Development of 35 µm Fine-Pitch SOF Technology for LCD Driver LSIs

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Abstract

Recently, SOF is increasingly used as the package for LCD drivers, replacing previously used TCP. The pitch of inner-lead connection could be reduced to less than 40µm in SOF, as compared to the limiting value of 40µm in TCP. We have developed a 35µm fine-pitch-SOF technology, utilizing the present SOF and a zigzag-pad-layout ILB technology. As the first supplier of the fine-pitch-SOF, Sharp has started mass production in January 2003.

Introduction

For LCD driver packages, TCP (tape carrier package) is in popular use. Sharp has led the industry by adopting TCP for LCD drivers and developing various TCP elemental technologies. SOF, which began to be adopted in 1998 in place of TCP, has been rapidly gaining popularity as mobile phone displays are made larger and color displays predominate. SOF has many advantages, as shown in **Table 1**, compared to TCP, and the creation of new LCD drivers is anticipated by making the best of these advantages.

Table 1 Merits of SOF

	No dies for slit (short delivery time)	Flexible package that fits the housing		Finer pitch (miniaturization and increased output)	High-density packaging (increased functions)
		Reduced number of package lineups	Bending angle		
SOF	Free of slits	Bendable at any place	Oblique bend enabled	Bonding pitch: 35 µm or less	Wiring at chip packaged section enabled
TCP	With slit (dies required for every profile)	Bent at slit (package developed for every housing)	Bent at right angles to wiring	Bonding pitch: limit value 40 µm	Slit opening for chip packaging section

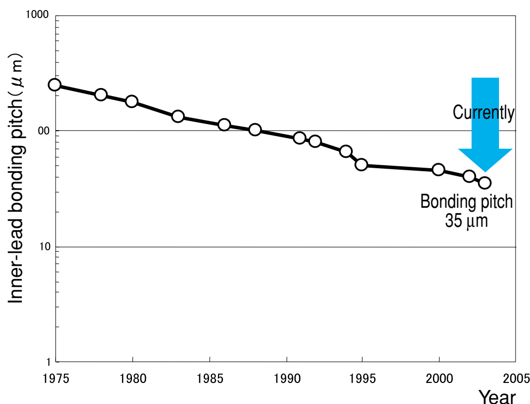

Fig. 1 Transition in refinement of inner-lead bonding pitch

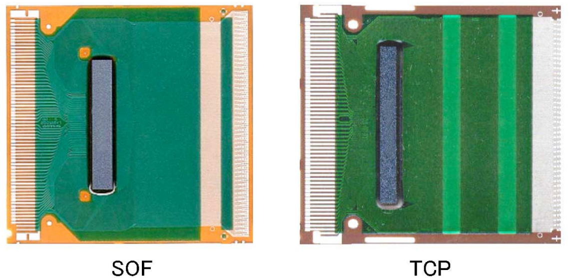

Fig. 2 Appearance of TCP and SOF

Increased refinement of bonding pitch, reported in this paper, is an advantage of SOF, and this bonding pitch is being further refined each year due to the increased output of LCD drivers and downsized semiconductor chips (**Fig. 1**).

Sharp has completed the development of the industry's first 35 μm fine-pitch LCD driver using this SOF and has begun volume production. This paper introduces the SOF with the 35 μm fine-pitch bonding technology.

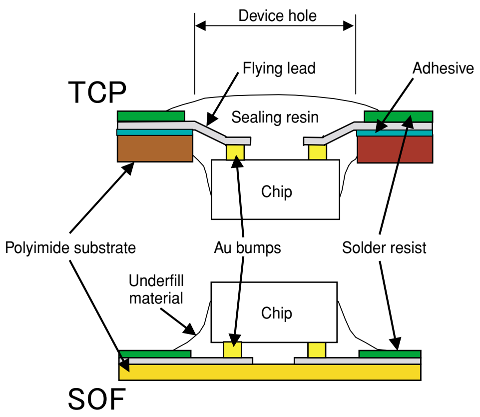

Fig. 3 Structure comparison of TCP and SOF

1. Package Structure

Fig. 2 shows the appearance of TCP and SOF. Because the material used for SOF is almost the same as that used for TCP, they look nearly identical.

Fig. 3 shows the structural differences between TCP and SOF. TCP has device holes in which protruding flying leads are located. When this flying lead is a 40 μm pitch or less, the leads deform and thus difficult to form fine-pitch tape wiring.

Since SOF has no flying lead, and all the inner leads are closely fixed to the tape substrate, the pitch can be made even finer without deforming the inner lead (**Fig. 4**).

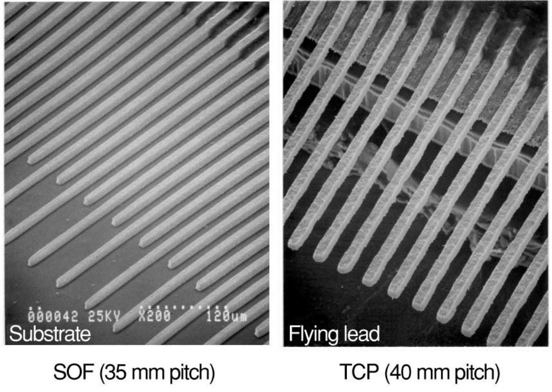

Fig. 4 Inner leads of TCP and SOF tape

2. SOF Fine-Pitch Assembly Process

2.1 Fabrication of SOF Tape

The SOF tape used for the 35 μm fine pitch is fabricated by forming Cr and Ni layers on a polyimide tape substrate by sputtering and plating copper on the layers. The tape wiring is formed by wet etching. Because the TCP copper foil is 12 μm thick at minimum and the SOF is 8 μm, it is much easier for the SOF with

thinner copper foil to form finer-pitch tape wiring. Currently, volume production is carried out with 30 µm wiring-to-wiring pitch for SOF tape. As the copper foil thickness can be further reduced to about 5 µm in the future, the tape wiring could be further refined to about a 20 µm pitch (**Fig. 5**).

