

# A Novel Method for the Formation of Polymer Walls in Reflective LCD

Dong-Chirl Jeong<sup>1</sup>, Hae-Sung Kim<sup>1</sup>, Won-Sang Park<sup>1,2</sup>, Kyoung-Ho Park<sup>1</sup>, Kwan-Young Han<sup>1</sup>,  
Jae Chang Kim<sup>1,2</sup>, and Tae-Hoon Yoon<sup>1,2</sup>

<sup>1</sup>Department of Electronics Engineering, Pusan National University, Pusan, 609-735, Korea

<sup>2</sup>Research Institute of Computer, Information and Communication, Pusan National University,  
Pusan 609-735, Korea

## Abstract

*In this paper, we propose a novel method to form polymer walls without accurate alignment of photo-mask. The method can be used to form polymer walls in reflective LCDs.*

## 1. Introduction

Recent interest in low power display technology has encouraged research into liquid crystal effects that exhibit bistability. The bistable twist cell (BTC) originally proposed by Berreman<sup>1-4</sup> has the potential to satisfy several requirements for low power passive matrix displays. Recently, encouraging results have been presented<sup>5-8</sup> showing significant performance gains in the addressing speeds of the original device. The display consists of two ITO and polyimide coated substrates that are rubbed and aligned such that the tilt at the two surfaces has the same rotational sense. Filling the device with a cholesteric liquid crystal yields a stable director configuration that depends on the ratio of cell thickness to intrinsic pitch of the liquid crystal ( $d/P_0$ )<sup>9</sup>. In the case  $0 < d/P_0 < 1$  the possible stable twist states are  $0^\circ$ ,  $180^\circ$ , and  $360^\circ$ . These three director configurations are topologically equivalent. This means that they can be continuously transformed from one to the other without the formation of a disclination line. The  $180^\circ$  twist state is topologically distinct from both  $0^\circ$  and  $360^\circ$  states. As a result, the  $180^\circ$  state becomes unstable in the presence of high fields with the boundary conditions. After removing a large field (about 40V) the display will relax into either the  $0^\circ$  or  $360^\circ$  state. Unfortunately, the  $d/P_0$  range where switching occurs is also the range where the energy of the  $180^\circ$  state is lower than that of either the  $0^\circ$  or  $360^\circ$  states.<sup>10-11</sup> This indicates that after a short period of time (about 1-2s) domains of the unwanted  $180^\circ$  state will grow back and erase the information present on the display. It is possible to refresh the display every

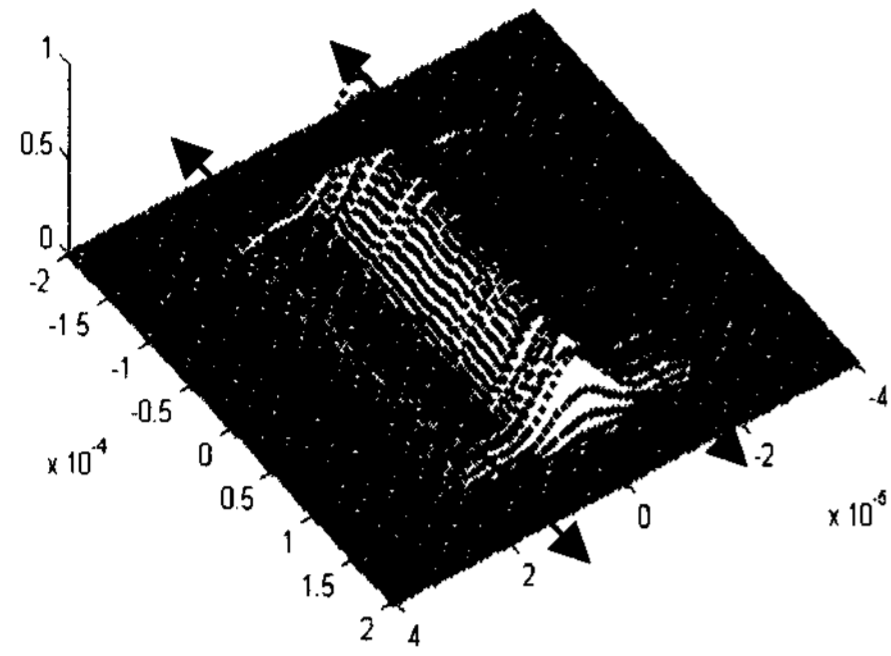
1-2s to eliminate this serious problem, but the method substantially increases power consumption and the refreshing occurs at rate which is distracting to the viewer. Berreman suggested a technique for confining the addressing regions and thus permanently eliminating the  $180^\circ$  twist state. The method requires a high pretilt in the spacing between pixels. The high pretilt significantly increases the energy of the  $180^\circ$  state inhibiting its formation. This result was achieved with photo-polymerized polymer walls in the interpixel spaces<sup>12-14</sup>.

