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COF Type TAB Tape for Superfine LCD

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ABSTRACT: LCDs (Liquid Crystal Displays) for use with personal computers and portable telephones advancing in the direction of high definition. Therefore, the development of IC wiring patterns for the LCD driver have also advanced in the direction of increasing the density. Therefore, the wiring pitches required for TAB (Tape Automated Bonding) have also been narrowing year after year. However, there has been a problem in that the flying leads were easily transformed, when wiring pitches are narrow. Hence, we started to develop a tape for COF (Chip On Film) in which the leads were made to adhere to the PI (polyimide) tape in order to contain the occurrence of lead deformation. The problem was rooted in the instability of the quality of the tape material. Thus, we strove to develop a technology for such a tape material to be used efficiently. We succeeded in establishing a high-quality and highly reliable COF-tape mass-production technology. In addition, we promoted refining the wiring based on this development and established practical application technology for a 30-μm-pitch COF tape.

〔1〕INTRODUCTION

High-definition liquid-crystal screens for use as personal computer and portable telephone displays require the formation of very minute wiring for the TAB (Tape Automated Bonding). The wiring pitch of such a high-definition TAB must be narrow, therefore, the copper foil used must be thinned. However, lead deformation occurs frequently when a copper foil is thinned, since the strength of the I/L (inner lead) at the device hole is insufficient, as shown in **Fig. 1**. Therefore, 40μm seems to be the wiring pitch limit. In the flying-lead-type TCP, an I/L pitch smaller than 40μm is unstable, and the COF-type TAB, in which the inner lead is made to adhere to a polyimide tape, is required. The concept of the COF has been around for a while, and some printed wiring board manufacturers have even adopted it ; however, there has been no demand from the market for TAB. However, by reexamining the advantages of COF, both users and manufacturers have investigated adopting a fine-pitch TAB. In the development of COF tape, LCD driver manufacturers required that the tape be transparent for recognition and accurate positioning of the I/L bonding. Moreover, flexibility was required as well to facilitate easy folding of the material. Thus, we undertook the development of a thin and flexible COF tape using a 2-layer material that formed a transparent film of plating copper on a PI tape. However, problems arose, such as adhesion between the PI tape and the copper plate, surface state, abnormal deposition in the tin plating, and whiskers that occurred in the merchandizing. In this report, these problems are described in detail along with the countermeasures developed to eliminate them.

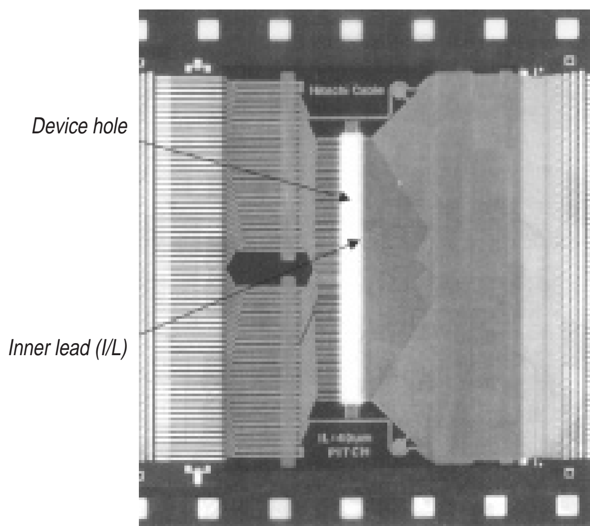

Fig. 1—Appearance of TAB for LCD
I/L has potential to be transformed for use the structure with the flying lead in the device hole division.

〔2〕ADVANTAGE OF COF TAPE

The COF tape has more unique characteristics than the conventional TAB used for an LCD. The COF tape follows the trend of underlying cost reductions of TABs for LCDs and the trend of a high-definition fine pitch.

