A Novel a-Si TFT Backplane Pixel Structure Using Bootstrapped Voltage Programming of AM-OLED Displays

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Abstract

We propose a novel pixel structure using bootstrapped voltage programming for amorphous-silicon TFT backplane of AM-OLED (Active Matrix-Organic Light Emitting Diode) displays. The proposed structure is composed of two TFTs and one capacitor. It operates at low drive voltage (0~5V) which can reduce power consumption comparing with the conventional pixel circuit structure using same OLED material. Also, it can easily control dark level and use commercial mobile LCD ICs. In this paper, we describe the operating principle and the characteristics of the proposed pixel structure and verify the performance by SPICE simulation comparing with the conventional pixel structure.

1. Introduction

Active Matrix – Organic Light Emitting Diodes (AM-OLED) displays have received an attention due to high brightness, good color purity, fast response time and wide view angle [1].

Pixel device of AM-OLED display uses mainly low temperature polycrystalline (LTPS) TFTs because the mobility can be one to two orders of magnitude higher than hydrogenated amorphous silicon thin-film transistors (a-Si:H TFTs). Therefore, the current of LTPS TFTs can drive more than a-Si:H TFTs in the same TFTs width. However, LTPS TFTs fabrication cost increases due to more fabrication steps. So, to achieve low fabrication cost using the existing facilities for fabrication, a-Si:H TFTs should be combined with OLED [2-5].

In this paper, to overcome low output current problem of the a-Si:H TFT backplane AMOLED, we propose bootstrapped voltage-programmed pixel circuit for AM-OLED. It can drive more output current than the conventional pixel structure in the same driving data voltage. Therefore, it can reduce power consumption.

2. Proposed Pixel Circuit Scheme

Figure 1 shows the proposed a-Si:H TFTs pixel circuit. The pixel circuit consists of switching TFT (T1), driving TFT (T2), one storage capacitor (C1) and three control lines (Data, Scan, V_{SW}). In case of n-type pixel structure, the anode node of OLED is connected to the driving TFT (T2) source node. Data signal and scan signal can be made by driver ICs. V_{SW} signal is inverted the scan signal. It can be made by integrated n-type inverter circuits using scan signal.

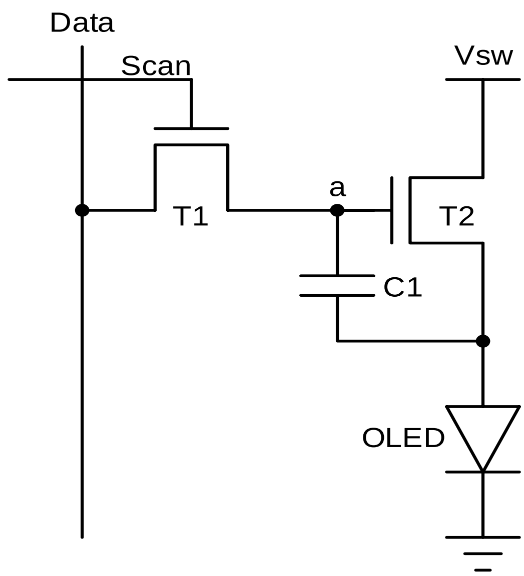

Figure 1. Proposed pixel design

The operation of the pixel circuit is described as follows in two stages shown in figure 2. In first stage, (A), data writing is performed. Scan, data signal goes high and V_{SW} signal goes low, turning T1 and T2 on. Thus, node “a” would be charged up close to data voltage, while data is applied to it. In second stage, as shown in figure 2 (B), bootstrap effect should be obtained during an emission period. Scan, data signal goes low and V_{SW} signal goes high, turning T1 off and turning T2 on. At this time, storage capacitor (Cs) is bootstrapped by the charge of anode node of OLED.

Finally, the driving TFT (T2) operates of saturation region and drives current through OLED.

