

# 固態晶體 Nd:YAG 雷射結晶之複晶矽薄膜電晶體

## 結晶機制分析與載子傳輸模型建立

研究生：黃章祐

指導教授：冉曉雯 博士

國立交通大學

顯示科技研究所碩士班

### 中文摘要

近年來低溫複晶矽薄膜電晶體已經引起大量的研究，其應用的方向是相當廣泛的。為了得到高品質的低溫複晶矽，雷射再結晶與其他結晶技術相比，是十分大有可為的。在本論文內，我們特別著重在經由高瓦數固態晶體 Nd:YAG 雷射再結晶的複晶矽薄膜，其結晶機制的分析與探討，以及從薄膜本身的特性，建立起以物理意義為根本的載子傳輸模型。

首先，經由高瓦數固態晶體 Nd:YAG 雷射再結晶的複晶矽薄膜，藉由分析其拉曼訊號以及電子掃描式顯微鏡圖形，完整的結晶機制已經被仔細的研究和探討。其發現到高斯分佈的雷射投射光波形，能成功的產生大的側向結晶製程區域。在此製程區域內，元件的載子傳輸率高達約  $250 \text{ cm}^2 / \text{Vs}$ ，而且臨界電壓小於  $1 \text{ V}$ 。非晶矽薄膜的厚度以及雷射掃描的重疊範圍對製程區域大小的影響也有被仔細的研究。另外，我們也成功的利用高瓦數固態晶體 Nd:YAG 雷射，再結晶出高品質的複晶矽鍺薄膜。矽鍺波峰的半高寬約為  $23.68 \text{ cm}^{-1}$ ，非常接近的單晶矽鍺的半高寬。

我們提出以物理意義為根本的載子傳輸模型，其中包含了晶粒邊界能障效應與聲子

晶格散射效應。其只利用幾個模擬參數，就能準確的推測電子傳輸率在各種閘極偏壓下的大小。此載子傳輸模型在元件通道長度  $30\ \mu\text{m} - 6\ \mu\text{m}$ ，通道寬度為  $6\ \mu\text{m}$  時，溫度從  $298\ \text{K}$  變化到  $343\ \text{K}$  下，皆能正確的描述出元件的特性。更進一步的，我們採用所提出的載子傳輸模型去模擬元件的電流電壓輸出特性，其模擬結果與實驗數據都相當的吻合。



# **The Crystallization Mechanism and the Mobility Model of Poly-Si TFTs annealed by Solid-State Nd:YAG Laser**

Student: Chang-Yu Huang

Advisor: Dr. Hsiao-Wen Zan

Institute of Display  
National ChiaoTung University

## **Abstract**

Recently, low temperature polycrystalline silicon thin-film transistors (TFTs) have been investigated extensively for their wide applications. In order to achieve high quality poly-Si at low process temperature, laser crystallization technology is a promising method compared with other techniques. In this thesis, we especially focus on the analysis on crystallization mechanism of poly-Si annealed by high power solid-state Nd:YAG laser and establish physically-based mobility model including temperature effect directly through thin film property.

Firstly, the poly-Si crystallization mechanism under the high power (200 W) Nd:YAG solid state pulsed laser annealing system have been carefully studied by analyzing their Raman spectra and scanning electron microscope . It is found that the Gaussian-distributed laser beam profile successfully produce large super lateral growth process window. The devices in the SLG process window exhibit field-effect mobility around  $250 \text{ cm}^2 / \text{Vs}$  and the threshold voltage lower than 1 V. The influence of a-Si film thickness and the laser scan pitch on the process window is also carefully inspected. In addition to poly-Si, high quality poly-SiGe annealed by SSL has been successfully achieved. The FWHM value of Si-Ge peak is about  $23.68 \text{ cm}^{-1}$  which is close to single crystal SiGe alloy.

The physically-based mobility model containing grain barrier height effect and phonon lattice scattering effect have been proposed. It can precisely predict the mobility over wide range of gate voltage bias by using only few fitting parameters. The model is valid for devices with channel length varying from  $30\ \mu\text{m}$  to  $6\ \mu\text{m}$  while channel width is  $6\ \mu\text{m}$  under a temperature range from  $298\ \text{K}$  to  $343\ \text{K}$ . Moreover, we adopt the proposed mobility model to simulate output characteristics of devices. Excellent agreements are found when comparing the calculated results and experimental data.