(1) The manufacturing process can be shortened (refer to **Fig. 2**). The punching process is unnecessary, because there is no device hole in the COF tape. A slit hole is unnecessary,

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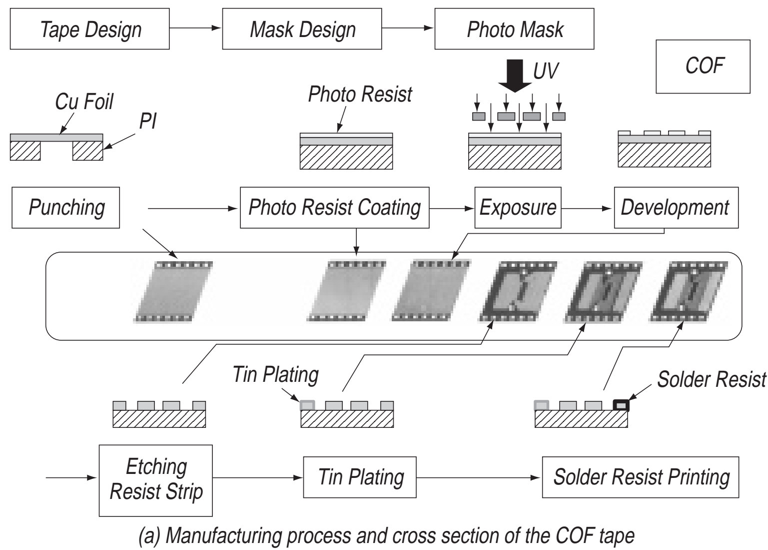
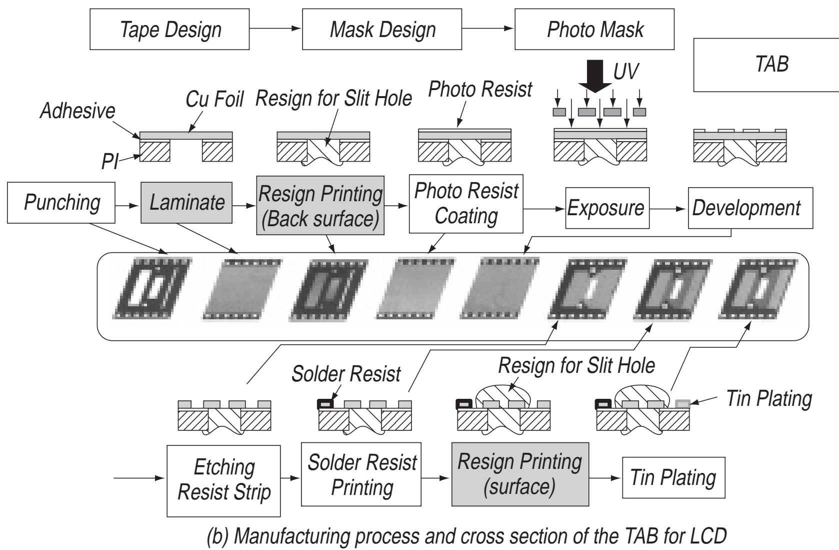


(a) Manufacturing process and cross section of the COF tape



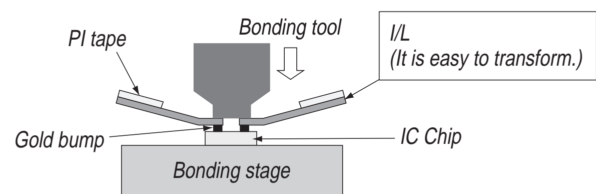
(b) Manufacturing process and cross section of the TAB for LCD

Fig. 2―Manufacturing process comparison of COF and TAB
COF manufacturing process is short. I/L of COF is not transformed.

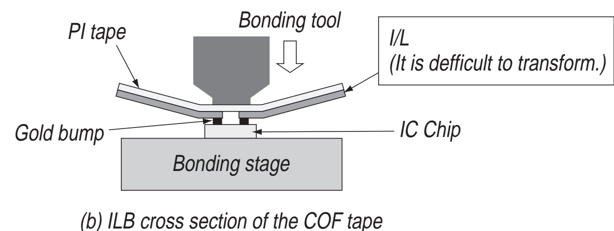
because the COF tape is thin. Therefore, the punching and resin-coating processes for the slit hole need not be performed.
(2) The copper foil laminate process is unnecessary, because the copper plate has already been conducted onto the PI tape. The I/L is not transformed (refer to **Fig. 3**). Since the I/L is adhered to the PI tape, it is not transformed. Therefore, packaging manufacturers will find it of practical use.