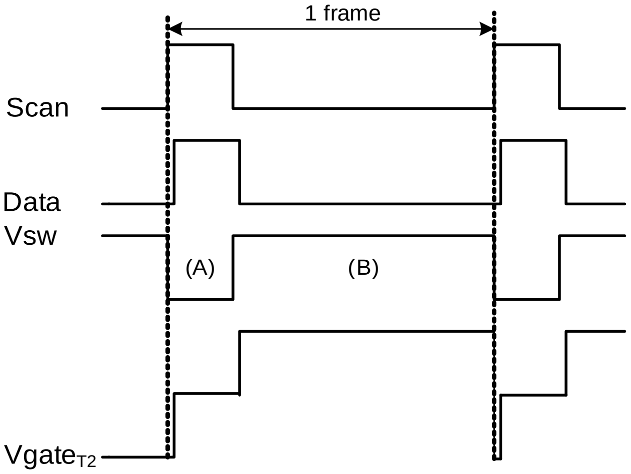

Figure 2. Timing diagram

3. Simulation Results

We performed circuit simulation by using SMART-SPICE to verify the proposed pixel circuit. Device parameters of a-Si:H TFT were extracted from fabricated a-Si:H TFT. The electrical characteristics of an OLED used in this simulation were replaced by diode-connected TFT of which device parameters were extracted from experimental data OLED having a luminance efficiency of ~2cd/A and ~220cd/m^2 at ~8V.

Table 1. Simulation parameters

Mobility	V_{TH}	W/L (T1)	W/L (T2)
0.563cm^2/Vs	1.09V	20 / 4 um	100 / 4 um
V_{SCAN}	V_{DATA}	V_{SW}	C1
-10 ~ 20V	0 ~ 5V	-10 ~ 20V	0.2 pF

Figure 3 shows the simulation results of the conventional pixel circuit (a) and the bootstrapped pixel circuit (b). In figures, input data voltage, drain, gate, source voltage of the driving TFT (T2) and data, scan voltage are represented. OLED current, I_{OLED} is related to driving TFT (T2) drain to source current of the I_{DS2} and the I_{DS2} is proportional to $(Vgs_2\text{-}Vt)^2$ where Vt is the TFT threshold voltage. Therefore, the higher Vgs_2 is, the higher OLED current is. Comparing Vgs_2 of driving TFT(T2) gate to source voltage for the conventional pixel circuit with Vgs_2 of driving TFT(T2) gate to source voltage for bootstrap pixel circuit, Vgs_2 was about 0.4V and 6V simulated respectively.

