低溫多晶矽薄膜電晶體的均勻度的統計性研究

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摘要

本論文主要由統計的觀點探討低溫多晶矽薄膜電晶體的均勻性以及其在應用上的影響。藉由量測來自不同元件佈局圖（device layout）的元件，調整元件與元件之間的距離，以觀察隨著元件距離不同，元件與元件之間的特性的變異性是否隨之改變。最特別的是，我們利用一種被稱為枕木型的元件佈局圖來降低製程變動所造成的影響以觀察宏觀變動的效應，並且發現元件的特性變動確實隨著元件之間的距離增加而改變。

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宏觀變動及微觀變動。由於一般生產線上在不同片玻璃上所萃取出來的元件參數已包含宏觀及微觀變動，我們提出一種新的元件佈局圖以屏除宏觀變動造成的影響。我們利用出枕木型的元件排列方式，並經由調整元件間隔距離統計其電性行為的差異，我們驗證在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。我

們發現宏觀變動將隨元件距離改變而產生改變。此外，我們進一步發現微觀變動並不隨著元件間距的增加而有明顯改變。

接下來我們具體展現元件的特性變動對於電路應用上以及可靠度預測上所帶來的困難。關於元件特性變動對於可靠度預測上所造成的影響，在對元件進行可靠度分析時，相同的偏壓下不同的元件將會有類似的劣化行為。然而我們的量測資料顯示對於具有不同起始電壓的薄膜電晶體在一個特定的偏壓條件下將會有不同的劣化行為。在這個偏壓條件下，劣化行為對於元件的起始電壓變動相當敏感，而薄膜電晶體的特性變動也因此在可靠度分析上造成額外的困難。

在電路方面，我們以一簡單的電路組合-源極隨耦器(source follower）出發，研究如果將電晶體替代為多晶矽薄膜電晶體並且有電性上的變動，將會對電路的行為造成如何的影響。模擬結果顯示，除了薄膜電晶體本身較為平緩的次臨界導通區域導致源極隨耦器的充電行為遠較一般 IC 上的行為緩慢以及不飽和輸出電壓(unsaturated output voltage)之外，薄膜電晶體的特性變動將會為電路設計者帶來額外的困難。

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則很少被討論。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。本篇論文中關於元件變動的特性及其影響亦點出了這個問題的重要及必要性。

Statistical Study on the Uniformity Issue of Low Temperature Polycrystalline Silicon Thin Film Transistor

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Abstract

This thesis studies the uniformity issue of low temperature poly-silicon thin film transistor (LTPS TFT) with a statistical method. By measuring devices from different device layouts and adjusting the distance between devices, the relationship of device behavior variance with respect to device interval is examined. In particular, we adopt the “crosstie” layout to get rid of the macro variation coming from process control and demonstrate that the device variation actually varies as the device distance increases.

Firstly we aim at the nature of device variation. We classify the variation as macro variation and micro variation. Since devices from typical layout are coupled with macro variation and micro variation, the “crosstie” layout is introduced 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. It is discovered that macro variation changes with device distance. It is further found that micro variation does not change as device distance increases.

Next we objectively demonstrated the difficulties in analyzing circuit

performance and device reliability with device behavior variation. In the prediction of device reliability, devices under the same stress condition will exhibit similar degradation behaviors. However, it is shown that TFTs with slightly different threshold voltages will exhibit apparent diverse degradation behavior under a critical stress condition. The degradation behavior under this stress condition is found to be very sensitive to the threshold voltage of the device. It can therefore be seen that the variation of device behavior will lead to difficulties in predicting reliability.

In the aspect of circuit performance, we start from a simple component, namely the source follower, to examine the behavior as the transistor is replaced by a LTPS TFT with electrical behavior variation. As the transistor is replaced to the LTPS TFTs with similar threshold voltages and different subthreshold swing, the charging behavior and the output voltage are quite different from our expectation. This reveals that in addition to the gradual transfer region compared to IC devices and the resulting unsaturated output voltage, the variation of device behavior will bring extra difficulties to circuit designers.

Most papers about LTPS TFTs are focusing on the improvement 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. This thesis suggests the importance and necessity of the device variation of the LTPS TFTs.