〔3〕 FEATURES OF 2-LAYER MATERIAL FOR COF TAPE

The 2-layer material for the COF tape is produced by using either the casting method or the metallization method. [1] A comparison of the two is shown in **Fig. 4**. The casting method is applied to the PI varnish on the copper foil and is performed to harden the material by curing. This method suffers from two demerits, and enjoys two merits. The first merit is the free material change of the copper foil. The other merit is that the peel strength is high, because the copper foil plane is rugged.



(a) ILB cross section of the TAB for LCD



(b) ILB cross section of the COF tape

Fig. 3―ILB cross section of each tape material (ILB: Inner Lead Bonding)
I/L of COF is not transformed because it is adhered to the PI tape. The flying lead may be transformed.

Name	Metallization method	Casting method
Process	PI Tape → Ni Alloy sputtering film → Cu plating film	PI varnish heater Curing after PI varnish application.
Merit	1. PI and copper plate thicknesses are changeable 2. Good transparency. (possible to use conventional ILB equipment.)	1. Copper foil material is changeable. 2.Good adhesion.
Demerit	1. Weak adhesion after high temperature heating. 2. Unstable quality of copper plate.	1. Poor transparency. (Impossible to use conventional ILB equipment.) 2. Insufficient feed capability.

Fig. 4—Peel strength comparison among 2-layer tape basis materials for COF
For this development, the transparent metallized material was used in the PI tape was adopted.

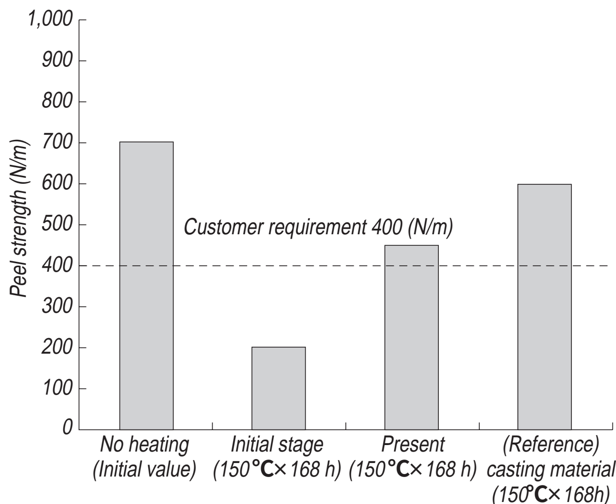


Fig. 5—Peel strength comparison among COF basis materials
Customer requirement was satisfied even for the present basis material by reexamining the manufacturing conditions.

The first demerit is that the packaging manufacturer cannot apply the conventional bonding facility because the transparency of the tape is low. The other demerit is that the production capability of COF basis material using the casting method is not sufficient at present. In the meantime, the metallization method of plating copper over a nickel alloy seed layer sputtered on PI tape will continue to see use.

In this method, there are two merits and two demerits. The first merit is it is easy to change the thickness of the PI tape and the copper plate. Therefore, continued study of the metallization method may result in future refinements. The second merit is that an packaging manufacturer can use their current bonding equipment, since the transparency of the PI tape fabricated by the metallization method is good. However, as mentioned above there are two demerits: the peel strength between the copper plate and the PI tape is inadequate, since the PI tape surface is smooth; the surface quality level of the copper plate is still low. We used a basis material produced by the metallization method in this development.

〔4〕PROBLEM AND COUNTERMEASURE OF 2-LAYER MATERIAL FOR COF TAPE

4.1 Adhesion of a copper plate film [2]

There was a problem of the adhesion of the PI film and copper plate film being lower after the tin plating process. The details is shown in **Fig. 5**. The bond strength of the 2-layer material was about 700N/m in the case without heat treatment. However, it became 200N/m after the heat treatment for 150℃×168 hr early in development process. Since the customer requirement is over 400N/m, the bonding strength was improved to 450N/m by using the following two methods. They are the optimization of the copper plate pretreatment condition by the 2-layer basis material manufacturer and optimization of the COF tape manufacturing process condition. The bond strengths before and after heating of the casting material do not fluctuate very much and they are about 600N/m. We examined the material and thickness of the seed layer and determined that an improvement of the bond strength had occurred as a result of the heat treatment of the 2-layer material.

