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Physical Properties and Fabricating Technology of Novel Type Resist for Color Filter in TFT LCD

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1. Introduction

High-resolution portable commodities fully demand flat panel display technology since new advanced TFT (thin film transistor) LCD (liquid crystal display) technologies have disclosed low power consumption technology with small-size panels. Reflective-mode LCD is developed and achieved high-efficiency energy saving, but due to front-light and some issues, reflective-mode LCD still cannot fully satisfy with the requirement of consumer devices. To resolve these issues, transflective-mode LCD is developed as a compatible counterpart for reflective-mode LCD[1-3]. This paper demonstrates a novel technology of fabricating novel-type, through-hole and half-tone color filter in TFT LCD with transflective-mode. Three primary color photo resists and optimal parameters of manufacturing processes have fine-tuned and satisfactorily targeted the required pattern and chromaticity.

2. Experimental Procedure

Color filter glass substrates size is 620x750mm^2, and three primary colorants of red(R), green(G) and blue(B) photo resists are AMTR63S, AMTG63S18 and AMTB20S. The procedure is: glass substrate initial cleaning and rinsing for 30~60sec, coating photo resists on the substrate at spinning coating rate of 400~700rpm, escaping the solvent under operating pressure of 1~10Pa, exposing by using proximity-mode exposure system and energy density of 100~200mJ/cm^2 and gap of 100~200μm, developing the designed pattern and final post-bake at 190~230^{o}C for 5~20min. Repeat these processing steps three times to pattern three primary colorant RGB on glass substrate[4].

3. Results and Discussion

Reflective- and transflective-mode LCD are the same as the transmissive-mode, but the reflective layer fabricates in reflective-mode and transflective-mode LCD. For transmissive-mode LCD, twisted-nematic-mode liquid crystal cell and polarizer film are used as optical valve to control transmittance ratio, but for reflective-mode, auxiliary light will pass through liquid crystal cell twice and an additional 1/4 phase retardant film will apply to adjust the transmittance ratio[2]. For transflective-mode LCD, the districts of transmissive- and reflective-pattern exit in this mode. To enhance optical transmissivity and to raise light efficiency, chromaticity may be sacrificed by decreasing the reflective zone thickness of colorants layer. This will result in inferior color performance in transmissive zone. Color reconciliation adjustment of brightness, contrast and color purity in reflective and transmissive zones is a challenge issue. Table I shows current color filter fabricating technologies of transflective-mode and reflective-mode.

Table I. Comparisons of the color filter fabricating technologies

	Chromaticity		Inter-	Mask No.	Coat
	Trans	Ref.	face	(with BM)	
Common CF	△	╳	◎	4	◎
2CF	◎	◎	◎	7	╳
PR Control (2PRs)	◎	◎	◎	7	╳
Thickness Dif. (Glass etching)	○	○	○	5	△
Thickness Dif.+OC	○	○	△	5	╳~△
Thickness Dif.+OC (Half-tone)	○	○	△	4	○~◎
Pinhole+OC (Through-hole)	○	△	△	4	△
Gray tone	○	○	○	4	○

╳: bad △: normal ○: good ◎: excellent

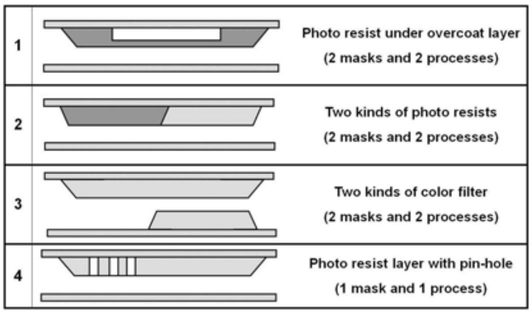

Fig. 1 4 basic and novel-type structures of color filter

There are four constructions of transflective-mode LCD shown in Fig. 1. From the manufacturing viewpoint, these constructions are similar, but the redundant reflective layer is fabricated in the substrate with TFT devices and the complete structure is embedded in the transflective-mode LCD panel. Current specification of LCD in color filter may not satisfy new commodities and fashion application anymore. The targeted specification of transflective-mode LCD in color filter with half-tone and through-hole is technically developed and successfully applied the assembly of liquid crystal cell.

