Study of Bonding Technology on Flexible Substrate

Li-Qiang Chen, Tao Sun, Hong Li, Qing-Hui Zeng,*
Wei-Feng Zhou, Shan-Chen Kao, Da-Wei Wang

*BOE Technology Group Co., LTD, Beijing, China

Abstract

IC and FPC bonding technology on flexible substrate (PI) using ACF is a key process for flexible display. In this paper, two methods for IC and FPC bonding were compared. The main difference between the two methods is whether PI substrate is laminated with bottom film or not. The results show that PI substrate without bottom film is more suitable for IC and FPC bonding.

Author Keywords

Flexible display, Bonding process, Bottom film

1. Introduction

Module process especially bonding technology using anisotropic conductive film (ACF) is essential for display manufacturing [1-2]. ACF bonding technology on flexible substrate is different from that on glass. According to different process flow of flexible AMOLED, the flexible substrate bonding process can be implemented before and after PI substrate separation from the original carrier glass [3]. It is difficult to lift-off PI substrate in bonding areas due to the high temperature and pressure during bonding process. Bonding on film substrate is more potential for flexible display manufacture.

Nowadays, flexible display is usually bonded with COF (chip on film). That is reasonable because COF and PI substrate are both flexible, which will not easily cause damage when under high temperature and pressure. However, this method is not suitable for high PPI display. In order to match high PPI display, the outer lead bonding pad pitch of COF can be as small as 20um or even smaller, which will tremendously lower the bonding yield and increase the whole cost. IC and FPC (flexible printed circuit) bonding is necessary to meet the requirements of high PPI and cost down.

In this article, IC and FPC was bonded on flexible substrate with and without bottom film respectively as shown in figure 1. Bottom film is usually consist of PET base film and adhesive layer.

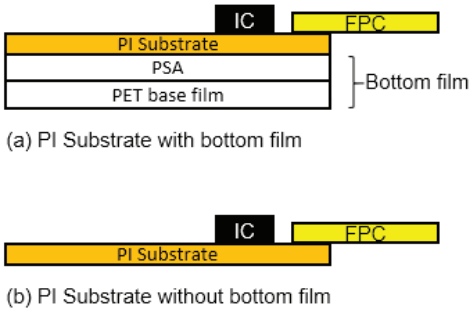

Figure 1. The structure of PI substrate with (a) and without (b) bottom film

2. Experiments and Results

2.1 IC bonding on PI substrate with bottom film

Experiment: After lifting off from original glass, PI substrate was laminated with bottom film using roll laminator on the back side. The adhesive layer is PSA (pressure sensitive layer). After laminated bottom film, the bonding area of PI substrate become flat which is convenient for mark aligning when bond IC and FPC.

IC was bonded on PI substrate with bottom film using normal bonding condition. The pressure is 60Mpa and the temperature is 180℃.

Result: Due to the difference of hardness between PET bottom film and IC, IC sank into PI substrate after main bonding process. That causes two problems:

1. Bonding pads in PI substrate crack due to the pressure of bump and may cause failure in electrical connecting.
2. IC area curves due to the temperature when IC is bonded, increasing the difficulty of FPC bonding.

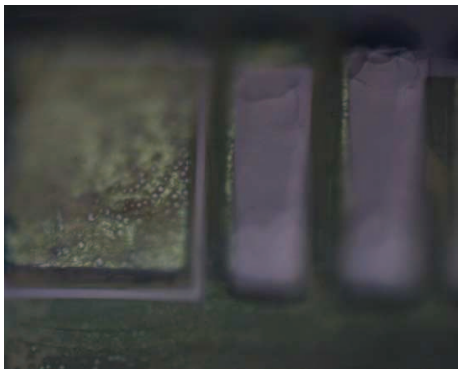

Figure 2. Graph of bonding pads crack (with 110um bottom film)

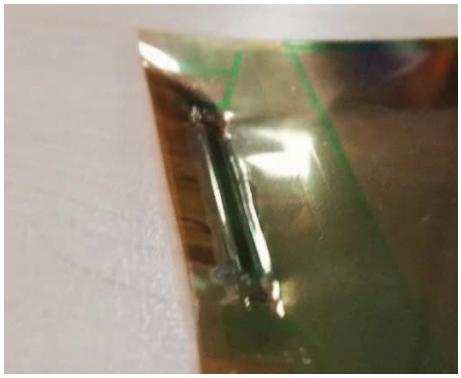

Figure 3. FPC bond area curve (with 110um bottom film)

Figure 2 and figure 3 shows IC bonding result of PI substrate with PET bottom film which is consist of 90um PET base film and 20um PSA. Bonding pads on PI substrate cracked severely and the whole FPC bonding area curved.

We tried thinner bottom film with PET base film 50um and PSA film 10um and got the same results as shown in figure 4 and figure 5.

