Researches of Process Reduction for Viewing Angle Controllable LCD

Shih-Bin Liu, Lujie Wang, Jun Jiang, Yanbing Qiao, Chia-Te Liao, and Te-Chen Chung*

InfoVision Optoelectronics (Kunshan) Co., Ltd., No. 1, Longteng Road, Kunshan, Jiangsu 215301, China

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ABSTRACT

In this paper, a better condition is found to maintain the thickness of PR for half-tone technology, and some issues of process reduction in B-ITO and M3 layers are solved. We also try to replace B-ITO layer with IZO, but color deviation tends to become noticeable. These issues of topology for M3 after ashing and last wet etching are still being studied.

1. INTRODUCTION

The viewing angle controllable liquid crystal display (VAC-LCD) is one useful and convenient technology on display panel which can well protect the security of personal information in narrow viewing angle (NVA) mode and easily switch back to wide viewing angle (WVA) mode. However, this switchable panel with hybrid viewing angle (HVA) which compared to using the anti-peeping film is still expensive. This subject plans to bring the cost down by reducing the total number of masks in the manufacture process.

Hydrogenated amorphous silicon (a-Si:H) is still the major material of active layer which is applied to the mass production in the liquid crystal display (LCD) industry.[1], [2] Some process innovations and new materials have been implemented in the last few years.[3-8] Before improving the manufacture process of our produces, eight photo masks are used to achieve the required functions that are this HVA mode and these special designs of corresponding circuits on the side of glass with thin film transistor (TFT). Here we utilize half-tone mask (HTM) and the method of 3-Wet and 1-Dry (3W1D) to combine these two masks of bottom indium tin oxide (B-ITO) layer and third metal (M3) layer into one process, so as to reduce the total number of masks.

2. EXPERIMENT AND DETAILS

2.1 Original process of VAC-LCD

Previous research results of IVO on this switchable viewing angle of HVA-LCD have mentioned on the other conference,[9], [10] and it mainly describes the property of optical characteristics. In this paper, the particulars of the process are discussed in more detail. In accordance with the earlier process, these masks are mainly used to fabricate the film layers, which are the first metal (M1) layer, gate insulator (GI, SiN_x) layer, a-Si:H layer, n+ a-Si layer, second metal (M2) layer, first passivation (PV1) layer, overcoat (OC) layer, B-ITO layer, M3 layer, second passivation (PV2) layer, and top ITO (T-ITO) layer, respectively. It needs

Tab. 1 Total photo engraving processes of the earlier method

PEP	Item	
PEP8	T-ITO	After anneal
PEP7	PV2 (TH)	
PEP6	M3	Depo
PEP5	B-ITO	After anneal
PEP4	OC	After baking
	PV1 (no mask)	
PEP3	M2	Depo
PEP2	n+	
	a-Si	Depo
		Remain
	SiN	Depo
		Remain
PEP1	M1	Depo
Glass		

eight photo engraving processes (PEPs) of this earlier method that shown in Table 1.

2.2 Modified process for mask reduction

This new process focuses on the fifth and sixth masks, which aims at reducing the B-ITO and M3 layers to one mask through half-tone technology and different etching sequence, as shown in Figure 1. According to the following sequence of

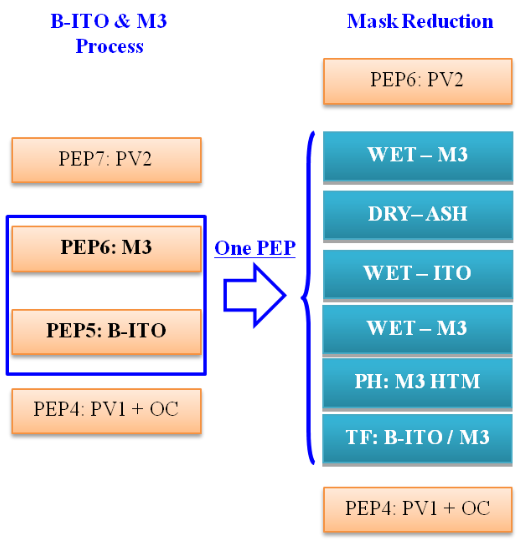

Fig. 1 Process of mask reduction for VAC-LCD

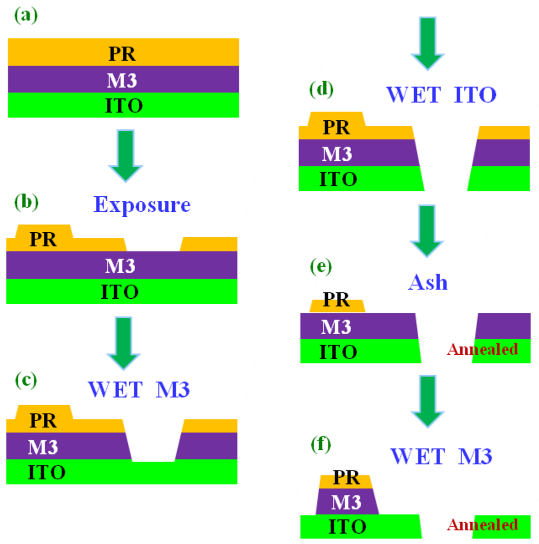

Fig. 2 Processing details of mask reduction

processes: First, it deposits B-ITO and M3 two thin films; and uses the HTM of M3 to develop photoresist (PR); then wet etches the M3 and ITO layers by aluminic acid (AlH_3O_3) and oxalic acid ($C_2H_2O_4$) respectively; and then dry etches the remaining PR by specific pattern for ashing; finally, etches the remaining M3 by aluminic acid again to form the final structure that product required. Three wet etching and one dry etching were used during this process, so it can also be called 3W1D technology. The influence of various procedures on the film layers can be referred to these details in Figure 2.

