High Pre-tilt Angle Control by Dual Alignment Thin Film Structures for Liquid Crystal Displays

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The optically compensated bend (OCB) mode liquid crystals (LC) in the pi cells exhibit fast response and wide-viewing angle characteristics for flat-panel displays (FPD). When driving a pi cell in the bend state, the LC molecules in the cell center experience zero elastic torque during the off-state relaxation process, thus providing a fast display response. A pi cell is usually fabricated with alignment layers of the same rubbing direction on both substrates, and the initial LC configuration is in a splay state. An applied voltage transits the pi cell from the splay state to the bend state, and the pi cell displays images by switching between two bend states. However, the initial voltage required to set the bend state is relatively high, so that the power consumption is inevitably increased. A potential solution to reduce the initial setting voltage is to use alignment layers that can induce an intermediate pre-tilt angle. When the pre-tilt angle is large enough, pi cells can be stable in bend deformation without a bias voltage, and thus are termed no-bias bend (NBB) cells.

In this study, we designed a patterned dual alignment thin film structure on glass substrates using a horizontal alignment polyimide (PI) in conjunction with a vertical alignment liquid crystal polymer (LCP). An array of protruding bumps was introduced into the LCP surface by photolithography. We also varied the concentration of LCP precursor solution with this new configuration. The experimental panels were then assembled for optical analysis by TBA-107 system. The results showed that the liquid crystal molecule pre-tilt angle had been significantly increased with the new alignment thin film structure. The horizontal PI alignment layer has a designated control of pre-tilt angle at 6-7° after the prescribed mechanical rubbing process. The pre-tilt angle became 24° when the LCP precursor concentration was 5%. It even increased to 61° with the concentration of 10%. The improvements were attributed to the combined forces acted on the liquid crystal molecules both from the horizontal alignment PI and the patterned vertical alignment LCP. In addition, the electrical response time and grey level variation showed promising results for potential applications. The new design can thus lead to the more effective control over pre-tilt angles, suggesting solutions for the OCB mode liquid crystal displays. Therefore, the display power consummation and response time would be greatly improved.

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