Research on Failure Factors of Salt Spray Test and the Solutions for COG 2.4mm-down-border LTPS LCM

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ABSTRACT

The salt spray test is failed more and more frequently for full-screen display. Experiments were done to research the possible factors. It revealed that the combination of PI (polyimide), silver conductive glue and the dispensed location resulted in the failure. Based on the analysis, the improvement solutions were proposed.

1 INTRODUCTION

In recent years, the full-screen mobile phone becomes very popular because of the significant improvement in visual experience. From the original ratio of 16:9, to the first-generation full-screen-display with an aspect ratio of 18:9, later to the second-generation full-screen-display with "Notch" design [1] and hole-in-display [2] mass production projects on the market, the extreme narrow border becomes development trend obviously, especially the down border, as shown in Figure 1. Up to now, there are two kinds of structures on the down border, including chip-on-film (COF) and chip-on-glass (COG). For COG technology, it has been widely used in the manufacturing industries. However, with the down border getting narrower and narrower, the full-screen displays are facing more and more serious reliability problems, such as, temperature humidity bias operation (THBO), the salt spray test and pressure cook test etc.

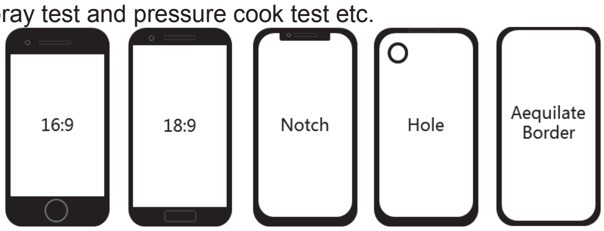

Fig. 1 The comparison of screen display: a) normal; b) first-generation full-screen-display 18:9; c) second-generation full-screen-display "notch"; d) third-generation full-screen-display "hole in display"; e) fourth-generation full-screen-display "aequilate border";

Among them, the salt spray test, as one of the most important ones, can simulate human sweat and indicate the resistance to sweat corrosion. However, LCD products based on COG technology began to fail in the salt spray test since the second-generation full-screen display. When the down border of COG product is 4mm width as the first-generation full-screen-display, it can pass salt spray test easily. When the size of down border decreases to 3.0~4.0mm, it starts to fail the salt spray test probability. When the width shrinks to 2.0~3.0mm, the failure ratio of salt spray test becomes higher.

In this article, the salt spray tests were carried out for different products. The possible factors to the salt spray test failure had been investigated. Based on the analysis, the improvement solutions were proposed. This research will be of great practical value by improving the reliability of salt spray resistance for the full-screen display.

2 EXPERIMENT

2.1 Failure Phenomenon

The salt spray test were carried out by exposing the products in salt fog of 5%±1% sodium chloride solution, PH 6.5~7.2, at 35±2°C for 48 hours and 96 hours. The common phenomenon of the failure salt spray test is shown in Figure 2. The failure area always occurs at the down border around Ag pad. As shown in optical microscope images, wrinkles can be observed in PI between CF Glass and TFT Glass. The failure alignment of PI leads to the liquid crystal arranging disorders. The causes of the failure phenomenon described above, had been researched from the aspects as follows.

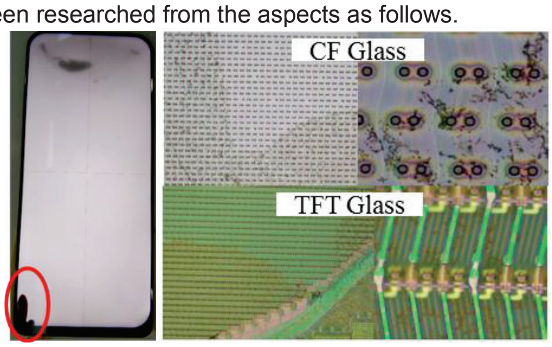

Fig. 2 Failure mode by electrical measuring after salt spray verification and the schematic diagram of failure analysis

2.2 Why narrow border?

To analyze the failure mode, section diagram of the COG structure shown in Figure 3 was researched minutely. LTPS-LCD is consisted of CF substrate and TFT substrate, packaged by seal all around. The PI layer lies on the top of TFT substrate and the following layers are SiN_x passivation (PV) layer and the planarization layer (PLN) in sequence. Silver glue pad is designed as the structure shown in Figure 3b. The up ITO layer is connected with the metal ground wire (M2) by passing through the PV hole. Silver glue is dispensed to connect the ITO layer with the CF substrate to achieve antistatic effect.

