Uniform bend transition and twist retention time improvement in a bistable chiral splay nematic liquid crystal cell

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Abstract

In a previous work we reported the bistable property by doping a chiral material in a splay cell. The bistable states are the splay state and the metastable 180° twist state. The retention time of the metastable state can be changed by the variation of d/p (cell gap over pitch), cell gap, pretilt angle, azimuthal anchoring force, liquid crystal material, and so on. In this paper we will present uniform bend transition and twist retention time improvement in a multi-domain BCSN LC cell by using the multi cell gap method.

1. Introduction

Since it was shown that nematic liquid crystal (LC) cells could be switched between two metastable twist states in early 1980s [1], there has been increasing interest on bistable liquid crystal devices. Up to now, the volume [2-4] and surface switching types [5-6] have been mainly demonstrated as the bistable devices.

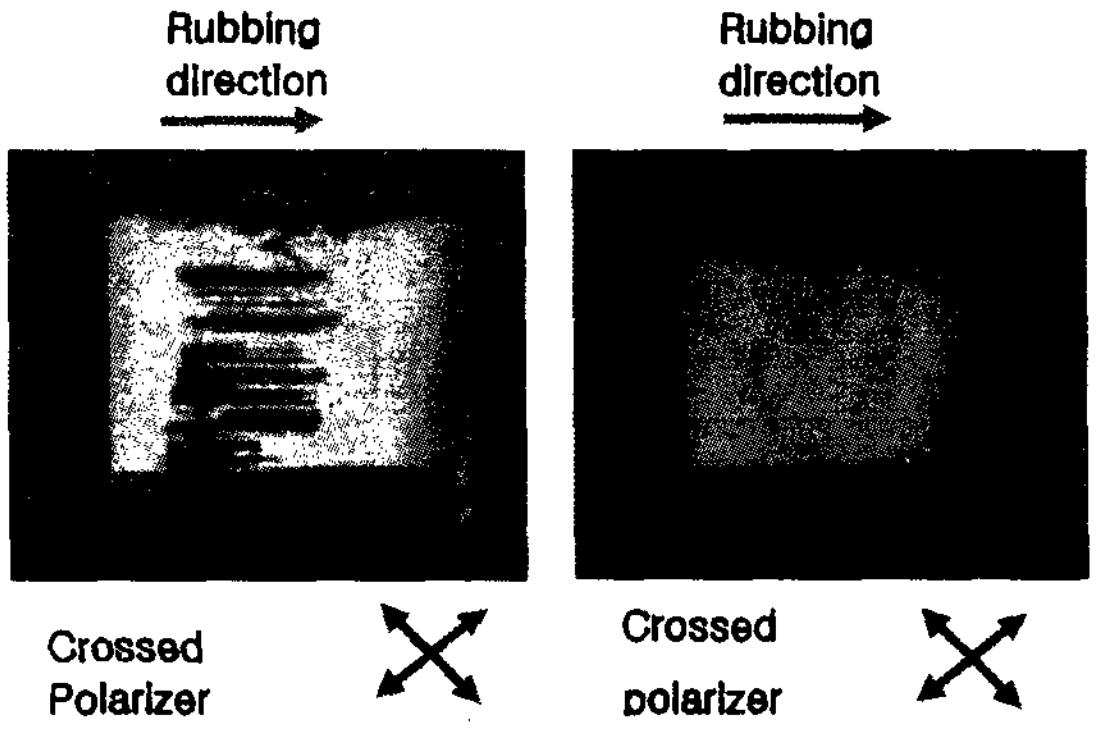
A bistable twisted nematic (BTN) LCD which is one of the volume switching type bistable LCDs has a serious problem that $\phi-\pi$ and $\phi+\pi$ twist states are metastable with a short retention time. Indeed, the intermediate ϕ twist state is more stable than both $\phi-\pi$ and $\phi+\pi$ twist states. Both metastable states will decay to the initial ϕ twist state within seconds. To extend its retention time, the polymer wall structure which separates each pixel was proposed by Hoke et al [7]. However, the residual polymer problem in a pixel is inevitable [8].

