55” High Contrast Ratio Panel Produced by Pixel Level Local Dimming Technology

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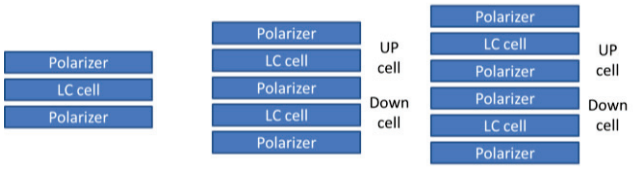
ABSTRACT

The contrast ratio is a important index for the LCD optics. The higher contrast ratio, the picture quality reconstructed by LCD is better. LCD module is constructed by back light and optical switch. And the LC is not an ideal optical switch, so the contrast ratio of LCD is lower than OLED. We use dual cell which can use pixel level local dimming to improve the contrast ratio, and it can make the contrast ratio from 5000:1 to 200000:1.

1 INTRODUCTION

Because the contrast ratio of LCD is not good, conventionally we use the local dimming technology to improve the contrast ratio. The more number of dimming zone, will cause the cost higher, so we used dual cell structure to make the pixel level dimming. Up cell is normal VA panel to show RGB picture, and the other one(Down cell) is the optical switch. There is not RGB in the down cell, and it is just a optical switch, and it will be used as the optical switch of pixel level local dimming[1][2].

Fig.1(a) is normal LCD, and fig.1(b) is 3-polarizer type dual cell and fig.1(c) is 4-polarizer type dual cell. The fig.2 is optics simulation result. Because the polarizer is not ideal, more number of polarizer will make higher contrast ration.



(a) (b) (c)

Fig.1
The structure of normal cell and dual cell

Item	Normal	3 polarizer	4 polarier
CR	5000	40000	200000
Transmittance	9.2%	7.6%	6.6%

Fig.2
The optics simulation result of normal and dual cell

2 EXPERIMENT

We use the 55” UD as up cell, and 55” FHD as down cell. The pixel arrangement of up and down cell as fig.3. Up cell is normal cell and down cell is white and black cell, and two sub-pixel of up cell are on one sub-pixel of down cell.

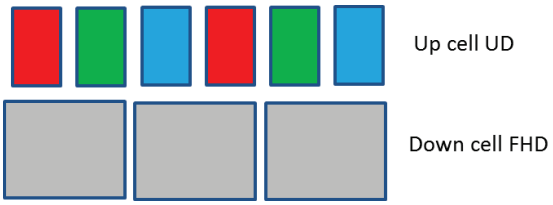


Fig.3
The structure of normal cell and dual cell

It need to fine tune gamma by new process as fig.4. First we kept the down cell in 255 gray level, then tuned the gamma of up cell as 2.2, and made the color of gray as same as white color. Finally we fine tuned the down cell make the dual cell as gamma 2.2.

The result of dual cell gamma tuning as fig.5. The gamma of up cell is almost 2.2, and the gamma of down cell is less 1. Finally we can make the gamma of dual cell module is gamma 2.2.