We suggest a more manufactural method for the formation of polymer walls in reflective LCD.

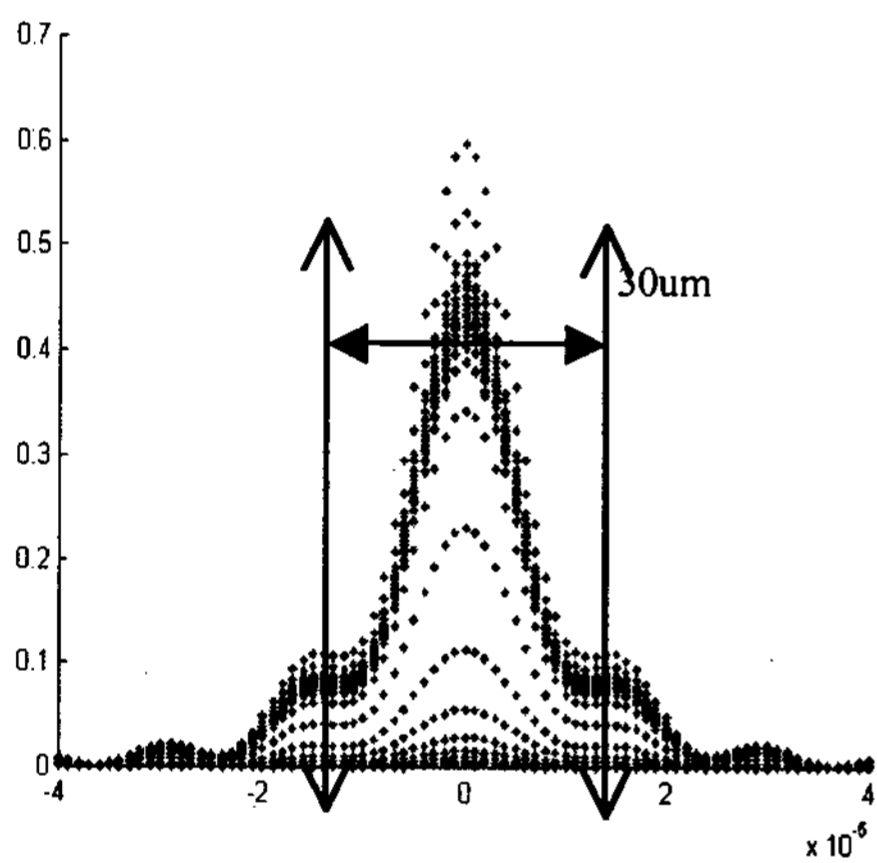
## 2. Simulation and Experiment

Generally, the formation of polymer walls were achieved by irradiating selective areas of a cell with UV light through a photo-mask, which is over the cell, to induce phase separation by photo-polymerization. In this case, the light passing through the edges of photo-mask is blurred by diffraction and the photo-polymerized polymer pattern can be affected by that phenomenon too. Figure 1 shows that the transmitted light forms a diffracted pattern that has a bigger shape than 30 um slit width, by computer simulation. The width of the photo-mask is 30 um and the region that is affected by diffracted light is about 40 um with 1/5 of max intensity. Special calculation and an accurate optical setup of the photo-mask and the cell are needed to get a desired width of polymer walls. To reduce the effect of diffraction pattern, we propose a method to form the structure easily and precisely with patterned polymer walls that are made by the pixel electrodes. If we use pixel electrodes on the substrate as a photo-mask pattern, it needs not to consider these effects and can make polymer walls more easily. The pixel electrode contacts directly with the liquid crystal layer, so the diffraction effect doesn't appear. Figure 2 shows the optical setting for

forming polymer walls of a conventional method and the proposed method. A patterned pixel is used instead of using a photo-mask.



