

Novel Technique for Splay to Bend Transition in a π Cell

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Abstract

A π cell is initially in splay state. Before driving a π cell, transition from splay to bend state is always necessary which originates from nucleation. We propose a novel technique to make bend transition fast and effectively by forming transition cores around the pixels with the technique of multi-domain alignment, where domain boundaries play a crucial role in splay to bend transition. This noble technique enables the splay to bend transition to occur within less than 2 seconds with a low applied voltage.

Keywords : DomainAlignment,Splay,LiquidCrystal,ViewingAngle

1. Introduction

A π cell is the most promising mode to display motion picture because of its fast response and wide viewing angle characteristics. However, a π cell is limited to practical use. Since the derived optical switching is between the bend states, it is always necessary to apply a critical voltage to make the LC configuration transit from initial splay to bend states. Because of topological inequivalence between splay and bend states, initial transition from splay to bend state takes relatively long time which originates from nucleation. Some pixels which remain unchanged even after more than a critical voltage is applied become defects as well. Bias voltage is also required. Recently, to make bend transition fast, researches about quick transition methods have been carried out [1-5].

In this work, we propose a novel technique to form bend transition core with multi domain alignment. Fast bend transition is achieved with this transition core formation technique.

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2. Transition Property of a π Cell

Fig. 1 shows the transition process of a π cell. When no voltage is applied, π cell is in the splay state, and molecules are aligned along the rubbing direction. In this geometry, when more than a critical voltage is applied to the cell, it is changed into the bend state. Transition between the splay and the bend states inevitably accompanies with bend nucleus, because the splay the bend states are topologically different.

For π cell it is hard to change into bend state without bend transition core even after more than a critical voltage is applied. To obtain uniform transition from splay to bend states, bend transition core must exist essentially.

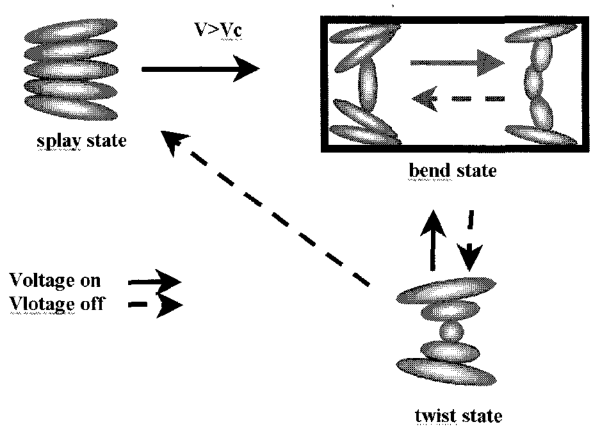

Fig. 1. Transition process of a π cell.

