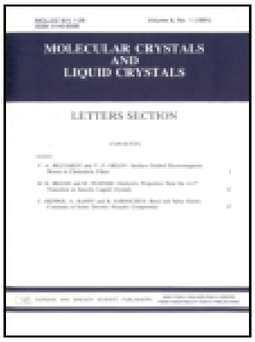

Molecular Crystals and Liquid Crystals

ISSN: 1542-1406 (Print) 1563-5287 (Online) Journal homepage: http://www.tandfonline.com/loi/gmcl20

Wall Pattern Design to Reduce Color Moire in Autostereoscopic 3D Display

Chang-Woo Jeon, Z. Hong, Sang-Hyun Park & Soon-bum Kwon

To cite this article: Chang-Woo Jeon, Z. Hong, Sang-Hyun Park & Soon-bum Kwon (2015) Wall Pattern Design to Reduce Color Moire in Autostereoscopic 3D Display, Molecular Crystals and Liquid Crystals, 613:1, 63-68, DOI: 10.1080/15421406.2015.1032046

To link to this article: http://dx.doi.org/10.1080/15421406.2015.1032046

Published online: 06 Jul 2015.

Mol. Cryst. Liq. Cryst., Vol. 613: pp. 63–68, 2015

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421406.2015.1032046

Wall Pattern Design to Reduce Color Moire in Autostereoscopic 3D Display

CHANG-WOO JEON,[1] Z. HONG,[1,2] SANG-HYUN PARK,[2] AND SOON-BUM KWON[1,2,*]

[1]Dept. of Display Engineering, Hoseo University, Chungnam, Korea
[2]NDIS Corporation, Chungnam,, Korea

For 2D-3D conversion, autostereoscopic 3D displays usually adopt an additional LCD panel, which provides parallax barrier, attached on the main display such as TFT-LCD or OLED. Polymer wall type thin film LCD developed for the additional panel has in general grid pattern polymer wall, so that it may induce 'color moire', which happens by the superposition of the color pixel of the main display and polymer wall. The wall pattern design to reduce the color moire and the experimental verification are presented.

Keywords Autostereoscopic 3D; Color moire; Parallax barrier; Wall pattern; Moire reduction

1. Introduction

Autostereoscopic 3D displays without need of glasses have been much developed for mobile applications, but the commercialization of them has been not so active. One of the reasons is that the thicknesses of the 3D displays including parallax barrier LCD are too thick due as compared to that of 2D display. As a favorable parallax barrier LCD, thin film LCDs using plastic substrates can be applied to autostereoscopic 3D displays.

Mechanical stability, specifically cell gap uniformity against external stress such as bending and mechnical shock, is a key issue for the thin film LCDs. As one way to secure the mechnical stability, the formation of polymer wall in LC layer as a spacer was proposed [1].

Polymer wall type thin film LCD developed for the additional LCD barrier has in general grid pattern polymer wall, so that it may induce 'color moire', which happens by the superposition of the color pixel of the main display and polymer wall. There have been several researches on the color moire in the 3D displays [2–6], but the one on this system was not carried out yet.

Kwon et al. firstly reported the specific design rule for the wall pattern to reduce the color moire [7]. In this paper, the color moire phenomena for various polymer wall designs based on the design rule for the color moire reduction will be discussed in detail.

* Address correspondence to Soon-Bum Kwon, Dept. of Display Engineering, Hoseo University, Chungnam 336-795, Korea. E-mail: sbkwon@hoseo.edu

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/gmcl.

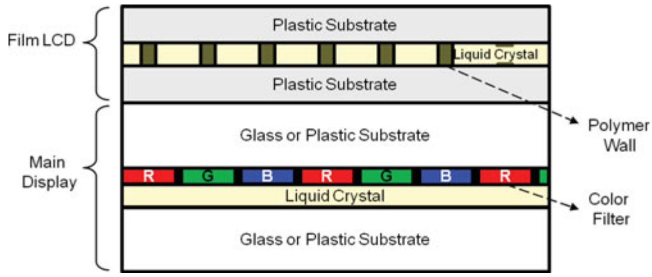

Figure 1. Cross-sectional structure of an autostereoscopic 3D display panel consisted of main display and polymer wall type film LCD.