(a)

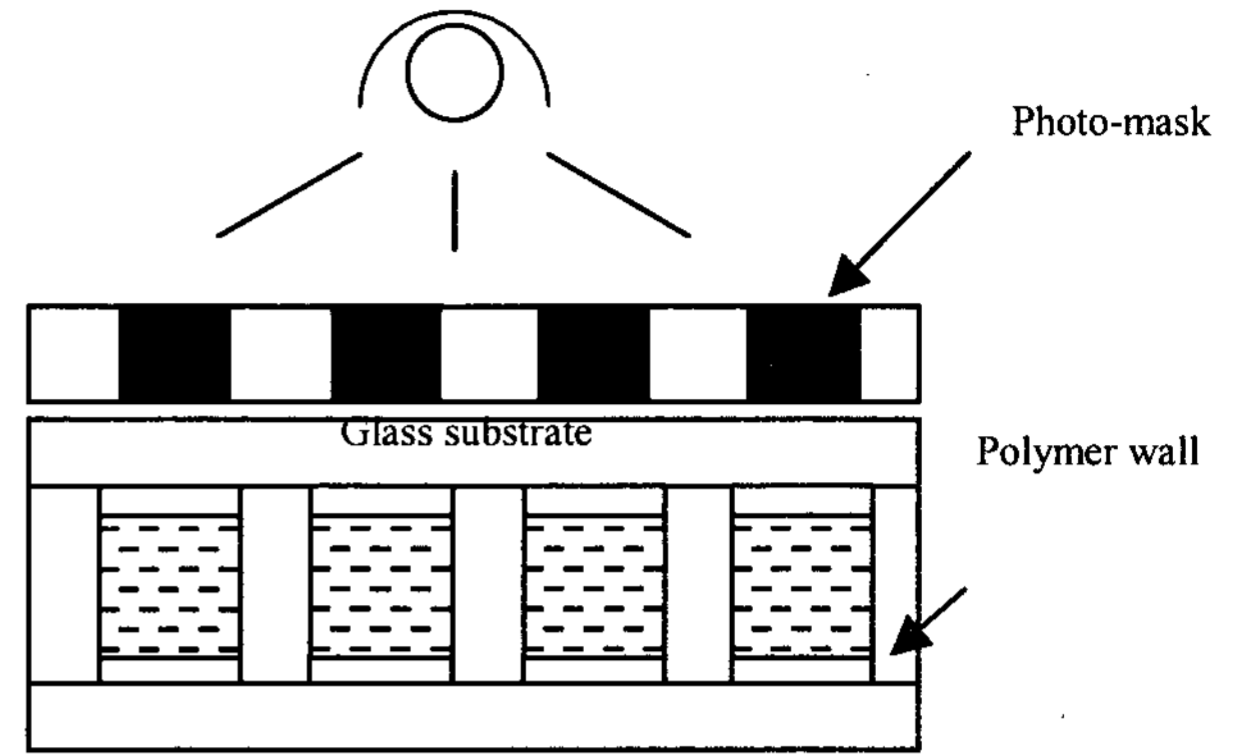


(b)

