Liquid Crystal Light Shutter for Transparent Displays

Byeong-Hun Yu, Jae-Won Huh, and Joon Heo, and Tae-Hoon Yoon
Department of Electronics Engineering, Pusan National University, Busan 609-735, Korea
Tel.:82-51-510-1700, E-mail: thyoon@pusan.ac.kr

Recently, transparent displays have drawn much attention as next-generation displays [1]. Each pixel of a transparent display includes a transparent window area through which the background image can be seen. However, transparent displays suffer from poor visibility because background images are always seen along with the displayed image because of this transparent window area. This visibility problem can be solved by placing a light shutter at the backside of a transparent display. By switching the light shutter, we can block or transmit the background image through a the transparent display. In other words, we can operate a transparent display in transparent or high-visibility display modes by using a light shutter.

The operational principle of a light shutter can be classified into two types: light scattering and light absorption. Polymer-dispersed liquid crystal, polymer-networked liquid crystal, and cholesteric liquid crystal devices can be switched between transparent and translucent states by the light scattering effect [2]. These devices can block the background image, as shown in Fig. 1(a), but cannot achieve a black background. In contrast, a black background can be realized using the light absorption effect in devices, such as suspended particle device, electro-chromic device, and dye-doped LCs [3]. However, these devices are unable to completely block the background image under the bright environmental condition, as shown in Fig. 1(b). To realize a high-visibility see-through display, a light shutter that simultaneously uses light scattering and light absorption effects is desirable. Although such a shutter can be achieved using a double-layered structure which consists of both a light scattering and a light absorption layer. However, double-layered structures have disadvantages that include low transmittance, complicated structure, high power consumption, and high fabrication costs. Figure 1(c) shows the poor transmittance of double-layered structure in the transparent state.

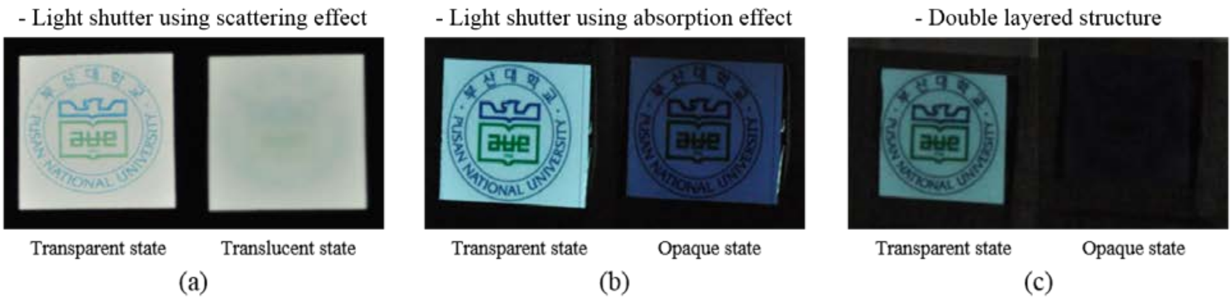

Fig. 1. Photographs of the fabricated cells classified by the operational principle.

For the practical application of the light shutter to a transparent display, a single-layered light shutter, wherein haze and transmittance can be simultaneously controlled, is desirable. In this study, we demonstrate a dye-doped long-pitch ChLC light shutter device that simultaneously uses light scattering and light absorption effects in a single-layered structure.

Acknowledgment

This work was supported by the IT R&D program of MOTIE/KEIT [10042412, More than 60″ Transparent Flexible Display with UD Resolution, Transparency 40% for Transparent Flexible Display in Large Area] and the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP) (No. 2014R1A2A1A01004943).

References

1. G. Gu, V. Bulović, P. E. Burrows, S. R. Forrest, and M. E. Thompson, *Appl. Phys. Lett.* 68(19), 2606 (1996).
2. K.-H. Kim, H.-J. Jin, K.-H. Park, J.-H. Lee, J. C. Kim, and T.-H. Yoon, *Opt. Express*, 18(16), 16745 (2010).
3. B.-H. Yu, J.-W. Huh, K.-H. Kim, and T.-H. Yoon, *Opt. Express*, 21(24), 29332 (2013).