Anisotropic Conductive Paste (ACP) Connection Technology

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Anisotropic conductive paste (ACP) is a material for connecting two circuits, or a circuit and an electrical device. It includes conductive filler and binder; the conductive filler passes electricity after heat press and the binder bonds the circuits.

Anisotropic conductive film (ACF) has the same function as ACP. Fujikura is supplying the membrane switches with ACF connection until now. But ACP is easier to produce and it is cheaper than ACF. So, we investigated the application of ACP, especially for connection between upper and lower electrical sheets of personal computer (PC) keyboards.

We successfully used the ACP connection technology with PC keyboards. This technology can be used for connections between circuits and their surrounding electrical parts like liquid crystal displays (LCDs).

1. Introduction

Recently, membrane switches are often used as electrical circuit parts instead of flexible printed circuits (FPCs). They are particularly useful for connecting LCDs and printed circuit boards (PCBs), which are frequently connected by ACP or ACF.

Fujikura has been using only ACF. It is mainly used to connect upper and lower sheets of PC keyboards. But ACP gives us many advantages over ACF as follows:

1) Low cost
2) Stability after curing
3) High standard of peeling strength
4) Low fluidity

Regarding cost, ACF requires many production steps and high maintenance costs. These steps are cutting, laminating, pre-heating, separator removal and final heating. On the other hand, ACP requires only three production steps: coating, curing and heat press. So, we can reduce the production time and cost if we use ACP instead of ACF.

To reduce the time and cost, we conducted a test of ACPs, which was successful. In addition, ACP has many advantages as above. This will allow us to apply it to many products, for example connecting circuits and electrical devices, heat seal connectors and so on.

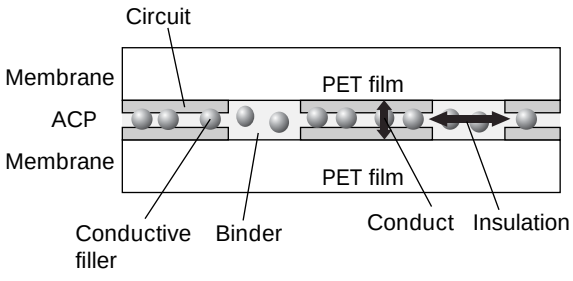

Fig. 1. Section of ACP Connecting Area.

2. Characteristics and Production

2.1 Characteristics

The composition and characteristics of ACP material are shown in Table 1. This material has three components, conductive filler, binder and solvent. The

Table 1. Component and Characteristics of ACP [1)]

Item		ACP material
Component	Filler	Au plated resin ball
	Binder	Synthetic rubber
	Thinner	Toluene, isopholone
Production steps		1. Paste coating (by printing or dispensing)
		2. Curing
		3. Heat press
Insulation		More than 100MΩ
Contact resistance		Less than 1Ω
Peeling strength		More than 600N/m width
Characteristics	Merit	High flexibility because binder is soft composition
		Long life after curing the paste
		Cheaper than ACF (about 1/10)
	Demerit	Can not use it with the fine pitch circuit because of big conductive filler
		Lower heat resistance than ACF

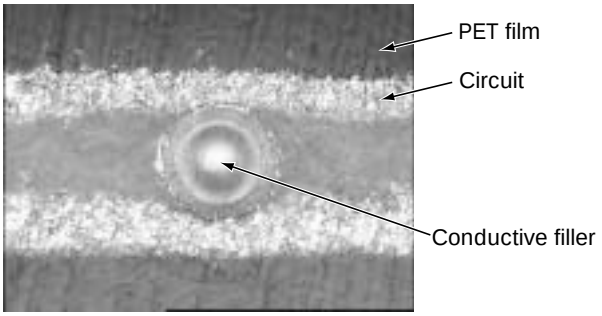

Fig. 2. Section Image of ACP Connecting Area (Scanning Electron Microscope).

