COF (Chip-On-Film) Technology for LCD Driver ICs Using Reel-to-Reel System

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Abstract

We developed a so-called "reel-to-reel method" COF technology using a long carrier tape for the LCD driver package. This method enables mass production of COF. We used the ILB (inner lead bonding) technique that connects inner leads on a 2-layered tape (glue-less) to Au bumps on an IC chip. COP tape material should be carefully selected with respect to both thermal expansion and heat resistance, because the IC chips are connected to the tape at a temperature over 400°C. In cooperation with a resin maker, we developed the underfill material, which enables filling the narrow spaces between the IC chip and the 2-layered chip without bubbles. The 2-layered tape also features easy installation onto CR parts and is flexible enough to bend freely. These features offer a promising advantage when this method is applied to compact appliances such as cellular phones and PDAs.

Introduction

At present, TCP (tape carrier package) is widely being used as a package for LCD driver ICs.

Sharp first began using TCP assembly processes for LCDs in 1985, and we have developed a number of TCP technologies, becoming a leader in the TCP industry. COF (chip-on-film) was first introduced in 1998 as a replacement for TCP. Since the summer of 2000, its use has advanced extremely rapidly with the evolution of larger color displays for mobile phones, and demand for COF has grown even stronger.

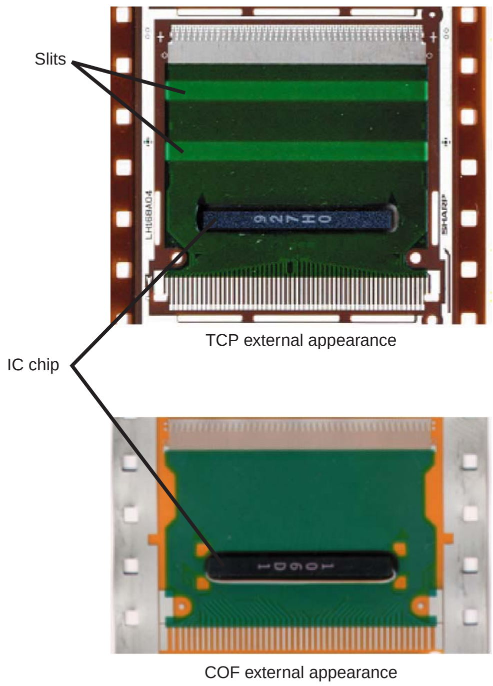

Fig. 1 Appearances of TCP and COF.

Figs. 1 and **2** show, respectively, photographs, and top views and cross-sectional views of TCP and COF packages. COF uses tape, and so its external appearance differs little from TCP. **Table 1** lists the strong points and shortcomings of TCP and COF, but the advantages and disadvantages of COF stem from the fact that it uses a 2-layered tape.

Note that slits must be opened in the TCP to allow flexing (one reason for high tape costs is because of the large external size of the TCP in the area of the slits). But COF offers many new strong points that TCP doesn't have, including the fact that it can be flexed even without the need to open up slits; the fact that there are no flying leads at the device holes as with

TCPs, thus making it easy to make leads with finer pitches (smaller chip size is possible); the fact that the copper foil is thinner means interconnects can be made with finer pitches and packages can be made more compact, and the fact that packages can be made thinner in general. Thus, there are significant advantages to using COF.

In the future, COF will find application not only in mobile phones, but also in the field of large-format LCDs.

1. Development of 2-layered tape

In developing a tape for use with COF, four requirements had to be met.

1) It had to tolerate temperatures in excess of 400°C when inner lead bonding (ILB) takes place.
2) It had to be thin enough to permit flexing at any point (however, it had to be conveyable in order to use the same production equipment as TCP).
3) It had to have little dimensional change during ILB.
4) The material had to be available in large quantities and in long lengths.

As a tape material satisfying these conditions, we selected a tape substrate (base thickness: 40 μmt) in which polyimide is coated onto a copper foil 12 μmt in thickness using a casting method. With the exception of having a low Young's modulus and being soft, its material properties differ little compared to TCP materials (**Table 2**).

The thickness of the copper foil in the COF tape is 12 μmt, and because this is thinner than TCP, etched wiring patterns as fine as 35 μm in pitch can be used with this tape in mass production.

