

# Contents

Abstract (in Chinese)	i
Abstract (in English)	iii
Acknowledge (in Chinese)	v
Contents	vi
Table Lists	ix
Figure Captions	x

## ***CHAPTER 1 Introduction.....1***

1.1	Overview of Low-Temperature Polycrystalline Silicon Thin Film Transistors (LTPS TFTs).....	1
1.2	Electrical Characteristics of LTPS TFTs.....	3
1.3	Reliability issues in LTPS TFTs.....	4
1.4	Motivation.....	5
1.5	Thesis Organization.....	6

## ***CHAPTER 2 Experimental Procedures and Review of Instability***

### ***Mechanisms under AC stress.....8***

2.1	Procedures of Fabrication of LTPS TFTs.....	8
2.2	Setup of Measurement Equipment and Extraction of the electrical parameters.....	10
2.2.1	Configuration of the Measurement Equipments.....	10
2.2.2	Waveform of the AC Signal.....	11
2.2.3	Measurement Methods.....	12
2.2.4	Extraction of Device Electrical Parameters.....	12
2.2.4.1	Determination of the Threshold Voltage ( $V_{th}$ ).....	13

2.2.4.2	Determination of the Field Effect Mobility ( $\mu_{FE}$ ).....	13
2.2.4.3	Determination of the Subthreshold Swing ( $SS$ ).....	14
2.2.4.4	Determination of the On-Current ( $I_{on}$ ) and Off-Current ( $I_{off}$ ).....	14
2.3	Variation of Experimental Electrical Parameters.....	14
2.4	Review of Instability Mechanisms under AC stress.....	16

## **CHAPTER 3 Instability of Low-Temperature poly-Si p-channel**

### ***Thin-Film Transistors under AC Gate Bias Stress...18***

3.1	Introduction.....	18
3.2	Measurement Methods and Sequences.....	19
3.3	Experimental Results and Discussion.....	21
3.3.1	Degradation under AC stress.....	21
3.3.1.1	Frequency Dependence.....	21
3.3.1.2	Peak Voltage Dependence.....	26
3.3.1.3	Rising time dependence.....	27
3.3.2	Hot-carrier-induced degradation in p-channel low-temperature poly-Si TFTs (LTPS TFTs).....	29
3.3.3	Correlating AC stress with hot-carrier stress.....	33
3.4	Summary.....	36

## **CHAPTER 4 Instability of Low-Temperature poly-Si n-channel**

### ***Thin-Film Transistors under AC Gate Bias Stress...37***

4.1	Introduction.....	37
4.2	Measurement Methods and Sequences.....	38
4.3	Experimental Results and Discussion.....	39
4.3.1	Frequency Dependence.....	39
4.3.2	Degradation Mechanisms under Accumulation- and Inversion-Mode Stress Condition.....	46
4.3.2.1	Degradation Mechanism under Accumulation-Mode Stress Condition.....	46
4.3.2.2	Degradation Mechanism under Inversion-Mode Stress Condition.....	54
4.3.3	Dependence of the Number of Pulse Repetitions under Accumulation-mode Stress.....	55
4.3.4	Falling Time Dependence under accumulation- mode stress.....	57

4.3.5	Base Voltage Dependence under accumulation- mode stress.....	58
4.3.6	Comparison of Degradation under Different Stress Condition.....	59
4.4	Summary.....	60

***CHAPTER 5 Conclusions.....61***

**References.....63**

**Vita**



# Table Lists

## Chapter 2

Table 2-1 Variation of electrical parameters and the corresponding possible degradation mechanics.

## Chapter 4

Table 4-1 Measured important electrical characteristics of TFTs after applied for 1000s of accumulation-mode stress-bias condition.

Table 4-2 Measured electrical characteristics of TFTs after application for 1000s of accumulation-mode stress-bias condition.

Table 4-3 Frequency dependence on accumulation-mode stress time.

# Figure Captions

## Chapter 2

Fig. 2-1 The cross-section views of n-channel LTPS TFTs with LDD structure.

Fig. 2-2 The cross-section views of p-channel LTPS TFTs.

Fig. 2-3 Measurement configuration for the p-channel poly-Si TFT.

Fig. 2-4 Waveform and definition of the AC signal.

Fig. 2-5 A schematic diagram for degradation model of the poly-Si TFT.

## Chapter 3

Fig. 3-1 (a) Stress configuration (b) The swing region was separated into the ON and OFF regions.

Fig. 3-2 Comparison of the degree of degradation under ON region and OFF region at frequency of 20 kHz.

Fig. 3-3 Comparison of the degree of degradation under ON region and OFF region at frequency of 100 kHz.

Fig. 3-4 Comparison of the degree of degradation under ON region and OFF region at frequency of 500 kHz.

Fig. 3-5 Dependence of swing region on device degradation.

Fig. 3-6 Frequency dependence of mobility degradation for poly-Si TFTs under ON and OFF region stresses.

