Reliability Improvement of Narrow Down-border TED Product Based on LTPS-TFT LCD Technology

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Keywords: TED, Metal corrosion, Potential difference, Full-screen-display

ABSTRACT

We analyzed the failure route of metal corrosion and solved this issue by improving the coverage effect of passivation film on metal line. Otherwise, electrochemical corrosion mechanism was carried out to explain the failure mechanism and low potential difference metal was proposed to decrease the defective rate to 0.

1 INTRODUCTION

As the development of the display technology and the eagerly visual demand for full-screen-display from consumer, the size of down-border in LCD device is getting smaller. While the size of down border decreases, the distance of AA (Active Area) to CF (Color Filter) glass, d1 as shown in Figure 1(a), and the distance of CF to panel, d2 as shown in Figure 1(a) decrease too. Limited by IC (Integrated Circuit) size and bonding technology, d2 cannot be compressed so much. In other words, narrowing down-border is mainly compressing d1. As a result, the exposed area ratio of metal line of fanout to CF glass is increasing, as shown in Figure 1(b). Consequently, the narrow down-border TED (Touch Embed Display) product will face more severe challenges of reliability issues after environmental testing, especially metal corrosion.

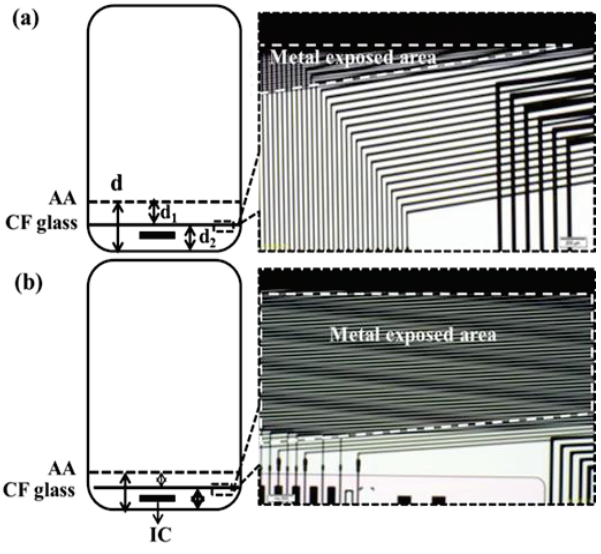

Fig. 1 The comparison of metal exposed area ratio of different size bottom border display: (a) normal screen display; (b) full-screen-display

In this paper, we study the cause of touch function failure and grid defect after RA (Reliability Analysis) in TED products. Through systematic and specific experiments, we found that touch line breakage from metal corrosion which caused by high temperature water vapor is the main reason of RA failure. Based on these, we proposed two options and effectively reduced the defective rate from 1.5-2.5% to less than 0.1%.

2 EXPERIMENT AND DISCUSSION

2.1 The failure route analysis

Through preliminary OM (Optical Microscope) examination, we found that capacitive touch failed and grid defect appeared after RA came from touch line lead open, as shown in Figure 2. Soaking RA failed glass in red ink for 12h, and we observed that red ink entered into the glass through UV seal cracks from the surface layer, and then crossed through passivation cracks into metal defective position. This is also the path of water vapor into the display during RA's process.

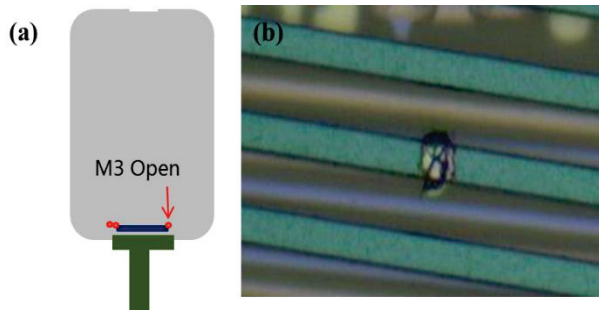

Fig. 2 (a) The defect area; (b) The morphology of touch line (Mo-Al-Mo) lead open

After a further study of 3D OM, obvious cracks could be seen on the PV (passivation layer, SiNx) surface and PV had collapsed completely. With assistance of FIB (Focused Ion beam), we verified that metal under defective PV had been corroded and the middle layer Al had disappeared, as shown in Figure 3(a) & (b). By comparing the different positions of metal morphology, we found that defective metal side wall exist undercut. We suspected this is the main reason of PV crack. In the subsequent stress, such as bonding IC process, PV prone to fracture strongly. By deteriorating undercut experiments, we validated the correctness of the suspicion.