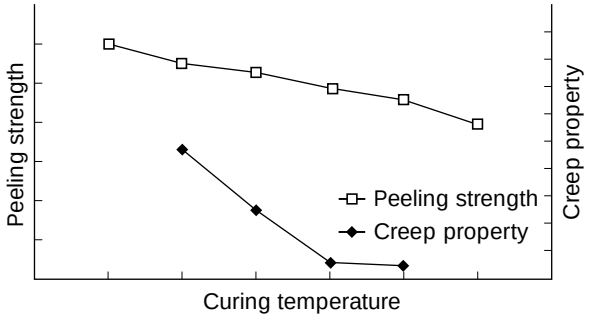

Fig. 3. Curing Temperature Dependence of Peeling Strength and Creep Property for ACP Connecting Area.

conductive filler is mixed with binder and solvent; its function is to pass electricity by its contact with upper and lower electrodes. Normally, the filler is produced as an Au-plated resin ball. The purpose of the resin ball is to keep the gravity of all filler constant. The binder's function is to bind and insulate each ball. There are three types: thermoset, thermoplastic and a mixture of the two types. The type is selected depending on the situationC.

The most important characteristic of Fujikura's ACP is soft composition, giving it high flexibility and durability. The second is that its shelf life is longer than that of ACF's. We can keep it for more than six months after curing the paste under room temperature.

Section diagram of connection part (connecting two membranes) is shown in Fig. 1, and the actual picture is shown in Fig. 2.

2.2 Production Flow

2.2.1 Coating

Coating production is important for ACP. This production has an effect on the properties after the product is complete. Fujikura coats ACP on membrane circuit, and then cures it. The customer does not require the care of ACP production except storage and heat press. Hence, Fujikura must control it suitably at this production.

ACP is coated by printing or dispensing technolo-

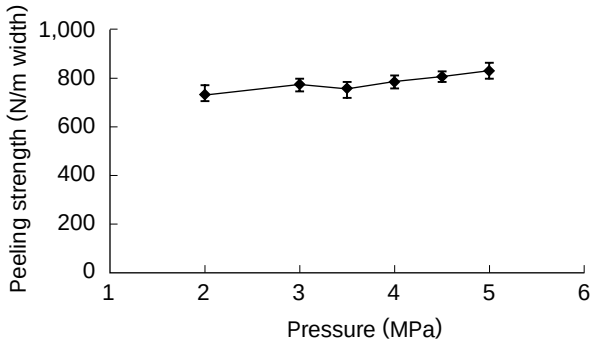

Fig. 4. Heat Pressure Dependence of Peeling Strength for ACP Connecting Area.

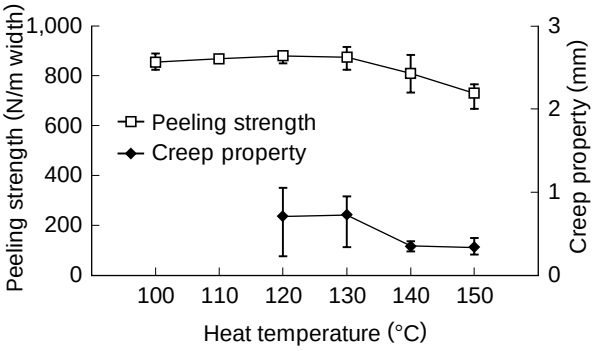

Fig. 5. Heat Temperature Dependence of Peeling Strength and Creep Property for ACP Connecting Area.

gy. Control of binder thickness and distribution of conductive filler are important at this production. A very high thickness interferes with the passage of electricity, while a very low thickness leads to weak connection with various environments. As regards conductive filler, too much filler results in poor insulation resistance. On the other hand, less filler causes high connection resistance.

2.2.2 Curing

After coating, ACP on the membrane is cured by heat device. At this time, the curing temperature and time affect binder cohesion and properties (peeling strength, creep and so on). Setting up of the suitable conditions is hence necessary.

The peeling strength decreases with curing temperature, but creep property increases. These conditions are shown in Fig. 3. It is important for total ACP property to design the curing temperature and time.

2.2.3 Heat Press

Heat press is the final production. ACP connects two membranes at this production. Before connecting the two membranes, they are positioned accurately, then they are pressed and heated. Two membranes fix mechanically, and electricity can pass between them by conductive filler.

The control points at this product are pressure,

temperature and time. They affect the peeling strength, creep and conductive. These properties are shown in Figs. 4 and 5.