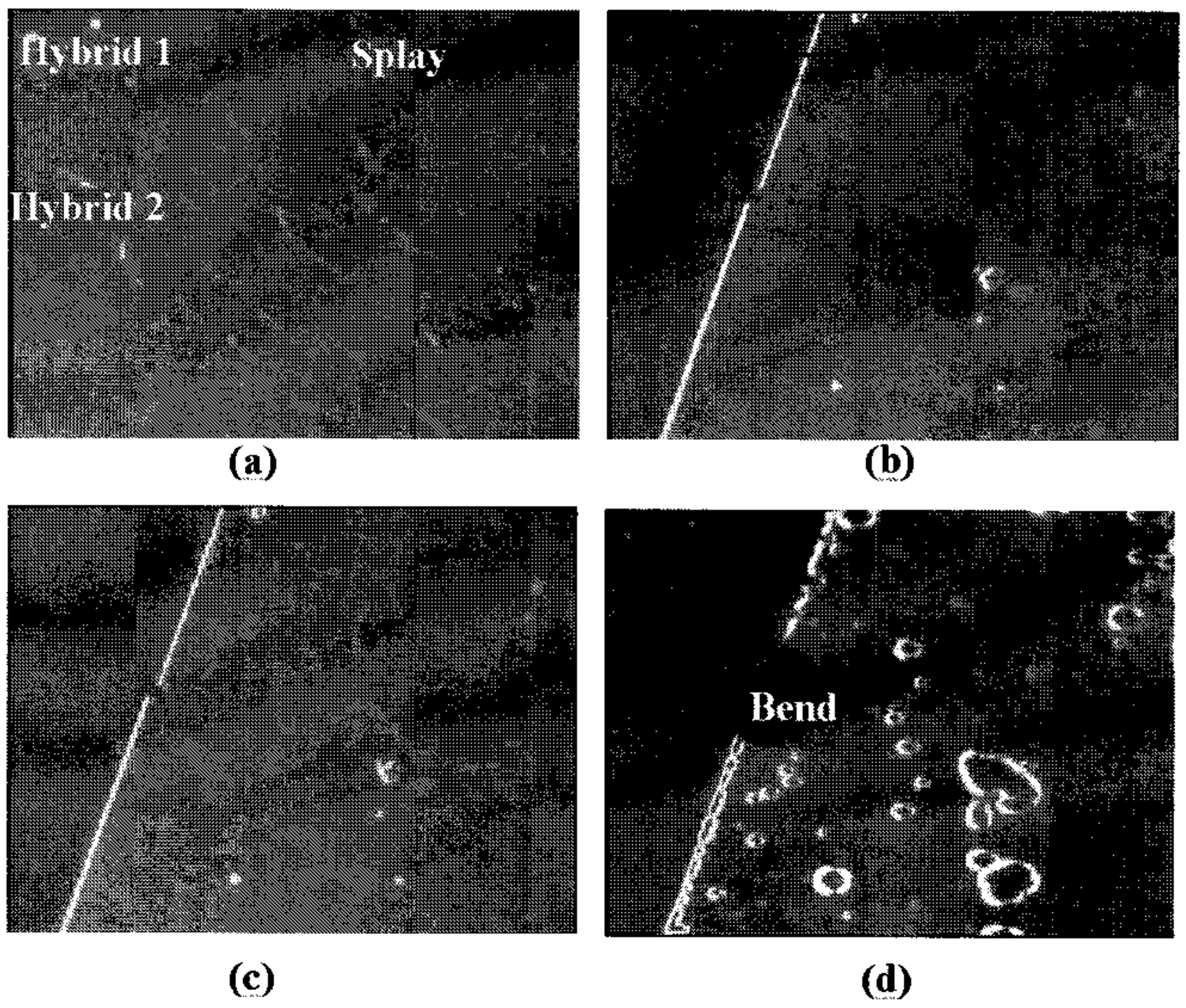

Fig. 2. Bend transition near two hybrid domains: (a) without applied voltage, (b)-(d) after 4 V is applied.