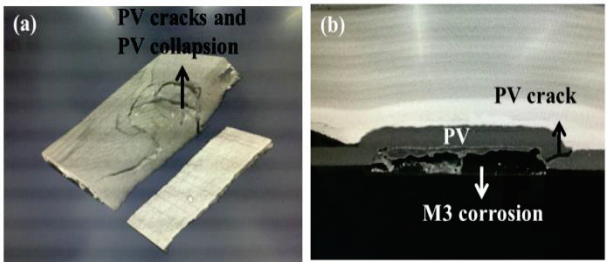

Fig. 3 (a) 3D morphology of defective area; (b) Observation of touch line (Mo-Al-Mo) film morphology from cross section by FIB

2.2 The mechanism of metal corrosion

On the basis of corrosion mechanism, the factors which affected corrosion in Mo-Al-Mo were analyzed. The literatures suggest that when PD is greater than 0.25 V, galvanic corrosion is more serious. The detailed process is showed in Fig.4. First, PD (Al/Mo) =1.462V>>0.25V, strong potential difference (PD) between Mo and Al would easily lead to the galvanic corrosion. Second, oxygen-rich environment promoted the formation of oxygen concentration cell, causing pitting corrosion. As cathode area contacted with the electrolyte is larger than the anode, the anode current is greater than the cathode current. So Al pitting corrosion is more severe. After environment oxygen was consumed, the chloride ion or other anion from electrolyte migrated into Al pitting. Finally Al3+ hydrolyzed to form the acid environment, Al active dissolved further, accelerating the metal corrosion. If there were chlorine ion or other anion as catalysis in the electrolyte, corrosion rate will be accelerated. Otherwise, high temperature can also accelerate the corrosion process. Moreover, galvanic corrosion also promoted stress corrosion. The two corrosion promoted each other, and eventually lead to Al disappear and the collapse of PV upon metal.

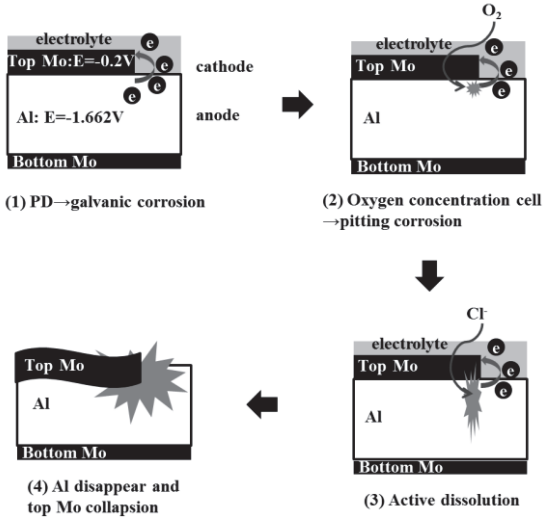

Fig. 4 The process of metal corrosion

3 IMPROVEMENT

Based on these discoveries, we proposed two main directions to improve metal corrosion. As chlorine ion and high temperature could catalyze Al active dissolution, we used saturated salt boiling experiments (saturated salt solution, Temperature: 70°C) to deteriorate metal corrosion defective rate. Based on upon research, we design a series of experiments. Detailed experiments and results are shown in Table 1.

