Curved Vertical-Alignment Liquid Crystal Display Development

An-thung Cho, Gui-qing Du, Yong-xiang Chen, Chen-I Huang, Yu-ming Xia, Wen-Bing Wu, Yong Zhang, Jeff Zhou, James Hsu, Wade Chen

E-mail address:david.cho@szhk.com.cn
ChuZhou HKC Optoelectronics technology Co., Ltd., China
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ABSTRACT

Curved liquid crystal display (LCD) suffers from an issue of uneven brightness among the vertical-alignment (VA) LCDs based on thin glass substrates. In this work, we successfully realized uniform brilliance for 27-inch QHD R1000 curved LCDs. The optical revealed that the dark areas on the bending sides of the curved LCD panel originated from the mismatch azimuth angle of the liquid crystals (LC). This issue could be resolved by engineering the pre-tilt angle of the LC on the color filter side. Through developing pre-tilt angle tuning technologies, we verified that the uniform brilliance could be achieved for 27-inch QHD 165Hz curved LCDs with 1000-mm curvature (R1000) on thin glass substrates.

1 Introduction

Recently, the curved LCDs develop rapidly, it can provide many benefits in better viewing sense [1]. In Fig.1, benefit from the great viewing, curved LCDs are integrated into various products, including TVs, monitors (MNT), and automotive displays, leading to the increasing demands of curved LCDs in the market. Therefore, the curved LCDs attract increasing attention to the development of relative technologies. Although the AMOLED is also a good candidate for curved displays, in certain application areas, the curved LCD is more competitive due to its low cost and mature manufacturing process [2]. To provide various viewing styles and human interfaces, different curvatures are designed. The curvature of curved TVs [3] and computer/gaming MNTs are usually 1000~1800 mm, wearable devices and mobile devices need a small curvature for R 50. In automotive application the curvature stays between R 50 and R1000. In consideration of cost, functionality, and manipulability, different substrates are applied for the curved LCDs, such as metal foil, ultra-thin glass, and plastic substrate, but the ultra-thin glass and colorless polyimide (PI) are the most popular substrates for the curved display due to high transmittance, good thermal stability, and chemical resistivity. In some applications with large curvature, the ultra-thin glass substrate is preferred due to its low cost, and high production and high yield based on ultra-thin glass substrate. However, the curved LCDs based on ultra-thin glass substrates suffer from an issue of uneven brightness among the vertical-alignment LCD panels. In this work, we investigated and successfully realized uniform brilliance for 27-inch QHD 165Hz curved LCDs with 1000-mm curvature on thin glass substrates.

2 Results and Discussion

We find that traditional LCD bending curved, the Array and CF glass shift in opposite direction because the stress difference in each glass and difference radius of curvature. Which make the CF glass shift some distance relative to array glass. The outcomes of the results cause oval dark mura in curved panel (in Fig.2). Schematic of the curved LCD (a) top view of CF and TFT substrate, (b) the phenomenon of Oval dark Mura for LC orientation domain shift, as shown in Fig. 2. The VA LC displays showed the non-uniform brilliance with R1000 curvature, and bending side is darker (in Oval mura region) than the center. The LC orientation domain shift was ascribed to the shift of the CF substrate relative to the TFT substrate, and leading to the decrease of the transmittance next to the ITO trunk. In Fig. 3, schematic of the LC with different pre-tilt angles design on CF substrate and TFT substrate (a) non-hybrid pre-tilt angle (Single PI) alignment (b) hybrid pre-tilt angle alignment. We decreasing pre-tilt angles of the LC on the CF substrate should be an effective strategy to improve the impact of the substrate shift on the LC azimuth angle in curved display. We developed the hybrid pre-tilt angles engineering technology with dual PI alignment process. Figure 4 show that curved MNT display with Cu/COA & POA process technology. We successfully realized uniform brilliance (without Oval dark Mura) for 27-inch QHD R1000 curved LCDs as demonstrated in Fig.5.

3 Conclusions

Curved liquid crystal display (LCD) suffers from an issue of uneven brightness among the vertical-alignment (VA) LCDs based on thin glass substrates. In this work, we successfully realized uniform brilliance for 27-inch QHD R1000 curved LCDs. The optical revealed that the dark areas on the bending sides of the curved LCD panel originated from the mismatch azimuth angle of the liquid crystals (LC). This issue could be resolved by engineering the pre-tilt angle of the LC on the color filter side. To develop pre-tilt angle tuning technologies, we verified that the uniform brilliance could be achieved for

27-inch QHD 165Hz curved LCDs with 1000-mm curvature on thin glass substrates.

