Amorphous Silicon Backplane for Active-Matrix Organic Light-Emitting Diodes

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In active-matrix OLED, a brightness uniformity is the most important issue for large area display, which is affected by the performance and stability of thin-film transistors (TFTs). The OLED with LTPS technology suffers from non-uniform brightness because of the threshold voltage variation which is caused by the nature of eximer laser annealed poly-Si materials. To overcome this, several methods, such as voltage modulation driving, current programming technology and digital modulation methods have been reported [1,2].

While, the a-Si:H TFT has a good uniformity in the threshold voltage and the mobility over large area. But the threshold voltage shift by gate bias during OLED operation is a serious problems [3,4].

In this study, we designed and fabricated the bottom-emission AMOLED of 1-inch diagonal size with 160X120 pixel using a-Si:H TFTs. We tested the degradation in light emission associated with the TFT stability. The stability of TFT depends on the deposition conditions of SiNx and a-Si:H.

Figure 1 shows the transfer and output characteristics of the a-Si:H TFT in the array. The TFT exhibited the field effect mobility of $0.4 cm^2/Vs$, the subthreshold slope of 0.74V/dec., and threshold voltage of 4.5V. Because of the contact holes, the TFT performance is a little degraded compared to a single TFT fabricated simultaneously.

Figure 2 shows the equivalent circuit diagram of AMOLED. It includes a switching TFT, a driving TFT, a storage capacitor (C_{st}) and an OLED. The operating characteristic of the circuit depends on the trans-conductance properties of driving TFT to produce a voltage controlled current source. To realize this pixel, we adopted inverted staggered back-channel etched tri-layer a-Si:H process with a maximum process temperature of 300^oC. The pixel has a pitch of 127μm (200ppi) and a bottom emissive aperture ratio of 40.6%. The sizes of driving and switch transistors are W/L = 120/5 and W/L = 25/5, respectively.

Figure 3 shows the J-V-L characteristics of OLED with a-Si:H TFT driving. The typical organic polymer was used for the OLED fabrication. The brightness of OLED shows $300cd/m^2$ at the data voltage of 8.8V and the current density of $12mA/cm^2$.

Figure 4 shows the top view of AMOLED with a-Si:H TFTs and its illuminated state. We achieved very uniform brightness over 160×120 pixels. At the luminance of $300cd/m^2$, the pixel current of the AMOLED pixel current was ~1μA.

The stability of a TFT as well as an OLED will be presented together with the dependence on the process conditions. The a-Si TFT can be used for AMOLED for over 10,000 operations under $300cd/cm^2$ without using a polarizer.

References

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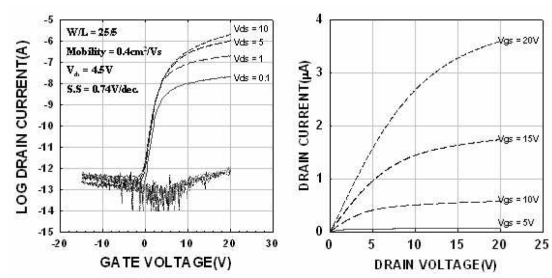


(a) (b)

Figure 1. Transfer (a) and output (b) characteristics of a typical a-Si:H TFT in AMOLED arrav.

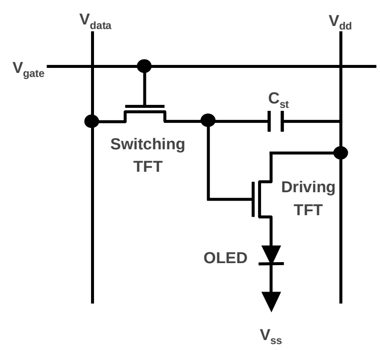


Figure 2. The equivalent circuit of a two TFT pixel for AMOLED.

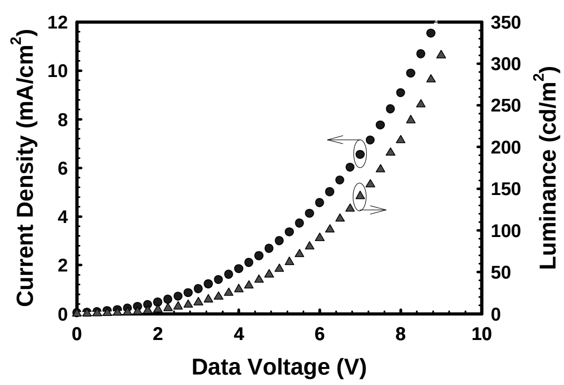
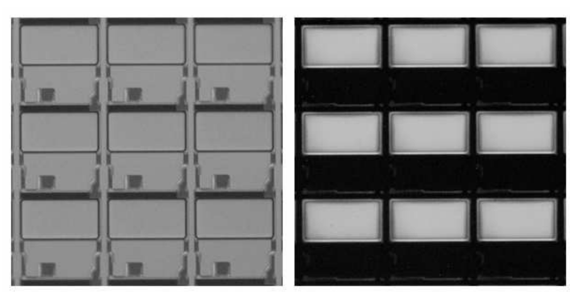


Figure 3. J-V-L characteristics of a polymer OLED with a-Si:H TFT driving. (Vgate = 15V ~ -5V, V_{dd} = 15V ~ -5V, V_{SS} = - 5V)



(a) (b)

Figure 4. Top view of a-Si:H TFTs AMOLED(a) and photograph of light-emitting over 3 x 3 pixels in AMOLED(b).