A zenithal bistable display (ZBD) which is one of the surface switching type bistable LCDs was demonstrated by Bryan-Brown et al [9]. It is switched with sub-millisecond pulses and has infinite retention time. However, ZBD has still the demerit that the manufacturing process for the surface alignment is troublesome compared with the conventional liquid crystal cells.

Previously we proposed a bistable chiral splay nematic (BCSN) LCD by adding a small amount of chiral dopant in a splay cell [10]. A BCSN LCD can obtain an excellent bistabililty and simplicity in the manufacturing process. A bistability is realized even with large cell gap. But there are two shortcomings in a BCSN LC cell. One is that twist retention time is not permanent. The other is that uniform bend transition can not be achieved. In this paper we report uniform bend transition and twist retention time improvement in a multi-domain BCSN LC cell by using the multi cell gap method.

2. Experiments and Results

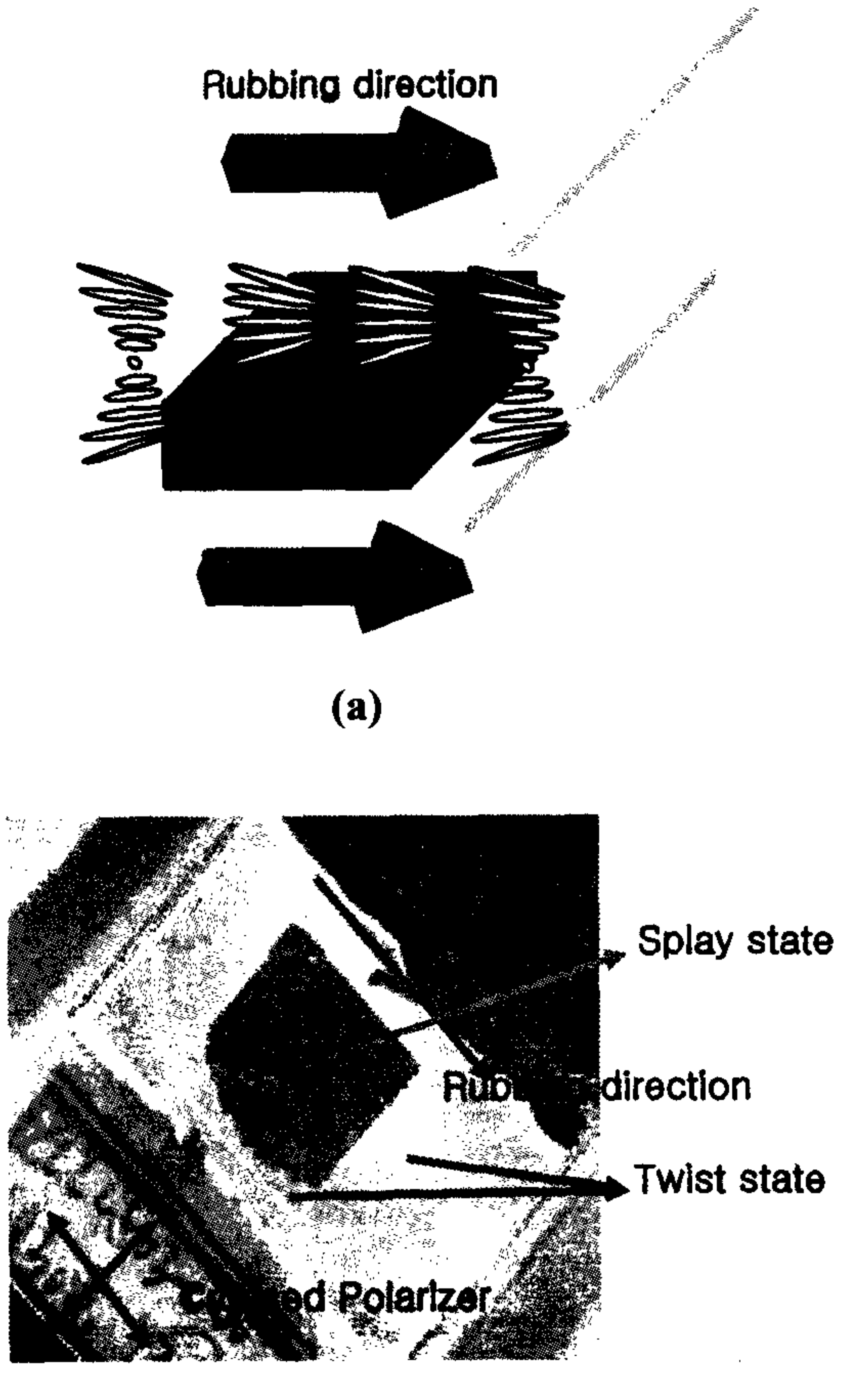
If d/p ratio is over about 0.25, careful treatment is needed since the initial state without a voltage may be the twist state. Fig. 1(a) illustrates liquid crystal director initially coexists in the twist and splay state at d/p=0.23, where LC material of ZLI-4803-000 is used. This can be varied according to LC material. Then, after the transition to the twist state by applying an electric field, the twist retention time becomes permanent as shown in Fig. 1(b).



