A Novel LTPS pixel circuit to achieve high uniformity at low gray scale

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Keywords: AMOLED, pixel circuit, initialization

ABSTRACT

A novel LTPS pixel circuit is proposed, which can achieve high uniformity at low gray scale and improve the image quality of displays. Simulation results show that a more complete initialization of OLED device is achieved compared to typical 7T1C circuit, which is more suitable for displays at high frame rate and can achieve high uniformity at low gray scale.

1 Introduction

Active-matrix organic light-emitting diode(AMOLED) display will be the next-generation display because of its high contrast ratio, fast response time, wide viewing angle, vivid colors, and high brightness[1-3]. Hydrogenated amorphous silicon thin-film transistors(a-Si:H TFTs) and low-temperature polysilicon (LTPS) TFTs have been extensively used as the backplane of AMOLED displays because of their low fabrication cost and high current driving capability, respectively with low temperature polysilicon thin-film transistor (LTPS-TFT) backplane because of the high mobility of LTPS-TFT and the fast response time of OLEDs.

As the resolution and frame rate increase for the requirement of good image quality, the reduced scan time leads to the insufficient initialization, leading to the poor image quality at low gray scale for the displays. the initialization time is limited at most to one horizontal line time (1H), which is determined by the frame rate and the vertical resolution of the display panel. The mura of OLED display tends to be severe as the initialization time decreases, especially at low gray scale. To extend the initialization time beyond this limit, a novel pixel circuit with initialization time doubled were proposed to realize high-resolution and high-frame-rate panels for high image quality of AMOLED displays.

This work proposes a new p-type LTPS pixel circuit for high-resolution and high-frame-rate AMOLED displays. By adding a TFT to the typical 7T1C, the initialization time is doubled, which can accomplish a more complete initialization of OLED device and achieve high image quality at low gray scale .

2 The Proposed Pixel Circuit

The typical 7T1C circuit is shown in Fig.1(a). A new pixel circuit is developed, as shown in Fig.1(b). It is composed of 8 TFTs and 1 capacitor. M8 is added between VREF signal and the anode of OLED, whose gate is controlled by S1_N signal.

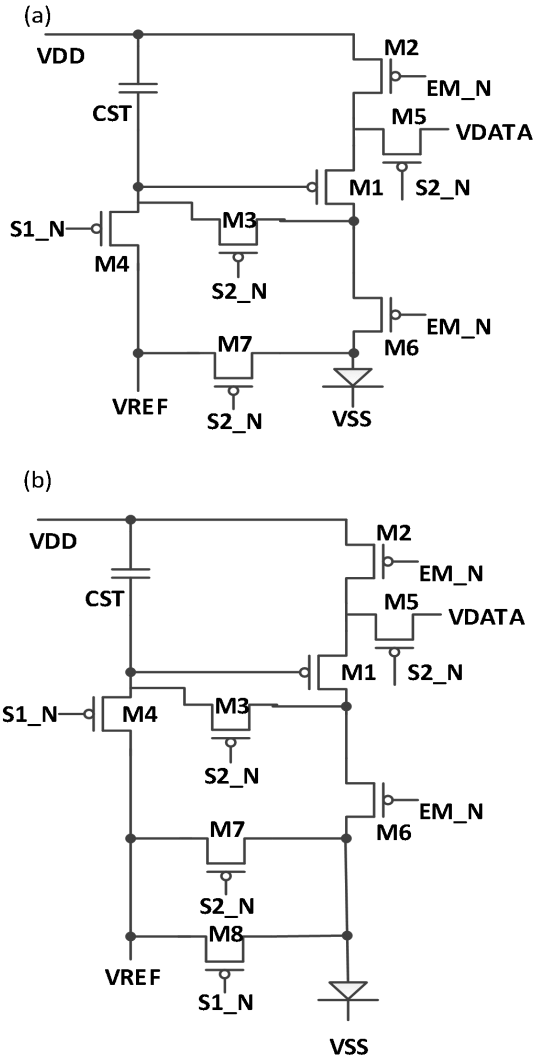

Fig.1 (a)Typical 7T1C circuit. (b) novel 8T1C circuit

And the driving wave-forms for the pixel circuit are shown in Fig.2. SCK1 and SCK2 is the clock signal of scan circuit. S1_N and S2_N is the one level and the next level of scan signal. EM_N is the emitting signal.

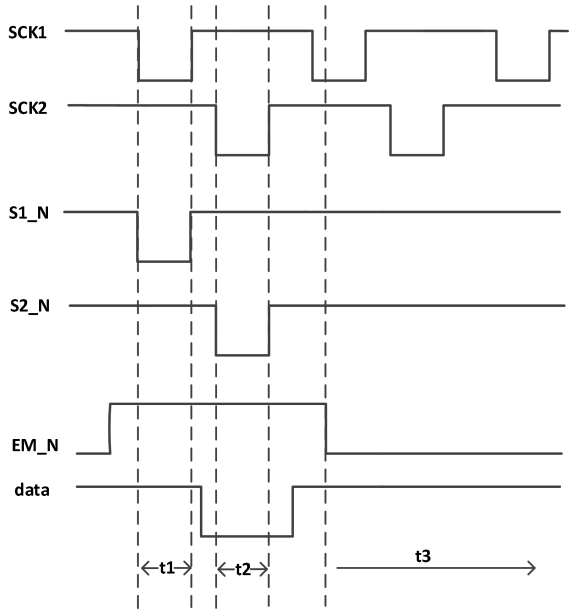

Fig.2 The driving wave-forms for the pixel circuit.

