

Camera Under Panel (CUP) Applied in 4K Ultra-High-Definition OLED Medium-Size Panel

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Abstract

We developed a 4K Real RGB ultra HD Camera Under Panel (CUP) medium-sized display OLED Panel. Due to the Real RGB arrangement, two R/G/B light-emitting units in CUP are driven by one pixel circuit. Compared with the SPR arrangement usually applied to small-sized display, the pixel circuits density is doubled, the wiring space in CUP border area is compressed, and the space required in border is large. We set two pixel circuit regions and added wires connected pixel circuit areas, narrowed the size of the border area to 1.5mm, the camera hole diameter is 3 mm, the CUP hole diameter is 6 mm. Due to the pixel circuits placed in the border area of CUP, the opening rate of Camera hole reaches more than 85%, the transmittance is 13.8% (550nm), and the luminance ratio between CUP and AA area is close to 1:1, it has a good display performance.

Author Keywords

4K Real RGB; CUP ; Narrow border

1. Introduction

CUP technology is divided into pixel circuits placed in the Camera hole area and in the border area. In order to improve the light transmittance in the Camera hole area, the pixel drive circuit is placed in the border area of the CUP (FIG 1). Camera under Panel (CUP) technology usually applied in mobile OLED Panel, which usually adopted Super Pixel Rendering, In the CUP area, 1 pixel circuit drives 2 red light-emitting units, 1 pixel circuit drives 2 green light-emitting units, and 1 pixel circuit drives 4 light-emitting units (FIG 1). The lateral distance between the pixel circuit columns is large (40~60u), the distance between the pixel columns can be moved down b (approximate a) is large, and CUP Border (c) is small (1-1.5mm).

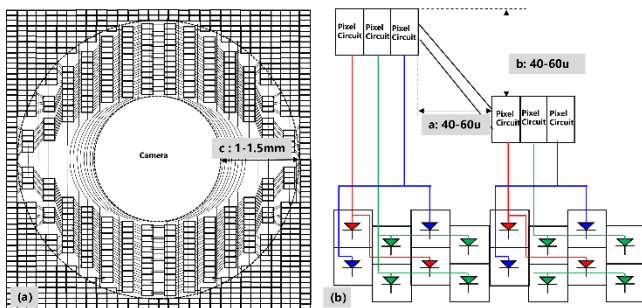


Figure 1 : (a) CUP pixel circuits placed in border area (b) CUP SPR pixel driving mode

The medium-size OLED Panel is usually arranged in Real RGB. When using the CUP technology whose pixel circuits placed in the border area (FIG 2), in order to ensure that the cell's luminous brightness ratio between CUP and AA is around 1:2. In the CUP area, 6 pixel circuits drive 12 light-emitting units, 2 pixel circuits drives 4 red light-emitting units, 2 pixel circuits drives 4 green light-emitting units, and 2 pixel circuits drives 4 light-emitting units(FIG 2), the pixel circuits density is doubled, the lateral

distance (a) between the pixel circuit columns is small (10~40u), the distance (b) between the pixel columns can be moved down is small(10u-40u), and the CUP Border (c) is large (> 2mm). The pixel drives in Camera hole and border are both 1:2 design. Compared with AA, the pixel resolution is decreased. The larger border, the larger CUP size, and the worse performance of the overall display.

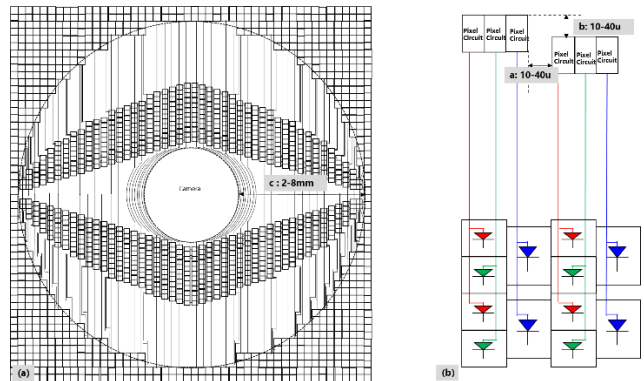


Figure 2 : (a) CUP Real RGB normal case (b) CUP Real RGB pixel driving mode

2. Continued Formatting Guidelines

To narrow the CUP Border size under the Real RGB arrangement, Figure 3 shows a narrow CUP border design, The pixel circuits in the CUP are roughly divided into region 1 (a1) and region 2 (a2). The region 1 and the region 2 are divided by the vertical line winding area (b1), Pixel circuits in region 1 is located above (or under) the vertical line winding area, Pixel circuits region 2 is located on the right side (or left side) of the vertical line winding area, Pixel circuits columns in region1 is placed slope, The bottom of pixel circuits columns in region2 aligned to the CUP middle, The lateral wire winding (b2) connects the pixel circuits in region 1 and the pixel circuits region 2; By this method, Can significantly reduce the border of the CUP.

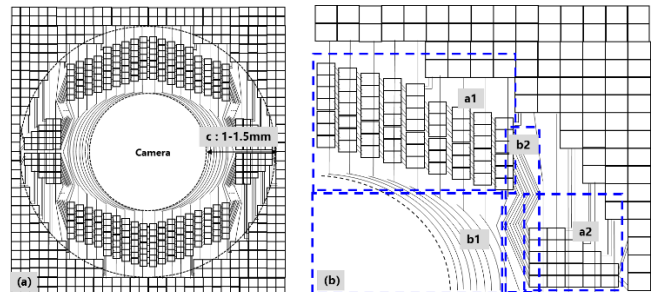


Figure 3 : (a) CUP Real RGB narrow border (b) LU part of (a)

We applied this design to the medium size 4K Real RGB ultra HD display. PPI 323, the lateral distance between pixel circuit columns in the CUP border area is only 14u, the maximum pixel circuit columns can be moved down 17u, CUP Border is 7mm and CUP

diameter is 17mm; After this design, border area is narrowed to 1.5mm, and CUP diameter is 6mm, close to the mobile OLED Panel whose CUP diameter usually is 5-6mm.