Table 2. Type and Condition of Environmental Test

Type	Condition
Heat Ⅰ	+85°C × 240hrs
Heat Ⅱ	+130°C × 2hrs
Cold	−40°C × 240hrs
Humidity	+60°C, 95%RH × 240hrs
Migration	+60°C, 95%RH × 240hrs (DC5V)
Thermal cycle	−40°C × 2hrs ←→ +85°C × 2hrs, changing temperature 2hrs, 40cycles
Thermal shock	−30°C × 1hr ←→ +80°C × 1hr, 25cycles
Life cycle test	Beating the ACP connecting area at 1,000,000 times Beating tool : Bakelite, Force : 1.5kgf, Cycle speed : 3 times/sec

3. Reliability

3.1 Environmental Property

Table 2 shows the type and condition of the environmental test. Figures 6 and 7 show the insulation (insulation resistance value of circuit gap) and conductivity (resistance of connecting circuit by ACP) before and after the test. Figure 8 shows the peeling strength after test.

All measurement values fulfilled the specification. (insulation = more than 100 MΩ, circuit resistance = less than 500 Ω, peeling strength = more than 400 N/m).

Peeling strength after test is particularly higher than ACF's. In case of ACF, it is normally about 400

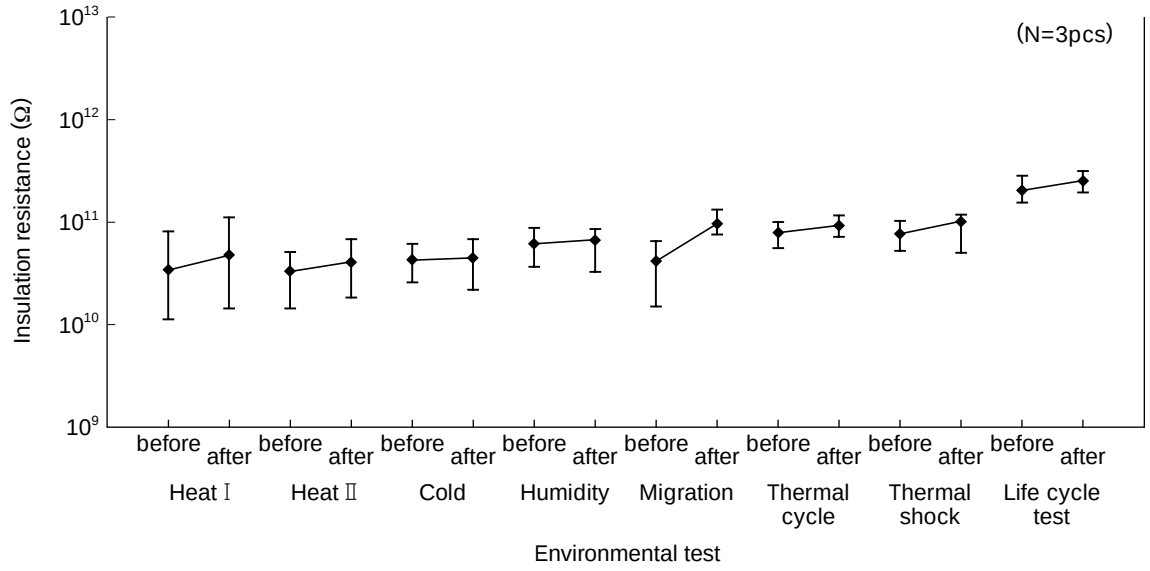

Fig. 6. Insulation Resistance before and after Environmental Test.

