

O13

New mode for flexible liquid crystal displays

Jong-Wook Jung, Hyun-Gee Lee, and Jae-Hoon Kim

Department of Physics, Hallym University, Chunchon, Kangwon-Do 200-702, Korea

We developed a new device structure using anisotropic phase separation from liquid crystals (LCs) and polymer composite materials for flexible display applications. In the device, the LC molecules are isolated in pixels where LCs are surrounded by polymer layers. These devices show very good mechanical stability against external pressure. The electro-optic characteristics and the mechanical stability of the devices are discussed in view of the flexible display applications.

I. Introduction

Liquid crystals (LCs) have been extensively studied and used for display applications because of their efficient light-control capabilities with low power consumption. These advantages come from LC's hydrodynamic properties and high birefringence. In general, LC devices are prepared by sandwiching a LC between two glass substrates with transparent electrodes and alignment layers to obtain specific configuration of the optic axis. One of primary role of these substrates is supporting LC molecular orientation from external bending or pressure, which alter the arrangement of LC molecules and diminishes optical properties of the device.

In recent years, LC devices using plastic film substrates have drawn much attention for use in applications such as smart cards, PDA, and head

mount displays because of their lighter weight, thinner packaging, flexibility, and reduced manufacturing cost through continuous roll processing¹⁻³. Different electro-optical modes have been proposed for use in plastic LCDs including TN/STN, cholesteric, polymer dispersed LC (PDLC), and bistable FLC modes.

However, it is clear that plastic substrates can't give a solid mechanical support for the molecular alignment of LCs between them. Specially, ferroelectric LCs show very weak mechanical stability because of the presence of fragile smectic layers even between glass substrates.

In order to overcome the above problem, polymer wall and/or network as a supporting structure have been proposed and demonstrated. These structures were fabricated using an anisotropic phase separation method from polymer and LC composite systems by applying patterned electric field or spatially modulated UV intensity^{4,5}. However, those methods require high electric field or there exist residual polymers in unexposed region which reduce optical properties of the device.

In this paper, we report pixel isolated LC (PILC) mode where the LC is isolated in the pixel surrounded by polymer. The PILC mode not only shows good mechanical stability, but also operates in low voltage.

II. Experimental

the high intensity region, to maintain their relative concentration, and join the polymerization reaction. The LC molecules are immiscible in and are expelled from the polymer. Therefore, the phase separation is anisotropic in 3-dimension.

Fig. 2 shows the resultant element after UV exposure. Due to three dimensional anisotropic phase separation, the LCs are isolated in the pixels surrounded by polymer wall, namely pixel isolated LC (PILC) mode. Any LC modes such as nematic, ferroelectric, and cholesteric modes can be applicable.

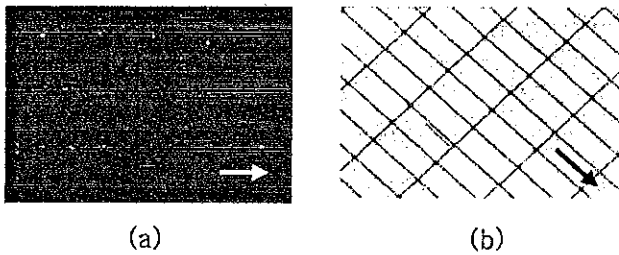


Fig. 3. Alignment textures of pixel isolated NLC cell: The rubbing direction indicated by arrow is rotated (a) 0° and (b) 45° with respect to one of crossed polarizers.

Fig. 3 shows microscopic textures of pixel isolated NLC (PINLC) cell at room temperature after UV exposure under polarizing microscope. The pixels were rich in LC with uniform alignment and the interpixels were rich in polymer with some embedded LC molecules.

We note that LC molecules in polymer can be controlled by mixing ratio, UV intensity and exposure time, environment temperature, and sample thickness.

The cross section image of PINLC using scanning electron microscope was shown in Fig. 4. It can be seen well defined polymer wall in interpixels and uniform polymer layer in upper glass. Therefore the LC molecules are surrounded by polymer and

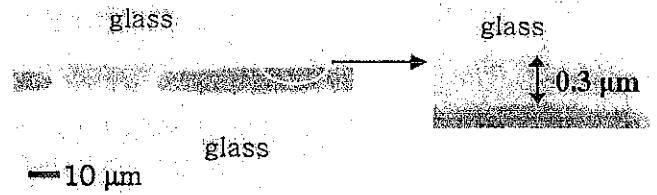


Fig.4. SEM image of PILC sample

isolated into pixels. The polymer walls act as supporting structure.

We now describe the alignment stability of PILC against an external mechanical shock. Such mechanical stability has been one of the main problems to commercialize plastic LCDs, specially using FLCs. Fig. 5 shows microscopic texture of normal [(a) and (b)] and pixel isolated FLC (PIFLC) [(c) and (d)] before and after an external pressure. In normal FLC, the texture shows crucial change due to broken smectic layers after mechanical shock. It can be seen from Fig. 5 (c) and (d) that no appreciable structural change in PIFLC was present.

