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Improve product aperture ratio by controlling magnitude of reverse tilt domain

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Keywords: aperture ratio, reverse tilt domain, pre-tilt angle, rubbing density, pile impression, disclination, black matrix

ABSTRACT

In thin-film-transistor LCD, aperture ratio is an important parameter of transmittance. In this paper, we describe the relation between aperture ratio and reverse tilt domain. We conclude that we can control the magnitude of reverse tilt domain by changing rubbing density, pile impression, cell gap and altitude of TFT. Consequently, relatively large aperture ratio could been obtained by decreasing the area of black matrix.

PREFACE

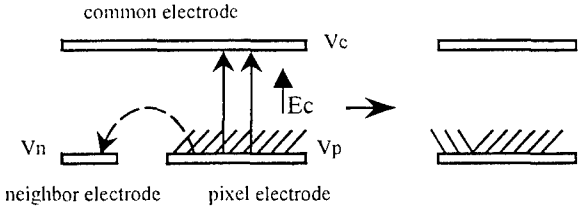
In TFT-LCD, tilt direction of liquid molecule is opposite between reverse tilt domain and tilt domain [1]. Consequently, the light leakage is observed at this boundary, especially in black picture. Furthermore, shade and contrast of reverse tilt domain are different to normally domain. In order to improve contrast and quality of picture, black matrix of color filter is used to cover reverse tilt domain. Aperture ratio depends on the area of black matrix, so we must reduce this area. The mechanism of reverse tilt domain is that voltage difference between pixel electrode and neighbor electrode change corner of liquid molecule tilt direction. Its position depends on rubbing direction, design of circuit and position of TFT. And its magnitude depends on cell gap, rubbing density, pile impression, and so on. Figure.1 Show the relation between electric field distribution and occurrence of reverse tilt domain [2]. According to this relation, we can increase pre-tilt angle to restrain reverse tilt domain, or decrease influence of voltage difference between pixel electrode and neighbor electrode.

EXPERIMENT

To focus on 6.4"'s product of PVI, we experimented with different conditions to measure reverse tilt domain, as follows:
First, to change roller revolution and moving velocity of rubbing machine to get different rubbing density [3].
Second, to change clearance between roller and stage of rubbing machine to get different pile impression.
Third, to change density of spacer and end sealing pressure to get different cell gap.
Fourth, to change array process to get different altitude of TFT.
Fifth, to change rubbing direction.
The above-mentioned conditions are show in Table 1.

Table 1. Different experimental condition

Rubbing density	50, 100, 150
Pile impression	0.25, 0.35, 0.45mm
Spacer density	60, 100 piece/mm^2
End Sealing Pressure	0.5, 0.7 kgf/cm^2
Cell gap	4.8 ~ 5.8 μm
Passivation layer	2000, 6000 Å
Conduction layer	2000, 6000 Å
Rubbing direction	↘, ↖



when Vpn > Vnc : Disclination appeared
Vnc > Vpn : Disclination disappeared
Vc > LC threshold voltage

Figure 1. The mechanism of reverse tilt domain

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RESULTS

Disclination line of 6.4", 1.8", 6.4"VGA production are shown in figure 2.

Pile impression

To decrease pile impression to increase pre-tilt angle, reverse tilt domain would be restrained effectively. The relation is shown in figure 3.

Rubbing density

Figure 4 shows the relation of rubbing density and reverse tilt domain. We find no regular relation among of them. The reason is that rubbing density changes pre-tilt angle lightly (about 0.8°), when rubbing density is from 100 to 200.

Cell gap

Figure 5 shows that cell gap decreasing would restrain reverse tilt domain. When cell gap decrease, electric filed intensity Ec and electric force Fc would increase, and reverse tilt domain would decrease.

Altitude of TFT

Altitude of TFT decrease, alignment would be improved at corner and reverse tilt domain would decrease.

Rubbing direction

Figure 6 shows that position of reverse tilt domai depends on direction of rubbing.

Spacer

Figure 7 shows that spacer would effect reverse tilt domain clearly, especially small size pixel.

Different Pixel Size

Table 2 shows that reverse tilt domain do not depend on pixel size, it is decided by driving signal and circuit layout.