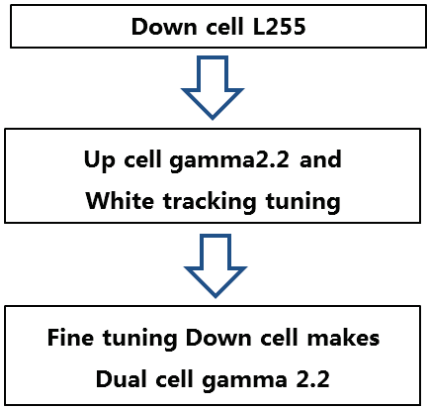


Fig.4
Gamma tuning process of dual cell

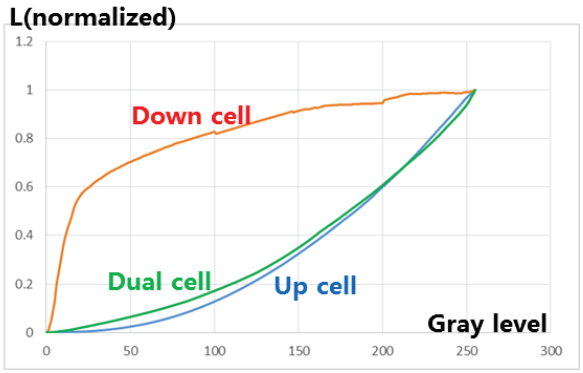


Fig.5
Gamma curve of up and down and dual cell

Up and Down cell pixel pattern as fig.6, fig.6(a) is up cell pixel structure, and there are RGB sub-pixels. Fig.6(b) is down cell pixel, and there is not RGB sub-pixel. When we laminate Up and Down cell, The misalignment between down and up cell caused by the accuracy of lamination. It will cause the moire issue, because there is interaction between up pattern and down pattern. Fig.6(c) is up cell combined with down cell, and we can see the moire issue if it occur misalignment between up and down cell [3][[4][5].

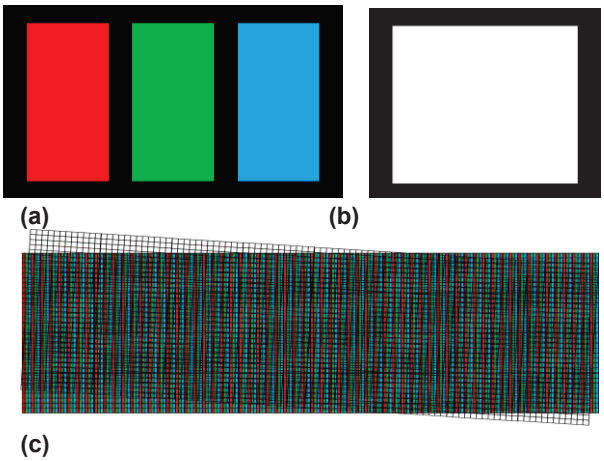
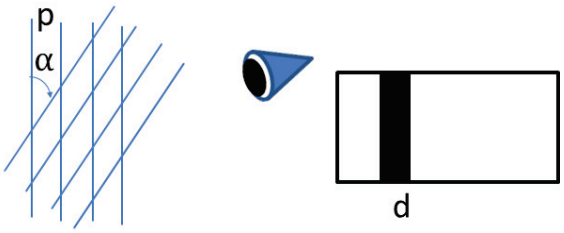


Fig.6
Up and Down cell pixel pattern

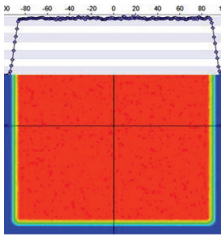
Fig.7 is the calculation of Moier issue. There are two regular pattern, and one patter rotated an angle α from the other one patter which caused by misalignment in lamination process. It will occur the moire issue, and we can estimate the width of moire. How wide the width of moire related with the angle α and pattern pitch p.



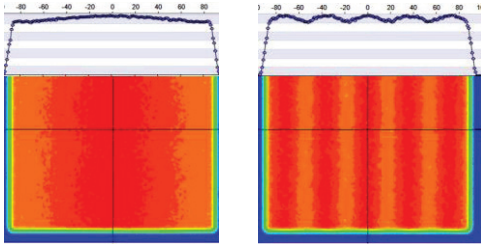
$$d = p/\sin\alpha$$

Fig.7
The calculation of Moire issue

We simulated the moire issue by light-tools, and we can find the bigger shift angle α , the narrower the width of moire, but the number of moire increased. Fig.8(a) is ideal lamination situation, and there is not misalignment between up and down cell, so it won't be found the moire. Fig.8(b) is misalignment 0.5 degree between up and down cell, and we can see the moire in center. From fig.8(b) and fig.8(c), we can find the bigger shift angle α , the narrower the width of moire, but the number of moire increased.