Fig. 6 shows electro-optic behavior of normal,

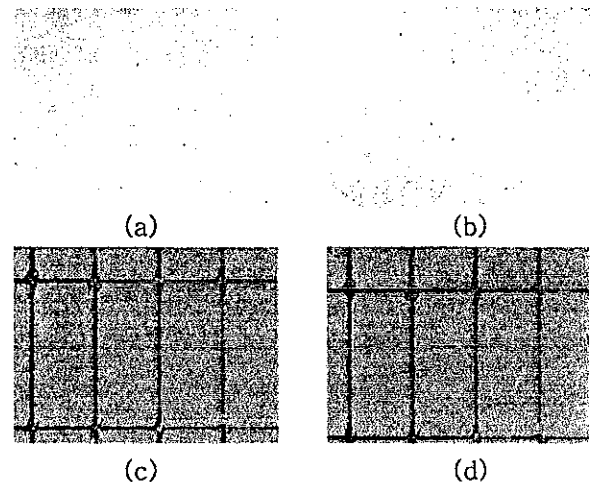


Fig. 5. Alignment textures before [(a) and (c)] and after [(b) and (d)] external pressure: (a) and (b) are normal SSFLC cell, and (c) and (d) are PIFLC cell.

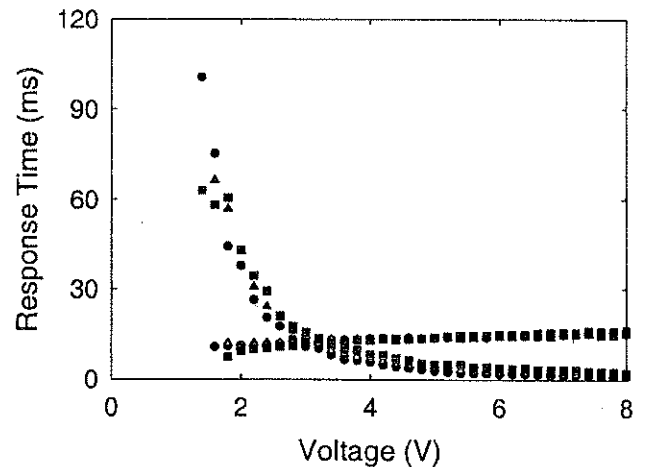
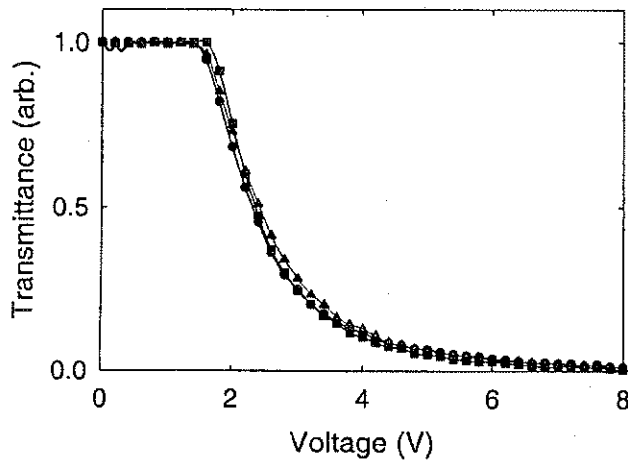


Fig. 6. Electro optical properties of normal (circle), PSCOF (triangle), and PINLC (square) as a function of applied voltages.

PSCOF and PINLC samples. In all samples, transmittance and response time show almost same behavior.

IV. Concluding Remarks

In conclusion, we successfully fabricated a new device structure using three dimensional anisotropic phase separation method. In the device, the LC molecules are isolated in pixels where LCs are surrounded by polymer layers. These devices show very good mechanical stability against external pressure. The electro-optic characteristics are almost same as normal nematic LC structure.

Acknowledgements

This work was supported from Information Display R&D Center, one of the 21st Century Frontier R&D Program funded by the Ministry of Science and Technology of Korean government.

REFERENCES

1. F. Matsumoto, T. Nagata, T. Miyabori, H. Tanaka, and S. Tsushima, SID '93 DIGEST, p965 (1993).
2. J. L. West, M. Rouberol, J. J. Francl, J. W. Doane, and M. Pfeiffer, ASIA DISPLAY '95 Conference paper, p55 (1995).
3. R. Buerkle, R. Klette, E. Lueder, R. Bunz, and T. Kallfass, SID '97 DIGEST, p109 (1997).
4. Y. Kim, J. Francl, B. Taheri, and J. L. West. Appl. Phys. Lett. 72, 2253 (1998).
5. H. Sato, H. Fujikake, Y. Iino, M. Kawakita, and H. Kikuchi, Jpn. J. Appl. Phys. 41, 5302 (2002).
6. Q. Wang, H. Choi, B. Acharya, V. Vorflusev, J. -H. Kim, and S. Kumar, IMID '01 Conference paper (2001).