The structure of conventional transflective-mode color filter is shown in Fig. 2(a). For the desired design of chromatic balance in reflective and transmissive zones, the reflective zone should design in the form of through-hole and half-tone, which can effectively decrease the chromatic difference between transmissive-mode and reflective-mode LCD. Typical structure of color filter with through-hole is shown in Fig. 2(b). The aperture ratio of pixel pattern in reflective zone could be optimized in chromatic characteristics while the through-hole zone is aligned with the reflective zone. For color filter with half-tone structure, the colorant layers with different thickness are fabricated in three primary colorant photo resists, shown in Fig. 2(c). For colorant layer on the reflective zone, it will acquire better color performance than color filter with through-hole. From the manufacturing viewpoint, transflective-mode color filter with half-tone is more complicated than through-hole.

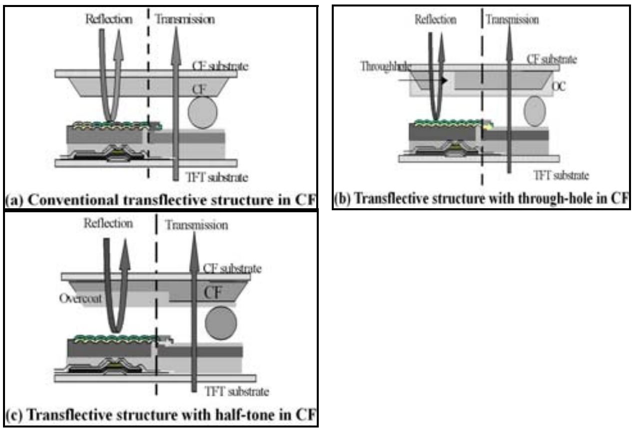

Fig. 2 Transflective structure of LCD cell with color filter type: (a) conventional type, (b) through-hole type and (c) half-tone type

Table II Comparison of chromatic characteristics

Trans.	Y	x	y	NTSC
R	26.230	0.589	0.337	45.0%
G	62.003	0.335	0.547	
B	81.464	0.139	0.149	
W	35.10	0.327	0.344	
Reflect. (without HT)	Y	x	y	NTSC
R	18.706	0.647	0.346	68.7%
G	44.012	0.310	0.610	
B	8.229	0.131	0.106	
W	23.65	0.331	0.348	
Reflect. (with HT)	Y	x	y	NTSC
R	23.903	0.584	0.336	45.0%
G	59.432	0.333	0.552	
B	16.389	0.139	0.151	
W	33.91	0.327	0.347	

p.s. NTSC: National Television System Committee

For the comparison between reflective-mode without half-tone and with half-tone on Table II, the brightness has raised from 23.65 to 33.91 whose improved value is closed to 35.10, the transmissive-mode LCD without half-tone. This technique benefits the improvement on brightness in reflective-mode and reduces the divergence in the extent of color while customers switch transflective-mode LCD between reflective-mode and transmissive-mode[5,6].

Conventional color filter photo resists(CFPRs) are facilitated in the stable zone with residue during manufacturing processes, but it is not suitable for transflective-mode color filter with half-tone. The optimal process conditions of CFPRs for transflective-mode color filter with half-tone are operated in the unstable zone, and the appropriate thickness in reflective zone can be fine-turned by manufacturing parameters. From the consideration of process in stability, the formation of uniform film thickness in the reflective zone is necessary. Photo resist will be etched by developing solution and resulted in no difference in thickness between transmissive and reflective zones. Besides, adhesion strength of CFPRs and glass substrate will be decreased and will cause discontinuity in pattern. The optical scanning pattern and atomic force microscopy of the resultant samples are shown in Fig. 3(a) and 3(b). From the observation of experimental results, film surface is flat and different in height in the extent of tolerance. Colorant films in thickness for transmissive and reflective zones can be arbitrarily adjusted in the range of tolerance under optimal processes.

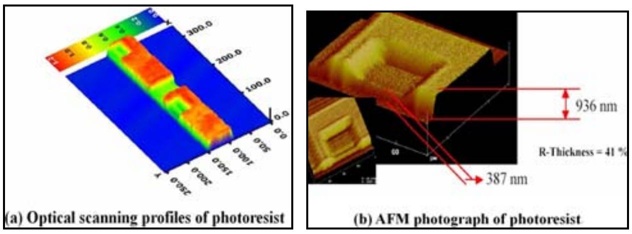

Fig. 3 (a) Optical scanning profiles, (b) atomic force microscopic photographs of through-hole type or half-tone type color filter

4. Conclusions

Conventional transflective-mode LCD cannot satisfy the consumer devices demand, so reflective-mode LCD of color filter has designed under economic consideration. These color filter fabricating technologies, through-hole and half-tone type of transflective-mode, have successfully developed, and chromatic characteristics have measured by spectrophotometer. Surface morphologies of color filter with novel structure have been observed by optical scanning profile and atomic force microscopy.

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