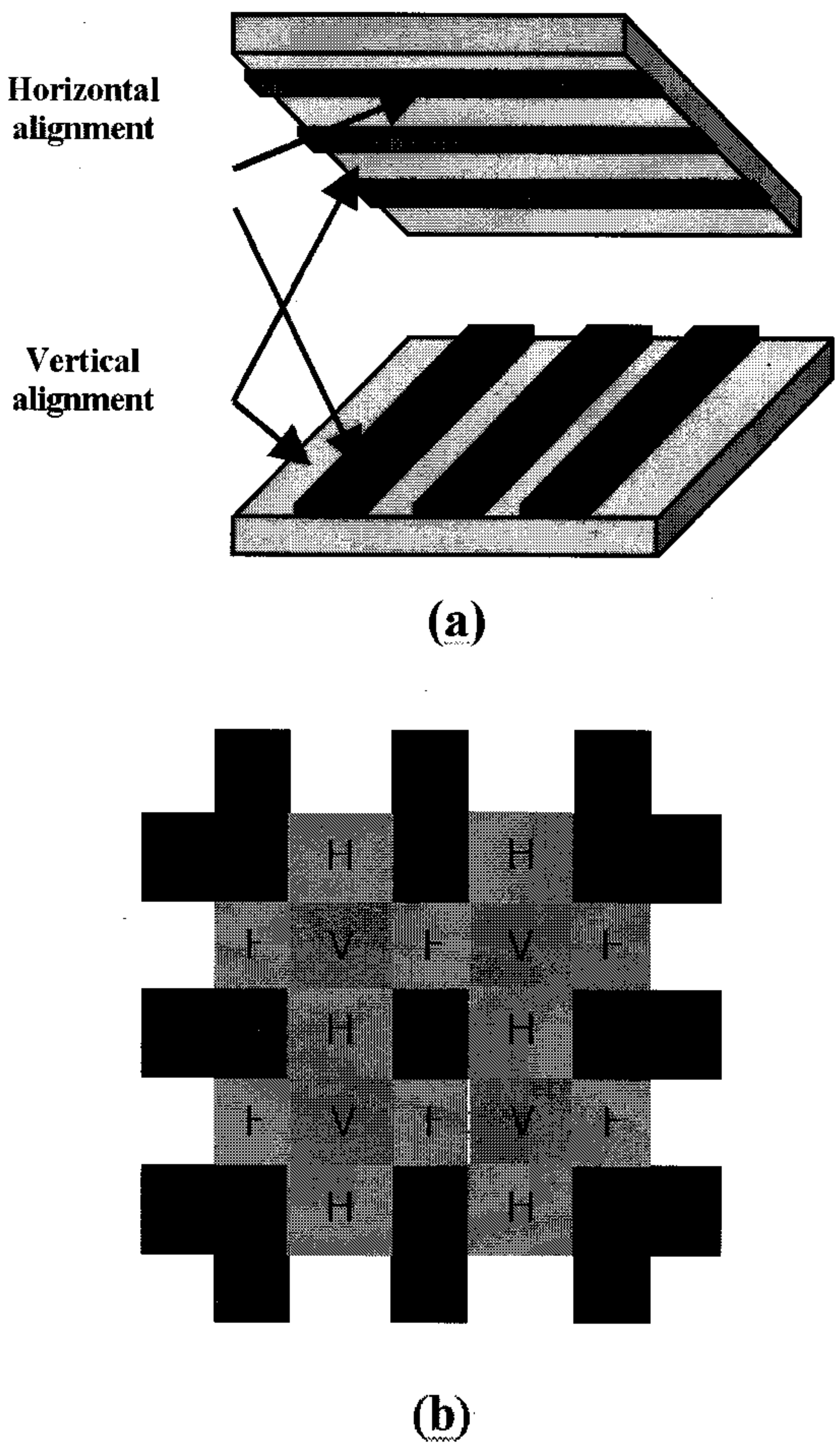

Fig. 3. Stripe patterns for multi domain: (a) stripe patterns on substrates, and (b) multi domain(**S : splay, H : hybrid, V : vertical aligned**).

3. Experiments

In the transition from splay to bend state, some transition cores which result from defects in the cell are necessary. We proposed previously hybrid domain as an artificial defect [4, 5]. Domain boundary plays a crucial role in the transition. Fig. 2(a) shows splay domain with two hybrid domains. If a low voltage is applied to the cell, the adjoining point becomes a starting point. Bend transition occurs from the adjoining point as shown in Fig. 2. Therefore adjoining point of three different domains would be more effective than domain boundary as artificial defects. Here, we extended this experimental observation to vertical aligned domain. The idea is to form a multi domain around a pixel by crossing two stripe patterns as shown in Fig. 3(a). In the stripe patterns, one stripe is coated with vertical alignment material and the other is coated with horizontal alignment material. Multi domain is formed as shown in the Fig. 3(b).

In the experiment, in order to obtain a proper retardation in the bend state, the MLC 6204-000(E. Merck) whose Δn is 0.1478 at 550 nm wavelength was used. And the cell gap was controlled by spacers of 7.9 μm. Fig. 4