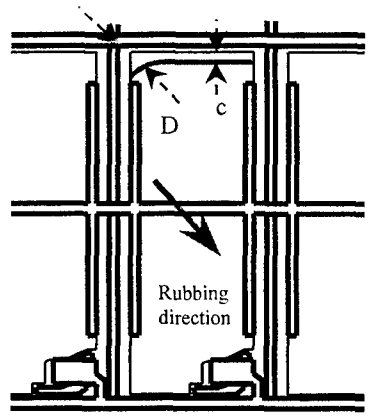

Figure 2.2 Structure of 6.4"'s pixel

Figure 2.3 Disclination of 6.4"VGA product

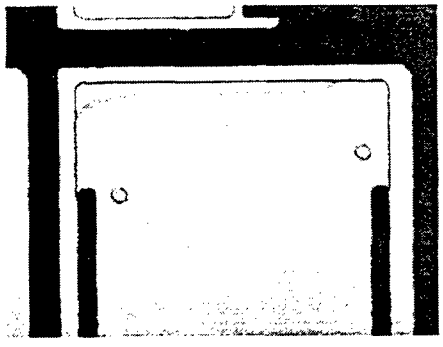

Figure 2.1 Disclination of 6.4" product

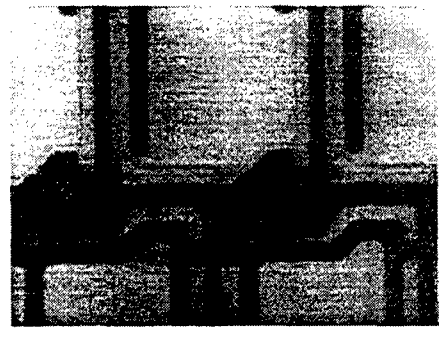

Figure 2.4 Disclination of 1.8" product

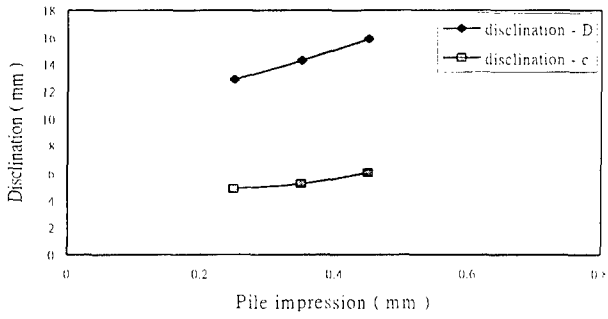

Figure 3.The relation of pile impression and disclination

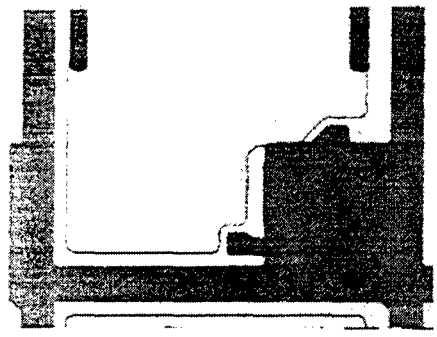

Figure 6.Disclination appears opposite direction after changing rubbing direction

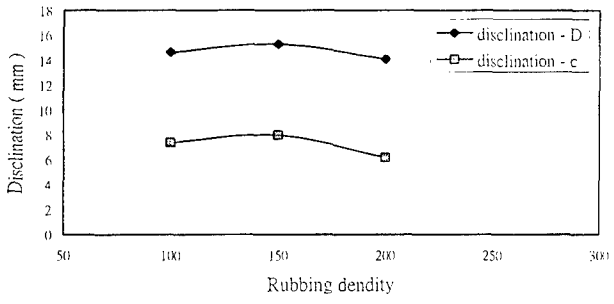

Figure 4.The relation of rubbing density and disclination

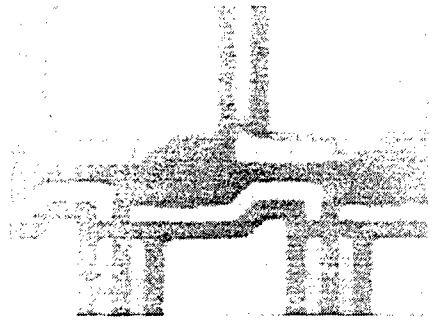

Figure 7.Effect of spacer

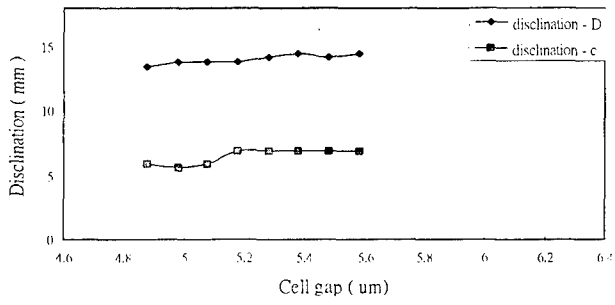

Figure 5.The relation of cell gap and disclination

Table 2. Disclination of different pixel size

Size	1.8"	6.4"	6.4"VGA
Disclination - c	7.05	7.2	7.94

DISCUSSION

We conclude that we can change the magnitude of reverse tilt domain. and that if we according to actual range of reverse tilt domain to re-design black matrix of color filter in present products, we can increase 4~5% aperture ratio to improve transmittance.

REFERENCE

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