The circuit works as below:

The operation of proposed circuit can be divided into three periods, including initialization period (t1), writing period(t2) and illumination period(t3).

t1 period: S2_N and EM_N are set to high level, S1_N is set to low level. VREF is a negative DC voltage level. As for typical 7T1C circuit, in this period, M4 is open and the gate of M1 is initialized to VREF.

t2 period: EM_N is kept at high level, while S1_N is set to high level and S2_N are set to low level. M5, M1, M3 is open and VDATA is written through M5, M1, M3 transistors to the gate of M1. the writing period is ceased when Vgs=Vth of M1. At the same time, as for typical 7T1C circuit, M3 is open and the anode of OLED is initialized to VREF. As for our novel 8T1C circuit, M7 is open during the t2 period and M8 is open during the t1 period. Therefore, the OLED is initialized at both t1 and t2 period. In other word, the initialization time is doubled.

t3 period: EM_N is set to low level and S2_N is set to high level, while S1_N is kept as high level. M2 and M6 is open, the OLED is illuminated. IOLED is described as below:

$$I_{\mathrm{OLED}} = \frac{1}{2}\mu\, C_{ox}\frac{W}{L}(\mathrm{V}DD - \mathrm{V}DATA)^2 \quad (1)$$

Here μ_{p}, C_{ox} and $\frac{W}{L}$ are the constants.

3 Results and discussion

We used SmartSpice of Silvaco Inc. and p-channel poly-Si TFT model to investigate the initialization degree of OLED. The model parameters of. Figure 3 shows the transfer characteristics of the p-channel poly Si TFT models used in the SPICE simulation. poly-Si TFT were extracted from the measured LTPS TFT characteristics in the commercial product.

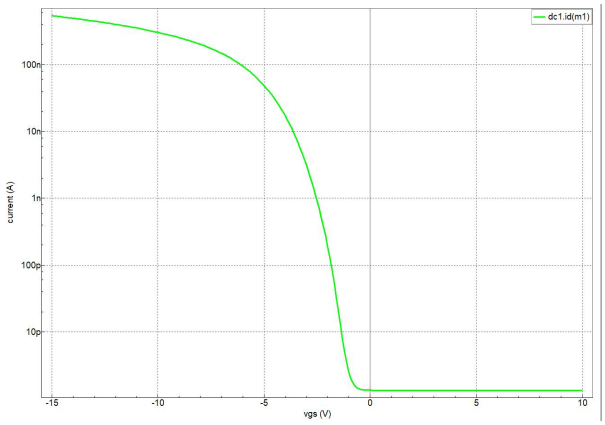

Fig.3 The transfer characteristics of the p-channel poly Si TFT models of W/L=4.5u/25u.

Fig.4(a) shows the simulation results of typical 7T1C circuit and our novel 7T1C circuit.The line in blue is the waveform of OLED anode voltage of novel 8T1C circuit while the line in cyan is the waveform of OLED anode voltage of typical 7T1C circuit. The green line is the waveform of S1_N and the red line is the waveform of S2_N.

As for typical 7T1C circuit, in the t1 period, the gate of M1 is initialized to VREF. In the t2 period, the anode of OLED is initialized to VREF. In our case, VREF is set to -3 V. As we can see, as the initialization time is limited, especially at high frame rate, the voltage of OLED anode is not fully initialized to -3V but to -2.982 V. There are difference between the loading of VREF at different area of the panel. For example, the loading of VREF at Display area far away from the IC is larger than that of display area near the IC. The loading of VREF at display area at the center is larger than that at the side of the panel. As a result, the initialization degree is various for the whole panel, which is non-negligible at low gray level and affected the brightness at different area. Therefore, the uniformity is largely affected.

As for our novel 8T1C circuit, in the t1 period, the gate of M1 is initialized. Meanwhile, the anode of OLED is also initialized. The anode of OLED is lower than that of 7T1C circuit. That is because the loading of S1 is smaller than that of S2. In the t2 period, the initialization of anode of OLED continues. In other words, the initialization time of OLED equals to t1 plus t2, which

means the initialization time is doubled. As the simulation results show, the voltage of OLED anode is initialized to -2.9906V, which is lower than that of typical 7T1C circuit. So a more complete initialization of OLED is accomplished. As a result, the uniformity is optimized as the difference of initialization is narrowed down.

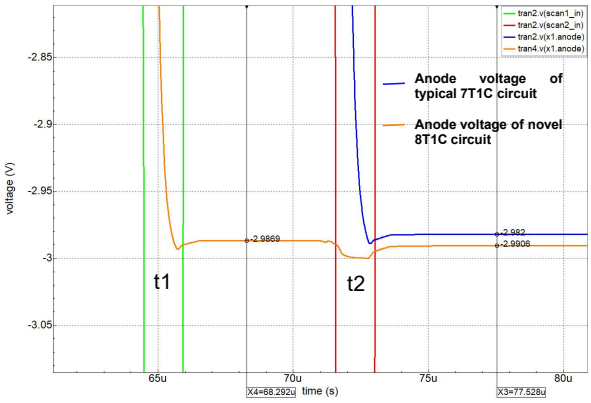

Fig.4 The simulation results at typical 7T1C circuit and novel 8T1C circuit

4 Conclusions

A novel LTPS pixel circuit is proposed, a complete initialization of OLED anode is achieved, which improves uniformity at low gray scale, resulting in high image quality of displays.

References

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