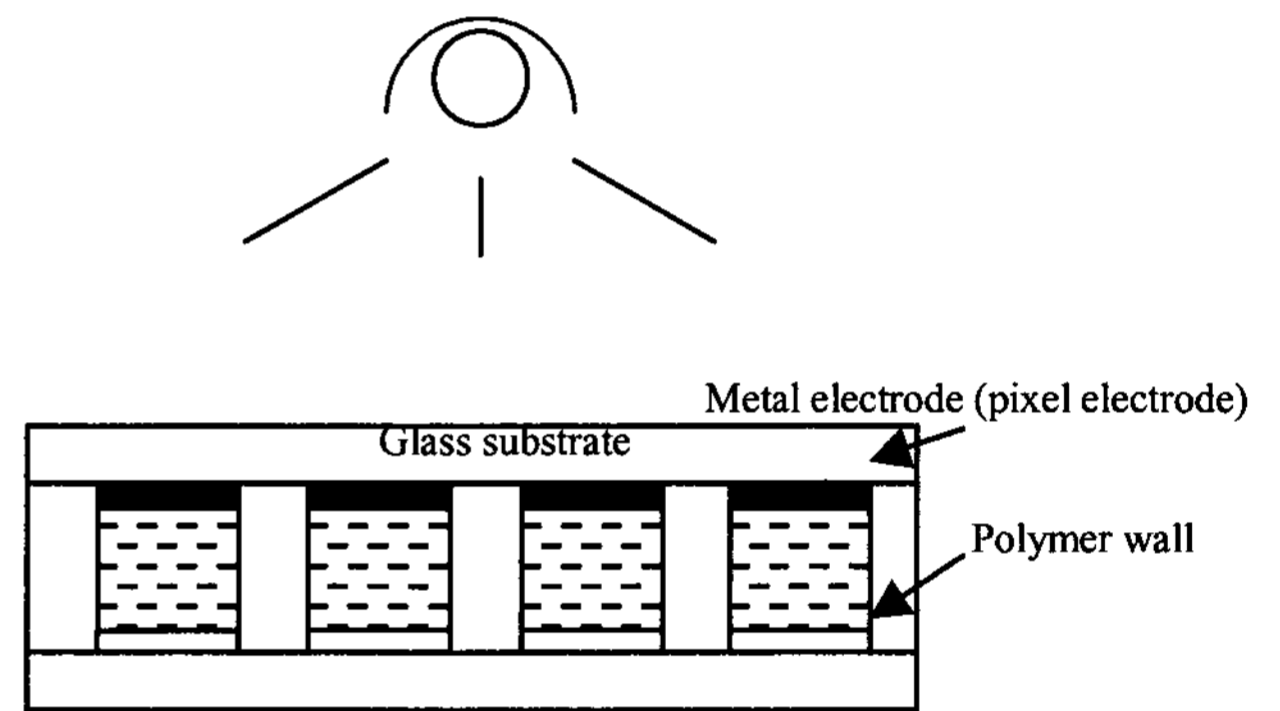
Figure 1. Transmitted light pattern (a) Diffraction pattern and (b) lateral diffraction pattern for the slit width of intensity slit size of cell 30 um

To form the polymer walls a mixture of liquid crystal, monomer was prepared. A chiral nematic mixture(CNM) composed of NOA65/ZLI-1557 in a 25:75 weight ratio was used for liquid crystal formulation(table1). The NOA65 is photo-polymerizable monomer of Norland optical adhesive company. The substrates were patterned glass plates coated with indium tin oxide. A metal electrode with an image of the desired walls was used instead of a

photo-mask. The cell gap was controlled using 4µm sphere spacers.



(a)



(b)

Figure 2. The optical setup comparison for forming a polymer wall of (a) a conventional method (b) and the proposed method.

Table 1. Weight concentrations of the components in the CNM

Material	Wt %
Merck ZLI-1557	73.2 %
Merck S811	2.2 %
NOA65	22.8 %
Photoinitiator	3 %

The cells were capillary filled at high temperature where the CNM/NOA65 mixture formulation was in the isotropic state. After filling, the cells were cooled

down to room temperature. The UV exposure was performed for 20 min using KALL-SUSS MJB-3 unit.

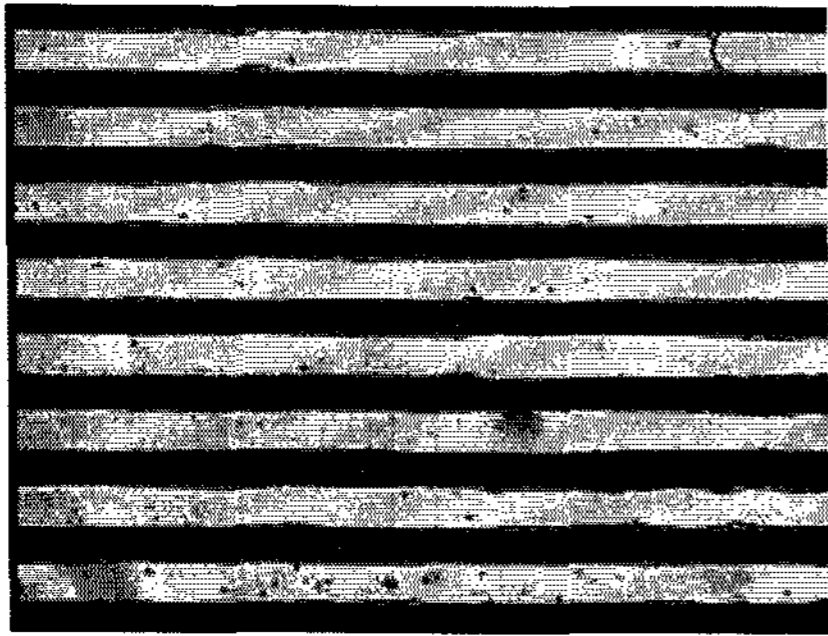


Figure 3. The polymer walls formed with a metal electrode as a photo-mask. The width of walls is almost same with the width of the metal electrodes.

