

## MASTER'S THESIS

### Materials for organic memory devices

Wu, Weimin

*Date of Award:*  
2009

[Link to publication](#)

#### General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

**Materials for Organic Memory Devices**

**WU Weimin**

**A thesis submitted in partial fulfillment of the requirements**

**for the degree of**

**Master of Philosophy**

**Principal Supervisor: CHEAH Kok Wai**

**Hong Kong Baptist University**

**September 2009**

## ABSTRACT

The technology of semiconductor is developing very fast during these decades. Along with the increase in CPU speed, the memory devices encounter new challenge. Recently, a new kind of memory devices named phase change memory attracted the attention of scientists and industry.

Although organic electronic devices are widely used in many fields, the use in memory is a new area for organic materials, and the mechanism of them is still undefined.

The greatest challenge for phase-change memory has been the requirement of high programming current density ( $>10^7$  A/cm<sup>2</sup>, compared to  $10^5$ - $10^6$  A/cm<sup>2</sup> for a typical transistor or diode) in the active volume. This has led to active areas which are much smaller than the driving transistor area. The higher thermal requirement has forced phase-change memory structures to package the heater and sometimes the phase-change material itself in sub-lithographic dimensions. This is a process disadvantage.

Our work focused on several types of small molecular organic materials which were used in OLED. We used them to fabricate memory devices with two and three electrodes. Their electrical characteristics were measured and their physical properties were also determined. The results show that these devices exhibit memory characteristics confirming there is phase change in our organic materials. We also measured the transfer curves of the OTFT devices to confirm that both type of devices, which were using PMMA and SiO<sub>2</sub> as insulating layers respectively, can exhibit the transfer curve shift, and then we proposed the potential mechanisms. For the device using PMMA as insulating layer, under different gate bias, Alq<sub>3</sub> can have different

configuration, this can change the  $\mu C_i$  value and lead to the memory characteristics. For the device using  $\text{SiO}_2$  as insulating layer, we assumed that the memory property was caused by electrons trapping under transverse electric field.

# TABLE OF CONTENTS

DECLARATION.....	i
ABSTRACT.....	ii
ACKNOWLEDGEMENTS .....	iv
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	vii
LIST OF FIGURES .....	viii
<b>Chapter 1: Introduction</b> .....	1
<b>1.1 Background</b> .....	1
<b>1.2 References</b> .....	5
<b>Chapter 2: Theory</b> .....	7
<b>2.1 Structures and memory effect</b> .....	7
<b>2.1.1 Two electrode structure</b> .....	7
<b>2.1.2 Three electrode structure</b> .....	9
<b>2.1.3 Memory effect classification</b> .....	11
<b>2.2 Theoretical Background</b> .....	14
<b>2.2.1 Fundamentals of Organic Thin Film Transistors</b> .....	15
<b>2.2.2 Charge transport in organic materials</b> .....	18
<b>2.2.3 Filamental Model</b> .....	21
<b>2.2.4 Phase Change Model</b> .....	24
<b>2.3 References</b> .....	26
<b>Chapter 3: Experimental Preparation and Procedures</b> .....	28
<b>3.1 Materials for organic memory device</b> .....	28
<b>3.1.1 ITO</b> .....	28
<b>3.1.2 mADN</b> .....	29
<b>3.1.3 Alq3</b> .....	30
<b>3.1.4 Al</b> .....	30
<b>3.1.5 Au</b> .....	30
<b>3.1.6 Si</b> .....	31
<b>3.1.7 PMMA</b> .....	31
<b>3.2 Sample fabrication</b> .....	32
<b>3.2.1 Pretreatment</b> .....	32
<b>3.2.2 Film coating</b> .....	33
<b>3.2.3 Spin coating</b> .....	34
<b>3.3 Sample measurement</b> .....	34
<b>3.3.1 I-V measurement</b> .....	34

3.3.2 <i>Transfer curve measurement</i> .....	35
3.3.3 <i>XRD measurement</i> .....	37
3.4 <b>References</b> .....	39
<b>Chapter 4: Experiment results and discussion</b> .....	40
4.1 <b>Single three-layer organic memory devices</b> .....	40
4.1.1 <i>Alq3</i> .....	40
4.1.2 <i>mADN</i> .....	44
4.2 <b>XRD measurement of devices</b> .....	48
4.3 <b>Organic TFT devices</b> .....	52
4.3.1 <i>Device using PMMA as insulating layer</i> .....	52
4.3.2 <i>Device using SiO<sub>2</sub> as insulating layer</i> .....	55
4.3.3 <i>Summary</i> .....	57
4.4 <b>References</b> .....	59
<b>Chapter 5 Conclusion</b> .....	60
<b>References</b> .....	62
<b>Curriculum vitae</b> .....	63