2.2 inch QCIF+ Active-Matrix Organic Light-Emitting Diode Display With High Performance and Mass Productive Ability

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Abstract

This paper described a 2.2" QCIF$^+$ (176xRGBx220) active matrix organic light-emitting diode display (AMOLED) using low-temperature poly-silicon (LTPS) technology. We have designed the OLED pixel to match the OLED material characteristic with COG specification and optimized pixel structure to improve color gamma adjustment and simplify signal complexity..

1. Introduction

In recent years, because of its thinness, high lightness, fast response and wide view angle, AMOLED displays are drawing attention as the next-generation flat panel display. Now the commonest application is portable product and cell phone panel, like PDA, cell phone and multimedia player, .etc.

AMOLED pixel can be driven in the manner similar to AMLCD, it needs a switch device to transfer image data into storage capacitance and the other TFT is taken as driving component. Due to OLED is current-driven device, the stable TFT output current is an important key of AMOLED displays. Low Temperature Poly-Si (LTPS) TFT have greater reliability and larger driving current than a-Si TFT. Consequently, LTPS TFT is applied in AMOLED pixel widely.[1] [2] [3]

In this paper, we only use LTPS TFT to design pixel with new consideration. In next product, the peripheral circuit will be integrated on the panel.

2. Pixel Design

The Product is fabricated by low temperature poly-si CMOS process. Because the pixel is bottom emission type, we use the simplest pixel circuit structure (2T1C) to increase aperture ratio and brightness.

2.1 LTPS TFT and OLED Characteristic

The LTPS TFT characteristic and parameters decide design condition and panel performance. In the cause of achieving optimum design, the LTPS TFT and OLED must be extracted accurately. As shown in Figure 1, the Id-Vg characteristic of TFT which is described. The Width/Length dimension of TFT is 8um/8um. Threshold voltage of n-type and p-type TFT are almost symmetry and their slope swing is below 0.4. And structure of n-type TFT is light doped drain (LDD) for decreasing off current and enhancing reliability and p-type TFT is self-align (SA) .

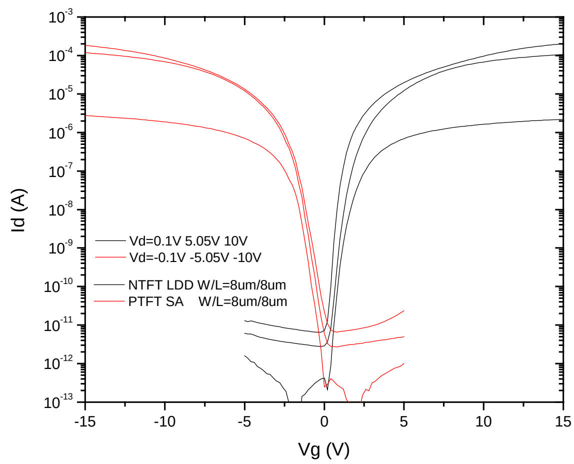

Figure 1.Characteristic of NTFT and PTFT

OLED brightness depends on TFT driving current which has close relation with mobility, threshold voltage and process variation. Therefore, the TFT uniformity will decide product performance as shown in Figure 2. On 550mm x 670mm glass substrate, the variations of threshold voltage and mobility conform to our design requirement.

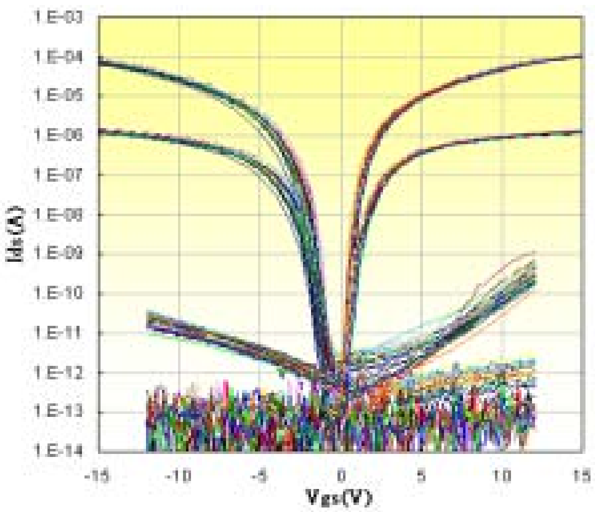

Figure 2.Uniformity of NTFT and PTFT on glass

2.2 Pixel Architecture

Owing to applying in high resolution cell phone panel, we adopt 2T1C framework to keep aperture ratio and simply processes. So the uniformity of TFT is very important to 2T1C structure.

In 2T1C framework, the LDD n-TFT is taken as switch device, p-TFT is driving element as shown in Figure 3. LDD n-TFT has low and stable leakage current to reduce data loss of storage capacitance for keeping precise gray level. Using p-TFT as driving device will avoid affecting OLED current on account of OLED voltage.