Figure 3 shows the polymer walls which were formed with metal electrodes. The width of polymer wall was almost the same with that of the metal electrode. And the boundary between the wall and liquid crystal is sharp.

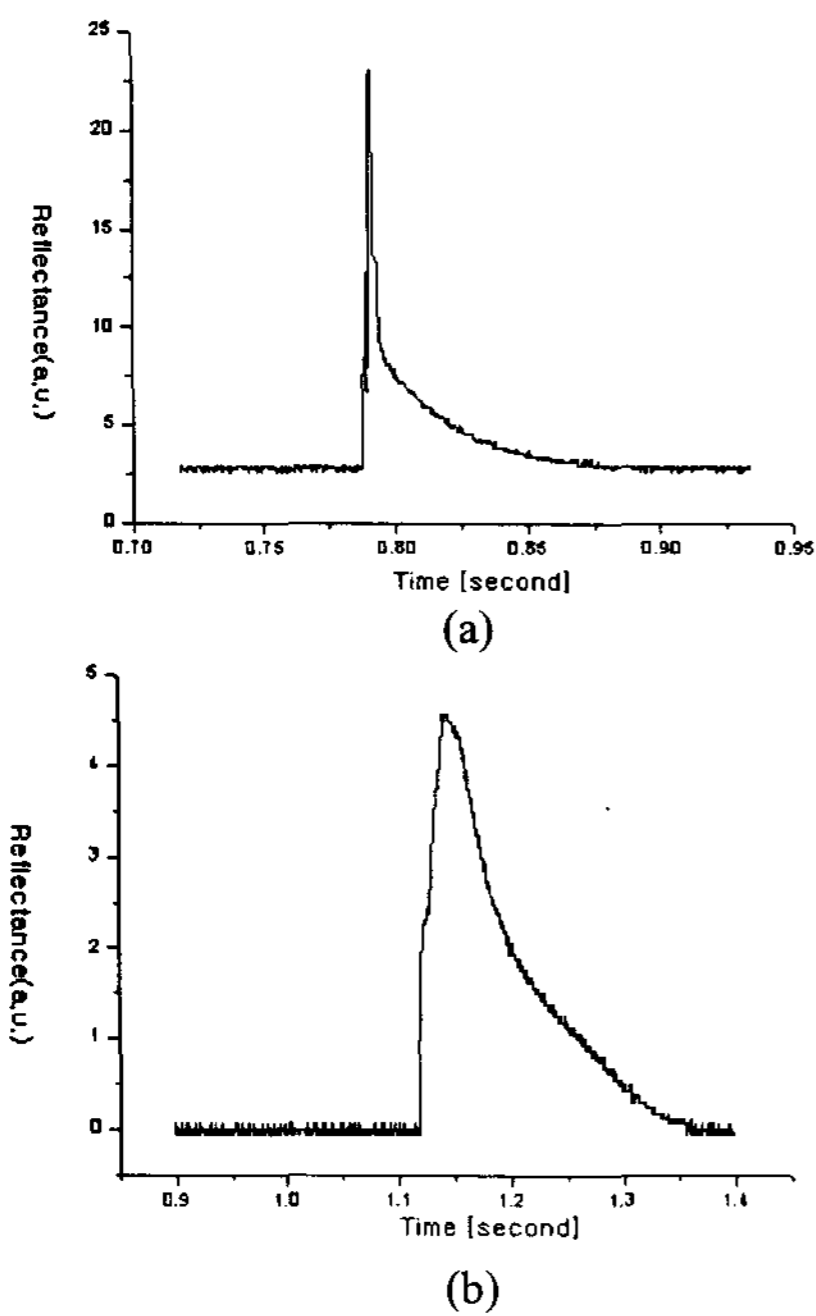


Figure 4. The optical characteristics of (a) conventional BTC and (b) a polymer-stabilized BTC.

The optical characteristics shown in Figure 4 inform that the holding time is doubled. This polymer-stabilized bistable twist cell (PSBTC) was made according to proposed new method. Figure 5 is the electrode pattern used in forming the polymer walls. The polymer rich walls had a pixel size of 300  $\mu\text{m}$  X 300  $\mu\text{m}$  and a spacing of 30  $\mu\text{m}$  between pixels. During the UV exposure an RMS voltage of AC 20 V was applied to the cell so that the polymer walls would lock the liquid crystal on the polymer wall in high tilt angle at that applied field.

