中文摘要

在本篇論文中，我們製備選擇性成長的氧化鋅奈米線並對其場發射特性進行研究。進而對單根氧化鋅奈米棒與金屬金和矽基版的介面特性作探討。

首先，我們利用多孔矽作基板，利用其粗造表面的特徵，鋅蒸氣較容易沉積在其表面上並形成一層附著層以降低表面能，卻不會在平坦的矽表面上，如此可無需使用觸媒而成長氧化鋅奈米線。我們證明使用多孔矽成長氧化鋅奈米線，有降低表面應力及增加成核點的優勢，這可能的成長機制應為蒸氣-固態(VS)的過程。

再者，利用電漿輔助氣相沉積法，成長定點控制的氧化鋅奈米柱，此選擇性成長的低溫製程可以使氧化鋅奈米柱被整合至光電元件平台。此外，此法的優點是可以控制生長的位置與變換相對距離進而控制密度。如此選擇性成長的氧化鋅奈米柱可被用來進行場發射的實驗，我們發現其機制是F-N穿遂模型，而中密度的試片比高密度的試片有更好的場發射提升因子。因此，藉由定點成長法，中密度且均勻分佈的奈米柱是非常需要的目標。而此一研究展示了一維氧化鋅奈米柱應用於場發射奈米元件並整合於矽基板的可行性。

此外，在場發射實驗中，我們發現藍光的產生。可能原因是電子從缺陷能階包含氧缺陷或鋅插入型缺陷到氧化鋅價帶的躍遷所放射出來，氧化鋅奈米柱因此可成為紫外與藍光發射的光源之一。

另一方面，我們對場發射試片的影響作探討。整體的場發射實驗中驗證雖是 F-N 穿遂機制。但是非線性的 F-N 圖形卻可從局部的實驗中發現。因此，我們研究懷疑缺陷含量的影響。我們從不同試片發現：氧缺陷多會容易產生吸附物進而改變功函數進而改變 F-N 圖形的斜率，氧缺陷的量和斜率變化的程度成正比，亦即造成功函數下降越大。

最後，我們利用鍍金探針的 AFM 和 SCM 量測單根氧化鋅奈米柱的電性。從 I-V 結果中可知氧化鋅和金的蕭基能障是 0.34eV，介面理想因子是 11，可能原因是接觸電阻太大與後面串聯一異質介面的電阻。而氧化鋅和矽的異直接面中，導帶差異為 0.3 eV，內建電壓為 0.48eV，此值比理想值略為下降的原因是由於介面能階的存在。總體而言，單根氧化鋅奈米柱用於場發射元件的頻率響應分為蕭基介面和異質介面，它們分別是 MHz 和 GHz 的速度。

ABSTRACT

In this thesis, we produced the patterned ZnO nanowires and its field emission device (FED) properties were also studied. Finally, the junction characteristics of one single ZnO nanorod with Au and Si substrate were investigated.

The PS surface provides a rough surface morphology, Zn vapor might condense easily on the PS surface and forms a wetting layer, but not on the flat Si surface., to form a wetting layer by decreasing the surface energy so that ZnO nanowires can grow without any catalyst. The rough morphology of a PS surface was proven advantageous for the growth of nanowires by reducing its strain and increasing the number of nuclei sites. The probable growth mechanism should be the vapor-solid (VS) process.

Moreover, Site-specific nanorods of ZnO were grown at low temperature by Plasma Enhanced Chemical Vapor Deposition (PECVD). The selective growth of ZnO nanorods at a relatively low growth temperature suggests that it can be integrated on device platforms for nanoelectronics. In addition, this technique also gives advantages of controlling the growth site and varying the proper interrod distance as well as the emitter density while growing the ZnO nanorods.

A field emission experiment for such patterned ZnO nanorods was conducted to indicate the F-N tunneling model. Sample of medium density is shown a better field enhancement factor than that of higher density. Therefore, uniformly distributed the nanorods with a medium density by site-specific growth is thus clearly required and this approach

was demonstrated the possibility of the integration of FE nanodevices by one-dimensional ZnO nanorods on a silicon substrate.

Besides, blue light might result from the exciton emission or the defect level emission in the FE experiments proved that the blue emission corresponds to the electron transition from the shallow donor level of oxygen vacancy and zinc interstitials to the valence band. ZnO nanowires are the promising candidate for UV and blue light emitter.

On the other hand, integrated Field Emission (FE) experiments were performed and involved the F-N tunneling mechanism. Nonlinearity of Fowler–Nordheim (FN) plot was observed under FE in local area. The relation between FE phenomena and defect amount of ZnO nanorods were studied. The phenomena can be explained by the adsorbate effects.and we found that the slope change had proportion to the amount of work function difference. The oxygen defects in ZnO nanorods might easily cause adsorption to lower fork function which decreased the slope of FN plots and hence affect the FE properties.

Finally, we measured the electric properties of single ZnO nanorod by conductive AFM and SCM. From those measurements, the schottky barrier height was about 0.34 eV and the ideal factor was about 11 due to the contact resistance and series connection of resistance from ZnO nanorod. The ΔE_C of heterojunction was also about 0.3 eV and the built-in voltage was about 0.48 eV below the ideal contact resulting from the interface state existing. For the application of FED, the frequency response of the two junctions, on -1~0 V is for schottky junction and 0-1 V is for heterojunction. They are MHz and GHz, respectively.

誌 謝

完成這本論文首先要感謝我的指導教授張振雄老師。因為有他的引導和鼓勵，我才可以學習到博士的研究精神與態度，並且在他辛苦的耐心與接納中，我的眼光與系統研究的思考模式才得以成長。另外，我也想對這些年之中，幫助我的老師們與最後給我指教建議的口試老師們，表達誠摯的謝意。包括王興宗老師、黃惠良老師、楊哲人老師、趙于飛老師、詹益仁老師、柳克強老師、劉國雄老師、簡世森老師，沒有這些老師與所屬實驗室學弟妹的幫忙，這論文的研究工作是無法完成的。

我也要感謝我們自己實驗室的學長學弟們，謝謝大家在人力物力，時間上的支援。這是我們曾經走過的歲月，一起努力的紀錄。此外，在工研院與在學術界的學長朋友們，這些年中對我無條件的幫助與鼓勵，小弟銘記在心。特別感謝鍾朝安、鄭志成、陳維恕、李樹恩、裴靜偉、魏鴻文、王廷玉、彭鈺樺、于世珩、鄒碧雲等人。

當然我要感謝愛我的上帝。賜我這一段光陰，放下順境逆境，成功與挫折，等待與盼望，使我不單學習知識的成長與追求卓越的態度，更學習作僕人的忍耐與對權柄的順服。上帝不斷的引領與垂聽禱告，培養出我積極樂觀的人生觀，這是最寶貴的禮物。

我也要感謝我家人的陪伴與扶持。父親的期望與要求、關心與

照顧是我珍惜的，母親的聆聽與掛念、支持與鼓勵也是令我感動的。姊姊妹妹的包容與照顧，讓我可以專心讀書而不用操心經濟問題，謝謝你們的犧牲。還有太多的人要感謝，一言難盡，只好再次說聲謝謝，也願上帝紀念你們所付出的。

謹此獻給我在天上的父親

Table of Contents

List of Table

List of figure