第五章、結論

綜合前一章所述之實驗觀察與分析結果，可歸納出以下幾點結論：

<u>高溫爐管系統</u>

主要是以物理氣相傳輸方式成長氧化鋅。藉由多次實驗與參考文獻來控制製程參數，系統真空度為 300 torr，Ar 流量 150c.c./min，分別在 Si（100）/Au(10 nm)、Al_2O_3/Au particles、Sapphire（11$\bar{2}$0）/Au particles 基板成長一維氧化鋅奈米結構，針對不同實驗參數討論氧化鋅之生長情形。

1. 在基板溫度影響方面，SEM 觀察顯示在不同溫度，但其他相同的製程條件下，無論是氧化鋅奈米帶或是奈米柱，尺寸皆隨著基板之溫度增加而變大。

2. 在成長時間影響方面，成長時間越長，奈米柱與奈米帶之尺寸亦隨著增加，另外觀察在 Al_2O_3 基板成長之氧化鋅隨時間增長，則由奈米柱轉變成奈米帶。

3. 在基板材料影響方面，Si（100）與 Al_2O_3 基板和氧化鋅並無磊晶關係，因此奈米帶之成長呈交錯複雜無定向之狀態，而 Sapphire 之 a 面與氧化鋅之 c 軸有良好的磊晶關係，可成長出高順向之氧化鋅奈米柱。

4. 綜合所得實驗結果，可發現在較低溫短時間下成長會生成氧化鋅奈米柱，而在較高溫長時間下成長則會形成氧化鋅奈米帶。

5. 由 TEM 的分析結果可知氧化鋅奈米帶均為單晶之 Wurtize 結構，而在 TEM 下觀察奈米帶之形狀是以一固定寬度延伸下去，但愈至末端可發現

寬度漸減，HRTEM 之影像顯示氧化鋅之邊界是以階梯方式讓寬度漸減，而奈米帶之末端有一形狀較不規則的金粒，金粒形狀具有刻面(facets)特徵，且金與氧化鋅相接之界面平整。

MOCVD 系統

主要是化學氣相沉積方式成長氧化鋅。藉由多次實驗與參考文獻來控制製程參數，系統壓力為 1 atm，N_2/O_2 流量 500c.c./min，基板溫度為 500℃，分別在鍍金與不鍍金之 Si（100）、石英玻璃和 Sapphire（$11\bar{2}0$）基板成長一維氧化鋅奈米結構，針對不同實驗參數討論氧化鋅之生長情形。

1. 在成長時間影響方面，SEM 下可觀察到在 Si（100）/Au(10 nm)基板上除成長一層均勻高順向之氧化鋅奈米柱外，另有一部分為尺寸較大之奈米柱，且隨著時間增加，其相對尺寸差異更明顯。整體來說隨著時間增加，氧化鋅奈米柱的尺寸會明顯增加。

2. Si（100）、石英玻璃與 Sapphire（$11\bar{2}0$）基板上鍍有金膜時，氧化鋅皆以奈米柱形式成長，且奈米柱形狀皆非常類似，頂端呈尖錐狀，沒有金球附在頂端；而同樣的基板上沒有金，但在相同製程條件下成長時，發現皆只能成長出氧化鋅薄膜。因此金有助於成長一維氧化鋅奈米結構。

3. TEM 可明顯觀察到排列整齊的氧化鋅奈米柱，SAD 分析結果可知奈米柱均為單晶之 Wurtize 結構，成長方向為[0001]，EDS 與 HRTEM 均可發現界面處有一層單晶金膜，具有[111]方位。金和氧化鋅之關係為$[01\bar{1}]_{Au} \parallel [2\bar{1}\bar{1}0]_{ZnO}$及 $(111)_{Au} \parallel (0001)_{ZnO}$。

4. 在較高倍率之 TEM 影像上可發現若是電子束照射時間增長,奈米柱之周圍會改變成有規律之鋸齒狀，長出尺寸約 5 nm 大小的奈米顆粒，這些奈米顆粒均為結晶型態，且與原來之奈米柱仍然維持固定的晶向關係。

5. 綜合所結果可確認氧化鋅奈米柱之成長並非以 VLS 方式進行

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