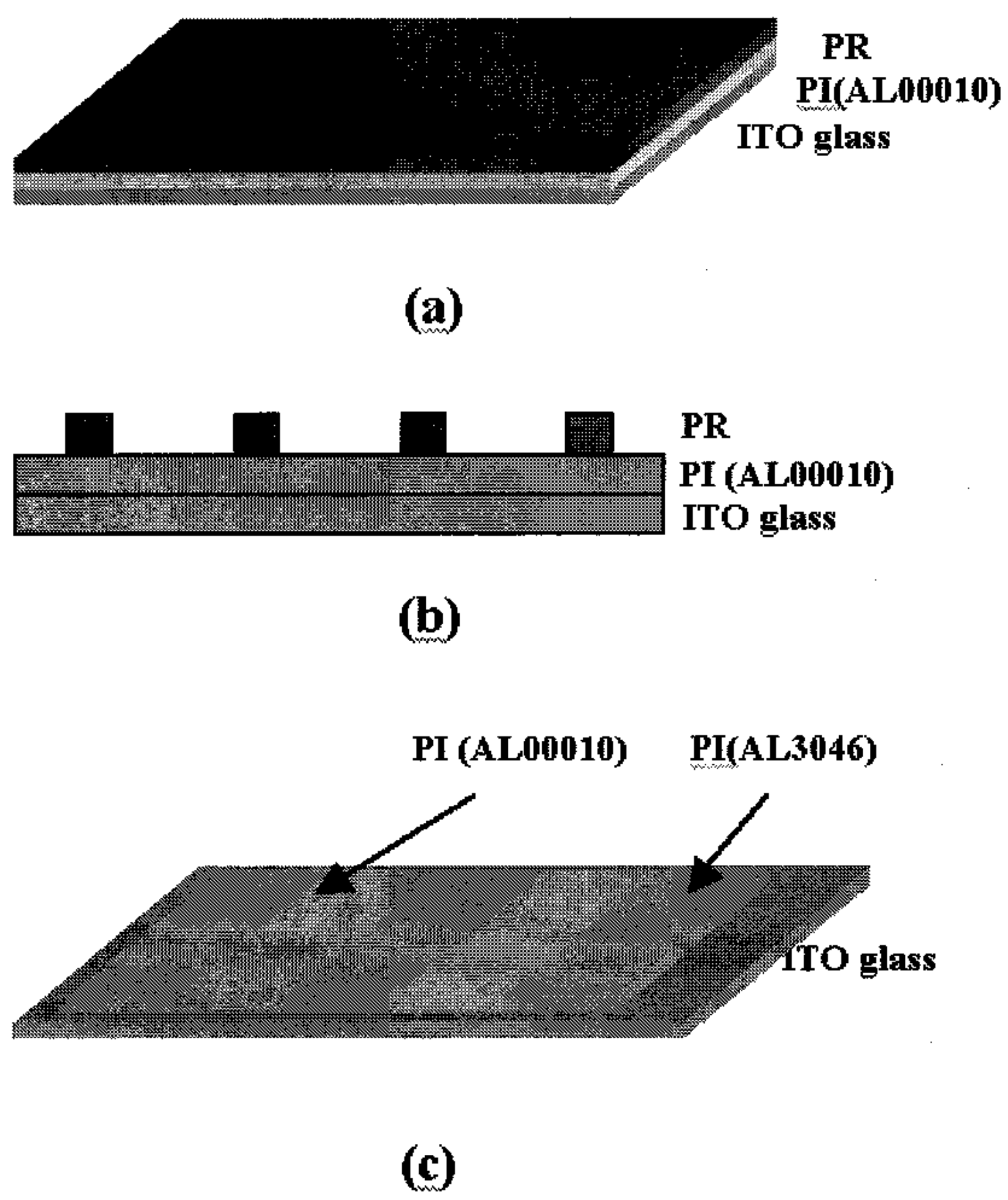

Fig. 4. The procedure to form multi domains: (a) PI (AL-00010) and PR coating on the ITO glass, (b) development after shedding the UV light, (c) removing PR after PI (AL-3046) coating.

illustrates the procedure of multi domain fabrication, First of all, we coated a vertical alignment material (AL-00010) on the substrate of ITO glass, and then negative photo resist (PR) was coated. The parts which are needed were remained by illuminating UV light. Then by coating a horizontal alignment material (AL-3046) on the substrate, after removing PR, we can obtain desired stripe pattern as shown in Fig. 4(c).

Fig. 5 shows the bend transition near two hybrid domains and vertical domain, the adjoining points of domain boundaries become also starting points for the transition from splay to bend state even when applied voltage is low enough. Transition times with or without the artificial defect with respect to the applied voltages are shown in Table 1. We also compare the bend transition with new core to that of hybrid domain we proposed before.