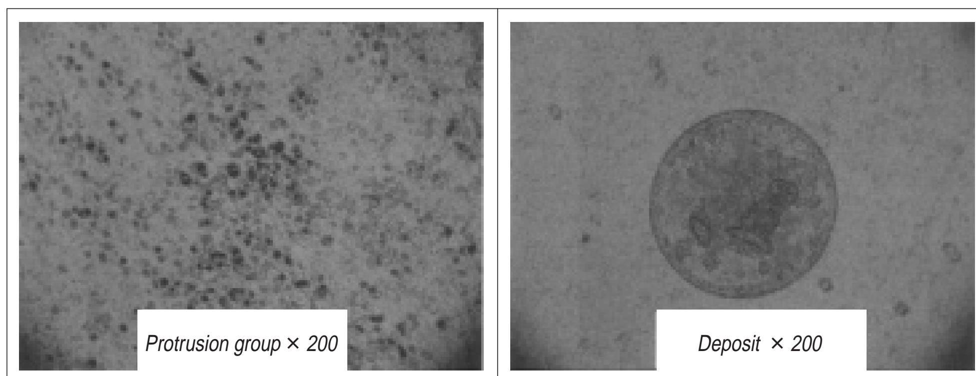


Fig. 6—Abnormality of copper foil surface of the 2-layer basis material for COF
Abnormal copper foil surface caused quality problerms in the pattern formation process. The quality of COF is being improved based on material improvements.

4.2 Surface quality of copper plate film

The protrusions and adhesion of foreign bodies shown in **Fig. 6** were mainly observed in copper plate surfaces formed by the metallization method. This apparent abnormality became caused pattern shorting and disconnection in the etch process of the COF tape. We promoted the improvement on the copper plate surface quality with the basis material manufacturer, and an improvement in quality was attempted for a yield of the practical level.

(5) THE EXAMINATION OF THE COF TAPE MANUFACTURING PROCESS

5.1 Abnormal tin plating depositions

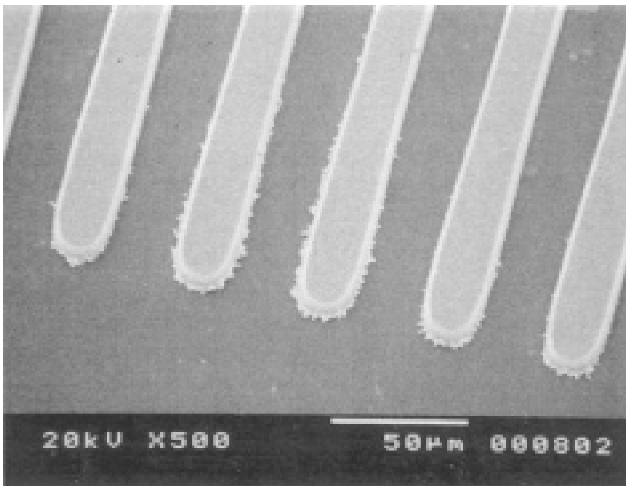
A large number of abnormal depositions occurred in the tin plating, as it is shown in **Fig. 7**. It was proven that there was a deep relation of the abnormal deposition of the tin in the seed layer to the adherence of the copper foil to the PI tape. It was proven that the abnormal deposition was partially generated by a local battery effect between the nickel alloy sputter layer and the copper plate film introduced by the increased tin deposition rate. The abnormal deposition problem was solved, when we devised a theoretical countermeasure as the result of our analyzing the mechanism of this phenomenon, (refer to **Fig. 8**).

5.2 Tin plating whisker

Tin plating whiskers, such as the example shown in **Fig. 9**, arose sporadically. This phenomenon is peculiar to tin plating, and it grows longer by the aging variation after the tin plating. We already know that whisker growth can be suppressed by annealing after plating.[3] Moreover, it was confirmed that there was no whisker generation after several months had elapsed when the anneal temperature was set at an appropriate temperature for the tape basis material. Thus, it became possible to realize a higher definition COF tape by overcoming the demerits of using the metallization method.

