國立交通大學

光電工程學系 顯示科技研究所

碩士論文

低溫多晶矽薄膜電晶體微觀變動行為之通道寬度相關性之研究

Study on the Channel Width Dependence on the Micro-Variation Behaviors of LTPS TFTs

研 究 生：趙育德 Yu-Te Chao
指導教授：戴亞翔教授 Dr. Ya-Hsiang Tai

中 華 民 國 九 十 六 年 六 月

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中文摘要

多晶矽薄膜電晶體(poly-Si TFTs)基於其優於非晶矽薄膜電晶體(amorphous silicon TFTs)的電流驅動能力，最近在液晶顯示器(AMLCD)及有機發光二極體(AMOLED)顯示器的周邊電路整合應用上皆備受矚目。

在本論文中，我們將對低溫多晶矽薄膜電晶體(low temperature poly-Si TFTs)的元件特性作一統計性的研究。首先，我們先著重於元件的變動特性的研究。我們將元件的特性變動區分為巨觀變動及微觀變動。我們利用一種被稱為枕木型的元件排列方式，並經由調整元件間距離統計其電性行為的變動差異，驗證出相鄰的低溫多晶矽薄膜電晶體的主要變動來源是來自其微觀變動。為了探討微觀變動所引起的非匹配特性，我們藉由分析元件間參數差值的標準差來做探討，發現叉合(Interdigitated)方法比傳統方法具有更優越的特性，其中位障電壓與遷移率差值的標準差與叉合數目呈現反比，特別是位障電壓。因此我們提出一個微觀變動性的模型來加以描述叉合法的效能。在這個我們所提出的模型對於實際

量測到的分布比較中，經過回歸分析所得之回歸變異係數(R square) 皆在 0.98 以上。此一結果代表我們所提出的微觀變動性的模型與實際的分布情況十分吻合，也反映出該模型的適用性。此外，我們也將個別針對單晶矽及非晶矽的微觀變動性行為先做探討與研究，並將這些個別的結果詳細比較之，結果發現元件特性越佳的，它的微觀變動量會越小。

更進一步的，將這個提出來的模型試著應用在評估實驗數據無法解釋的變動性與大、小通道寬度間的關係。從模擬結果顯示，我們可以預測大通道寬度的微觀變動量，但是通道寬度小的微觀變動量，我們卻無法對他做預測。

先前關於低溫多晶矽薄膜電晶體的研究中主要著重於元件特性的改良。關於元件特性變動及其影響的問題很少被討論。然而，在低溫多晶矽薄膜電晶體能被廣泛使用於平面顯示技術前，其元件變動特性必須做進一步的研究。

Study on the Channel Width Dependence on the Micro-Variation Behaviors of LTPS TFTs

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Abstract

Low Temperature Polycrystalline Silicon (LTPS) thin film transtrators (TFTs) have attracted much attention in the application on the integrated peripheral circuits of display electronics such as active matrix liquid crystal displays (AMLCDs) and active matrix organic light emitting diodes (AMOLEDs) due to its better current driving compared with a-Si (amorphous silicon) TFTs.

In this thesis, the variation characteristics of LTPS TFTs are statistically investigated. Firstly we aim at the nature of device variation. We classify the variation as macro variation and micro variation. We adopt the “crosstie” layout to banish macro variation from micro variation. By analyzing the variance of electrical behavior with respect to difference device interval, we confirm that the main source of variation for the neighboring devices comes from the micro variation. In order to investigate the mismatching effects that cause by the micro variation, to analyze the standard deviations of parameters’ differences, it is found that the interdigitated method is indeed superior than the original. Besides, threshold voltage and mobility are inversely proportional to the interdigit’s finger numbers, especially the threshold

voltage. Therefore, a model of the micro variation is proposed to predict the performance of the interdigitated method, and it is proper to describe the variation behaviors with different device distances, for which the R square (Coefficient of Determinations) are higher than 0.98, which has high accuracy with the real data, reflecting the validity of the model. Besides, we applied the interdigitated method to the other devices with different grain structures, like the single crystal silicon and the amorphous silicon devices, and found that the micro variations of devices decline while device performance gets better. Furthermore, the proposed model is desired to evaluate the quantitative relationships between the variation and channel width in the regions where experimental data are not applicable. It is possible to be used to evaluate the variation of the larger channel width devices, but may not be capable of predicting the smaller channel width ones.

Most papers about LTPS TFTs are focusing on the improment of device performance. Few papers aim at the device variation and the corresponding influence. However, before LTPS TFTs can be widely used in flat panel displays, the variation of these devices in mass production must be well-controlled.

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Contents

Figure captions

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Table Lists

Chapter 3

Chapter 4