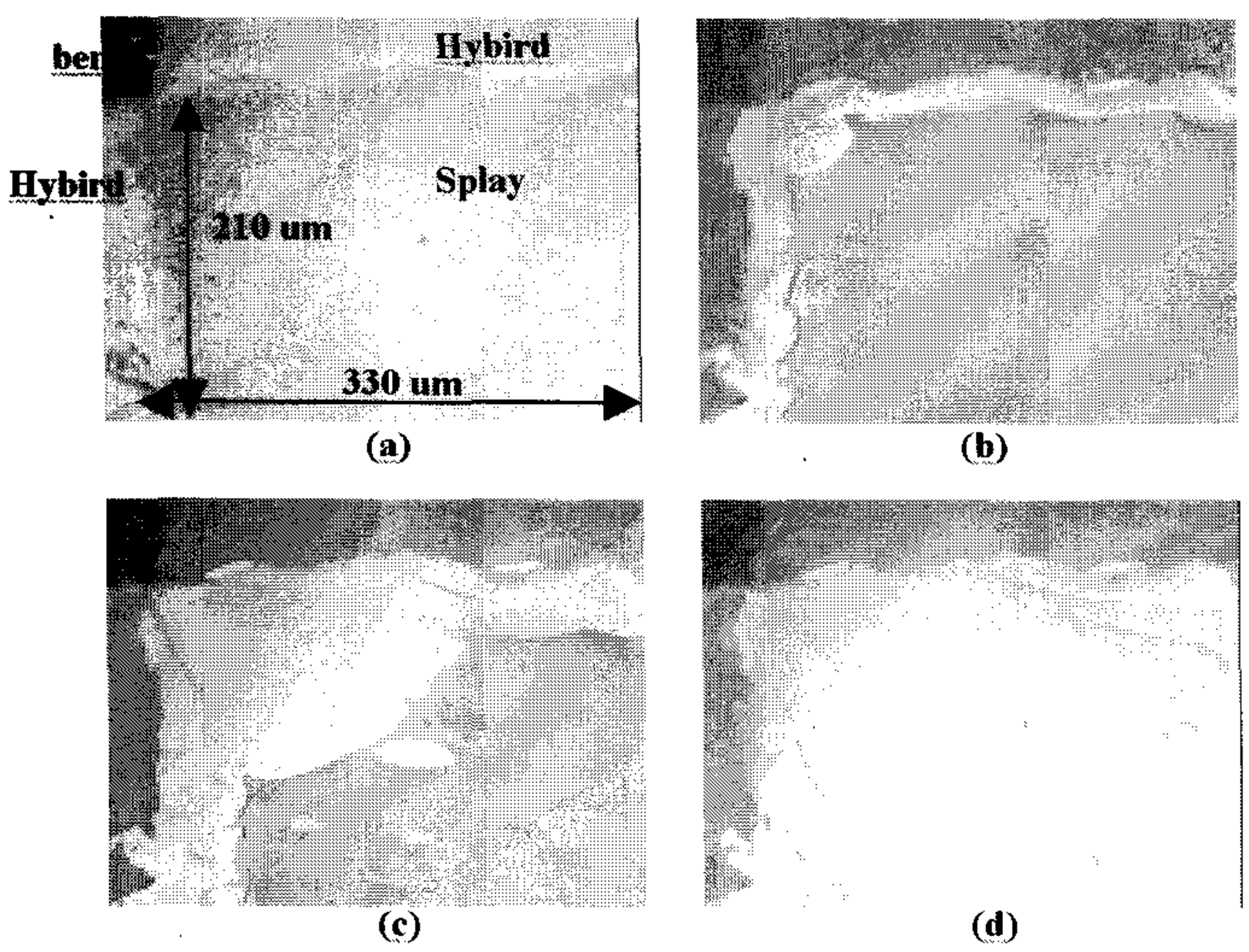

Fig. 5. Bend transition with the proposed transition core: (a) without applied voltage, (b) 2 seconds after 2.5 V is applied, (c) 4 seconds later, (d) 8 seconds later.

Table 1. Splay to bend transition time with respect to applied voltages

Applied Voltage	With New transition core (330 x 210 um)	Hybrid domain (330 x 270 um)	Without transition core (370 x 270 um)
2.5 V	30 sec	No transition	No transition
3 V	22 sec	45 sec	No transition
4 V	5 sec	7 sec	No transition
5 V	3 sec	4 sec	36 sec
6 V	2 sec	3 sec	30 sec
7 V			15 sec

We fabricated several test cells in which the splay domain is as large as a real pixel size. Splay, hybrid and vertical domains were 133 μm x 133 μm, 133 μm x 25 μm and 25 μm x 25 μm, respectively. All pixels were simultaneously and uniformly changed from splay to bend states. Fig. 6(a) shows splay state in each pixel before a voltage is applied. Fig. 6(b)-(e) show the transition states of each pixel in time sequence after 3 V is applied. Fig. 6(f) shows when 2 V is applied as bias voltage. This noble technique enabled the splay to bend transition to occur within less than 2 sec even when an applied voltage is 3 V.

When 6 V is applied to the cell, all of the pixels were transited to bend state after 1 second as shown in Fig. 7. The higher voltage was applied the fast the bend transition occurred.