2. Design of Wall Pattern for Color Moire Reduction

Figure 1 shows the cross-sectional structure of an autostereoscopic 3D display panel. The polymer wall type film LCD as a parallax barrier is attached on a main display.

The nature of the color moire originates from the break of white balance. As shown in Figure 2, white balance is in general broken by the polymer wall superimposed on the color pixels of main display.

In order to investigate color breaking of the 3D display, the projected length to the LC layer of film LCD, P'_{sub} of the sub-pixel pitch of the main display, P_{sub} must be compared to the pitch of patterned walls (Figure 3).

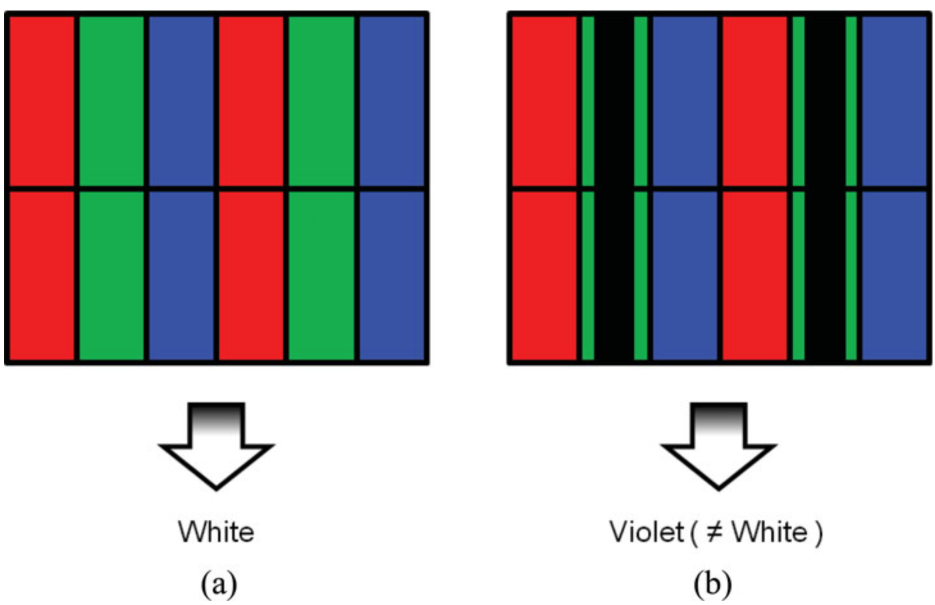

Figure 2. (a) White balance with RGB colored pixels and (b) Color break caused by white balance break in RGB colored pixels superimposed by polymer wall

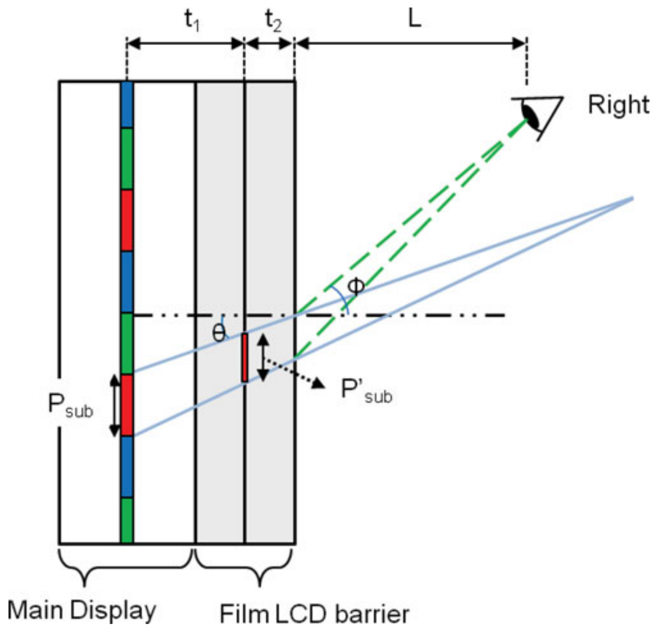

Figure 3. Geometrical configuration to show the projected length to the LC layer of film LCD, P'_{sub} of the sub-pixel pitch of the main display, P_{sub} : t_1 = distance between two LC layers of main display and film LCD, t_2 = distance between the LC layer and front surface of film LCD, L = viewing distance

The P'_{sub} is calculated from the geometry shown in Figure 3 by the following equation:

$$P'_{sub} = P_{sub}\frac{t_2 + nL}{t_1 + t_2 + nL}$$

where n = the average refractive index of the 3D panel.