Table1. Detailed experiments and results

NO	Defective / Condition	12h		24h		36h		144h	
		quantity	rate	quantity	rate	quantity	rate	quantity	rate
1	Reference	0/50	0	0/50	0	6/50	12%	/	/
2	increasing THK of UV	0/50	0	0/50	0	2/50	4%	/	/
3	increasing THK of PV1	0/50	0	27/50	54%	/	/	/	/
4	PV1 THK U% improvement	0/50	0	0/50	0	5/60	10%	/	/
5	SiNx→PLN	0/50	0	0/50	0	0/50	0	/	/
6	Mo-Al-Mo→Ti-Al-Ti	0/50	0	0/50	0	0/50	0	0	0

3.1 The isolation of intrusion path

First, isolate the water vapor intrusion path to metal into the electrolyte. We can strengthen the UV sealant for better vapor isolation, to ensure the water vapor cannot enter into metal surface, especially Mo-Al-Mo side wall. But it mainly depends on the UV seal's sealing ability and coating technology. Without changing the UV material, increasing the coating thickness of UV can limitedly improve defective rate, as showed in NO.2. For some products, defective rate even became worse. So simply changing the thickness of UV seal is not a good improvement method. On the other hand, increasing coverage or thickness of passivation on the metal seems like good choices, but it is also a difficult work if metal undercut morphology isn't solved well. So the source to improve the passivation coverage is to improve the metal etching condition. While, Mo-Al-Mo etching mainly uses wet etching, undercut of metal is unavoidable. Actual experimental results were validated our speculation, as showed in NO.3 and NO.4. However, changing rigid SiNx to acrylic resin material is actually a better selection, as acrylic resin material has nice ductility. Hence resin passivation wouldn't crack with subsequent stress or external force, even below metal had slight undercut. After the experiment of 36h, metal (Mo-Al-Mo) morphology below passivation was undamaged, as shown in Fig.5.

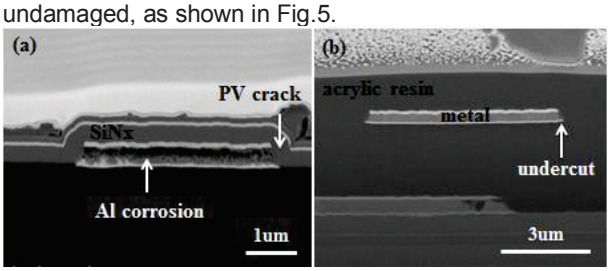

Fig. 5 The morphology of metal that changing PV film from (a) SiNx to (b) acrylic resin

3.2 Metal Potential

The other solution is change metal to lower potential difference, such as Ti-Al. Specific reasons are as follows. As PD (Al/Mo) is higher to 1.462V, much greater than 0.25 V, galvanic corrosion is more severe.

E (Al^{3+}/Al) =-1.662V,
E (Mo^{3+}/Mo) = -0.2V,
PD (Al/Mo) =1.462V;
E (Ti^{2+}/Ti) =-1.628V,
E (Al^{3+}/Al) =-1.662V;

Obviously, PD (Al/Ti) is lower to approaching to 0V. Predictably, the Ti-Al-Ti is less likely to corrode. As we expected, the touch function of display used Ti-Al-Ti were fine after 144h boiling in saturated salt solution. Observing all the exposed area, we didn't find metal corrosion, as shown in Fig.6. From the cross SEM of metal, we also found Ti-Al-Ti has better sided morphology than Mo-Al-Mo after etching. Consequently, passivation coverage is also improved. This method has excellent performance of metal reliability in the TED product, reducing the metal corrosion defective rate to less than 0.1%.

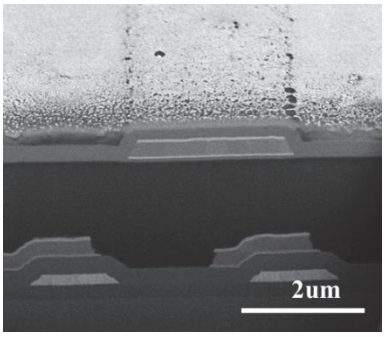

Fig. 6 The morphology of metal that changing touch line from Mo-Al-Mo to Ti-Al-Ti after saturated salt boiling experiments

4 CONCLUSIONS

We explained the RA failure of metal corrosion mechanism of TED products. Based on these, a series of effective solution are proposed. Though material choose and process optimization, we effectively enhance the metal reliability. The results have guiding significance for the metal corrosion improvement of narrow down-border TED product.

REFERENCES

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