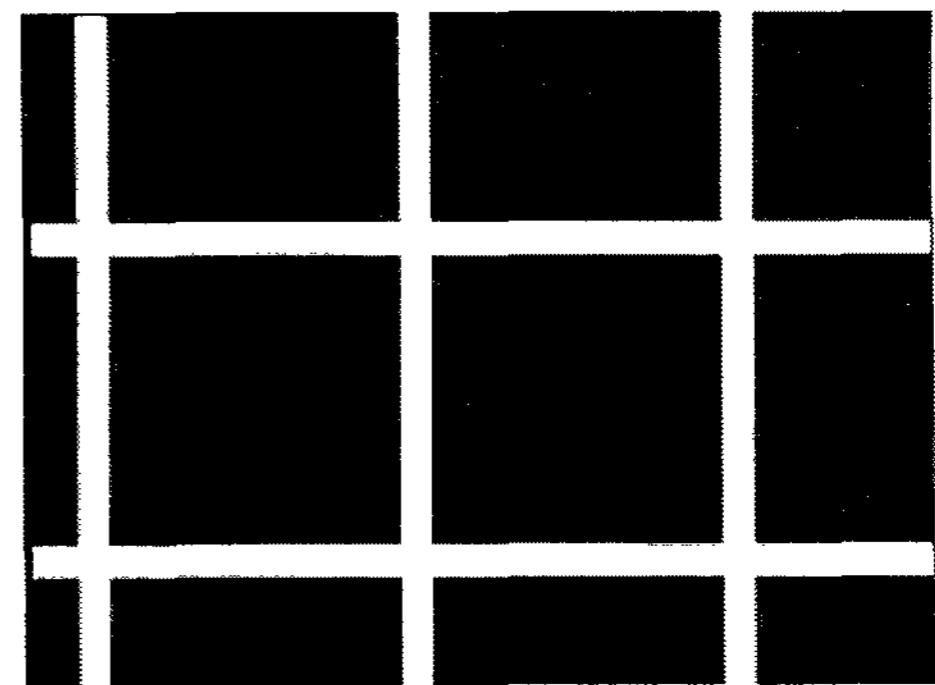


Figure 5. Pixel electrode pattern

### 3. Conclusion

The suggested method used the pixel electrodes on the substrates as a photo-mask pattern to form polymer walls in a bistable twist cell. This method removes a photo-mask in the process of forming polymer walls of PSBTCs. The width of polymer walls is almost the same with that of the metal electrode and their boundaries are sharp.

### 4. Acknowledgements

This research was supported by University IT Research Center Project.

### 5. References

- [1] D.W. Berreman and W.R. Heffner, Appl. Phys. Lett. 37, 109(1980)
- [2] D.W. Berreman and W.R. Heffner, J. Appl. Phys. 52, 3032(1981)
- [3] D.W. Berreman and W.R. Heffner, Proc. SID 22, 191(1981)

- [4] W.R. Heffner and D.W. Berreman, J. Appl. Phys. 12, 8599(1982)
- [5] T. Tanaka, Y. Sato, A. Inoue, Y. Momose, H. Nomur and S. Lino, Proc. Asia Display 259(1995)
- [6] C.D. Hoke, J.R. Kelly, and P.J. Bos, Jpn. J. Appl. Phys. 36, L227(1997)
- [7] G.D. Lee, K.H. Park, K.C. Chang, T.-H. Yoon, J.C. Kim, and E.S. Lee, Jpn. J. Appl. Phys. 38, 809(1999)
- [8] G.-D. Lee, H.-S. Kim, T.-H. Yoon, J. C. Kim, and E.-S. Lee, Proc. SID 98, 842(1998)
- [9] G-D. Lee, G-H. Kim, K-H. Park, K-C. Chang, T-H Yoon, and J.C. Kim, Proc. SID 99, 863(1999)
- [10] C.D. Hoke, J. Li, J. Kelly, and P.J. Bos, Proc. SID 28, 29(1997)
- [11] C.D. Hoke, J.R. Kelly, and P.J. Bos, Proc. IDRC, 85(1997)
- [12] R.A.M. Hikmet and P.J. Bos, Proc. IDRC 85(1997)
- [13] N. Yamada, S. Kohzaki, F. Funada and K. Awane, Proc. SID 26, 255(1995)
- [14] C.D. Hoke, P.J. Bos, Proc. Sid 98, 854(1998)