It can be thought in case of grid type polymer wall that color break happens if the polymer wall pitch P_w is not equal to multiple of P'_{sub}. Also the color break appears when $P_w = 3 \cdot P'_{sub}$ because one of RGB colors is blocked by polymer wall. Therefore, no color break condition can be given by

$$P_w = m \cdot P'_{sub}$$

where m = natural number except for multiple of 3.

As another configuration of polymer walls not to give color break, one can consider zigzag type of them. Zigzag type polymer walls have advantage of big alignment tolerance for the assembly of main display and barrier LCD. Figure 4 shows the geometrical configuration for zigzag type polymer walls and projected sub-pixels of main display on the barrier LCD.

Similarly in case of grid type polymer wall, no color break condition in case of zigzag pattern polymer wall can be given by

$$P_w = m \cdot P'_{sub},$$

where m = natural number except for multiple of 3.

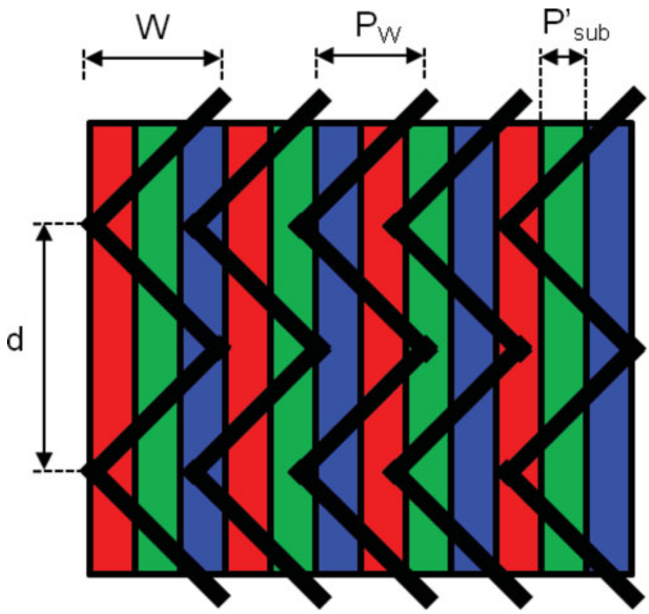

Figure 4. Geometrical configuration for zigzag type polymer walls and projected sub-pixels of main display on the barrier LCD: W = length of polymer wall in horizontal direction, P_w = pitch of polymer wall in horizontal direction, d = pitch of polymer wall in vertical direction

In this case, there can be another conditions for no color break when $P_w = 3 \cdot P'_{sub}$ given by

$$W \geq P_W \text{ and } W \geq 3 \cdot P'_{sub},$$
$$d = k \cdot P'_{sub} \text{ (where k is around 6)}$$

3. Experimental Verification

In order to verify the theoretical prediction for no color break condition described above, we fabricated the test samples and observed the color moire phenomena. We made two kinds of displays with different pixel sizes, the key parameters of which are summarized in Table 1.

Table 1. Key parameters of 3D panels

	4.5″ panel	7″ panel
Resolution (mm)	1280×720×RGB	800×480×RGB
P_{sub} (mm)	0.0257	0.0629
t_1 (mm)	0.380	0.710
t_2 (mm)	0.575	0.575
L (mm)	300	
n	1.5	
P'_{sub} (mm)	0.02568	0.0628

Table 2. Split test conditions

Grid type	Case 1 $P_w = 2P'_{sub}$	Case 2 $P_w = 3P'_{sub}$	Case 3 $P_w = 4P'_{sub}$
Zigzag type	Case 4 $P_w = 2P'_{sub}$ $W = 3P'_{sub}$ $d = 5P'_{sub}$	Case 5 $P_w = 3P'_{sub}$ $W = 2P'_{sub}$ $d = 6P'_{sub}$	Case 6 $P_w = 4P'_{sub}$ $W = 6P'_{sub}$ $d = 6P'_{sub}$

We made polymer wall type barrier LCDs for 4.5″ and 7″ main display panels, polymer wall configuration of which are summarized in Table 2. The polymer wall parameters for the case 1, 3, 4 and 6 are determined among the conditions to satisfy the no color break conditions, while those for the case 4 and 5 are determined among the conditions not to satisfy the no color break conditions described above.

