Surface Controlled 8-Domain Patterned Vertical Alignment Mode with Reactive Mesogens.

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ABSTRACT

We propose the 8-domain patterned vertical alignment mode with UV curable reactive mesogen (RM). The RM mixed with alignment layer alter pretilt angle according to the applied voltage through UV exposure and can generate the 8-domain by differentiating the pretilt angle spatially in pixel area.

1. INTRODUCTION

As a demand for large size flat panel display (FPD) increases gradually, liquid crystal display (LCD) devices become a front-running device with high display performance for a display market. In LCD, various LC modes such as twisted nematic (TN) [1], in-plane switching (IPS) [2], fringe field switching (FFS) [3], vertical alignment (VA), patterned vertical alignment (PVA) [4-5] and multi-domain vertical alignment (MVA) [6] modes have been developed for improvement of the image quality such as wide viewing angle and fast response characteristics. Among them, PVA mode is an advanced VA mode to improve the viewing angle property using chevron type electrode for generating the multi-domains. However, 4-domain structure is not enough to obtain the high image quality in off-axis directions without optical compensation film. According to these demands, the methods of adopting additional capacitor or thin film transistor (TFT) for each pixel, named as super-PVA (S-PVA) mode, were proposed [7-9]. In S-PVA mode, an operating region of the each pixel was divided into two regions with the additional capacitor or TFT. Therefore, independent control for LC reorientation over each region can be enabled, so different voltage-transmittance characteristics which make possible to increase the viewing angle characteristics for off axis also can be realized. However, because of additional capacitor or TFT system, many side effects are resultant such as complexity of driving scheme, lack of turn-on time, low aperture ratio and complex manufacturing processes.

Recently, surface controlled PVA (SC-PVA) mode [10] was proposed to enhance the response time using reactive mesogen (RM) which were mixed in alignment material. The RM monomers are polymerized along voltage induced LC direction under UV exposure in the presence of applied voltage. The polymerized RMs produced the certain pretilt angle which determined the LC falling direction over whole panel area, so the response time could be improved dramatically.

In this paper, we propose the advanced method to improve the viewing angle characteristics in PVA mode using RMs. The polymerized RMs produced the two kind different pretilt angles in each pixel using shadow mask under UV exposure with different driving voltage. As a result, we could realize the 8-domain PVA mode of which viewing angle characteristics are improved for off-axis.

2. EXPERIMENTAL

In the experiment, we mixed a vertical polyimide (PI) alignment layer (AL60101 from JSR), RM (from BASF) and photo initiator (IRGACURE 651 from Ciba chemical) with proper rates. The mixture was mixed using magnetic stirrer sufficiently and spin coated on both ITO substrates with chevron type electrode pattern at 1500 rpm for 10 seconds and 4000 rpm for 20 seconds. The sample was pre-baked at 80°C for 10 min followed by curing for imidization at 180°C for 1 hour. The cell gap was maintained by glass spacer about 3 um and filled with nematic LC of MLC-6610 (Merck) which has a negative dielectric anisotropy.

With applied voltage which is larger than threshold voltage (V_{th}) in the PVA mode, oblique field which determines the LCs falling direction is generated due to the alternately patterned electrodes. LCs are tilted downward with four diagonal directions to each other and RMs are aligned along the direction of LC molecule on the alignment layer and polymerized under UV exposure. It is well known at SC-PVA mode that the polymerized RMs can generate pretilt angle which are dependent on applied voltage. So, we can produce the various pretilt angles by controlling the applied voltage during UV curing.

In experience, we exposed the UV light to PVA sample at proper voltage (5V) with stripe shape shadow mask covering the half of each pixel. The polymerized RMs produce a certain pretilt angle that is maintained even in field off state. And then, 2nd UV was exposed to the cell for polymerizing the uncured RM monomers protected by the shadow mask without applied voltage. Therefore, pretilt angles of each part are independently generated and 8-domains are realized without any additional devices.

3. RESULTS

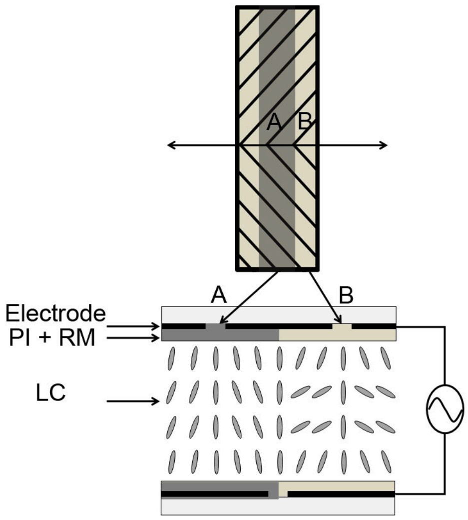

Fig. 1 Basic operating schematic diagrams of fabricated two kinds of pretilt angles in one pixel at the PVA sample. Region A and B have low and high pretilt angle, respectively.