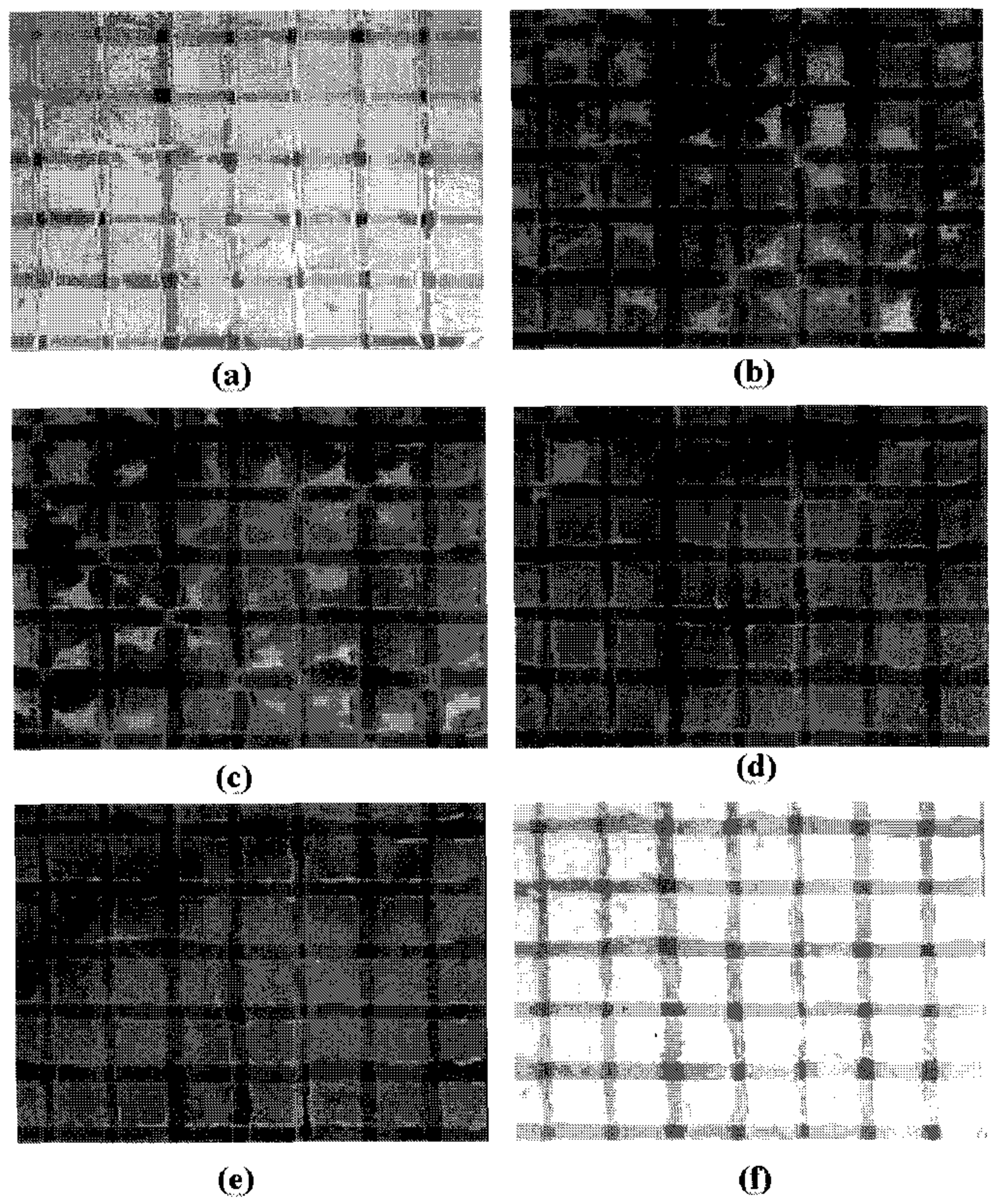

Fig. 6. Bend transition in each pixel with an applied voltage of 3 V: (a) without applied voltage, (b) 0.25 sec after 3 V is applied, (c) 0.5 sec. later, (d) 1 sec. later, (e) 2 sec. later, and (f) an applied voltage of 2 V.

