In-Plane-Switching Transflective LCD Using Image Enhancing Reflectors

Gak-Seok Lee, Jae Chang Kim, and Tae-Hoon Yoon
Department of Electronics Engineering, Pusan National University
e-mail : neodol@pusan.ac.kr

We proposed novel configurations of a transflective liquid crystal display (LCD) using image-enhancing reflectors (IER) with the IPS (in-plane switching) mode. With IER, a single cell gap transflective LCD which requires neither multi-domain nor multi-driving can be realized. IER is formed above the transmissive region. *IER can make the light in the transmissive region travel the reflective region* like the ambient light. A transflective LCD using IER with IPS showed excellent optical characteristics.

In mobile displays, transflective LCDs have more advantages than transmissive and reflective LCDs. In these days, transflective LCDs generally adopt muticell-gap-type or single cellgap-type. But, there are some drawbacks of these two types.

For a multicell-gap type transflective LCD, the cell gap in the reflective region is half of that in the transmissive region. The response time of the transmissive region is four times of that of the reflective region. And, as the cell gap tolerance is very low, a fabrication yield in the industry can be lower.

Then, for a single-cell gap type transflective LCD, it needs multi-domain or multi-driving. The incident light in the reflective region passes through the LC layer twice, but the light in the transmissive region does through the LC layer once. Since the retardations in the reflective and the transmissive regions have to be $\lambda/4$ and $\lambda/2$, respectively, the different modes have to be adopted or the two regions have to be driven separately.

To overcome these drawbacks, we proposed optical configurations of a transflective LCD, which uses IER[1] to allow the back-light to traverse the reflective region twice and adopts IPS mode to realize the excellent optical properties.

We calculated electro-optical characteristics of three configurations. Three configurations are shown in Fig. 1. The basic principle of design is that the polarization state of the light reflected by IER must be the same as the polarization state of the ambient light after the polarizer. As there is no electrode in the transmissive part, LC molecules above it is not rotated even with applied voltages. So, once the retardation above the transmissive part is compensated, the change of the polarization state of the back-light and the ambient light is the same. All the configurations adopt wide-band $\lambda/4$ structure or wide-band $\lambda/4$ plate to realize good optical spectra properties.[2]

For the configuration 1, liquid crystal (LC) layer has the retardation of $\lambda/4$ in the off state and is switched from 75° to 30° with applying voltages. The slow axis of quarter wave plate under the reflector is set at the angle of 165° to compensate the retardation of transmissive part.

For the configuration 2, LC layer has the retardation of $\lambda/2$ in the off state and is switched from 15° to 37.5° with applied voltages. The slow axis of half wave plate under the reflector is set at an angle of 105° to compensate the retardation of the transmissive part.

For the configuration 3, LC layer has the retardation of $\lambda/2$ in the off state and is switched from 0° to 22.5° with applying voltages. And, because the LC layer is aligned at 0°, there is no need to use a retardation plate to compensate the retardation of the transmissive part.

As shown in Fig. 2, the proposed transflective LCDs have good optical spectra properties.

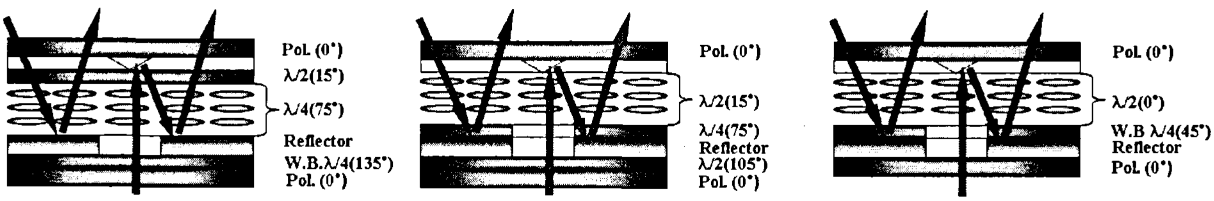
We designed novel configurations of transflective LCD using IER with IPS mode. In these configurations, not only single cell-gap structure but also single driving and same electro-optic characteristics in the transmissive and the reflective parts can be realized. Additionally, as IPS mode is adopted, wide viewing angle is expected.

Acknowledgements: This work was supported by LG. Philips LCD, Ltd.

References

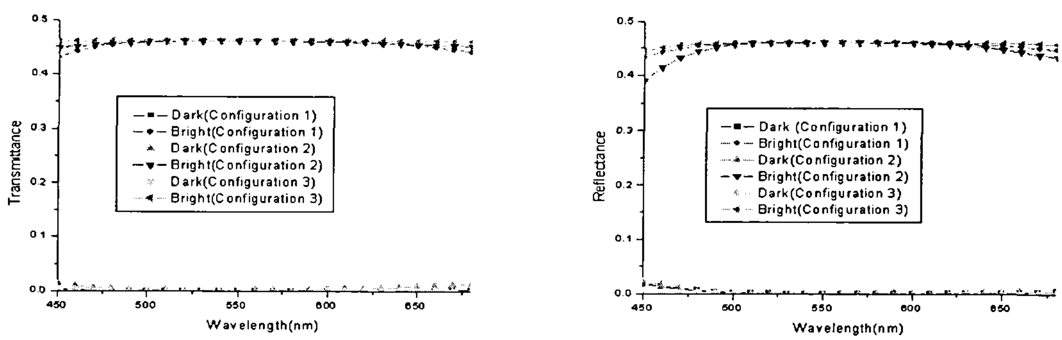
[1] Y.-I. Huang, M.-J. Su, and H.-P. David Shieh, **SID '03 Digest**, pp. 86-89 (2003).

[2] T. H. Yoon, G. D. Lee, and J. C. Kim, **Opt. Lett.** vol. 25, pp. 1547-1549 (2000).



(a) Configuration 1 (b) Configuration 2 (c) Configuration 3

Fig. 1. Three configurations of a transflective IPS LCD using IER.



(a) Transmissive part (b) Reflective part

Fig. 2. Calculated optical spectra of the proposed transflective LCD.