(6) DEVELOPMENT OF FINE PITCH COF TAPE

The development situation and the roadmap of the COF-tape fine pitch are shown in **Fig. 10**. We mass-produce the 44-μm-pitch COF tape using metallization material with 8-μm



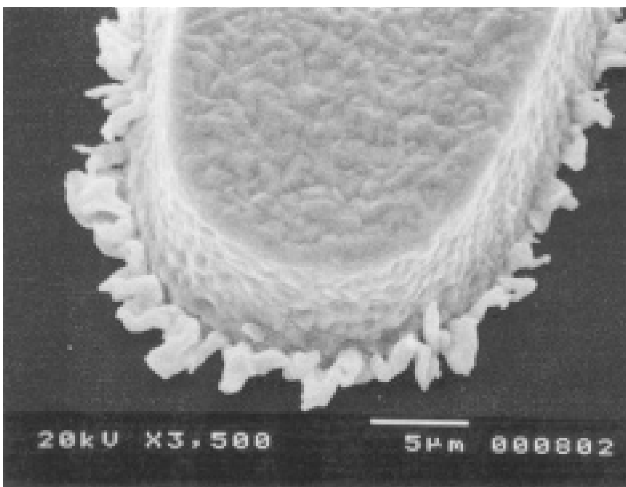
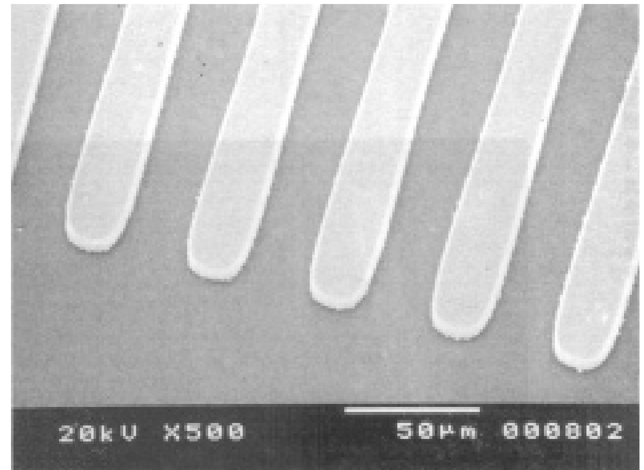


Fig. 7—Abnormal tin plating deposition
Large number of protuberances arose from side of lead.



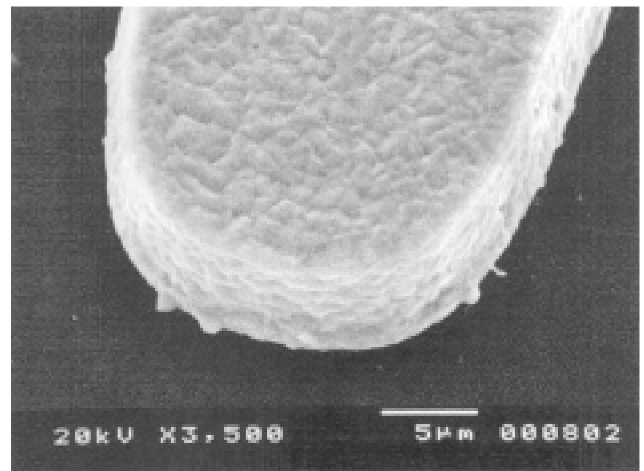


Fig. 8—Appearance of tin plating after impprovement
We studied the mechanism of the abnormal deposition and devised a countermeasure. As the result, we suppressed the abnormal deposition and ensured the stable quality of the COF.

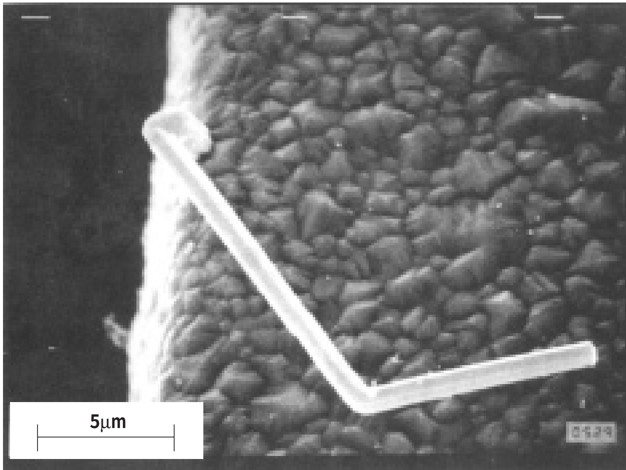


Fig. 9—Appearance of tin plating whisker:
Whisker grows over time and causes shorts between leads.