3. Results and discussion

Transmittance :

Due to the use of pixel circuits placed in the border area, the camera hole only has the anode pattern which is unclear, the opening rate of camera hole is 85.8%, and the transmittance is 13.8% @550nm(TAB 1), the blue light transmittance affected by the substrate yellow PI is only 1.88%^[1]. Figure 4 shows the detail transmittance curve along the wavelength.

TAB 1. Camera hole transmittance at different wavelength

Wavelength	Transmittance
430nm	1.88%
550nm	13.8%
700nm	16.2%

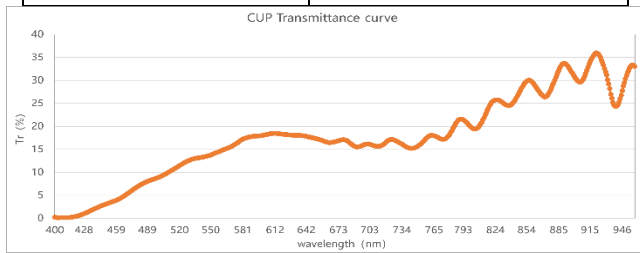


Figure 4 : CUP Camera transmittance curve

In the subsequent transmittance improvement scheme: such as Yellow PI → substrate glass/colorless PI^[2]; it can be optimized to 18%; this hybrid structure will be recommended by NB with CUP technology; COE to replace POL scheme; the transmission rate can be increased to more than 22%, however, the reflectivity is about 20% , we may use uniform illumination film to reduce the visibility of CUP area as much as possible.

Luminance Uniformity :

$$Lu = Tr * CIE * I_{pixel} * S_{pixel}$$

$$Lu_{(CUP)} / Lu_{(AA)} = I_{CUP} / I_{AA}$$

CUP area pixel driving mode is 1 to 2 design, to reach the same luminance, the current of pixels in CUP should be two times of AA area, for CUP increases the current, DTFT & Cst in pixel should be differentiated, DTFT W / L increases & Cst is reduced, the current of CUP area increases, so that the current of CUP area is 2 times of AA area. Involving the bright color difference between CUP and AA areas, The intuitive impact is mainly the high and low bright visible problem; The general optimization scheme is after the commissioning of Gamma, Location next to the acquisition CUP area; Brightness makes the gamma setting target, Then the advantage is that highlighting can achieve 2% brightness difference, Low brightness optimization is within 3.5% of the brightness (FIG 5) ; Combined with the Demura algorithm to further reduce the effect of the bright spot difference; In the subsequent improvement scheme, low light and low gray scale are easy to gamma NG problem, Will consider gamma interpolation solution, The main reason is that under the low light screen, The larger the screen body is, Local bright color difference is obvious, The bright color difference of the collection point affects the CUP Gamma debugging results; It is also related to the technological

ability of the screen body itself;

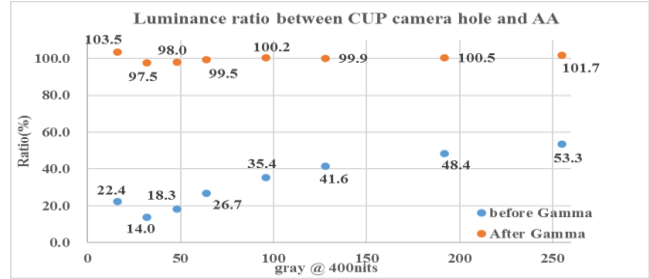


Figure 5 : Luminance ratio between CUP camera hole and AA CUP Life Span:↵

Another problem with CUP products is the low life span of the CUP area, Long-term use will also exist due to the rapid brightness reduction of the CUP area, Leading to the display of visible conditions, Mainly due to the low rate of pixel opening in the CUP area, When displaying the same brightness as the AA area, Increased current density, Further affect the pixel luminescence lifetime, It is also a visible pain point when CUP products are used for a long time, The effective scheme is to use the De-burn in algorithm for the CUP and AA regions, By setting up the multiple gray-scale capacities, can increase the CUP life span by more than three times, Further improve the product service cycle, Reduce the visible effect of the CUP area; ↵

Discussion:

Combined with the difficulty of low life and poor brightness control, and the characteristics of further improvement of the CUP technology, focus on development with COE stack and CPI scheme; corresponding also brings new materials, new technology difficulties, technology iteration to further improve product performance, provide consumers with the latest technology products, will also bring more extreme comprehensive screen experience; ↵

4. Conclusions

In this paper, we introduce the development process and progress of 4K Real RGB CUP medium-sized display OLED Panel(Figure 6). We have further analysis and discussion on CUP narrow border, Transmittance improved, Luminance uniformity improved, and CUP life improved, to provide reference for the subsequent development of CUP medium-sized display OLED Panel.

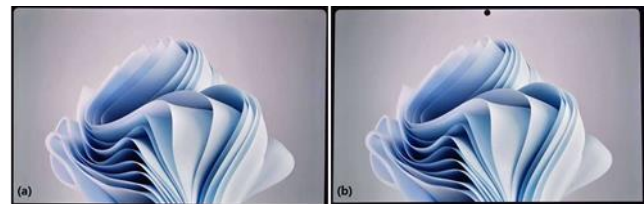


Figure 6 : (a) Display mode (b) Camera mode

5. References

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