Acknowledgements

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References

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(a)

(b)

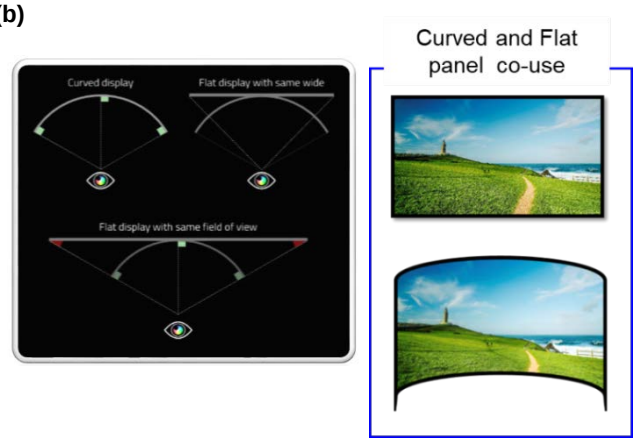
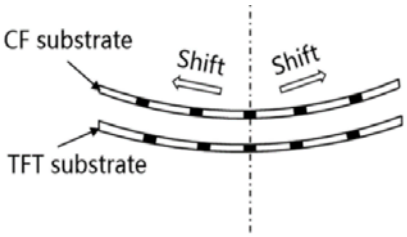


Figure 1 (a) Curved computer/gamming monitor, and (b) great viewing sense

(a)



(b) Oval dark Mura **LC orientation domain shift**

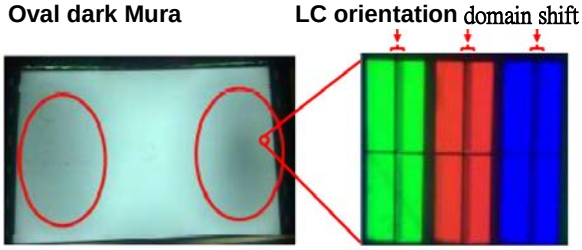
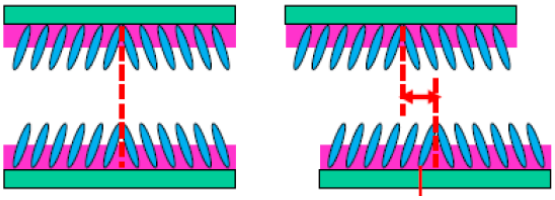


Figure 2 Schematic of the curved LCD (a) top view of CF and TFT substrate, (b) the phenomenon of Oval dark Mura for LC orientation domain shift

(a) Non-hybrid Pre-tilt Angle (Single PI) → with Oval dark Mura obviously

Normal State **LC domain shift (Curved)**



(b) Hybrid Pre-tilt Angle (Dual PI) → Improved the Oval dark Mura effectively (Curved R1000)

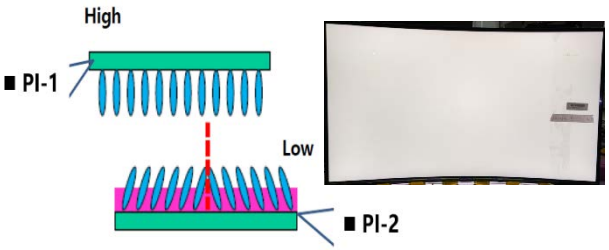


Figure 3 Schematic of the LC with different pre-tilt angles design on CF substrate and TFT substrate (a) non-hybrid pre-tilt angle (Single PI) alignment (b) hybrid pre-tilt angle alignment

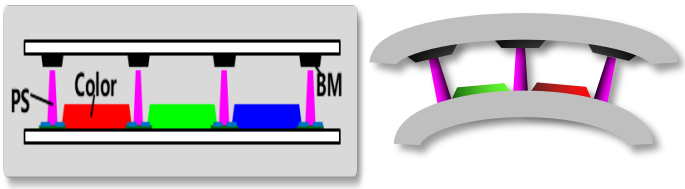


Figure 4 Curved MNT display with Cu/COA & POA process technology

Figure 5 Curved R1000 27-inch QHD 165Hz MNT demonstration