A novel bistable LCD with function of monostable operation

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1. Introduction

We propose a novel LCD mode named Bistable of Twisted Direction Switching (BTDS) LCD enables to work not only a memory LCD with the bistability but also as a conventional LCD with the monostability. The fundamental schematic model is shown in Fig. 1. When this LCD is performed as a memory LCD using the bistability, the twisted direction of the director orientation in the cell is switched between the right twist (Φ) and the left twist ($\pi-\Phi$). The twisted angle Φ can be designed to any value within the bistable condition.

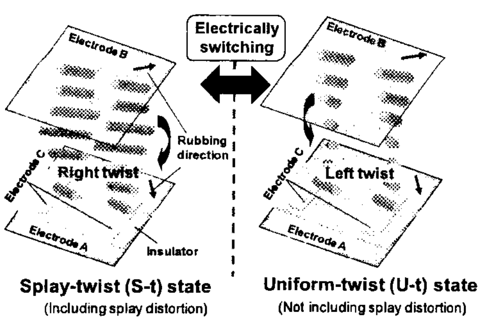

Figure 1: Schematic model of BTDS cell in each memory state

2. Condition of Cell Parameters for Bistability

The Gibbs energies caused by the distortion of director orientation inside the cell due to the twisted alignment state of both right twist [Φ] and left twist [$\pi-\Phi$] were designed to be equal by the numerical calculation. For example, the cell parameters used for calculations were as follows; a pretilt angle, amount of chiral dopant, an angle formed by rubbing directions between upper and lower substrates. Moreover, since the azimuthal anchoring works on each substrate surface, then two orientation states can exist independently due to an appropriate magnitude of energy barrier between each state. If those states can be switched electrically, a bistable LCD can be realized. Since we can design any twisted angle Φ in our BTDS LCD mode, we believe that there is also a high flexibility in the optical design.

3. Electrical Operation of BTDS Cells

3.1 Switching for Bistable Mode

In the S-t state, if the electric field is applied along with the cell thickness direction, the orientation state can be transitioned into the U-t state. On the other hand, in the U-t state, when the electric field is applied to in-plane direction such as an IPS[1] or an FFS[2] modes, the orientation sate is transitioned again into the S-t state.

The example of the LC cell in the bistable mode applied to a reflection type is shown in Fig. 2, using a λ/4 plate and one polarizer. The cell parameters were follow; pretilt angle θ_0=35°Φ , = 70°, a ratio of cell thickness and chiral pitch d/p_0 was approximately 0.03, and retardation Δnd = 0.32 μm. Then, 24.1 of the optical contrast ratio was obtained.

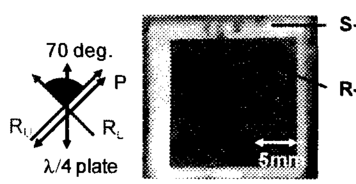

Figure 2: Reflective type of BTDS cell operating in bistable mode

3.2 Normal Video Display with Monostable Mode

Under the S-t state, even if the horizontal electric field with any value of the voltage is applied, the orientation state remains in the S-t state and does not transition to the U-t state. That is, by applying the horizontal electric field in the s-t state, a normal type of LCD which is displayed the voltage controlled grayscale image can be realized. Alternatively, even in the U-t state, the monostable operation is possible in the same way by using the applied electric field in the cell thickness direction. A moving image can be displayed as a normal LCD, and still image can be displayed using the bistable memory function as needed, although, the still image is a binary display without grayscale.

4. Conclusion

We proposed BTDS-LCD using nematic LCs and described the fundamental principle of it. While this BTDS-LCD is a novel LCD mode that exhibits bistable memory function applicable as an electronic paper, it is also capable of moving picture display with grayscale images as a monostable mode like ordinary LCDs, and those modes can be switched arbitrarily.

5. Acknowledgements

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6. References

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