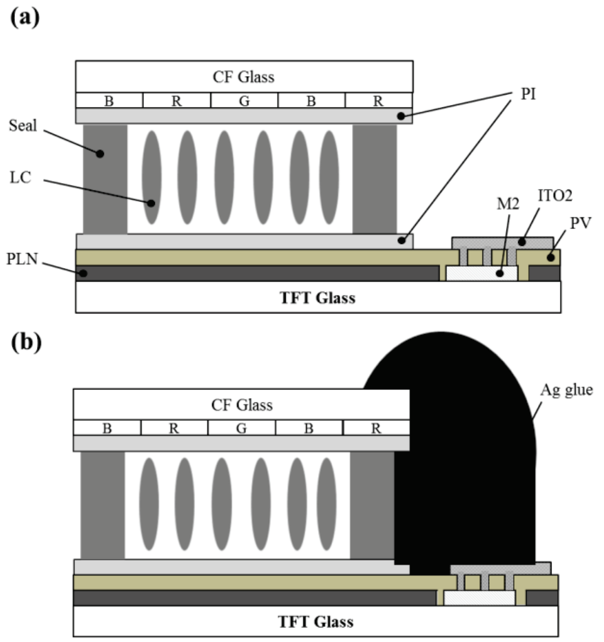

Fig. 3 Section diagram of the LTPS-LCD COG structure

Since the failure layer is PI layer, the study was set out on it. In the actual process, we found that the PI boundary can't be limited in the design area, as shown in Figure 4. The actual PI area is wider than the design one, and takes greater risk in contacting with the Ag glue.

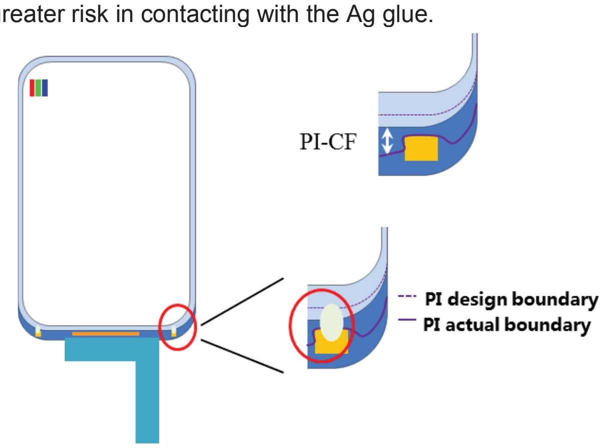

Fig. 4 schematic diagram of PI coated on the glass surface morphology

The narrower the down-border width becomes, the shorter the PI-CF distance would be. PI-CF distance means the distance of PI near TFT glass, to the edge of CF glass, as shown in Figure 4. Thus, when the distance of PI-CF is short to a certain extent, the PI boundary spreads out of CF edge, inevitably. Our experiments showed that with the distance of PI-CF lengthened from 171 um, 250 um, 440um to 750 um, the failure ratio lowered from 100%, 40%, 21% to 0% after exposed the products to the salt fog for 96 hours, as shown in Figure 5a. It could be concluded that the longer distance PI-CF was of, the smaller percentage the failure tests had. That is, PI is one of the essential factors for the failure.

When the PI exceeds the CF boundary, the components which contact the PI would be PV, ITO and PLN etc. The bonding forces of PI-other component had been studied. The results revealed the strong-to-weak sequence of the bonding force for PI- other component is PI-PLN, PI-ITO and PI-PV. ITO as the most possible component to contact to PI with PI spread out had been under consideration. Thus, some experiments about PI-ITO distances had been done. With the distance of PI-ITO shortened from 100 um, 0 um to -150um, the failure ratio lowered from 100%, 21% to 0% after exposing the products to the salt fog for 96 hours, as shown in Figure 5b. In other word, the ITO layer extends inward to PI, as PI-ITO is of stronger surface force, the failure ratio will be reduced, which means better salt-resistance capacity.