copper plate films. We are progressing in our efforts develop even higher definition wiring patterns. We already have a wiring forming technology for the 30-µm pitch that is at the practical application level. The reliability evaluation of the 30-µm-pitch COF tape sample is also being carried out (no problems have arisen) and the 25-µm pitch COF tape is presently under development. The appearance and a cross-section photograph of the 30-µm-pitch COF are shown in **Fig. 11**. In the meantime, 12µm is the mainstream copper foil thickness for the casting material. Therefore, though the casting material is more disadvantageous than the metallization material in the formation of the fine pattern, it is advantageous in terms of the peel strength. Both the metallization material and the casting material have advantages and disadvantages. We will continue to monitor the market trends for COF tape materials. Furthermore, we will establish a correspondent COF-

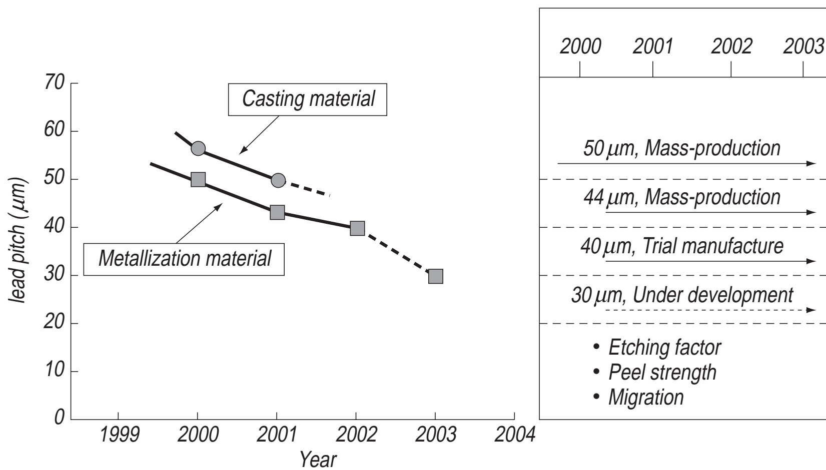


Fig. 10—The trend of fine pitch using 2-layer tape material by the etching method
Both tape materials have advantages and disadvantages. 30-µm-pitch COF will be required in 2003.

Product specification	Inner lead (I/L) pitch 30 µm	
	Appearance	Inner lead division
• Base film Thickness: 38 µm • Copper foil Thickness: 8 µm • Kinds of plating Electroless tin plating • Solder resist polyimide type • I/L pitch 30 µm		I/L 30-µm-pitch division Cross section

Fig. 11—Appearance and cross and cross section of fine pitch COF
It is already at the practical application level.

tape mass-production technology for use with any material.

(7) CONCLUSION

The following conclusions resulted from this examination.

(1) 2-layer material produced by the metallization method was adopted, and a mass-production technology for high-quality and highly reliable COF tape was established.

(2) Technological examinations of the 2-layer material manufacturers and the development of a COF tape manufacturing process were carried out. The problems of the peel strength and quality of the copper plate film were solved.

(3) The mechanism of the abnormal deposition, in which protuberant crystals in the tin plating were generated in great numbers, was clarified and an effective countermeasure was devised. As a result, a COF tape with stabilized appearance can be produced. In addition, the whisker problem was also overcome by examining the annealing condition after the plating.

(4) As a result of our study, a higher definition wiring pattern based on the above-mentioned technology, a wiring forming technology for a 30-μm-pitch COF tape achieved the practical level.

REFERENCES

(1) Nishikawa et al., Metallization film, surface technology, Vol. 45, No. 5, pp. 456-463 (1994).

(2) Yonemoto et al., Applied polyimide film and adhesion of the Cu sputtering film, Vacuum, Vol. 36, No. 3, pp. 199-201 (1993).

(3) Goto et al., Development of the Electroless Tin plating TAB, Hitachi Cable, pp. 31-36 (1993-1)

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