主動矩陣有機發光二極體用之低溫複晶矽薄膜電晶體畫素設計之研究

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摘要

在本篇論文中，我們以低溫複晶矽薄膜電晶體為基礎，探討低溫複晶矽薄膜電晶體對於主動矩陣有機發光二極體的影響，並依據元件尺寸、元件佈局以及電路設計等主題，提出完整的討論與電路改良技術，進而提升主動矩陣有機發光二極體之顯示品質。

首先，我們以低溫複晶矽薄膜電晶體為設計元件，分別進行電路模擬與製作傳統畫素架構之測試電路後，探討各項電晶體尺寸大小、電容大小及佈局方式對於傳統主動矩陣有機發光二極體的影響。根據電路模擬與實際量測的結果，在傳統佈局技術中，我們發現切換電晶體大小對於主動矩陣有機發光二極體陽極電壓並無明顯的關連性。而當驅動電晶體尺寸變大，由於驅動電流增大，造成有機發光二極體陽極電壓的增加，這也同時導致畫面會有較高之亮度。而在電容尺寸方面，適當的設計電容大小可以有效的控制其充電時間長短以及維持電壓能力。相較於傳統佈局技術，使用本論文所提出之多通道之結構佈局可以有效增大電流，亦可獲得均勻性較佳之結果。由實驗的結果可以證實，多通道結構之佈局方式，對於主動式有機發光二極體陽極電壓與均勻性均可以有效的提升。然而由於低溫複晶矽薄膜電晶體電特性變異極大，嚴重阻礙面板

畫面亮度之均勻性。

為了進一步的提升主動矩陣有機發光二極體之顯示品質，我們先從各種校正電路的方法進行評估。雖然數位驅動方式可同時校正截止電壓以及載子移動率之變異性，但受限於製程能力以及驅動速度，因而不適用於高階產品，故非未來趨勢。而類比驅動方式可分為電流驅動及電壓驅動，其中，電流驅動具有同時校正截止電壓以及載子移動率之優點，並且可直接控制灰階，但缺點為驅動速度較慢，且源極驅動電路設計會因此更為複雜。相較於前兩種驅動方式，電壓驅動方式因結構簡單，對於未來朝向高解析度及低成本之技術應用上較具潛力。傳統的畫素架構，經由實際量測結果，可以很清楚的瞭解當驅動的低溫複晶矽薄膜電晶體的截止電壓有所不同時，有機發光二極體陽極電壓也會有明顯之差異，也因此輸出電流不同，導致畫面亮度之不均勻。

在類比電壓驅動中，為了改善畫面顯示品質，我們提出兩種新型的電路操作模式來校正低溫複晶矽薄膜電晶體之截止電壓變異性之問題。在第一種操作模式中，驅動過程分為三個階段，第一階段中，所有的電晶體皆開啟，其主要目的為預先將電壓值重置。接著進入校正階段，信號電壓進入，此時由於驅動電晶體連接成二極體的形式，故信號電壓加上電晶體截止電壓將儲存於電容上。最後則進入發光階段，流過有機發光二極體的電流乃由電容上所儲存的電壓所提供。在採取電路模擬於提出最佳化設計後，藉由實際量測結果證實，我們所提出的電路架構確實可以有效地縮小元件變異性之問題，而且可以獲得輸出電壓增大的好處。然而，在第一階段時有機發光二極體亦會有電流通過，而導致消耗功率將因而提升。

因此，我們進一步提出第二種電路操作模式來改善上述的缺點。我們將其中一個電晶體由 N 型換成 P 型，並改由切換訊號控制，在充電階段時此顆電晶體將阻止不必要的電流流過有機發光二極體，藉以降低消耗功率。

總而言之，本篇論文所提出的電路，除了可以提升輸出電壓以增大畫面亮度外，同時可以大幅提昇面版亮度之均勻性，故此電路設計在未來主動矩陣有機發光二極體應用上極具潛力。

Study on the Pixel Designs of Low-Temperature Polycrystalline Silicon Thin Film Transistors for Active Matrix Organic Light Emitting Diodes

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ABSTRACT

In this thesis, based on the low-temperature polycrystalline silicon thin film transistors (LTPS TFTs), the influences of LTPS TFTs on the active matrix organic light emitting diodes (AMOLEDs) have been investigated. From the topics of device dimension, layout method and circuit design, systematic study and two pixel compensation circuits have been proposed to further enhance the image quality of AMOLEDs.

First, SPICE simulation and testing pixel circuits of conventional pixel schematics have been accomplished and fabricated base on LTPS TFTs. Besides the effects of layout method, the dimensional effects of transistors and storage capacitors are investigated in detail. According to the results of simulation and experiments, it is observed that for the conventional layout method, the dimension of switching TFT has no impact on the anode

voltage of OLED. When the size of driving TFT is increased, the anode voltage of OLED will be increased due to the larger driving capability. Therefore, the brighter image can be obtained. As to the storage capacitor, the appropriate determination of the magnitude for storage capacitor can control the charging time and storage capability effectively. Compared with conventional layout method, the transistor slicing layout of driving TFT in this work can promote the output current for display effectively. Besides, the non-uniformity across the panel can be reduced. By experimental results, it is verified that the transistor slicing layout can enhance the driving capability and the uniformity effectively at the same time. However, the conventional pixel structure suffers from pixel to pixel brightness non-uniformity problem resulted from the electrical characteristic variations of the transistors.

In order to further enhance the image quality of AMOLEDs, the different driving methods have been compared and evaluated. Although digital driving methods can compensate the variation of threshold voltage and mobility, it is not suitable for them to be applied to high resolution products due to the limited process ability and the high driving speed. Analog driving circuits can be divided into current programmed circuits and voltage programmed circuits. Current programmed circuits not only can compensate the variation of threshold voltage and mobility but can control the gray scale directly. However, they have the limitation of the writing time and the data driver IC needs more complicated design. Compared with digital driving method and current programmed method, voltage programmed circuits show great potential for high resolution and low cost applications in the future because of the simple structure. By means of experimental results of conventional pixel design, because of the variation of threshold voltages in LTPS TFTs, the different anode voltages of OLED are obtained. As a result, the different current flow through OLED would result in the non-uniform brightness across the panel.

In order to improve the image quality of AMOLED by voltage programmed circuits, two new pixel circuits for compensating the variation of threshold voltage in LTPS TFTs are proposed. In the first circuit design, the driving scheme is divided into three stages. In the first period, all TFTs in the pixel are on state in order to reset the pixel circuit. The second period is for compensation. At this time, data signal is transferred into the circuit. Because driving TFT acts as a diode, data voltage and threshold voltage will be stored in the capacitor. The last period is for emitting. The OLED output current will be determined by the stored voltage in the capacitor. By means of experimental results, it is verified that the proposed pixel circuit can reduce the problem of device variation. In addition, higher output voltage can be obtained. However, the power consumption is increased because there is a current flow through OLED device.

Therefore, modified circuit design is further proposed to overcome the problem. By using the modified pixel design which replaced a n channel TFT with a p channel TFT in order to block the current flow path through OLED during pre-charge period, lower power consumption can be obtained.

In conclusion, in the proposed circuit designs in this work, besides the higher driving capability, the better uniform image quality can be obtained. Therefore, the circuit designs possess the potential for the AMOLED panel application in the future.