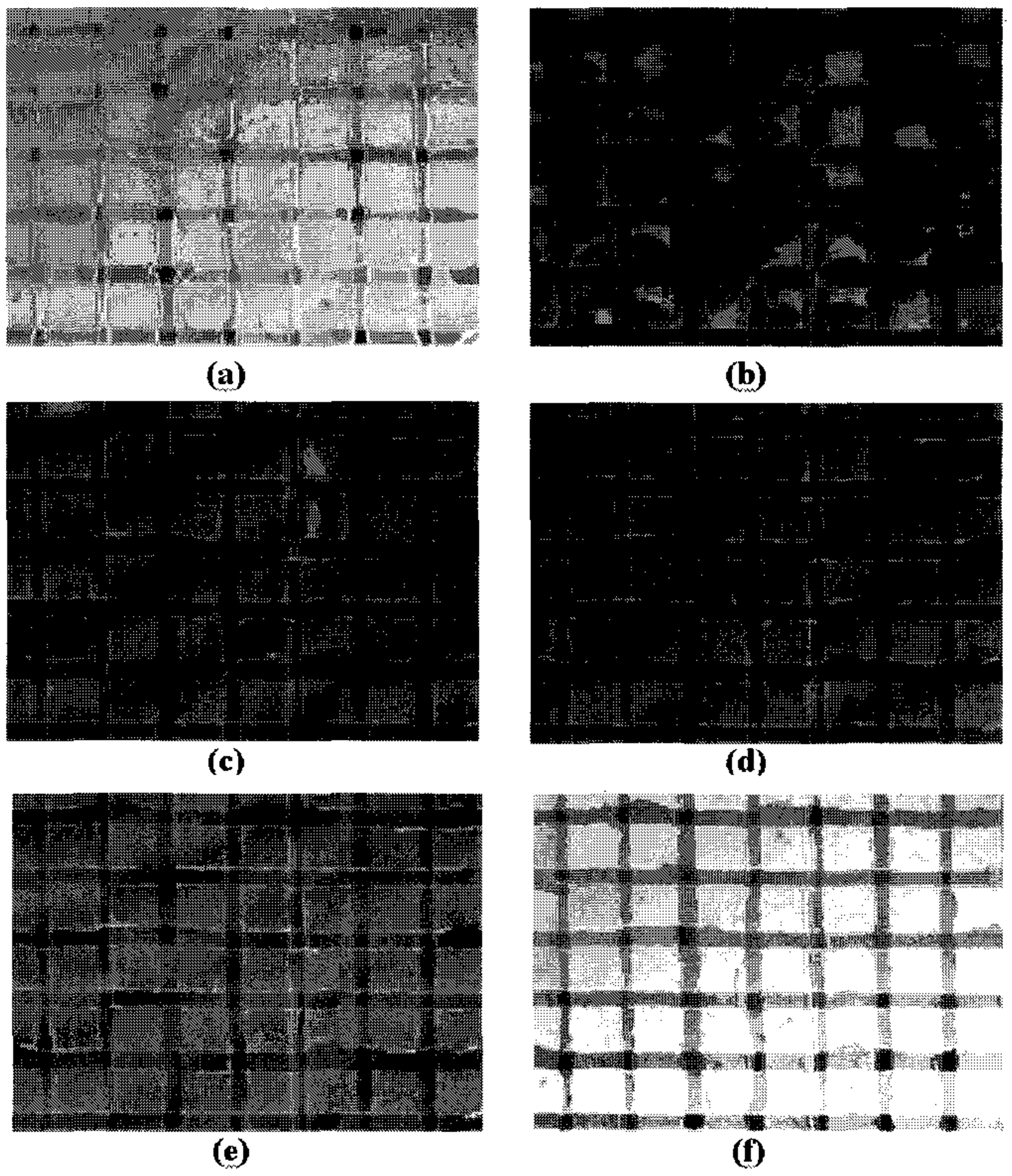

Fig. 7. Bend transition in each pixel with an applied voltage of 6 V: (a) Without applied voltage, (b) 0.25 sec. after 6 V is applied, (c) 0.5 sec. later, (d) 1 sec. later, (e) 2 sec. later, and (f) an applied voltage of 2 V.

4. Conclusion

In this work we demonstrate a novel technique to form bend transition core with multi domain alignment. Fast bend transition is achieved with the multi domain transition cores. The adjoining points of domain boundaries play a crucial role in splay to bend transition than domain boundaries. This new technique enables the splay to bend transition to occur within less than 2 sec even when an applied voltage is low enough.

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