Fig. 3-7 Degradation of p-channel TFT after OFF region stress at frequency of 500kHz. With stress time increasing, on current and mobility were increased, while the leakage current and  $|V_{th}|$  were decreased.

Fig. 3-8 Degradation of p-channel TFT after ON region stress at frequency of 500kHz. With stress time increasing, drain current and mobility were nearly unchanged.

Fig. 3-9 (a) Peak voltage dependence on the device degradation under OFF region stress at frequency of 500kHz (b) Three rectangular pulses with different peak voltages.

Fig. 3-10 Rising time dependence on the device degradation.

Fig. 3-11 Mobility degradation versus stress time with various duty ratios (D.R.) and falling times (tf).

Fig. 3-12 Mobility degradation versus stress time after stressing at  $V_g=15V$  and  $V_d=V_s=0V$ .

Fig. 3-13 Threshold voltage shift versus gate voltage for fixed  $V_d=-16V$  at different stress times.

Fig. 3-14 Mobility degradation versus stress time under strong saturation:  $V_g= -4V$  and  $V_d=-16V$ .

Fig. 3-15 Mobility degradation versus stress time under weak saturation :  $V_g= -16V$  and  $V_d=-16V$ .

Fig. 3-16 Schematic diagram illustrating a hot-electron injection.

Fig. 3-17 The mobility and threshold voltage shift versus stress time after OFF region stress.

Fig. 3-18 Threshold voltage shift versus stress time under strong saturation current stress and OFF region stress.

Fig. 3-19 The mobility and threshold voltage shift versus stress time after ON region stress.

## Chapter 4

Fig. 4-1 (a) Stress configuration (b) The swing region was separated into the ON and OFF regions.

Fig. 4-2 Comparison of the degree of degradation under ON region and OFF region at

frequency of 500 kHz and falling time of 100 ns.

Fig. 4-3 Comparison of the degree of degradation under ON region and OFF region at frequency of 100 kHz and falling time of 100 ns.

Fig. 4-4 Comparison of the degree of degradation under ON region and OFF region at frequency of 50 kHz and falling time of 100 ns.

Fig. 4-5 Comparison of the degree of degradation under ON region and OFF region at frequency of 20 kHz and falling time of 100 ns.

Fig. 4-6 Transfer characteristics in the linear regime of the virgin device and the stressed characteristics at off-state stress-bias condition:  $V_g = -15V$ ,  $V_d = 0V$  after 1000s stress time. The measurement was done at  $V_d$  of 5V. (a) Drain current in linear scale (b) Drain current in log scale. After the stress, the ON current was increased and leakage current was decreased.

Fig. 4-7 Mobility before and after dc stress of  $V_g = -15V$  and  $V_d = 0$  for 1000s stress time.

Fig. 4-8 Transfer characteristics in the linear regime of the virgin device and the stressed characteristics at on-state stress-bias condition:  $V_g = 19V$ ,  $V_d = 0V$  after 1000s stress time. The measurement was done at  $V_d$  of 5V. (a) Drain current in linear scale (b) Drain current in log scale. After the stress, the ON current was decreased and leakage current was increased.

Fig. 4-9 Mobility before and after dc stress of  $V_g = 19V$  and  $V_d = 0$  for 1000s stress time.

Fig. 4-10  $\oplus$  denotes positive oxide trapped charge, which results in effective short channel effect.

Fig. 4-11 Mobility degradation v.s. stress time under different bias-stress condition.

Fig. 4-12 The spatial distribution of doping concentration. Bias stress condition is  $V_g = -15V$ , and  $V_d = V_s = 0V$ .

Fig. 4-13 The spatial distribution of electric potential. Bias stress condition is  $V_g = -15V$ , and

$V_d=V_s=0V$ .

Fig. 4-14 The spatial distribution of hole density. Bias stress condition is  $V_g=-15V$ , and  $V_d=V_s=0V$ .

Fig. 4-15 The spatial distribution of electric field. Bias stress condition is  $V_g=-15V$ , and  $V_d=V_s=0V$ .

Fig. 4-16 The distribution of lateral  $E_x$ , vertical  $E_y$ , and the total,  $E=(E_x + E_y)^{1/2}$  electrical field, 10nm below the  $SiO_2$ /polysilicon interface.

Fig. 4-17 The spatial distribution of hole density and electric field at  $SiO_2$ /poly-Si interface under gate bias stress. Bias stress condition is  $V_g=-15V$ , and  $V_d=V_s=0V$ .

Fig. 4-18 The evolution of threshold voltage and mobility with stress time.

Fig. 4-19 Dependence of the number of pulse repetitions as a parameter of frequency.

Fig. 4-20 Dependence of degradation on number of repetition as a parameter of falling time.

Fig. 4-21 The base voltage dependence on mobility degradation.

Fig. 4-22 Mobility degradation with stress time under different stress condition.