The basic operating schematic diagrams of the fabricated two kinds of pretilt angles in one pixel are shown in Fig. 1. At initial state, LCs are aligned vertically to the surface in region A as a conventional PVA mode does. Therefore, LC cell has a normally black mode under crossed polarizers. The pretilt angle of the region B which was generated by 1st UV exposure is higher than the region A and influences the initial state of LC alignment. So, when applied voltage, the LC falling degree is increased compared to the region A. Therefore, the voltage-transmittance characteristics are different in the region A and B, so we could get the 8-domains in chevron shaped PVA mode.

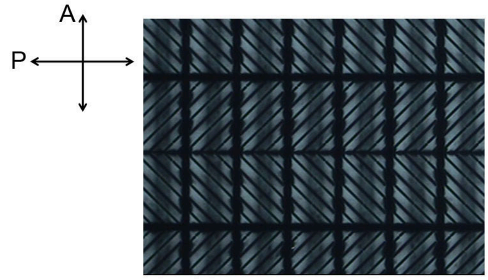

Fig. 2 Polarized optical microscopic (POM) image of the 8-domain PVA sample at the gray level. The arrows indicate a polarizer (P) and an analyzer (A).

Figure 2 shows the microscopic images after 2-step UV exposure with stripe shape shadow mask. Stripe shaped shadow mask structure is obviously represented in the POM image and we can notice the different brightness of each part which caused by different pretilt angles depend on applied voltage during UV exposure. Compare to conventional S-PVA mode, our method represents the similar microscopic textures without additional operating components such as TFTs or capacitors.

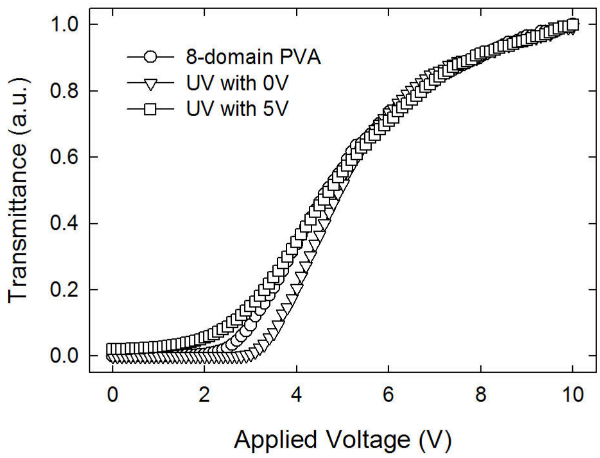

Fig. 3 The voltage-transmittance characteristics according to the UV curing voltage and fabricated 8-domain PVA.

Figure 3 shows the measured voltage-transmittance (V-T) characteristics for 4-domain PVA cell with different UV curing voltage and 8-domain PVA cell. As well known, high pretilt angle cell generate low threshold voltage and the V-T curve is shift to left to the low pretilt angle cell. In 8- domain PVA mode which has two regions of high and low pretilt angle, the curve exists in the middle of the two curves of each region.

Generally, conventional PVA mode has the critical response time problems at high voltage due to the undefined LC falling direction between each slit. However, similar to the SC-PVA mode, we can also realize the excellent fast response time by defining the falling direction of LC directors over whole panel area through surface control with polymerized RMs which are aligned along with LC directors and memorize the azimuthal and polar direction of LCs.

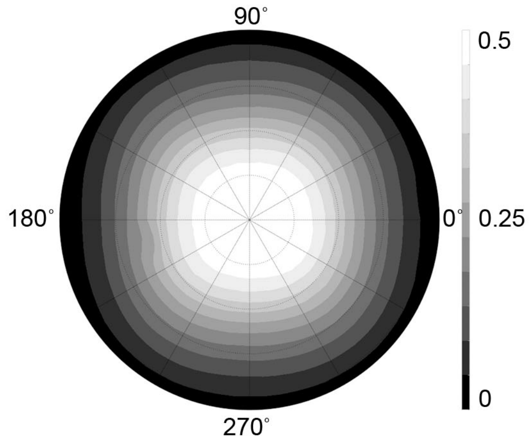

Fig. 4 Viewing angle performance for proposed 8-domain PVA mode at 5V (mid-gray level). Sidebar indicates the normalized transmittance.

Figure 4 shows the experimental result of viewing angle characteristics of the proposed 8-domain PVA mode at 5V (mid-gray level). In LCD devices, it is important to obtain the uniform viewing angle characteristics in every viewing direction. And 8-domain PVA has the constant transmittance characteristics through whole azimuthal and polar direction. That is because the 8-domain PVA cell has twice as many domains and it can compensate and minimize the image distortion for images viewed.

And, if we can use the various sized shadow mask and voltage step, twice or larger domains in one pixel can be realized through additional UV curing processes. Moreover, we can also obtain the better image quality by using this method.

4. CONCLUSION

We realize the 8-domain PVA mode using RM mixed with polyimide alignment material with stripe shape shadow mask by altering the pretilt angle of half pixel area. The uniform viewing angle characteristics and the excellent fast response time could be achieved by defining the falling direction of LC molecules by polymerization of the RM. Also, our proposed method is expected to become an important technology to produce the large-sized LCDs due to simple fabrication processes without an additional capacitor or TFT array.

5. REFERENCES

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