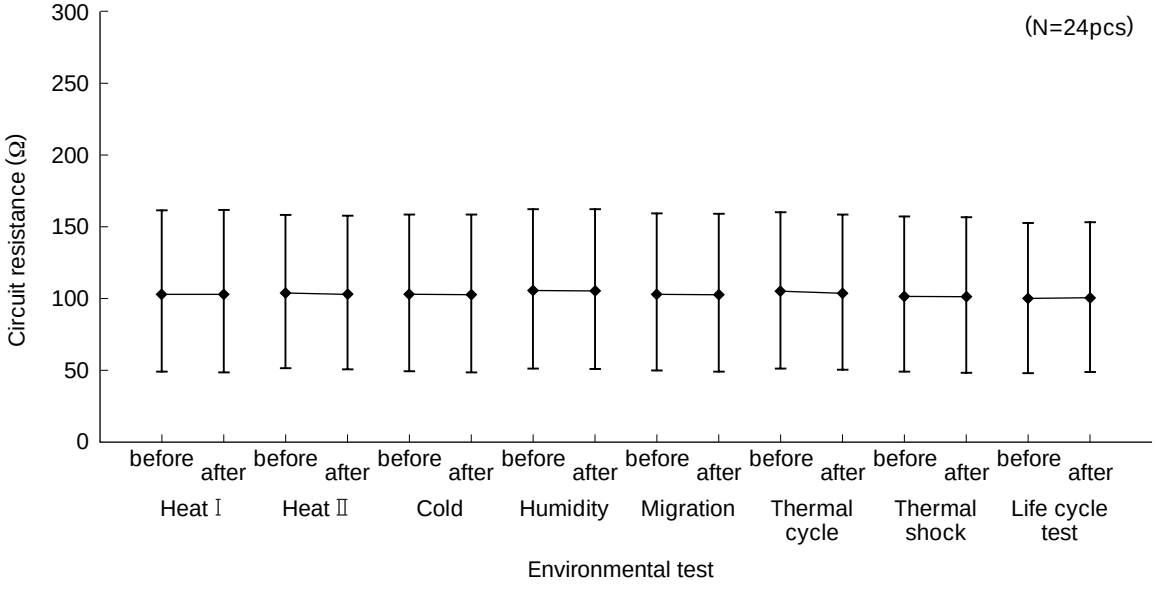

Fig. 7. Circuit Resistance before and after Environmental Test.

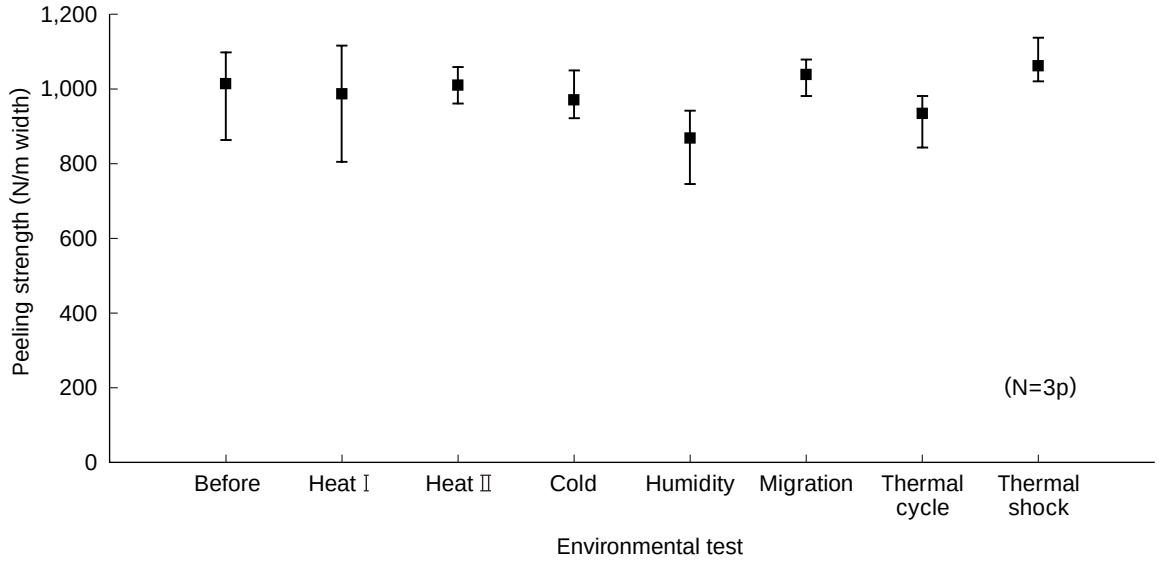

Fig. 8. Peeling Strength after Environmental Test (Include the Value before Environmental Test).