(a) (b)

Fig. 1. A cell filled with LC material of ZLI-4803-000 with d/p = 0.23 : (a) initial state, (b) twist state by applying an electric field.

So, we fabricated a multi-domain BCSN cell by using the multi cell gap method as shown in Fig. 2. The center part of a test cell is initially in the splay state, while the remaining part is initially in the twist state. A splay domain, the center part of a cell, is d/p = 0.2 with cell gap of 3.25 um and a twist domain, the remainder part of that, is d/p = 0.46 with cell gap of 7.9 um. To make a test cell, the following materials are used : LC material ZLI-4803-000, the polyimide of AL-3046 and chiral dopant of S-811.

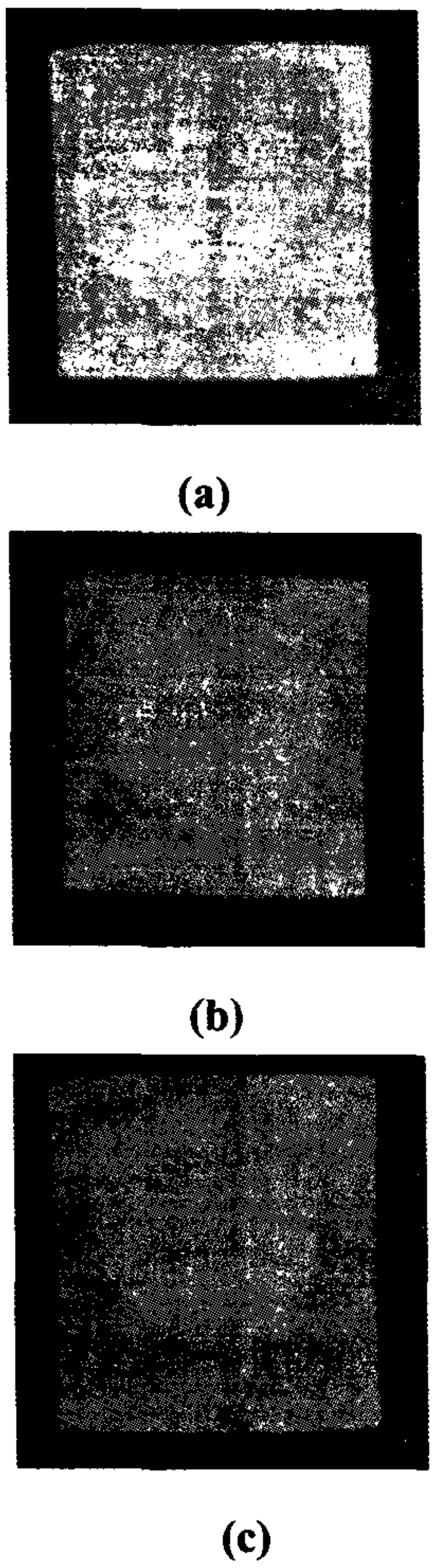


(a)

(b)

Fig. 2. A structure and a test cell of a multi domain BCSN LC cell : (a) a structure, (b) a test cell.

Because a topological structure of the twist state is equivalent to that of the bend state, a twist domain of a multi domain BCSN cell can act as bend core [11]. When a voltage above the critical voltage (Vc) is applied to a test cell, uniform bend transition appears on a splay domain as shown in Fig. 3. To clarify the bistable property between a multi domain BCSN LC cell and a BCSN LC cell without multi domain we fabricated a BCSN LC cell without multi domain under comparatively equal conditions, such as d/p, liquid crystal material and cell gap, with a multi domain BCSN LC cell.