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# Contents

**Chinese Abstract**

**English Abstract**

**Acknowledgment**

**Contents**

**Figure Captions**

**Table Captions**

## **Chapter 1. Introduction**

1.1 An overview of poly-Si TFTs technology	1
1.2 Laser crystallization technology	2
1.3 Motivation	2
1.4 Thesis Outline	3

## **Chapter 2. Experimental Procedures**

<b>2.1 a-Si thin film re-crystallization and poly-Si TFTs fabrication</b>	<b>5</b>
2.1.1 Laser annealing system	5
2.1.2 Device fabrication flow	5
<b>2.2 a-SiGe thin film re-crystallization by SSL</b>	<b>6</b>
2.2.1 UHVCVD system	6
2.2.2 Deposition and crystallization of a-SiGe thin film	7
<b>2.3 Material analysis of thin film</b>	<b>8</b>
<b>2.4 Methods of device parameter extraction</b>	<b>9</b>
2.4.1 Determination of field effect mobility	9
2.4.2 Determination of threshold voltage	10
2.4.3 Determination of Subthreshold Swing	10
2.4.4 Extraction of thermal activation energy of turn-on region	10

## **Chapter 3. Results and Discussions**

<b>3.1 Crystallization mechanism by SSL</b>	12
3.1.1 Thin film analysis	12
3.1.2 Crystallization mechanism	13
3.1.3 Device performance	14
3.1.4 Process window definition	15
3.1.5 Comparison between SSL and ELA	16
3.1.6 Discussion of a-SiGe crystallization	17
<b>3.2 Mobility modeling of poly-Si TFTs by SSL</b>	18
3.2.1 Two main mechanisms affecting mobility	18
3.2.2 Modeling equation and Physical meaning	19
3.2.3 Mobility fitting results	22
3.2.4 Output characteristics	23
<b>Chapter 4. Conclusion</b>	25
<b>References</b>	26



## Figure Captions

### Chapter 2.

Fig. 2-1 Schematic cross sectional view of poly-Si TFT.

Fig. 2-2 The illustration diagram of laser annealing.

Fig. 2-3 The schematic diagram of UHVCVD system.

Fig. 2-4 Arrhenius Plot of the drain current of  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  n-channel device for different gate voltages and  $V_{DS} = 0.1 \text{ V}$ . The slope of each line defines the activation energy ( $E_a$ ).

### Chapter 3.

Fig. 3-1 SEM images of poly-Si grain annealed by laser energy density that varies from 392  $\text{mJ} / \text{cm}^2$  to 645  $\text{mJ} / \text{cm}^2$ .

Fig. 3-2 Relationship between Raman peak position (left axis), FWHM (right axis) and laser energy density.

Fig. 3-3 Illustration diagram to describe the crystallization mechanism with three regions and two specific energies.

Fig. 3-4 The SEM images of poly-Si films annealed by the same laser energy density (438  $\text{mJ} / \text{cm}^2$ ) but different scan pitches ((a) 1  $\mu\text{m}$ , (b) 2  $\mu\text{m}$  and (c) 5  $\mu\text{m}$ ).

Fig. 3-5 The SEM images of poly-Si films annealed at the same laser energy density (507  $\text{mJ} / \text{cm}^2$ ) but different scan pitches ((a) 2  $\mu\text{m}$  and (b) 5  $\mu\text{m}$ ).

Fig. 3-6 Relationship between electrical property and laser energy density. The scan pitch is fixed to be 2  $\mu\text{m}$ . The active layer is 50-nm Si. The device channel width and length are 6  $\mu\text{m}$  and 12  $\mu\text{m}$ . (a) field effect mobility (b) subthreshold swing and threshold voltage

Fig. 3-7 Relationship between electrical property and laser energy density. The scan pitch is



fixed to be  $2 \mu\text{m}$ . The active layer is  $100\text{-nm}$  Si. The device channel width and length are  $6 \mu\text{m}$  and  $12 \mu\text{m}$ . (a) field effect mobility (b) subthreshold swing and threshold voltage

Fig. 3-8 The Raman peak positions and FWHM versus laser energy density of  $50\text{-nm}$  Si annealed by ELA.