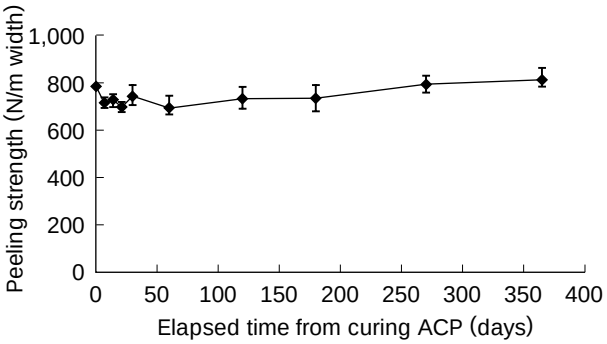

Fig. 9. Relationship between Elapsed Time from Curing ACP and Peeling Strength.

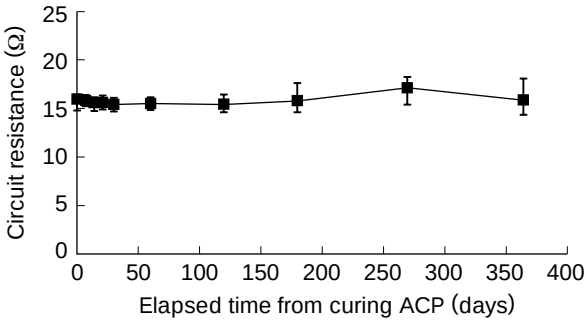

Fig. 10. Relationshiop between Elapsed Time from Curing ACP and Circuit Resistance.

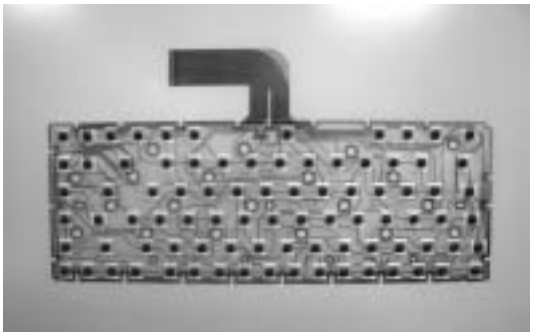

Fig. 11. PC Keyboard Membrane.

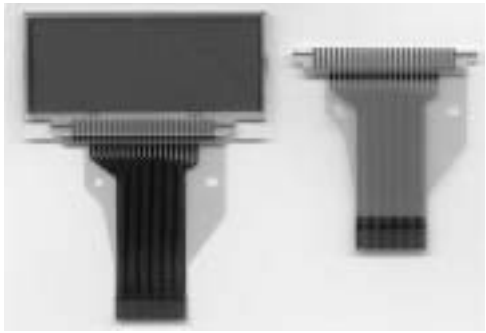

Fig. 12. Heat Seal Connector.

N/m, but ACP is twice as strong as ACF.

This test showed that ACP had a higher ability compared with ACF.

3.2 Maintaining Stability after Curing

One of the specialities of ACP is maintaining stability after curing. Normally, ACP is used for connecting LCDs or other electrical parts with membranes. In this case, ACP is coated on the membrane, and then cured by Fujikura after which they are delivered to the customer. Then, the customer assembles them with LCDs or other electrical parts. It indicates that ACP-coated membranes are kept for some weeks or months until they are assembled. So, maintaining stability is a very important factor.

Fujikura's ACP has a long life. Figures 9 and 10 show the transition of ACP property (peeling strength and circuit resistance) under room temperature.

ACP material is normally weak against humidity. But graphs show that Fujikura's ACP are stable for one year, which is adequate to store ACP by both Fujikura and the customer.

4. Application with ACP Technology

We had developed ACP connection technology and produced the keyboard membrane of PC (refer to Fig.11) with ACP. This technology can be applied to the connection between the membrane and LCD (refer to Fig. 12). Also, this can be applied to chip mounting without soldering, as it is used in FPC product.

5. Conclusion

ACP technology has achieved higher reliability. It can reduce the production time and cost compared with ACF. In regard to characteristics, peeling strength is higher and life after curing is longer than ACF's.

This technology can be applied to many fields, for example heat seal connectors or chip mounting and so forth. In the future, we plan to develop it further so that it can be applied to fine pitch circuits that are printed by R-R (Role to Role) produce line.

Reference

1) K. Motoki, et al.: Connecting Technology of Anisotropic Conductive Materials, Fujikura Technical Review, No.31, 2002