members having low heat resistance. As an alternative to solder, our anisotropic conductive film can be connected at low temperatures and is effective even when there is an oxide film on the electrode surface. However, the dimensional stability after connection is low. Therefore, "IC-01A", an isotropic conductive film that can be connected to an electrode having an oxide film and having high dimensional stability, was developed by combining conductive particles having a specific shape with an anisotropic conductive film and an adhesive composition that suppresses bleeding before and after connection.

2 Characteristics of the Product

- Applicable to a wide range of metal electrodes (gold, aluminum, copper, stainless steel, etc.)
- Can connect at 100 °C.
- High dimensional stability before and after connection.

3 Background of the Development

Devices such as smartphones incorporate many electronic circuits, and noise caused by electromagnetic waves emitted from the circuits causes deterioration in quality. Shielding the source of the electromagnetic waves and improved grounding of the circuit are effective countermeasures to this problem.

We received a request from an electronic component manufacturer to develop a new conductive connection film that can connect the metal foil of electromagnetic shielding parts to non-heat-resistant parts. Two properties are required: low-temperature and low-pressure connection to electrodes with an oxide film such as aluminum or copper, and high dimensional stability before and after connection. Hitachi Chemical has developed the world's first circuit connection material, ANISOLM® anisotropic conductive film. It is employed mainly in the field of flat panel displays[1] and is more effective than solder for components with low heat resistance[2]. However, pressure is required to flatten the conductive particles onto electrodes with an oxide film, and it suffers from issues of low dimensional stability due to the adhesive oozing out. We therefore started development to achieve both connection to electrodes with an oxide film and high dimensional stability based on the concept that stable conduction is possible without flattening the conductive particles.

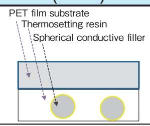
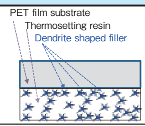
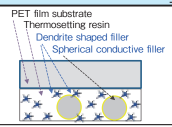
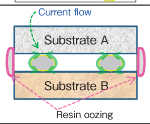
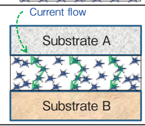
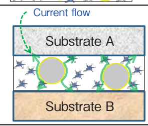
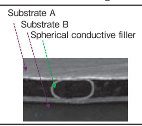
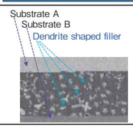
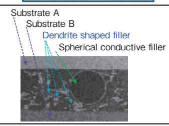
4 Technical Details

The development goal was to be able to connect to electrodes with an oxide film on the surface layer without flattening the conductive particles, that is, a low-pressure connection.

Based on the idea that it might be effective to break through the oxide film on the metal electrodes through local pressure application by the conductive particles, we first investigated various conductive particles, focusing on the particle shape, and selected dendritic metal particles with a sharp shape (hereinafter, "dendritic particles"). Next, we evaluated investigation item (1) that optimized the ratio of the high molecular weight component to reactive component to suppress the flow of the adhesive. As a result, it satisfied the standard value of the connection resistance immediately after connection (0.1 Ω or less) and the standard value for oozing of the adhesive (5 % or less). On the other hand, it significantly exceeded the standard values after the thermal shock test. This seems to occur because, even if the flow of the adhesive is small at the time of connection and the dendritic particles are stacked and make contact with the electrode to ensure conduction, it is assumed that the dendritic particles could no longer contact the electrode due to shrinkage of the adhesive in the thermal shock test.

To solve this problem, plastic spherical conductive particles (hereinafter, "spherical conductive particles") plated with metal are used that enter between the dendritic particles stacked between the electrodes. As the spherical conductive particles have plastic cores with a linear thermal expansion coefficient close to that of the adhesive, these particles closely follow the expansion and contraction of the adhesive during the thermal shock test. It is thought that this makes it easy to maintain the contact of the dendritic particles with the electrode. Evaluation of investigation item (2) (product name: "IC-01A") that uses both of the two types of conductive particles above together shows that it suppressed the increase in connection resistance after the thermal shock test and met the standard values. Investigation item (2) achieved high contact reliability for contact with aluminum or copper, even at low contact pressure that did not flatten the spherical conductive particles. **Table 1** shows a comparison of various anisotropic conductive films. **Table 2** shows the general characteristics of "IC-01A".

Table 1 Comparison of Various Anisotropic Conductive Film

Item	Anisotropic conductive film (ACF)	Investigation item(1)	Investigation item(2) Isotropic conductive film IC-01A
Product structure (cross-sectional schematic)			
Diagram of connection state and current flow			
Cross-section example of connection part			
Typical required bonding pressure	1.0 MPa	0.2 MPa	0.2 MPa
Connection resistance*1(Initial)	0.2 Ω	≦0.1 Ω	≦0.1 Ω
Connection resistance*1(500cycles)	≦0.5 Ω	≦10 Ω	≦0.1 Ω
Adhesive flow ratio*2	36%	≦5%	≦5%

*1 Connection film size : 3 mm × 3 mm
Substrate : 3 mm × 40 mm Al foil (25 μm^{t}), 3 mm × 40 mm Cu foil (25 μm^{t})
Bonding conditions : 120 ℃ / 10 s /0.2 MPa
RA test condition : Thermal cycle test 500 cycles (1 cycle : -40 ℃ / 30 min to 100 ℃ / 30 min)
*2 Connection film size : 2 mm × 2 mm
Substrate : 18 mm × 18 mm slide glass (1.0 mm^{t}) (Set connection film between two glass slides)
Bonding conditions : 120 ℃ / 10 s /0.2 MPa
Adhesive flow ratio = (Connection film size (after bonding) / Connection film size (before bonding) × 100

Table 2 General Characteristics of IC-01A

Item		Unit	Character
Resin type		-	Thermosetting
Thickness		μm	25
Base film		-	PET
Bonding condition	Temperature	℃	≧100
	Time	s	≧30
	Pressure	MPa	≧0.2
Connection resistance*1		Ω	≦0.1
Adhesive flow ratio*2		%	≦5
Peeling strength*3		N/cm	≧10
Elastic modulus(25 ℃)		GPa	2.3

*1 Connection film size : 3 mm × 3 mm
Substrate : 3 mm × 40 mm Al foil (25 μm^{t}), 3 mm × 40 mm Cu foil (25 μm^{t})
Bonding conditions : 120 ℃ / 10 s /0.2 MPa
RA test condition : Thermal cycle test 500 cycles (1 cycle : -40 ℃ / 30 min to 100 ℃ / 30 min)
*2 Connection film size : 2 mm × 2 mm
Substrate : 18 mm × 18 mm slide glass (1.0mm^{t}) (Set connection film between two glass slides)
Bonding conditions : 120 ℃ / 10 s /0.2 MPa
Adhesive flow ratio = (Connection film size (after bonding) / Connection film size (before bonding) × 100
*3 Connection film size : 1.5 mm × 40 mm
Substrate : 15 mm × 40 mm Al foil (25 μm^{t}), 15 mm × 40 mm Cu foil (25 μm^{t})
Bonding conditions : 120 ℃ / 10 s /0.2 MPa
Peeling angle : 90°

5 Future Business Development

- Searching for new fields of application
- Connection to curved parts

【References】

1) Isao Tsukakoshi: Development History of the Anisotropic Conductive Film, Hitachi Chemical Technical Report, 41, pp7-18, (2003)
2) Naoki Fukushima, Osamu Watanabe, Kazuya Matsuda, Kenzo Takemura: Application of Connection Film Alternative to Solder, Hitachi Chemical Technical Report, 49, pp17-22, (2007)