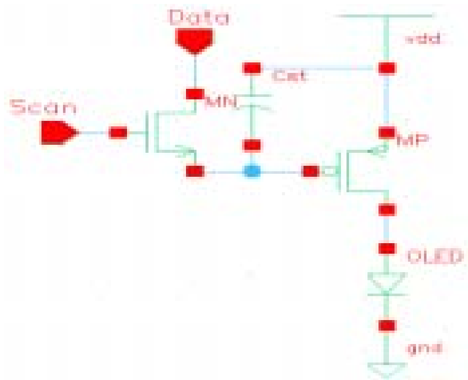

Figure 3.Archtiture of OLED Pixel

2.3 Design Specification

The B-J-V curve and CIE coordinate of RGB OLED shows in Figure 4 and Figure 5. As shown in Table1, we design pixel in accordance with product specification including brightness, gray scale, etc. White CIE coordinate would be set at (Wx, Wy) = (0.285, 0.293) at 9300K and brightness is 150 nits (cd/m^2).

According to RGB CIE coordinate, red-OLED must contribute 212 nits, green-OLED contribute 59nits and blue-OLED contribute 179nits per each pixel for gaining brightness of panel (150nits).

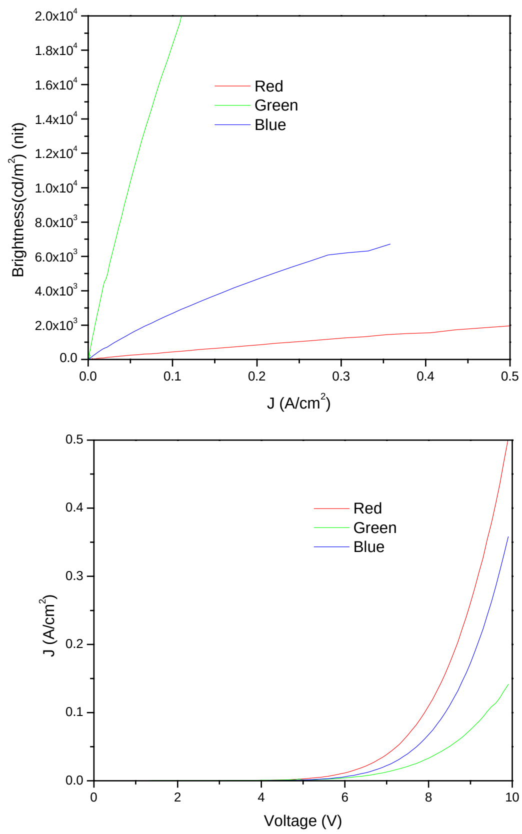

Figure 4.B-J and J-V Curve of RGB OLED

Active area	2.2" diagonal
Resolution	(176 R.G.B) x220 QCIF+
Pixel size	66umX198um
Colors	6bit 262k
Brightness	150 nit @ 9300K

Table 1.Design Specification

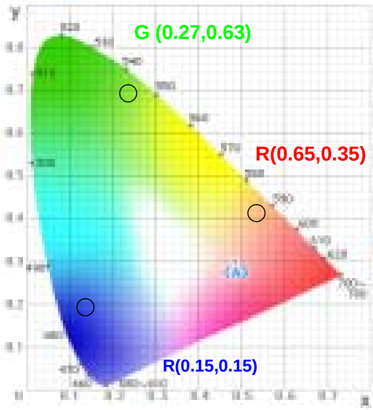

Figure 5.CIE Coordinates of RGB OLED

Due to RGB OLED efficiency and CIE coordinates, the aperture ratio of RGB pixel was set Red=50%, Green=30% and Blue=40%. So the brightness of red, green, blue is 424nits, 197nits and 448nits. From Figure 4, we can obtain the corresponding OLED current of RGB sub-pixel. The relation of brightness and current density is almost linear, therefore, the 6 bit (64) gray level current also is calculated directly.

2.4 Design Consideration of Pixel TFT

We change OLED gray scale current by controlling Vgs of PTFT as driving current source and operate TFT during saturation region to avoid OLED voltage influencing TFT drain current. It plays a very important role that choosing suitable TFT size in OLED pixel. In order to keep stable output current, we design long channel TFT which has few channel moderation effect and kink effect.

As is known to designer, RGB OLED material have different optoelectronic characteristic. For the sake of achieving optimum display quality, the OLED panel used three gamma data IC to adjust RGB gray level individually. This method increases routing complexity and IC cost, therefore, we design special pixel TFT and OLED emission area to simply signal gamma to cost down and lower routing line numbers. It could simply panel system and raise yield effectively.

As shown in Figure 6, we tried to revise the relations of TFT size and OLED emission area to gain approximate single gamma and operate OLED at high lighting efficiency region. In green sub-pixel, we use Width/Length=3um/150um long channel length TFT to compatible gamma of red, blue sub-pixel.

We simulated driving PTFT with OLED with extracted spice model and plotted the result as shown in Figure 7. The OLED load line was maintained at saturation region to reduce current variation.

Then the LDD n-type TFT was treated as switch device that has low leakage current (~0.7pA). Figure 8 showed characteristic of switch NTFT which keep about one gray level loss.