The number of output lines for LCD drivers is increasing, with up to 480 outputs now in mass production. Making the copper foil even thinner will make possible high density COF with even finer pitches, with ample capacity to handle even greater numbers of LCD driver outputs in the future.

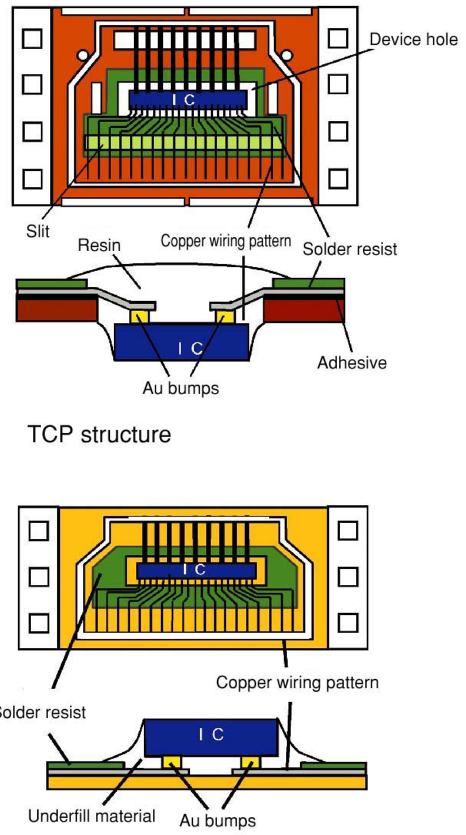

Fig. 2 Structure comparison of TCP and COF.

Table 1 Comparison of TCP and COF.

	TCP	COF	
Flexing degree of freedom	△	○	Possible anywhere
Finer lead pitches	△	○	Pitches of 30μm possible
Tape cost	△	○	Low cost with no inner lead deformation
Design freedom	△	○	Wiring is possible freely using slits and chips
Thinner form factor	△	○	Less than 0.8 mm

Table 2 Physical properties comparison of TCP and COF tape.

Parameter		TCP	COF
Tensile strength	kg/mm²	35.8	27
Young's modulus	kg/mm²	710	370
Breakdown voltage	kV	9.6	10
Dielectric constant	1MHz	3.27	3.5
Thermal shrinkage	%	0.02	0.03
Thermal expansion coefficient	ppm	18.9	20
Coefficient of moisture absorption	%	1.46	1.5

2. ILB (inner lead bonding) technology

For ILB (inner lead bonding), we re-engineered an inner lead bonder used with TCP. Compared to TCP tape (tape substrate: 75 μm; copper foil: μm), COF tape is thinner (tape substrate: 40 μm; copper foil: 12 μm), and thus to make this thin COF tape conveyable, we had to ensure that the COF tape wouldn't come off the carrier gears. In addition, because heat could not be applied from the tape side for ILB, a heating function was added to the stage component to enable heating from the chip side (**Fig. 3**).

Connections are similar to those of TCP, with a gold-tin eutectic formed between the gold bumps and the tin of the inner leads. However, when the temperature of the contact section is low, the inner lead eutectic is inadequate, leading to separation failures of the inner leads. In addition, when the temperature of the contact section is high, the bonding tool is raised with the gold-tin eutectic still in the molten state, and there is a tendency for similar inner bonding separation failures to occur. In addition when the temperature is low and the tin plate on the inner lead is thick, the tin plate will not be absorbed into the gold plate (no eutectic formed), and a well of tin plate will form. This tin-plate well is a source of problems with shorts and leakage. Such problems can be improved by setting the temperature appropriately, thereby enabling stable COF production.

Pitches of TCP ILBs are becoming smaller, with pitches as fine as 45 μm currently in mass production. However, problems with inner lead deformation are causing a turn away from further efforts to reduce pitch beyond this level.

The ILBs of COF have good stability down to 45 μm, and can be employed in mass production (**Fig. 4**). Because of the shrinking size of LCD driver ICs and the increasing number of outputs, ILB pitches must be made finer.

3. Potting technology (development of underfill materials)

The underfill material adopted is similar to the resins used in TCP, and a solventless epoxy resin was chosen. The use of solvent-type underfills tends to lead to the formation of air bubbles. A needle is used to open a gap (approx. 20 μm) between the chip and the COF tape. Several mg of the underfill material is then injected into the gap. To ensure that the underfill material readily fills the gap, the material was made to have a viscosity of less than 1 Pa・s, and no fillers were incorporated. The use of this underfill material enables the production of COFs without bubbles and with high reliability.