3. RESULTS AND DISCUSSION

3.1 Residues of B-ITO

In order to achieve this target that lessening the cost, we choose to combine two masks, M3 and B-ITO, into one half-tone mask. The main reason for using this combination is that graphics of these two masks are relatively simple so that there is a larger margin of processing, as shown in Figure 3. These SEM images show the actual results of process improvement, and this drawing indicates the location of contact hole. The states of processing can be detected from the surface situation, and then adjust the experiment conditions.

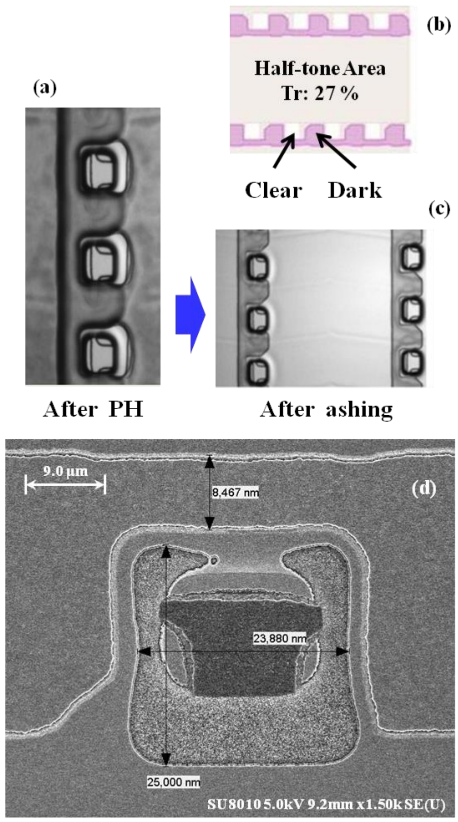

Fig. 3 Photographs of patterning after process improvement

A better condition is found to maintain the thickness of photo resist (PR) after testing with various exposure and etching conditions, and there is no big issue till the ashing step. In this process, we try to replace B-ITO layer with IZO. But it is discovered that the correlated color temperature (CCT) will be gradually decreased and the color will gradually turn from blue to yellow when the thickness of IZO film increase from 400 Å to 1000 Å. The phenomenon of color deviation tends to be more noticeable. This color is very close to the existing products when the thickness of IZO film is about 400 Å, but there is still a difference about 0.002 in the W_y value.

Tab. 2 Results of ashing verification after HTM method on M3 layer

HTM–ASH Verification										
NO.	Time	Topology for M3								
		OK		Sawtooth		Disconnection		Deletion		Residue
		Margin	Middle	Margin	Middle	Margin	Middle	Margin	Middle	
1	170 s	56.3 %	100 %	16.7 %	0	20.1 %	0	6.9 %	0	In the middle
2	180 s	28.5 %	98.6 %	22.2 %	1.4 %	25.7 %	0	23.6 %	0	Non
3	190 s	0.7 %	95.8 %	7.6 %	1.4 %	14.6 %	1.4 %	77.1 %	1.4 %	Non
4	200 s	0	76.4 %	6.3 %	15.3 %	14.6 %	5.6 %	79.2 %	2.8 %	Non

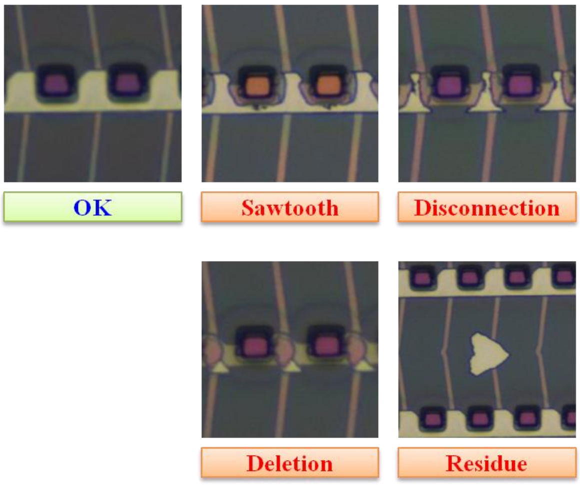

Fig. 4 SEM images after HTM method in M3 layer

In the following step, some residues of B-ITO are found in a through hole (TH) after first two wet etching. From the figure 3(d), a portion of B-ITO is showed off at right and left edges of TH area. Based on the thickness analysis of half-tone area, it come from one tendency that thickness will get thicker on center region, and the area of circum edge doesn't have the same trend. Therefore, it can be assumed that the situation of half-tone region is affected by the uniformity of exposure energy. After this exposure method is changed to weakly expose of 3.8 μm on M2 layer and weakly expose of 2.0 μm on OC layer, no residues of B-ITO are found in the TH.

3.2 Ashing process verification

We further confirm the results of wet etching after ashing. Although this residue issue of B-ITO layer in TH has been solved, but there are some other issues after ashing and last wet etching. The detailed results of ashing verification after HTM method on M3 layer are shown in this Table 2, and the actual statuses of issues after ashing are shown in Figure 4. Residue, deletion, disconnection, and sawtooth of morphology on M3 layer can be observed from the SEM images. These issues come from the poor yield (~56 %) of PR in the margin of half-tone area on one sheet. The effective solutions are still being studied at the present time. We prefer to adjust the design of mask to repair this issue.

4. CONCLUSIONS

Photo-masks account for a large proportion of the fabrication cost in the whole process of LCD production. Hence this use of HTM technology which combined with two masks not only can subtract one mask but also can shorten the overall time of production. It is very helpful to increase the capacity of production and decrease the cost of LCD. And we also utilize the IZO to replace B-ITO for testing this property of manufacturing process. Although it will cause the issue of color deviation in the end, but it is also a good start to try new processes.

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