A High Aperture Mobile in the FFS TFT-LCD by the using Fine Patterning Process

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Abstract

In order to increase the transmittance of panel, in process of FFS TFT-LCD, fine patterning process which is adopted to the optimum passivation(PVX) hole was applied fine metal line patterning process and was made with optimum efficiency of liquid crystal by using space/bar size control of pixel electrode. We fabricated 2.03" mobile FFS devices with fine patterning process. Further, this technology will be applied to the basis of other process for higher PPI or higher aperture ratio technology.

1. Objective and Background

The fringe-field switching (FFS) devices was well known to exhibit higher transmittance and wide-viewing angle at the same time [1,2]. In the FFS devices, the fringe field is utilized to rotate homogeneously aligned LC molecules almost in plane above whole electrode surface unlike the in-plane switching (IPS) or the patterned vertical alignment (PVA) device, giving rise to high light transmitted area. Specially, these good properties of FFS device are profitable to mobile. Panels such as mobile are required of the special qualities of high transmittance, high Contrast Ratio and etc. To meet high transmittance is to increase aperture ratio in defined pixel electrode area. In order to increase aperture, metal lines and passivation (PVX or Via) hole have to be diminished, finally, BM areas are reduced. Also, the efficiency increment of liquid crystal (LC) by using space/bar size control of pixel electrode contributes to high transmittance.

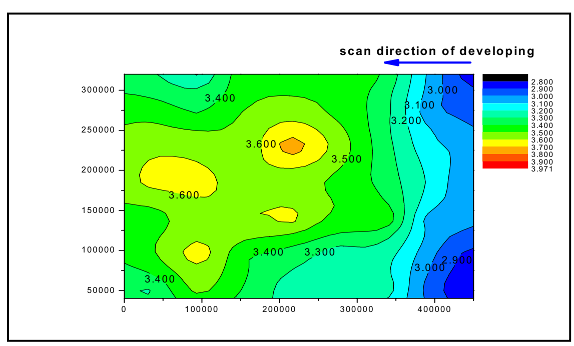
The reduction of metal lines often brings about open or short of metal lines. So the uniformity control of critical dimension signifies more in the small metal line. Also, the contact hole areas between source and pixel electrode hide transmittance areas and aperture decreases. Therefore, in order to increase the aperture ratio. It is necessary to reduce the PVX and source metal areas.) For improving transmittance of panel, another way, the efficiency of liquid crystal (LC) increases by using space/bar size control of pixel electrode.

In this paper, we proposed and applied fine patterning process such as metal line and PVX hole and optimum efficiency of liquid crystal by using space/bar size control of pixel electrode. We fabricated 2.03 inch FFS devices with fine patterning process.

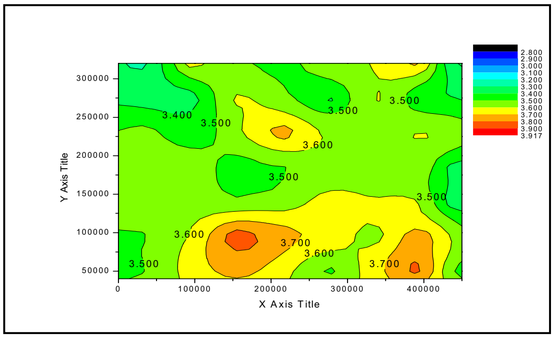
2. Results

2.1 Metal line fine patterning

The reduction of metal lines often would bring about open or short of metal lines. So the uniformity control of critical dimension (CD) and smaller etch bias is an important point in smaller metal lines. First, in order to control uniformity of CD by exposure dose (in Nikon_FX-501), the process of an individual shot exposure was applied to this experiment. Therefore, the deviation of CD in the glass could be diminished. Figure 1 shows the distribution chart of CD in the glass.



(a): a general shot exposure



(b) an individual shot exposure

Fig 1. The distribution chart of CD in the glass.