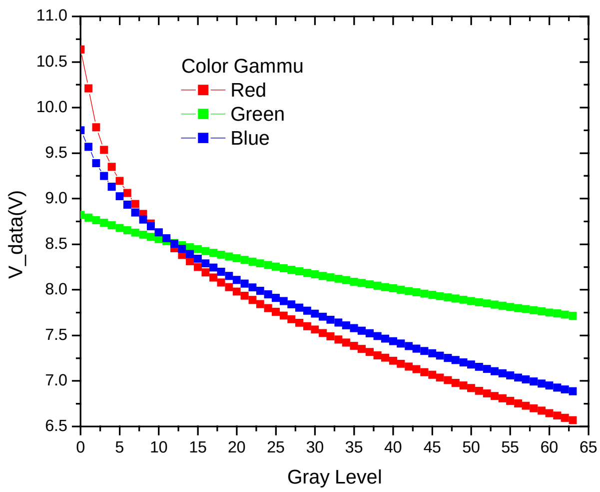

Figure 6.Relation of Data and Gray Level

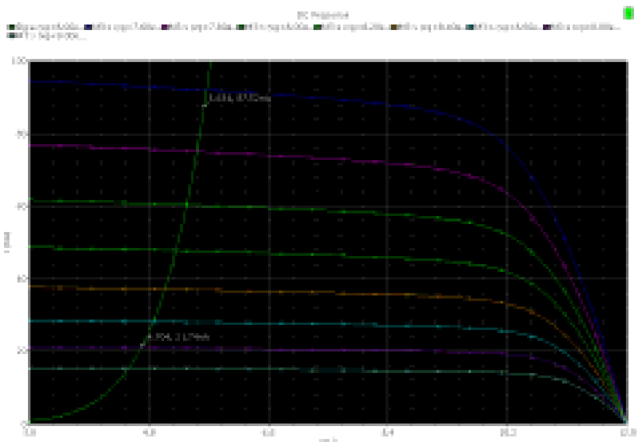

Figure 7.Load Line of OLED and TFT

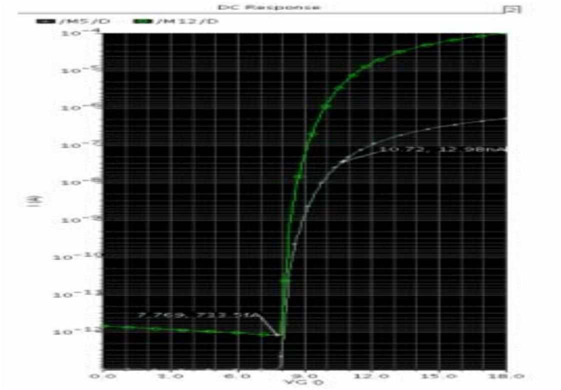

Figure 8.Characteristic of Switch Device

3. Panel Design

In this case, we use integrated gate driver and source driver COG. Besides, we also considered voltage dropping issue and adjusted power line width to reduce gray level loss. The panel diagram shows as Figure 9.

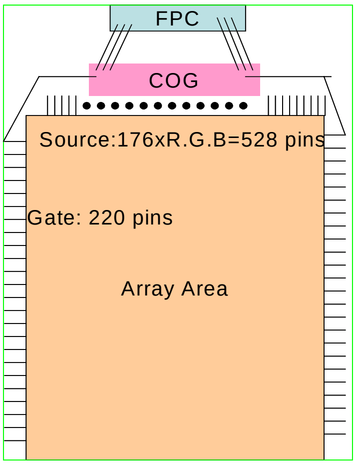

Figure 9.Panel Diagram

4. Summary

We have developed a 2.2 inch "QCIF+" (176xRGBx220) AMOLED using LTPS technology. This new pixel using one gamma adjustment was designed to simplify the driving system of OLED. The Figure 10 shows the pixel layout, RGB pixels have different emission area and power lines are combined to increase active region. In next step, we would integrate gate driver and source driver on glass to reduce I/O pins and scale down the frame of panel.

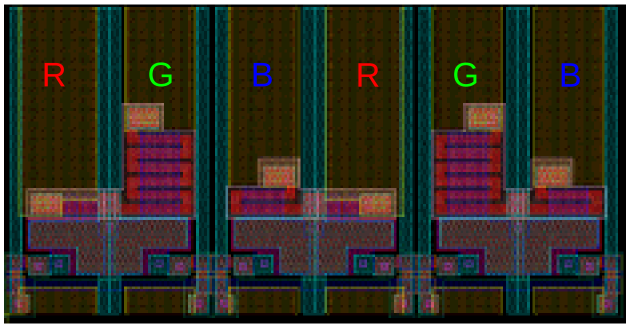

Figure 10.RGB Pixel Layout

5. References

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[2] M. Johnsom, etc., IDW 00, p235~238.

[3] S Z . M. Meng, H.S.Kwok and M. Wong, SID 02 Digest, 976(2002)