(a)

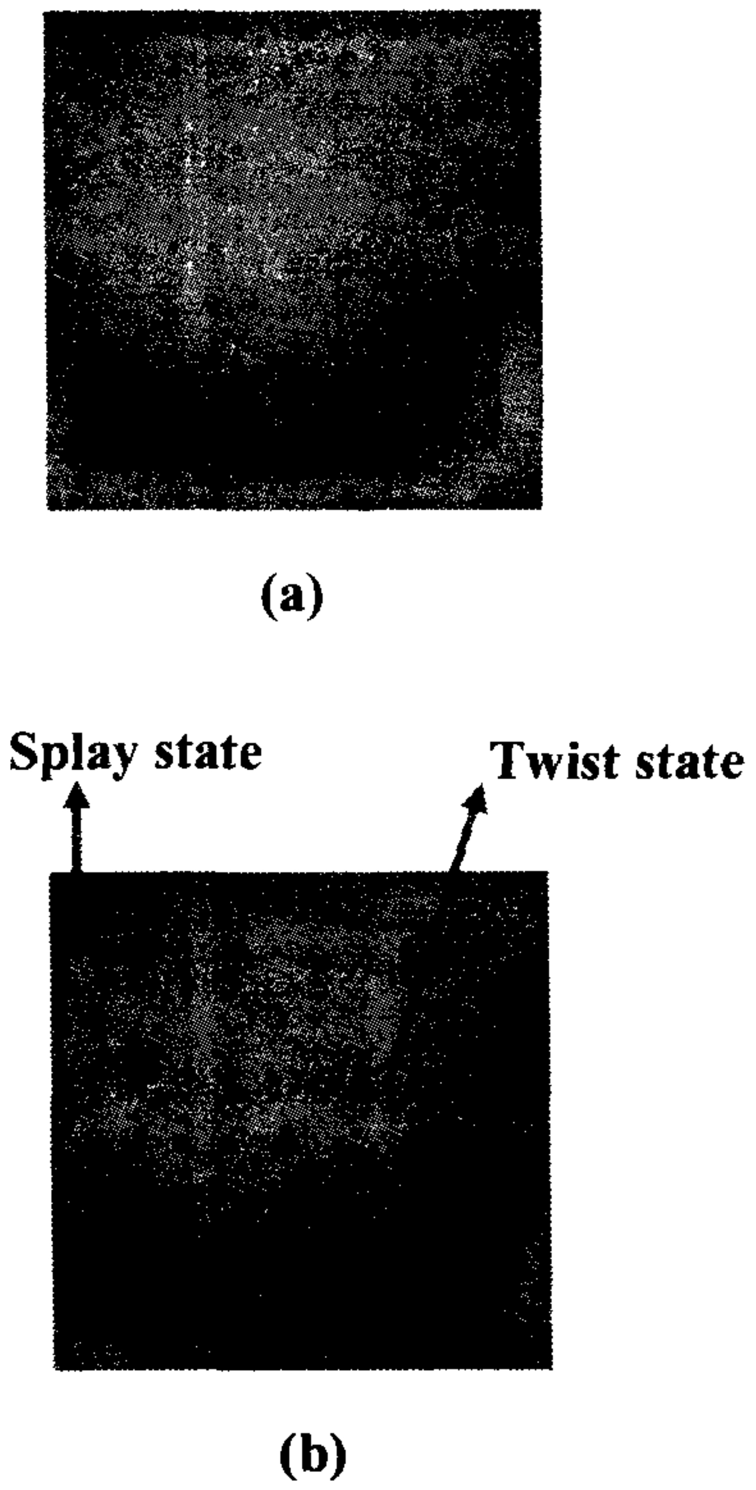
(b)

(c)

Fig. 3. Bend transition process in a multi domain BCSN LC cell when a voltage is applied. : (a) 1 minute, (b) 2 minutes, (c) 3 minutes after a voltage applied.