Table 1. A comparison between general exposure and individual exposure

	Avg	3σ	MAX.	MIN.
General exposure	3.55	1.32	4.578	2.938
Individual exposure	3.46	0.56	3.827	3.172

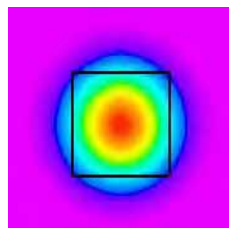
In shown Figure 1.(a), the CD at the start position of scanning for developing process (at the scan start position of developing process) is smaller than (it) at other positions. So, the uniformity of CD in glass had to be improved in the numerical value. In comparison with Figure 1.(a), the Figure 1.(b) shows the uniform of contour line according to the deviation of CD. Table 1. shows the numerical value of deviation of CD.

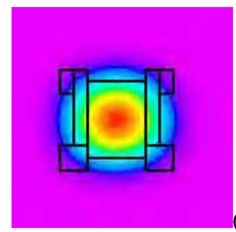
In order to diminish etch bias, we used optimum etch recipe through the split test of etch mode as like dip and spray mode. In particular, the dip mode test has the several conditions, because the dip mode deeply influences the etch bias. The etch bias which was applied to new recipe conditions was 1.6 ±0.3μm, so we obtained the 2μm width of fine metal line (real result was 2.1±1.09μm).

2, 2 Passivation (PVX) hole fine patterning

The key point of PVX hole fine patterning is to decreaseetch bias by dry etching. In order to decrease etch bias, we used an isotropic etch process with (which reduced etch) process pressure and SF6 gas amounts. After all, the vertical profile of PVX hole was formed and the etch bias was decreasing in comparison with normal etch bias (4.5~6.5μm).

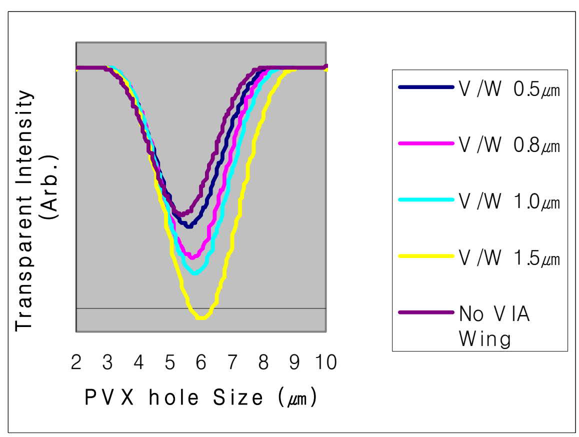
In this paper, we introduced the optimum passivation design with changing the edge design of PVX hole by optical simulation. Figure 2. shows the simulation result which appears transmittance curve of passivation hole mask with a regular and optimum design. The spatial intensity profile of the patterned g-h-i line is simulated by the OPTOLITH module of ATHENA which is a commercial program from SILVACO. OPTOLITH includes an imaging module utilized in the Fourier series approach and scalar diffraction theory. It can be stated that the scalar diffraction theory gives a reliable limit for imaging system numerical apertures 0.1 [3].


(a)


(b)

(a)The image of PVX hole 2.5μm (no via wing)

(b) The image of PVX hole 2.5μm (via wing :0.8μm)



(c) Simulation result of transparent Intensity by PVX hole design

Fig 2 Simulation Results of transparent Intensity and image by PVX hole designs

Table 2. Changing of PVX hole size with via wing size.

VIA Wing Size (MASK	No Wing (2.5㎛)	0.5µm (2.75㎛)	0.8µm (2.90㎛)	1.0µm (3.0㎛)	1.5µm (3.25㎛)
across	Standard	0.28 (2.78㎛)	0.61 (3.11㎛)	0.89 (3.39㎛)	1.43 (3.93㎛)
diagonal		0.15 (2.65㎛)	0.54 (3.04㎛)	0.73 (3.23㎛)	1.44 (3.94㎛)

Table 3. Changing rate of transmittance with via wing size.

VIAWing Size (㎛)	Transparent Intensity
No via wing : standard	
0.5	8%
0.8	22%
1.0	28%
1.5	41%

In this process, the designed PVX hole size is less small than stepper (Nikon_FX-501) equipment resolution (4µm). The light transmittance was dropped and this problem was more serious at the edge of square hole. Therefore, in order to raise light transmittance of mask and make an appropriate CD, it is necessary to apply the specific PVX hole design with via wing. So, we proposed new design rule of PVX hole in the FFS TFT-LCD.

