Chapter 7

Summary and Conclusions

In this dissertation, design for variations between LTPS-TFTs devices is the core idea. Nowadays, variations are a major limitation for manufacturing these polysilicon thin film transistors in the display. Various device structures with traditional process and circuit compensation techniques are two aspects to be researched and developed in this work.

In the chapter 2, a variety of closely spaced arrays of nominally identical devices were manufactured with various geometries. The matching properties of LTPS TFTs have been measured and analyzed. It is observed that interdigitated arrangement have better tolerance than parallel arrangement and perpendicular arrangement in electrical data statistically of matching TFTs. The uniformity in the multi-channel structure of low-temperature polycrystalline silicon thin film transistors has been proved to be superior to the single channel, especially in the threshold voltage and sub-threshold swing. Only layout method must be modified without changing the original process or additional masks.

Three possible mechanisms influencing uniformity have been discussed to explain the better uniformities which are effective tri-gate structure, passivation effect, and grain distribution effect. Among these possible mechanisms, grain distribution effect is considered to be the dominate factor in our experiment. The major advantages are that the threshold voltage and sub-threshold swing difference between multi-channel devices will be reduced.

In the chapter 3, dimensional effects of transistors and storage capacitor in conventional pixel circuit are simulated proving individual functions. An overview of all pixel compensation circuits for active matrix organic light emitting diodes are simulated and compared in detail. Digital driving method needs high addressing speed causing higher power consumption or complicated processes for high resolution or high gray scale display. Since high addressing speed is difficult for time ratio method, and the decrease of a pixel pitch may be difficult for area ratio method.

As for current programming method, it compensates both threshold voltage and mobility variation. However, a critical problem happens that takes long charging time when low data current occurs in current copy method. Cost will be raised that additional driver IC must be added providing constant current source. Otherwise, if current mirror method is adopted still has matching transistor issues. It is believed that the voltage programming method is more beneficial and attractive to integrate poly-Si TFT data drivers on the display when realizing better uniformity and system on panel.

To overcome the problems caused by spatially non-uniform characteristics between thin film transistors across the glass panel, two new pixel circuit designs for active matrix organic light emitting diodes based on the low-temperature polycrystalline silicon thin-film transistors were proposed and verified by SPICE simulation results. Diode connection concept was adopted in this compensation circuit. Threshold voltage compensation pixel circuits consisting of five TFTs, one additional control signal, and one storage capacitor were used to enhance display image uniformity. For eliminating the current flow through OLED during the reset period in each frame, a p-channel TFT is replaced to block the emission current through OLED.

In the chapter 4, to measure the impacts of each component on individual pixel circuit, a measurement system was set up to evaluate the anode voltage of OLED successfully. Dimensional effects of conventional pixel circuit are investigated and explained by the experimental results. Through experimental results, it is verified that the proposed circuit is capable of reducing the threshold voltage variation problem of conventional pixel circuit and possessing larger output current.

Compared with conventional 2T1C pixel circuit and other pixel, the new pixel circuits show much consistence of driving current against threshold voltage variations from experimental results.

In the chapter 5, operational amplifier type and source follower type analog buffer circuits are simulated and compared in this section. In addition to large output variation, op-amp type analog buffer needs many transistors not only occupy large area but also cause high power dissipation. Therefore, it is believed that the source follower type analog buffer is the better candidate for the "System on Panel" applications. Except the threshold voltage difference of driving TFTs, the unsaturated of output voltage arisen from the significant sub-threshold current will also result in the difficulty of the buffer circuit design.

A novel source follower type analog buffer have been presented and measured, where the driving circuit is formed by only two n-type thin film transistors, one capacitor, and four switches. Much improved output voltage stability and simple configuration are achieved by adding the bias circuit and the compensation operation principle.

In the chapter 6, conventional source follower type analog buffer circuits with multi-channel structure are fabricated and measured. It is clear that multi-channel structure improves the uniformity applied to the conventional source follower circuits. In conclusion, multi-channel structure of LTPS-TFTs can improve uniformity not only in device level but also in circuit level.

As for the proposed analog buffer circuit, during the compensation period, driving TFT is in the saturation region while the active load is also operated in the saturation region. However, during the data input period, the active load may operate in the saturation or the linear region depending on the bias voltage or data voltage while the driving TFT is still in the saturation region. As the bias voltage is lower than the input voltage, the active load will operate in the saturation region and the output voltage is very closely to the input data voltage. Through the simulation, measured and formula proved results, the proposed source follower type analog buffer is capable of minimizing both of the variations from signal timing and the device varied characteristics remarkably. Regarding bias voltage, proper design consideration of the bias voltage is required to achieve excellent performance.