We found the transition time of a multi domain BCSN cell from twist to splay is roughly three times longer than a BCSN cell without multi domain as shown in Fig. 4 and Fig. 5.

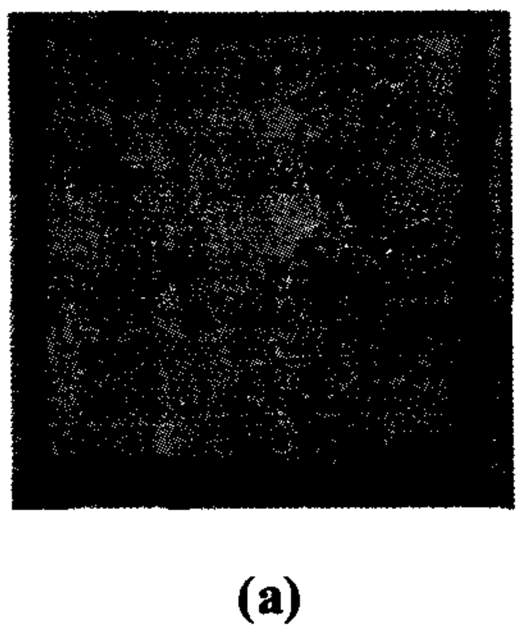
This indicates that twist retention time of a multi domain BCSN cell is roughly three times longer than a BCSN cell without multi domain. It is expected that this phenomenon in a multi domain BCSN is caused by the interaction of liquid crystal directors between a splay domain and a twist domain. We consider that forming a twist domain around the pixel of a multi domain BCSN LC cell prevents nucleation of a defect and the subsequent motion of a disclination line [12]. While we expected that the novel structure of a multi-domain BCSN makes twist retention time permanent, we got a different result that a splay domain was growing in the step. Without the step, we could get the expected result.

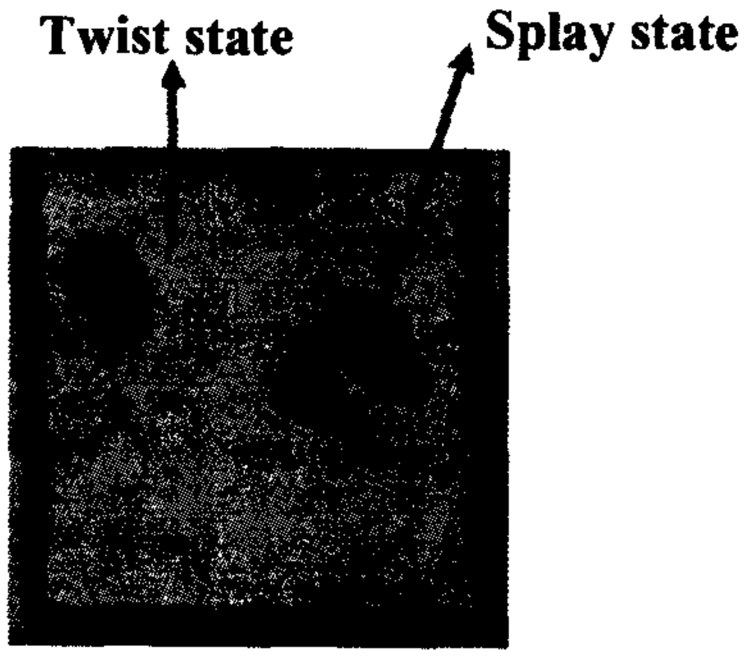


(a)

(b)

Fig. 4. The transition process from twist to splay in a multi domain BCSN LC cell : (a) after 1 minute, (b) after 5 minutes.


(a)



(b)

Fig. 5. The transition process from twist to splay in a BCSN cell without multi domain : (a) after 1 minute, (b) after 5 minutes.

3. Conclusions

To improve the bistable property, we applied a novel structure in a BCSN LC cell named a multi domain BCSN LC cell using the multi cell gap method. We have demonstrated that uniform bend transition can be realized by a multi domain BCSN LC cell with a splay domain and a twist domain, which plays a role of bend core. And twist retention time of that is superior to a BCSN cell without multi domain owing to the interaction of liquid crystal directors between a splay domain and a twist domain.

4. Acknowledgement

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5. References

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