Figure 2. shows normal image of PVX hole design(a), the special image of this(b), and the figure 2(c) shows simulation result of transparent intensity according to PVX hole design. (and) Table 2.3 showes(.) the changing of PVX hole size with via wing size and the changing rate of transmittance with via wing size. It has been seen that the increasing rate of mask light transmittance became sharply large in 0.8µm of via wing size, so then PVX hole size grew larger than defined design in shown Table 2. In this paper, as the final goal of fine patterning technology makes the optimum size of fine pattern, only the via wing design is needed to increase mask light transmittance. The defined design value of PVX hole with 0.75µm via wing size is 2.5µm and the DI_CD result value is about 2.8µm with over exposure dose of about 20%.

Next, in order to decrease the etch bias of PVX hole, the isotropic etch method is required.The gas amounts of SF6 and process pressure were dropped. The ion etch ratio relatively rises, the FI_CD result value is about 5.5µm with new etch recipe. After all, the fine PVX hole is formed by tuning all array process conditions.

The transmittance of fine patterned panel is higher than it of normal panel as shown in Table 4. It results from the increment (increasing) of aperture ratio by fine patterning technology.

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2.3 Fine pattering technology of space/bar at pixel electrode.

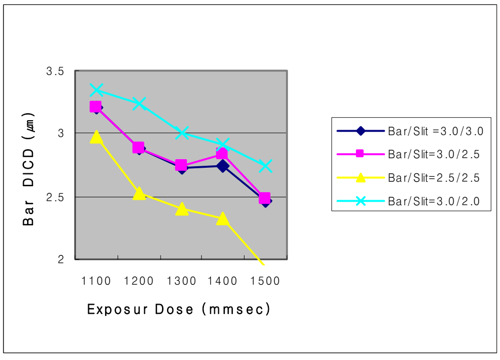
It is very effective to control for the size of space/bar control of in LC efficiency, so we can make panel with high transmittance property by using this fine pattering technology. The key point of space/bar fine patterning is an accurate patterning with proper exposure dose and the uniform size control of CD. The appropriate exposure dose was obtained through exposure unit test by test mask and simulation result.

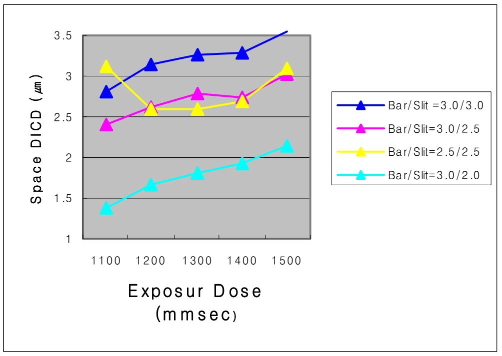
Table 4. The simulation result of LC efficiency in 2DMOS simulation with LC(MAT_04_355) factor

Bar / Space	2.0	2.5	3.0	3.5	4.0
2.0	80.28	78.48	74.16	71.02	68.68
2.5	85.58	84.56	82.78	80.72	77.82
3.0	88.02	86.62	85.72	83.36	81.8
3.5	87.7	87.28	85.32	84.3	82.34
4.0	87.46	85.98	84.7	83.44	81.74
5.0			83.52%		

In shown Table 4, the best space/bar size for high LC efficiency is 3/2 (~88%). It is higher LC efficiency than 5/3 (space/bar size) about ~4% .The smaller bar and space size, the higher driving voltage in defined pixel electrode area. Therefore, in this paper, we would only investigate the space/bar fine patterning technology.

Fig 3. The Curves of Bar/Space DI_CD vs Exposure dose by various bar/space test mask





In order to make the bar/space size of 2/3, we controlled the proper exposure dose with various bar/space test mask and its value is 1200mmsec as shown Table 5. By using this condition, the fine bar/space (2/3) was formed and the result is bar (1.94±0.42μm), space (2.72±0.38μm).

3. Conclusions

We have developed higher transmittance panel of mobile with fine patterning process conditions. There are some merits such as increment of the brightness and contrast ratio. As having seen , we have confirmed the designs of optimum PVX hole and the process conditions for fine patterning through experiments and simulations. In the future, this technology will be applied to the basis of other process in higher PPI or higher aperture ratio technology

4. References

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