

Contents

Abstract (in Chinese)	i
Abstract (in English)	iii
Acknowledgments (in Chinese)	vi
Contents	vii
Table Lists	xi
Figure Captions	xii

Chapter 1

Introduction.....	1
1.1 Overview of the Organic Light Emitting Diode (OLED) Displays.....	1
1.2 Display Architecture for OLED.....	3
1.2.1 Passive Matrix OLED (PMOLED).....	3
1.2.2 Active Matrix OLED (AMOLED).....	5
1.3 Driving Schemes for AMOLED.....	6
1.3.1 Comparison between Active Matrix Liquid Crystal Display (AMLCD) and Active Matrix Organic Light Emitting Diode (AMOLED).....	6
1.3.2 Amorphous Silicon Thin Film Transistors (A-Si TFTs) versus Low-Temperature Polycrystalline Silicon Thin Film Transistors (LTPS TFTs).....	7
1.3.3 Complementary Transistors: N-Type TFT and P-Type TFT.....	10
1.4 Emission Structures for AMOLED.....	11
1.4.1 Bottom Emission Structure.....	12
1.4.2 Top Emission Structure.....	12
1.4.3 Top and Bottom Emission (Transparent) Structure.....	13

1.5 Processes in the fabrication of AMOLED.....	13
1.6 Motivation.....	15
1.7 Thesis Organization.....	17

Chapter 2 Overview of All Pixel Circuits for Active Matrix

Organic Light Emitting Diode (AMOLED).....18

2.1 Introduction.....	18
2.2 Digital Driving Circuits.....	20
2.2.1 Area Ratio Gray Scale Control (ARG).....	21
2.2.2 Time Ratio Gray Scale Control (TRG).....	22
2.3 Analog Driving Circuits.....	23
2.3.1 Voltage Programmed Circuits.....	24
2.3.1.1 Self-Compensation.....	24
2.3.1.2 Diode Connection.....	25
2.3.1.3 Resistance or Active Load.....	26
2.3.1.4 Matching TFTs.....	27
2.3.1.5 AC Driving.....	29
2.3.2 Current Programmed Circuits.....	30
2.3.2.1 Current Copy.....	30
2.3.2.2 Current Mirror.....	32
2.3.3 Novel Driving Circuits.....	33
2.3.3.1 Clamped Inverted Driving.....	33
2.4 Summary.....	34

Chapter 3 Dimensional Effects of Transistors and Storage Capacitors on Conventional Pixel Circuit

Schematic.....	36
3.1 Introduction.....	36
3.2 Basic Design for AMOLED.....	38
3.2.1 Fundamental Element of Pixel Circuits.....	38
3.2.2 Fundamental Element of Pixel Circuits.....	39
3.3 Dimensional Effects of Transistors and Storage Capacitor.....	41
3.3.1 The Effect of Switching TFT.....	43
3.3.2 The Effect of Driving TFT.....	44
3.3.3 The Effect of Storage Capacitor.....	45
3.3.4 The Effect of Transistor Slicing Layout.....	46
3.4 Experimental Results and Discussion.....	49
3.5 Summary.....	55

**Chapter 4 New Pixel Circuits for Driving Organic Light
Emitting Diodes Using Low-Temperature
Polycrystalline Silicon Thin Film Transistors.....57**

4.1 Introduction.....	57
4.2 Conventional Pixel Design.....	60
4.3 Compensation Method Using Diode Connection Concept.....	61
4.4 Proposed Pixel Design.....	62
4.5 Simulation Results and Discussion.....	64
4.6 Experimental Results of the Proposed Pixel Design and Discussion.....	72
4.7 Modified Pixel Design with Simulation Results and Discussion.....	75
4.7.1 Modified pixel design.....	75
4.7.2 Simulation Results and Discussion.....	77
4.7.3 Comparison between the Two Proposed Pixel Circuit and Other Pixel Circuit	

Design.....81

4.8 Summary.....84

Chapter 5 Summary and Conclusions.....85

References.....87

Vita

Publication Lists



Table Lists

Chapter 4

Table 4.1 Circuit simulation parameters.



Figure Captions

Chapter 2

- Figure 2.1 Gray scale theory of area ratio gray (ARG).
- Figure 2.2 An example of time ratio gray scale (TRG).
- Figure 2.3 Self-compensation pixel circuit with the timing diagram.
- Figure 2.4 Diode connection pixel circuit and its timing diagram.
- Figure 2.5 Compensation pixel circuit by an active resistor.
- Figure 2.6 Compensation pixel circuit by the matching TFTs with its timing diagram.
- Figure 2.7 AC driving for AMOLED.
- Figure 2.8 Current programmed pixel circuit and its timing diagram.
- Figure 2.9 Current programmed pixel circuit and its timing diagram.
- Figure 2.10 Circuit structure of the pixel.
- Figure 2.11 Timing diagram of OLED driving.