27

Proceedings of the 6th

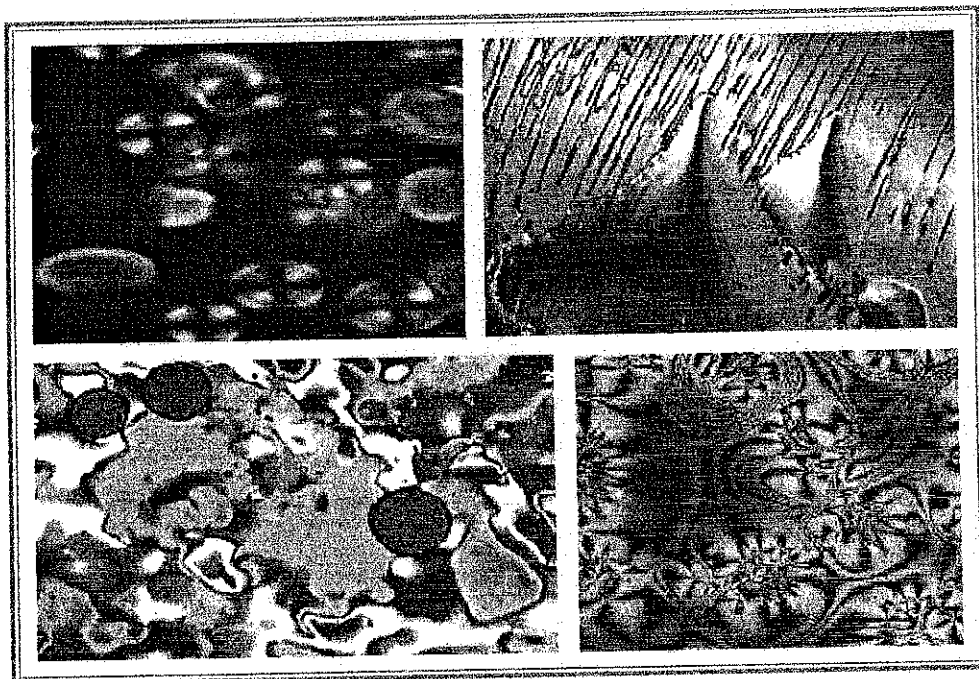
KIAS The
KOREAN
INFORMATION
DISPLAY
SOCIETY

KLCC '03

**KOREA
LIQUID CRYSTAL
CONFERENCE**

Korea University, Seoul, Korea

August 22 - 23, 2003



Organized by
Basic Science Research Center at Korea University
Korean Liquid Crystal Association
Liquid Crystal Research Center at KonKuk University

O09. Time-resolved infrared spectroscopy of molecule/binding site reorientation during FLC electro-optic switching	39
<i>Won Gun Jang and Noel A. Clark*, KOPTI, *University of Colorado, USA</i>	
O10. Development of the High Speed Response and High Clearing Temperature LC Mixtures for TV Application of IPS-LCD	45
<i>S. K. You and Y. B. Kim, Konkuk University</i>	
O11. Electro-optical Characteristic of Multi-domain Vertically Aligned Liquid Crystal Displays with Patterned electrode	49
<i>Ju-Han Kim, Sung-Min Jung, and Woo-Sang Park, Inha University.</i>	
O12. Synthesis of soluble conducting polymer and its application to transparent electrode	53
<i>Eung Ju Oh, Keuk Ryul Song, and Yong Bae Kim*, Myongji University, *Konkuk University</i>	
O13. New Mode for Flexible Liquid Crystal Displays	57
<i>Jong-Wook Jung, Hyun Gee Lee, and Jae-Hoon Kim, Hallym University</i>	
O14. Efficient white organic light-emitting devices consisting of RGB emitting layers	61
<i>Changhee Lee, Namheon Lee, Munjae Lee, Jun-Ho Song, and Do-Hoon Hwang*, Inha University, * Kumoh National Institute of Technology</i>	
O15. A Geometric Structure for Uniform Bend Transition in a pi cell	63
<i>Tae Jin Kim, Seo Hern Lee, Kyoung-Ho Park, Jin Seog Gwag, Gi-Dong Lee, Tae-Hoon Yoon and Jae Chang Kim, Pusan National University</i>	
O16. Photochemical reaction on the polymer layer for liquid crystal display	67
<i>Dong-Mee Song and Dong-Myung Shin, Hongik University</i>	
O17. Diffraction Grating in Holographic PDLC Based on Rubbery Polymers.	71
<i>Eun Hee Kim, Ju Yeon Woo, and Byung Kyu Kim, Pusan National University</i>	
O18. Electro-Optic Characteristics of the Fringe-Field driven Reflective Hybrid Aligned Nematic Liquid Crystal Display	75
<i>T. B. Jung, C. H. Park, J. S. Son, J. M. Rhee, and S. H. Lee, Chonbuk National University.</i>	
O19. Fast Response Liquid Crystal Display Device by Switching New Electrode Structure: "The LCD now Catches the Bee's Flap"	79
<i>Seung Min Seen, Kung Won Rhie and Shin Tae Shin, Korea University</i>	