Figure 5 shows the picture of 4.5″ split test 3D display samples for color moire test. In the picture taken in normal direction, color moire definitely happens in Case 2, where the design rule was broken. No color moire happens in other area (Case 1,3,4,6), where the design rule was satisfied. No color moire happens in Case 5, even in case that the design rule was broken.

In the picture taken in oblique direction, the same phenomena as that in the picture taken in normal direction were observed except for the Case 1 and 5. Black and white moire happens in Case 1, caused by the interference of the black matrix pattern of main display and the wall pattern of LCD barrier in case of the slight align mismatch between two displays. Color moire happens in Case 5, where the design rule was broken. The results imply that interference fringe and color moire images clearly appear in oblique directional view.

Figure 6 shows the picture of 7″ split test 3D display samples for color moire test. The same phenomena as that of 4.5″ display were observed except for the Case 1 and 5. Color moire also definitely happens in Case 2. No color moire happens in other Cases. The phenomena observed in normal direction were the same as those in oblique direction. The difference of the phenomena between 4.5″ and 7″ can be understood by the difference of display resolution and alignment accuracy: the alignment accuracy between main display and barrier LCD was set to be much better for 7″ than 4.5″.

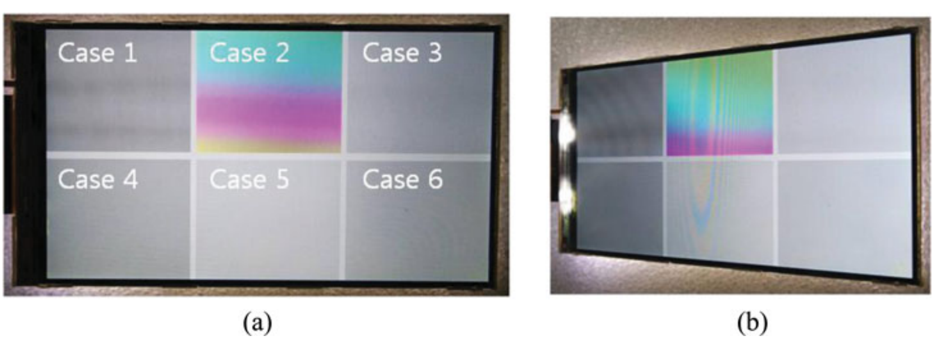

Figure 5. The picture of 4.5″ split test 3D display samples for color moire test taken in (a) normal direction and (b) oblique direction.

Figure 6. The picture of 7″ split test 3D display samples for color moire test taken in oblique direction.

4. Conclusion

The wall pattern design method to reduce the color moire for two types of wall pattern, grid and zigzag patterns in polymer wall type barrier LCD attached on main display was developed, which was experimentally verified. The experimentally confirmed design rules are as follows:

For grid type wall, $P_W = m \cdot P'_{sub}$, where m = natural number except multiple of 3 and zigzag type wall, 1 $PW = m \cdot P'_{sub}$, 2 $W \geq P_W$, 3 $W \geq 3 \cdot P'_{sub}$, 4 $d \leq 6 \cdot P'_{sub}$.

These results enable to make no color moire autostereoscopic 3D displays using polymer wall type barrier LCDs.

References

[1] Jung, J.-W., Park, S. –K., Kwon, S. –B., & Kim, J. –H. (2004). *Jpn. J. Appl. Phys.*, *43*, 4269.
[2] Okui, M., Kobayashi, M., Arai, J., & Okano, F. (2005). *Appl. Opt.*, *44*, 4475.
[3] Chen, C.-H., Yeh, Y.-C., & Shieh, H.-P. (2008). *J. Disp. Tech.*, *4*, 92.
[4] Uehara, S.-I., Hiroya, T., Shigemura, K., & Asada, H. (2009). *SID Digest.*, 1363.
[5] Boev, A., & Gotchev, A. (2011). *Proc. SPIE*, *7881*, 78810B–1.
[6] Kim, J., Jung, J.-H., Hong, J., Yeom, J., & Lee, B. (2012). *J. Opt. Soc. Kor.*, *16*, 29.
[7] Kwon, S.-B., Park, S.-H., & Hong, Z. (2013). *Korea Patent*, 10–1317882.