Chapter 3

- Figure 3.1 Fundamental element of the AMOLED pixel circuits.
- Figure 3.2 The current density – voltage (J-V) – brightness characteristics of OLED.
- Figure 3.3 Simple pixel circuit for AMOLED.
- Figure 3.4 The measured and simulated OLED current versus bias voltage characteristics.
- Figure 3.5 The measured and simulated transfer characteristics of n channel TFTs.
- Figure 3.6 The anode voltage of OLED versus input voltage characteristics with varied dimensions of switching TFTs.

- Figure 3.7 The anode voltage of OLED versus input voltage characteristics when the dimension of driving TFT varies.
- Figure 3.8 The stored voltages in the capacitors with varied capacitances when $V_{\text{data}} = 5\text{V}$.
- Figure 3.9 Conventional layout and transistor slicing layout.
- Figure 3.10 The non-uniformity of the output current when the input voltage varies from 1V to 6V with 10 times Monte Carlo simulation.
- Figure 3.11 The anode voltage of OLED versus input voltage characteristics with different layout methods.
- Figure 3.12 Optical micrograph of conventional 2T1C pixel circuit.
- Figure 3.13 Measurement system for conventional 2T1C testing pixels.
- Figure 3.14 The measured and simulation results of OLED anode voltages versus input voltages when the dimension of switching TFT varies.
- Figure 3.15 The measured and simulation results of OLED anode voltages versus input voltages when the dimension of driving TFT varies.
- Figure 3.16 The measured results of the stored voltage in the capacitor when $V_{\text{data}} = 5\text{V}$.
- Figure 3.17 The measured and simulation results of non-uniformity with conventional layout and slicing layout.
- Figure 3.18 The measured and simulation results of OLED anode voltages versus different input voltages.
- Figure 3.19 Cross-section of driving TFT with slicing layout.

Chapter 4

- Figure 4.1 Cumulative distributions of the device parameters from 30 n-channel LTPS TFTs fabricated on the same glass substrate.

- Figure 4.2 Examples of compensation by diode connection in the n channel TFT circuit and p channel TFT circuit.
- Figure 4.3 Proposed pixel design and the timing diagram of signal lines.
- Figure 4.4 The measured and simulated OLED current versus bias voltage characteristics.
- Figure 4.5 The measured and simulated transfer characteristics of n channel TFTs.
- Figure 4.6 Transient response of the conventional 2T1C pixel circuit.
- Figure 4.7 Transient response of the proposed pixel circuit.
- Figure 4.8 The gate voltage in the capacitor as the threshold voltage of driving TFT is varied.
- Figure 4.9 The simulation results of (a) conventional pixel design and (b) proposed pixel design with 30 times Monte Carlo simulation.
- Figure 4.10 The non-uniformity of the output current when the threshold voltage deviation of driving TFT is ± 0.33 volt.
- Figure 4.11 Optical micrograph of proposed pixel circuit.
- Figure 4.12 Measurement system for testing pixels.
- Figure 4.13 The measured results of conventional pixel circuits and proposed pixel circuits with different data voltages.
- Figure 4.14 Simulated and measured results of non-uniformity compared with conventional 2T1C pixel circuit.
- Figure 4.15 Modified pixel circuit and the timing diagram of control signals.
- Figure 4.16 The measured and simulated transfer characteristics of p channel TFTs.
- Figure 4.17 Transient response of the modified pixel design.
- Figure 4.18 The gate voltage in the capacitor for ± 0.33 V threshold voltage fluctuations.
- Figure 4.19 Simulation results showing the range of current flowing through the OLED at different V_{data} and threshold voltage variation ($\Delta V_{th} = -0.33$ V, 0V, and

+0.33V).

Figure 4.20 The error rate of output current in our proposed pixel circuit due to the threshold voltage variation when input data voltage ranges from 0.5V to 5V.

Figure 4.21 Non-uniformity of the output current for $\pm 0.33\text{V}$ threshold voltage fluctuations.

Figure 4.22 Power dissipation of the circuit designs for different input data voltages.

Figure 4.23 Power reduction of the modified circuit design compared with the first one.

