新穎自我定位有機/無機薄膜電晶體
於軟性電子應用之研究

研究生：劉政欽　　　　　　　　　　　　　指導教授：鄭晃忠　博士
游萃蓉　博士

國立交通大學
電子工程學系　電子研究所碩士班

摘要

近年來，有機顯示器成為市場上的前瞻技術，利用有機發光二極體和有機薄膜電晶體可以製作出低成本、可彎曲、全彩的平面顯示器。理論上，高分子薄膜電晶體的漏電流主要來自兩條路徑，第一條是來自材料本身，另一條則是經由穿越閘極氧化層而產生的漏電流。傳統的高分子有機薄膜電晶體製作，為了簡化製程，結構上皆使用共同閘極以及整面未結構化的主動層之結構，導致漏電途徑大增，也使得電晶體的開關電流比大為下降。因此我們致力於製作結構化有機薄膜電晶體之元件結構與製程開發，利用黃光微影製程以及乾式蝕刻技術，定義出高分子主動層的區域，並成功製作出高開關電流比結構化有機薄膜電晶體。跟未結構化的有機薄膜電晶體相比，載子移動率相似，但開關電流比提升了10000倍之多。

接下來我們利用新穎之兩階段修飾層成長自我定位的製程方式來製作元件，其原理

為利用主動層區域內外之表面能差異的方式達成。首先將可溶性主動材料液體以旋轉塗佈或滴沾的方式來沈積主動層，由於主動層區域表面能較高，可溶主動材料液體會選擇性的在主動區殘留，進而達到圖案化的目的。在第二章中，我們利用交鏈高分子介電層為絕緣層，高分子聚-(3-己基噻吩) (P3HT) 為主動層，塑膠基板的選擇是很重要的課題，在應用上需要高透光度，低熱漲冷縮係數以及低吸溼效應，所以我們最後選擇PET當我們軟性基板。最後成功的在本實驗室做出首顆低成本軟性基板的有機薄膜電晶體，並且擁有不錯之電性，具有10^4之電流開關比與2.66伏特的低臨界電壓。

由於上述利用有機介電層令電流開關比不盡理想，所以我們在第三章中，我們將尋找最佳二氧化矽介電層沈積參數來得到最佳之元件電性。首先使用濕式二氧化矽介電層(閘極未圖案化)時，元件可得到最佳之電流開關比約10^7。在電漿促進沈積二氧化矽介電層中，我們設計三種二氧化矽厚度，並將對其所製作之元件特性進行探討。當厚度加厚至300nm，可得到耐高壓的二氧化矽介電層，其電流開關比並且可達到10^6，其高電流開關比電晶體應用於積體電路的可能性將增加。

我們介紹表面能的算法，利用量測基材與極性、非極性二種液體之接觸角大小與接觸角公式計算，將其求出已知值帶入Good-Girifalco (幾何平均)方程式即可求出表面能的大小。求得出當表面能差異約12 mJ/cm^{2}可有效將溶液自我定位

在第四章當中，將此方法首先應用在雙閘極有機薄膜電晶體中，將二種閘極加不同偏壓，進而對臨界電壓來加以控制。除了P3HT有機半導體高分子之外，我們並將此新穎之自我定位的製程方式應用於poly[9,9-dioctylfluorenyl-2,7-diyl)-co-(bithiophene) (F8T2)、氧化鋅 (ZnO) 、Pentance前驅物等等來當作有機薄膜電晶體元件之主動層材料。由於氧化鋅為N型，配合F8T2等P型材料，可以製作出互補式有機薄膜電晶體。

Study on the Novel Self-Organized Organic /Inorganic Thin Film Transistors for the Flexible Electronics Applications

Student：Cheng-Chin Liu　　Advisors：Dr. Huang-Chung Cheng
Dr. Tri-Rung Yew

Department of Electronics Engineering & Institute of Electronics
National Chiao Tung University

ABSTRACT

Recently, active matrix organic diode displays (AMOLEDs) become the most advanced technology in the market; organic light-emitting diodes (OLEDs) and organic thin film transistors (OTFTs) enable the fabrication of low-cost, flexible, full color flat panel displays. In principle, there are two primary leakage current paths of OTFTs; one is the conductive bulk current of P3HT, and the other one comes from the gate leakage current. Conventional OTFTs share a common gate, in which case the leakage current goes through the gate dielectric and the value is much more significant, and leads to a low I_{ON}/I_{OFF} ratio. Therefore, we had efforts on defining the active layer via the photolithographic technique and RIE drying etching for improving device performances. We have successfully proposed a patterned method for the TFT devices with the similar mobility and high I_{ON}/I_{OFF} ratio which is significantly improved by over four orders of magnitude than that of conventional ones.

Moreover, in this thesis we also fabricated OTFT devices by the novel self-organized method via two steps modification layer growth which provides different surface energies between the active region and non-active region. Soluble organic/inorganic semiconductors were deposited by dip casting or spin coating. Then the soluble active materials were selectivity deposited over the active region automatically due to different surface energies on the substrate surfaces. In chapter two, the cross-linked PVP and P3HT were acted as the dielectric and semiconductor materials, respectively. The key point for choosing the plastic substrate is the transparency, thermal expansion coefficient, and permeation of H_2O parameters. Polyethylenterephtalate(PET) is the best choice for our devices. We fabricated OTFT devices on the flexible substrate with on/off current ratio of 10^4 and threshold voltage of 2.66 volt.

Due to the poor on/off current ratio with PVP dielectric, in chapter three we optimized deposition parameters for obtaining the best electric performance with SiO_2 dielectric. The best I_{ON}/I_{OFF} ratio is up to 10^7 with wetted thermal oxide. We also fabricated devices with three kinds of thicknesses with PECVD oxides. High breakdown voltage and high I_{ON}/I_{OFF} ratio were observed with PECVD oxide thickness of 300nm. It has a great potential in integrated circuits.

The surface energy was obtained by measuring the contact angles of polar and non-polar liquids and calculating with the Good-Girifalco (geometric mean) equations. The organic semiconductor solvent was self-organized clearly with surface energy difference of 12 mJ/cm^2.

In chapter four, we also fabricated the novel double-gate structure OTFT devices with this self-organized method to control the threshold voltage by two gate bias. High threshold voltage will limit its application of OTFTs on low power consumption flexible electronics. Besides P3HT polymers, several other active materials, such as poly[9,9-dioctylfluorenyl-2,7-diyl) -co-(bithiophene) (F8T2), ZnO and, Pentance precursor were utilized for OTFT devices. Because the ZnO and F8T2 are N-type and P-type semiconductors, this could apply to the Complementary-OTFT device.

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