Fig. 3-9 The SEM images after secco etching of  $50\text{-nm}$  si annealed by ELA and SSL at each optimum laser energy density. (a) ELA (b) SSL

Fig. 3-10 Comparison of typical transfer characteristic for n-channel poly-Si TFTs annealed by ELA and SSL at each best laser condition.

Fig. 3-11 The light absorption versus wavelength of a-Si and a-SiGe thin film.

Fig. 3-12 Raman spectra obtained on a-SiGe thin films before and after laser irradiations performed in different conditions. (a) sample A (b) sample B

Fig. 3-13 The field effect mobility versus gate voltage at different temperature for n-channel TFT with various geometries. (a)  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  (b)  $W/L = 6 \mu\text{m} / 6 \mu\text{m}$

Fig. 3-14 The relationship of grain barrier height versus gate voltage for different laser energies. (a)  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  (b)  $W/L = 6 \mu\text{m} / 6 \mu\text{m}$

Fig. 3-15 The field effect mobility versus gate voltage at different temperature for two laser energies. ( $W/L = 6 \mu\text{m} / 30 \mu\text{m}$ ) (a)  $100 \text{ W}$  (b)  $95 \text{ W}$

Fig. 3-16 The mobility versus average grain size at various low gate voltage biases for different channel lengths. (a)  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  (b)  $W/L = 6 \mu\text{m} / 6 \mu\text{m}$

Fig. 3-17 The illustration diagram of grain and grain boundary for mobility modeling.

Fig. 3-18 Comparison of field effect mobility between the simulation results and experiment data at different temperatures. ( $W/L = 6 \mu\text{m} / 30 \mu\text{m}$ ) (a)  $T = 298 \text{ K}$  (b)  $T = 313 \text{ K}$  (c)  $T = 328 \text{ K}$  (d)  $T = 343 \text{ K}$

Fig. 3-19 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 12 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-20 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 6 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-21 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 30 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-22 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 12 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-23 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 6 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-24 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 30 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-25 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 12 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-26 The field effect mobility versus gate voltage at different temperatures. ( $W/L = 6$

$\mu\text{m} / 6 \mu\text{m}$ ) (a) experiment (b) simulation

Fig. 3-27 The  $C-V$  and transfer characteristics of devices annealed by different laser energies are put together to determine  $V_{on}$ . ( $W/L = 6 \mu\text{m} / 30 \mu\text{m}$ ) (a) 110 W (b) 95 W

Fig. 3-28 The comparison of measured (symbols) and modeled (solid line)  $I-V$  output characteristics for  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 110 W. (a)  $T = 298 \text{ K}$  (b)  $T = 313 \text{ K}$  (c)  $T = 328 \text{ K}$  (d)  $T = 343 \text{ K}$

Fig. 3-29 The comparison of measured (symbols) and modeled (solid line)  $I-V$  output characteristics for  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 100 W. (a)  $T = 298 \text{ K}$  (b)  $T = 313 \text{ K}$  (c)  $T = 328 \text{ K}$  (d)  $T = 343 \text{ K}$

Fig. 3-30 The comparison of measured (symbols) and modeled (solid line)  $I-V$  output characteristics for  $W/L = 6 \mu\text{m} / 30 \mu\text{m}$  n-channel poly-Si TFTs annealed with laser

power 95 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-31 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 12\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 110 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-32 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 12\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 100 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-33 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 12\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 95 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-34 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 6\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 110 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-35 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 6\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 100 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

Fig. 3-36 The comparison of measured (symbols) and modeled (solid line)  $I$ - $V$  output characteristics for  $W/L = 6\ \mu\text{m} / 6\ \mu\text{m}$  n-channel poly-Si TFTs annealed with laser power 95 W. (a)  $T = 298\text{ K}$  (b)  $T = 313\text{ K}$  (c)  $T = 328\text{ K}$  (d)  $T = 343\text{ K}$

## Table Captions

- Table Comparison of device performance at each best laser condition for ELA and SSL  
( $W/L = 6 \mu m / 30 \mu m$ )
- Table The relationship between laser power, laser energy density and average grain size which is defined from SEM images after secco etching.
- Table Key parameters used to simulate mobility and output characteristics with different channel geometries and laser powers.
- Table The threshold voltage ( $V_{th}$ ) and on voltage ( $V_{on}$ ) with their corresponding grain barrier heights at 298 K with different channel geometries and laser powers are listed.