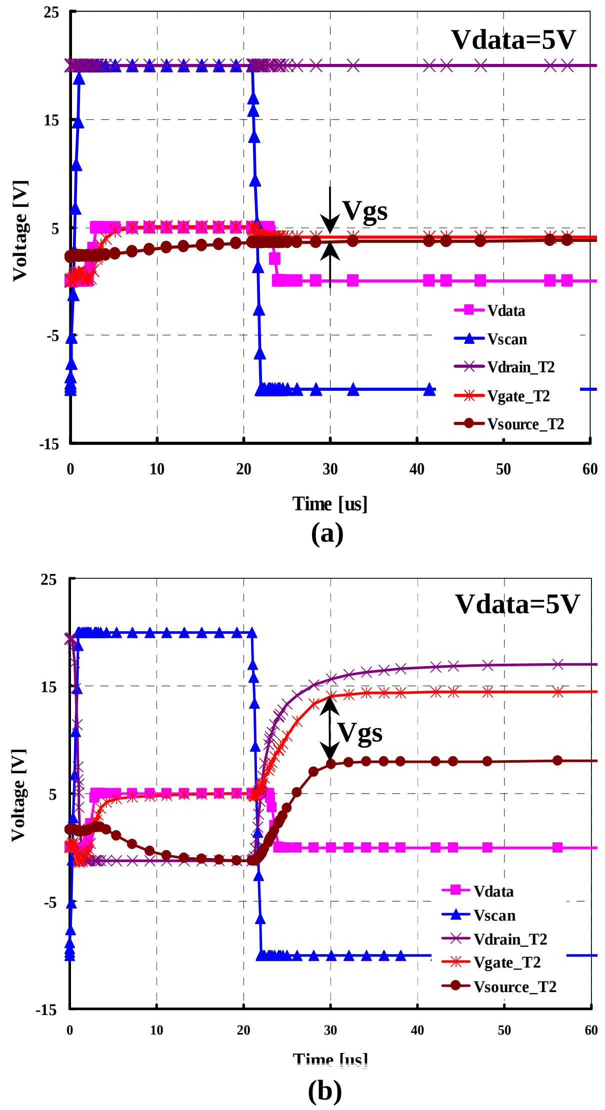

Figure 3. Simulation results: voltage of each node's and input signal for conventional 2TFT 1Cap. (a) and for bootstrap 2TFT 1Cap. (b)

Figure 4 shows the difference in I_{OLED} when it applied data input 5V to conventional pixel circuit and bootstrap pixel circuit. A significant difference is shown over emission period. I_{OLED} was about 0.003uA and 2.4uA simulated respectively. Figure 5 shows the simulated OLED current versus 6bit gray-level counting, where use data 0~5V.

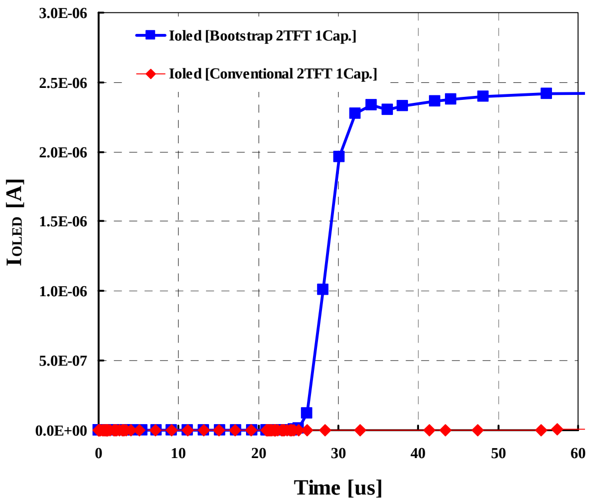

Figure 4. Simulation results: OLED current of input data=5V

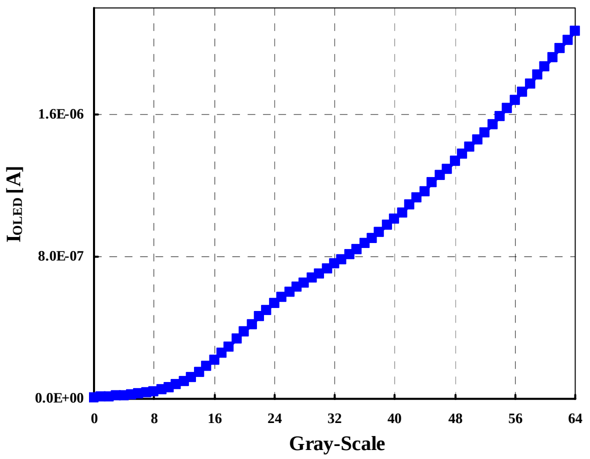

Figure 5. Simulation results: OLED current versus Gray-level characteristic

4. Conclusion

We have proposed a novel pixel circuit using bootstrapped voltage programming for a-Si:H TFTs backplane AM-OLED. The proposed pixel design was verified by SPICE simulation, which is based on extracted parameter by experimental measurement of a-Si:H TFTs. The simulation results show that operates low drive voltage (0~5V) and controls gray-level. Therefore, the pixel circuit can reduce power consumption as well as use mobile LCD driver ICs. The proposed pixel circuit may suitable for small size AM-OLED display based on a-Si:H TFTs backplane.

5. References

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