(a) non-misalignment



(b) misalignment 0.5° (c) misalignment 1.0°

Fig.8
The simulation result of Moire issue

As fig.9 we add an optical film to improve the moire issue. The optical film is high haze value to improve the moire. The high haze value optical film will diffuse the light from down cell, and deform the patter of down cell, so it can decrease the interaction between up and down cell, and improve moire issue

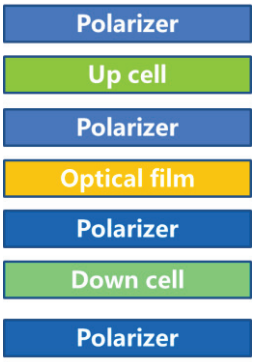
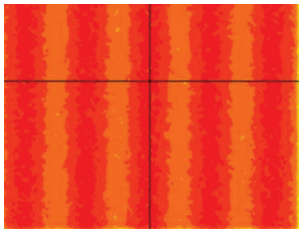
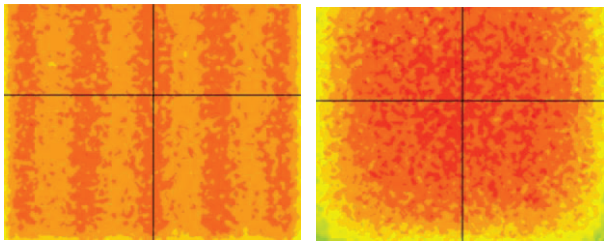


Fig.9
The cell structure to improve Moire issue

We simulated with different haze value optical film. Frist we can see the serious moire phenomenon without optical film between up and down cell. Second we simulated and find the moire became slight by 40% haze value optical film, and the moire is invisible with 90% haze value optical film.



(a) Without optical film



(b) 40% Haze (c) 90% Haze

Fig.10
Simulated moire with different haze value optical film

Fig.11 is moire phenomenon with different haze optical film. Moire is serious without optical film. It became slight when increased haze value to 40%, and the moire is invisible if we increase haze value to 90%. The real phenomenon is similar as simulation. We used haze 90% optical film between up and down cell to improve the moire issue.

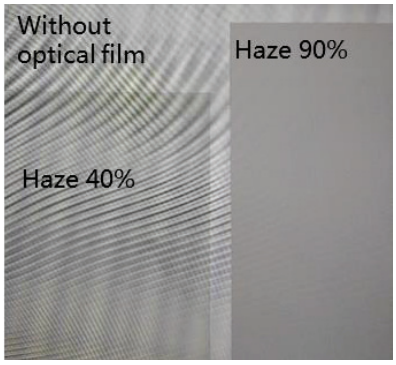


Fig.11
Moire with different haze value optical film

3 RESULTS

As table.1 we compared the optical performance of dual cell with normal VA. 55” UD which is normal VA and the resolution is 3840x2160 RGB. 55” UD Dual cell is two 55” cell laminated, and up cell is 55” UD normal VA cell and down cell is 55” FHD without RGB.

The contrast ratio(CR) of 55” UD dual cell is very high, and it can reach about 1:200000, so the light leakage is almost 0, and it can show the perfect dark. Because dual cell is two cell laminated and there is high haze value optical film between two cell, the transmittance of dual cell is lower than normal VA. The NTSC of dual cell is almost the same with normal VA.

Item	55" UD VA	55" UD Dual Cell
NTSC	73.0%	72.8%
CR	6269	201943
L(nits)	384	176
Tr	4.85%	2.20%

Table.1
The optical performance of 55” UD VA and Dual cell

Fig.11
The optical performance
with pixel dimming OFF or ON

Fig.11 we can see the different if the pixel local dimming ON or OFF. When the pixel local dimming ON, the brightness of dark is lower than local dimming OFF. The picture sharpness is high when the pixel local dimming ON, and the picture quality is better.

4 DISCUSSION

Because dual cell is two cell laminated and there is high haze value optical film between two cell, the transmittance of dual cell is lower than normal VA. Next we will try to fine tune the pattern of pixel to avoid the interaction between up and down cell, which can improve the moire, and decrease the haze value, then we can increase the transmittance.

5 CONCLUSIONS

We used two laminated cell to make high contrast ratio, then we applied the high haze optical film to improve the moire issue. Finally we created the high contrast ratio LCD, and solved the low contrast ratio problem of LCD successfully.

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