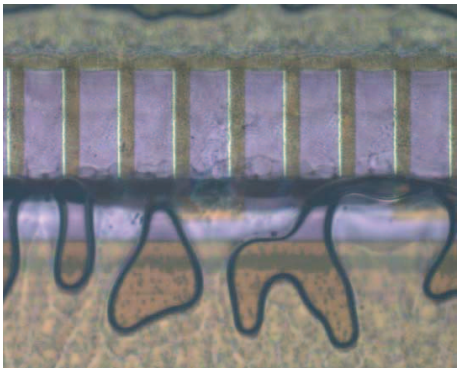

Figure 4. Graph of bonding pads crack and bubbles (with 90um bottom film)

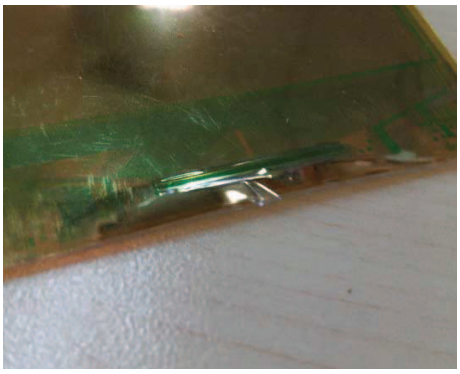

Figure 5. FPC bonding area curve (with 90um bottom film)

It is reasonable to get the results. Since IC is much harder than bottom film, PSA absorbs most of bonding pressure and causes pads crack [3]. The bubbles in figure 3 illustrate the flow of PSA and pads crack near the bubbles. Therefore, thick PSA will be harmful to the IC bonding. However, the contradiction for bonding process and bottom film lamination is, in order to insure adhesion, the thickness of PSA can't be reduced dramatically.

2.2 IC bonding on PI substrate without bottom film

Experiment: Since IC and FPC can be bonded successfully on PI substrate with original glass, we tried bonding IC and FPC directly on PI substrate. Bonding area of PI substrate without bottom film is very thin and vulnerable to the stress around it. Former process such as lamination of barrier film may cause curve in this area and it is difficult for IC alignment. Vacuum hole is used to fix and flatten the bonding area. IC bonding process on PI substrate is nearly the same to that on glass substrate, the pressure is 60Mpa and the temperature is 180℃.

Result: There is no crack in bonding pads and the indentation of conductive particle (akkon) is clear as shown in figure 6. IC bonding process will cause curve in FPC bonding area (figure 7), but it can be flattened by vacuum hole and available for FPC bonding. We successfully lighted flexible panel using that method as shown in figure 8, the glue is not uniform because it was coated manually.

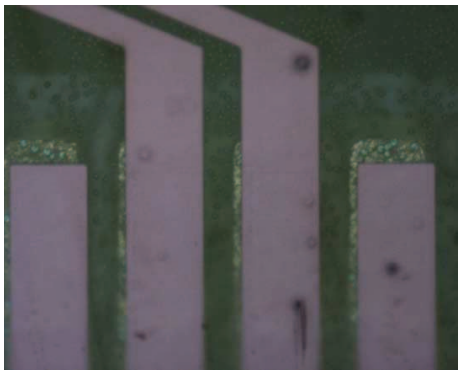

Figure 6. Graph of bonding pad and akkon (without bottom film)

Figure 7. FPC bonding area curve (without bottom film)

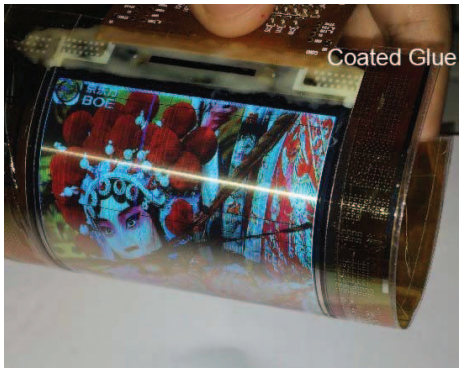

Figure 8. 4.8 inch flexible display through bonding process on PI substrate without bottom film

2.3 Problems to be resolved

There are still some problems to be resolved for manufacturing.

PI substrate is very thin and easy to be bended, especially after IC and FPC bonding, which will cause IC peeling or metal pattern crack when handling panel. Protection of bonding area is necessary. Coating glue around IC and FPC bonding area is a good way. For increasing endurance, the whole bonding area are coated as shown in figure 8.

Besides, for some specific purpose, function film such as bottom film and graphite sheet should be laminated after bonding process. Because of IC and FPC, the front side of panel is irregular and this will be difficult for lamination process.

3. Conclusions

IC and FPC can be successfully bonded on PI substrate without bottom film. This method can avoid bonding pads crack and provide better reliability compared to bonding on PI substrate with bottom film. Though there are still some problems to be resolved in the future, such as protection of bonding area and lamination process after bonding IC and FPC, this method is potential for IC and FPC bonding during flexible AMOLED commercial manufacture.

4. References

[1] I. Watanabe and Y. Gotoh, "Driver IC Packaging Technologies using Anisotropic Conductive Films in Flat Panel Display" *SID Dig.*, 19.1, pp 240-243, 2008.

[2] Yen-Huei Lai, Wan-Tsang Wang, Chia-Hsun Tu, et al. Study of ACF Bonding Technology in Flexible Display Module Packages. *SID Dig.*, 4.2, pp 12-15, 2015.

[3] M. Takeichi, "History of ACF Development and New Solutions" *SID Dig.*, 19.2, pp 244-248, 2008.