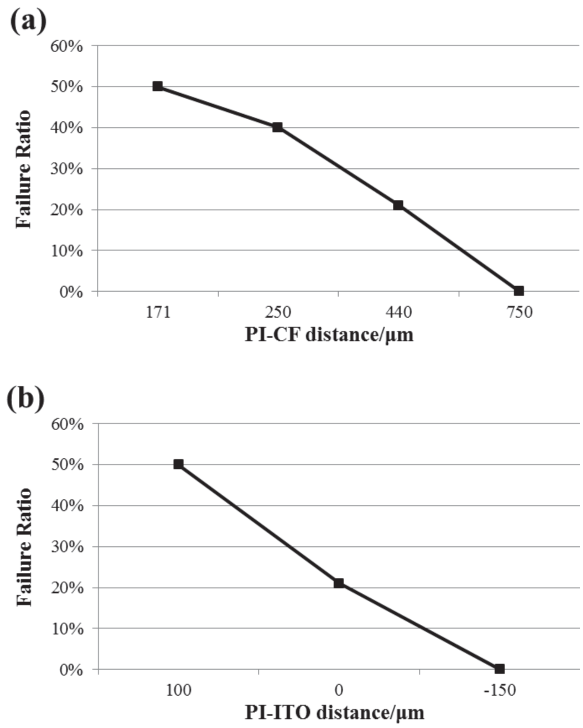

Fig. 5 The contrast of salt spray tests for different products (a) for the PI-CF distance, (b) for the PI-ITO distance

2.3 Why Ag pad?

The failure area was located above the Ag glue pad. So another hypothesis was formed that Ag glue and its relative site may have an effect on failure. In this, there were two aspects to be verified. One was, cancelling the Ag glue, the test data are good. It showed Ag glue was another failure factor. And the other was, the dispensed site was changed to the middle of the down border, instead of at the both ends of the down border. The former tests all passed while the latter ones failed, as shown in Figure 6. It indicated Ag glue must be dispensed at given site-Ag pad, acted as the last essential role on failure.

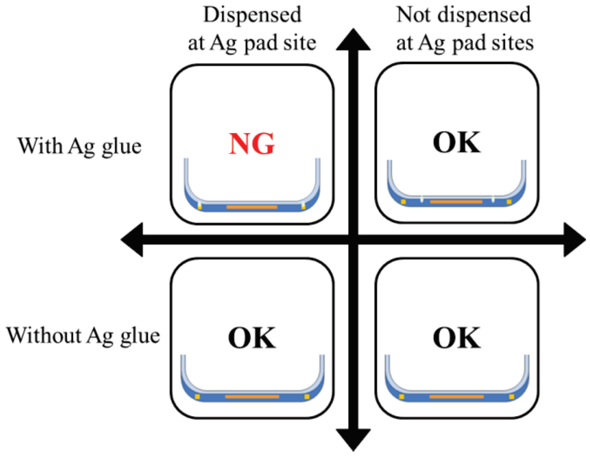

Fig. 6 Cause-effect relations of Ag glue and its dispensed sites

3 RESULTS

Therefore, the combination of PI, Ag glue and the dispensed site resulted in the weak salt resistance of the COG products. In view of the need for antistatic, Ag glue and Ag pad film are essential parts for electronics. To improve the failure, the solutions must be related with PI. Based on the analysis above, two methods are worthwhile to be adopted. By optimizing structural design, keeping PI away from the danger area as far as possible becomes the preferable choice. For example, the existing R corner is applied by designer to move up the PI boundary. This structure is of long distance of PI-Ag glue. The other method is etching PLN blocks between PI area and Ag glue, if the first design doesn't work. The PI can be separated in this area, which restricted the combination of the three factors. In our experiments, the COG products with PLN blocks in front of Ag pad suffered less failure ratio than the ones without the blocks.

4 CONCLUSIONS

In summary, the analysis of the failure products showed that the combination of PI, Ag glue and the dispensed location resulted in the failure salt spray tests. Correspondingly, the solutions of improving the salt resistance of full-screen display were proposed. One of the improvement advices is keeping the PI design boundary away from the Ag glue, like R corner, and the other is etching PLN blocks between PI area and Ag glue, to separate the sprawling PI.

The analysis of the failure factors for the salt spray tests has a great referential significance. The solutions of improving the salt-resistance reliability of the full-screen display were proposed and confirmed on the COG 2.4 mm. It will offer great support to the full-screen high-quality display in the future.

REFERENCES

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