2.2 Assembly Process

Fig. 6 shows the SOF assembly process. All processes of SOF assembly take place using the reel-to-reel manufacturing system with long tapes. On the tape, 2,000 LCD drivers are packaged, which makes it suitable for volume production. As shown in **Fig. 7**, in the ILB (inner lead bonding) process, the Au bumps of semiconductor chips and the tape wiring (tin-plated) are bonded by gold-tin eutectic crystal. The bonding pitch here is 35 µm, and adopting the SOF tape and the zigzag pad design with the bumps alternately arranged on the semiconductor chip have enabled fine-pitch bonding (**Fig. 8**).

After ILB, an underfill material that is a solvent-free epoxy resin is injected a few mg in the clearance (15 µm) between the semiconductor chip and the tape substrate. For the underfill material, a product with super-low viscosity of 0.5 Pa･s or less should be used to provide high filling capacity for the fine-pitch wiring. In addition, it is also possible to equip the SOF with peripheral parts such as sockets and chip capacitors, thus allowing application in mobile phones and PDAs.

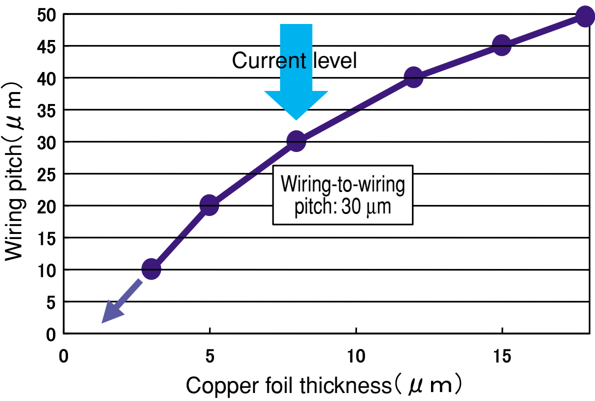

Fig. 5 Relation between copper thickness and wiring pitch of the SOF tape

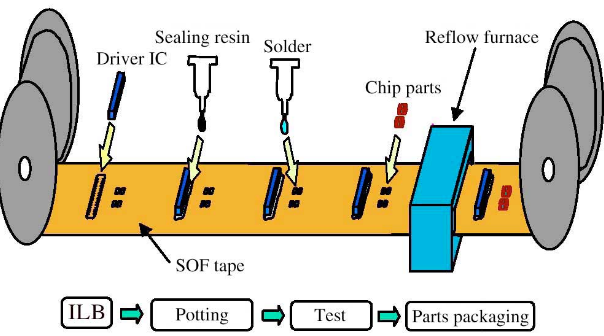

Fig. 6 Assembly process of SOF

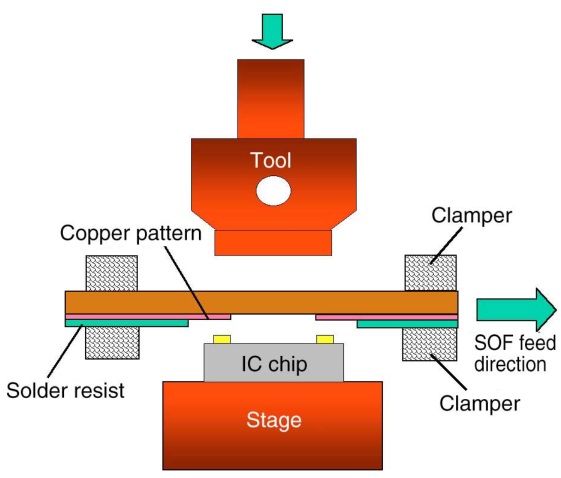

Fig. 7 ILB method of SOF

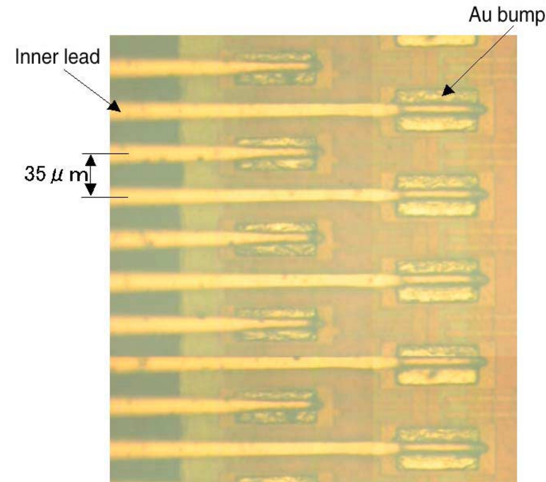

Fig. 8 35 µm ILB

3. Reliability

The material and bonding method used for SOF are nearly same as TCP, and a reliability level equivalent to TCP can be achieved (**Table 2**).

Table 2 Reliability evaluation results of SOF

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

Conclusion

Sharp has developed the industry's first 35 µm fine-pitch bonding SOF assembly packaging technology and has begun volume production. It is anticipated that the bonding pitch can be further refined, and since fine-pitch bonding smaller than 35 µm has been made possible by SOF, expectations for SOF technology as a packaging technology of LCD drivers will continue to grow.

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