應用於薄膜電晶體之平面顯示器
玻璃基底上的類比電路設計

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摘要

低溫複晶矽 (low temperature poly-silicon) 薄膜電晶體 (thin-film transistors)已被視為一種材料廣泛地研究於可攜帶式系統產品中，例如數位相機、行動電話、個人數位助理 (PDA) 、筆記型電腦等等，這是由於低溫複晶矽薄膜電晶體的電子遷移率約是傳統非晶矽 (amorphous silicon) 薄膜電晶體的一百倍大。此外，低溫複晶矽技術可藉由將驅動電路整合於顯示器之週邊區域來達到輕薄、巧小且高解析度的顯示器。這樣的技術也將越來越適合於系統面板 (system-on-panel) 應用之實現。

近年來，低溫複晶矽技術具有朝向將所有控制和驅動電路整合進玻璃基板的趨勢。一般而言，液晶顯示器驅動電路包含閘極驅動電路、資料驅動電路以及直流對直流轉換電路。資料驅動電路則是由移位暫存器、閂鎖器、電位移轉器、數位類比轉換器以及類比輸出緩衝器所組成。然而，由於使用狹小雷射製程窗口來產生大顆粒的複晶矽薄膜電晶體，這會使得複晶矽薄膜電晶體因為巨大的元件特性變化而具有較差的一致性。元件特性的變化對於在液晶顯示面板上的類比電路設計已經逐漸成為一個很嚴重的問題。也由於這個原因，在本論文中將著重於資料驅動電路中的類比電路設計。

在本篇論文當中，提出了一個適用於面板資料驅動電路且同時具有珈瑪校正功能的新型數位類比轉換器以及一個著重在元件特性變化之考量用於資料驅動電路上之類比輸出緩衝器，此兩電路均以 8-μm LTPS 製程技術實現。此一新型數位類比轉換器由於是採用電阻串的架構，所以非常適合珈瑪校正的設計。藉由此提出之新型架構其面積與複雜度也都能大大地被降低。此一新型的數位類比轉換器非常有利於將資料驅動電路整合至液晶顯示器的週邊區域。而所提出具有 P 型差動輸入對之類比輸出緩衝器則能操作在 50 kHz 下並具有至少 1 至 9 V 的輸出範圍。藉著使用 P 型差動輸入對來抑制元件特性變化的方法除了能夠保持電路原有之效能外，還能夠提昇整體電路的製程良率。這樣的一個類比輸出緩衝器更加適用於資料驅動電路的輸出端來提供顯示器一個均勻的亮度以及較高的解析度。

最後，此具有珈瑪校正功能之新型折疊電阻串數位類比轉換器已在 8-μm 以及 3-μm LTPS 製程下成功驗證。而擁有抑制元件特性變化之類比輸出緩衝器也已經在 8-μm LTPS 製程下成功地被設計並製造出。此外，關於其它的數位類比轉換器電路之分析與比較也將會在此篇論文中做討論及整理。

Analog Circuits Design on Glass Substrate for TFT Panel Applications

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ABSTRACT

Low temperature poly-silicon (LTPS) thin-film transistors (TFTs) have been widely investigated as a material for portable systems, such as digital camera, mobile phone, personal digital assistants (PDAs), notebook, and so on, because the electron mobility of LTPS TFTs is about 100 times larger than that of the conventional amorphous silicon TFTs. Furthermore, LTPS technology can achieve slim, compact, and high-resolution display by integrating the driving circuits on peripheral area of display. This technology will also become more suitable for realization of system-on-panel (SOP) applications.

Currently, LTPS technology has a tendency towards integrating all control circuits and driver circuits on the glass substrate. In general, the liquid-crystal display (LCD) driver contains gate driver, data driver, and DC-DC converter. The data driver is composed of shifter registers, latch, level shifters, digital-to-analog converters (DACs), and analog output buffer. However, the poly-Si TFTs suffered poor

uniformity with large variations on the device characteristics due to the narrow laser process window for producing large-grained poly-Si TFTs. The device variation becomes a very serious problem for the analog circuit design on the LCD panel. For this reason, the analog circuits of the data driver are the focus in my works.

In this thesis, a novel DAC with gamma correction for on-panel data driver and an on-panel analog output buffer for data driver with consideration of device characteristic variation are proposed in 8-μm LTPS technology. This new proposed architecture of the DAC is more suitable for gamma correction design due to the resistor string type of this DAC circuit. The area and complexity of the DAC also can be reduced greatly by this proposed architecture. This new DAC architecture is beneficial for data driver to be integrated in the peripheral area of the TFT-LCD panel in LTPS process. The proposed analog output buffer with P-TFTs input differential pair can be operated at 50-kHz operation frequency with at least a 1-to-9 V output swing. The device variation suppression method by using P-TFTs input differential pair can effectively maintain the performance of on-panel analog output buffer and increase the manufacturing yield of the circuit. This analog output buffer with suppressing device variation is more suitable for using in the on-panel data drivers to provide a uniform brightness and high resolution display

Furthermore, the novel folded R-string DAC with gamma correction has been verified in 8-μm and 3-μm LTPS technology. The analog output buffer with suppressing device variation also has been designed and fabricated in 8-μm LTPS technology. The analysis and comparison of the other DAC circuits are also included in this thesis.