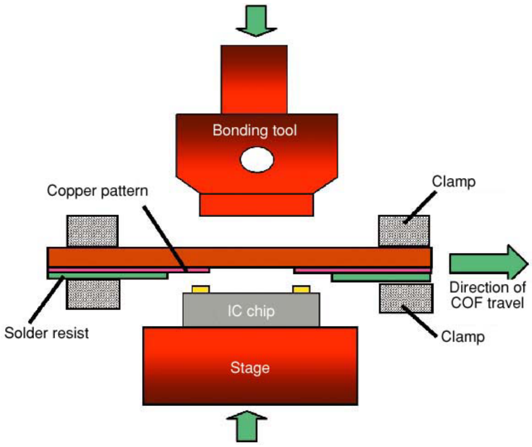

Fig. 3 ILB method of COF.

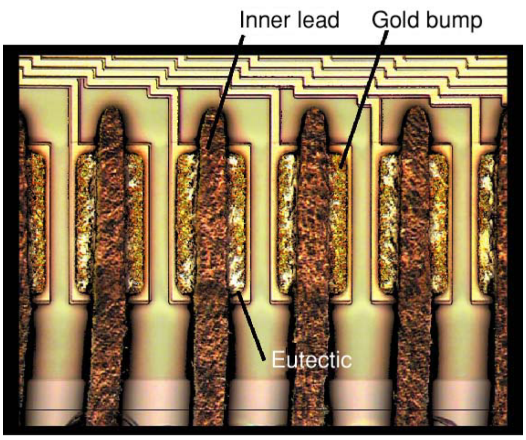

Fig. 4 ILB joining department of COF.

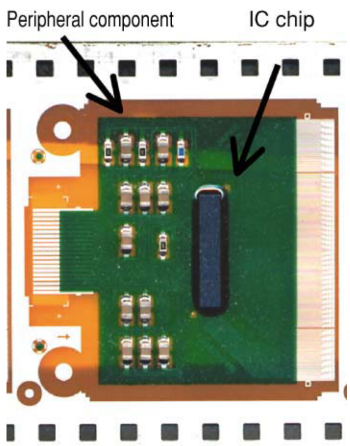

Fig. 5 Appearance of COF with CR parts.

Table 3 Reliability evaluation of COF.

Test Term	Conditions	Results
HT Operation	125℃, 1000H	0/45
HT/HH Bias	85℃/85%RH, 1000H	0/22
TCT	-45～125℃(each 30min.), 300cyc.	0/22
PCT	121℃/100%RH/2atm, 100h	0/22

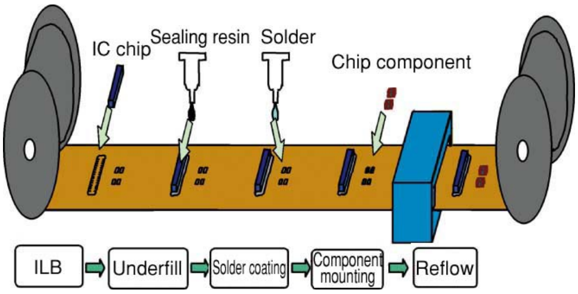

Fig. 6 COF assembly process with the reel-to-reel method.

4. Component mounting technologies

Small 0603 CR parts along the length of the COF tape can be mounted using solder reflow. By printing solder on the COF tape, reflow of CR parts can be done in situ.

By securely anchoring the highly flexible length of tape horizontally in a manner similar to a rigid substrate, uniform solder reflow can be achieved, making it possible to mount CR parts with a high degree of accuracy (**Fig. 5**).

5. Reliability

The materials and attachment methods used in COF are nearly identical to those used with TCP, and reliability is at equivalent levels (**Table 3**).

Conclusions

A reel-to-reel COF assembly mounting technology was developed using a long 2-layered tape, and put into mass production (**Fig. 6**). The present COF technology enables not only mounting of a variety of peripheral components, but it is also possible to load a number of individual chips (multi-chip technology) on the tape. It is widely anticipated that this technology will become essential in simplifying the systematization of devices such as mobile phones and PDAs in the future.

Acknowledgments

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