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Abstract

In this thesis, combining low-pressure metal-organic chemical vapor deposition technology with metal-catalyzed the growth of nanowire onto silicon substrate is the main purpose. We hope to synthesize GaN nanostructure possesses quantum confinement effect.

In this study, 5nm-thick Au thin film used as catalyst for synthesizing nanowires sputtered onto monocrystalline silicon (100). TMG, NH_3 and C_2H_2 gases were used as Ga, N and C precursors respectively. The structural characteristic of the material was examined with scanning/ transmission electron microscope, Raman spectra and X-ray powder diffraction. On the side, the optic characteristic and quantum confinement effect were measured by Photoluminescence spectra.

First, carbon nanotubes (CNT) were used to confine the radial growth simultaneously growth of GaN and carbon nanotube. The presence of the wurtzite structure GaN nanowires encapsulated inside the cavity along the length of a multi-wall carbon nanotube by experiment result. In the experiment, the inner and outer diameters and GaN nanowire encapsulated inside the carbon nanotube were changed with the flow rate of C_2H_2 was controlled. The outer diameter of CNT is about 20-50 nm and the diameter of GaN nanowire is about 10-15nm while the flow rate of C_2H_2 was controlled to be 50sccm. The outer diameter of CNT is about 15-20 nm and the diameter of GaN nanowire is about 6-8nm while the flow rate of C_2H_2 was controlled to be 25sccm. The diameter of GaN nanowire is decreasing with the flow rate of C_2H_2 reduced and conforms with the inner diameter of CNT as well as the band-gap has blue-shift. Gold can not catalyze the growth of CNT is already knew ago, but we

find that the carbon nanotube can be catalyzed by Ga in documents. Hence we suppose the growth of CNT was catalyzed by Ga-Au alloy and the sections of GaN nanowire were caused by the different speed of growth.

On the side, we synthesize GaN nanowire by 2-step method. The first part of GaN nanowire was synthesized at 750℃ and the second part was synthesized while the temperature cooling down. The GaN nanowire was defined to be wurtzite structure from experiment result. The first part of the wire was observed from TEM image that has triangular cross section with 36 nm diameters and the second part of the wire was observed from TEM image that has 5nm diameter. We can not observe obviously the quantum confinement effect from the analysis of spectra due to the second part GaN nanowires are too short. Hence we suppose that the synthesis of second part of GaN nanowire was catalyzed by using the minority of Au was not covered by nitrides as catalyst during cooling down.

In this study, the way of synthesizing GaN@CNT is efficiently to control the diameter of GaN nanostructure. That is efficiently and simply to synthesize a large amount of semiconductor materials possess quantum confinement effect.

中文摘要

本論文中主要的目的為結合低壓有機金屬化學氣相沉積技術以及金屬觸媒催化作用在矽基板上成長奈米線，希望製造出具有量子侷限效應的氮化鎵奈米結構。

本研究中我們利用濺鍍的方式在單晶矽(100)基板上鍍上約 5nm 厚的金薄膜作為合成奈米線的催化劑。另外利用 TMG,氨氣及乙炔氣體作為成長所需鎵、氮、碳等元素的來源。藉由掃描式/穿透式電子顯微鏡，拉曼光譜,X-ray 繞射圖形來觀察材料的結構與組成，另外材料的量子侷限效應藉由光激光譜的量測來確認。

首先我們利用碳管小內徑的特性來限制氮化鎵的徑向成長,由實驗結果顯示所成長出奈米線是一個多層奈米碳管包覆 wurtzite 結構氮化鎵的奈米線。實驗結果顯示改變乙炔的流量，碳管的內徑外徑與內層的氮化鎵奈米線也會隨著流量而改變，在乙炔為 50sccm 時碳管的外徑約為 20-50nm 氮化鎵奈米線直徑約為 10-15㎚，乙炔為 25sccm 時碳管外徑約為 15-20nm 氮化鎵奈米線直徑約為 6-8㎚，因此氮化鎵奈米線的直徑也隨著變大，同時由光激螢光光譜也發現隨著氮化鎵奈米線直徑的變小，氮化鎵的能階也有藍位移的趨勢。由於金對於碳管並沒有催化能力，但由文獻顯示鎵具有催化成長奈米碳管的能力，因此我們推測碳管是藉由鎵與金的合金催化而成長，並且由於碳管成長

速度較快也就造成氮化鎵奈米線形成一節一節的結構。

此外，我們利用 2 階段成長的方式，先成長一段氮化鎵奈米線並且在降溫同時持續成長，實驗結果顯示所長成之氮化鎵奈米線是具有 wurtzite 結構的 2 段式結構，第一段是直徑約 36nm 的三角形橫切面的氮化鎵奈米線以及第二段直徑約 5nm 量子尺度的氮化鎵奈米線，由於 2 段式氮化鎵奈米線的第二段極短因此在光譜分析上並沒有很明顯的量子侷限效應，由實驗結果顯示極細氮化鎵奈米線可能是由於在降溫同時金觸媒逐漸被氮化物包覆僅存極小部分可持續催化，因此而成長出第二段的奈米線。

在本研究中所發展出氮化鎵/碳管的製程方法可以快速且大量的成長半導體量子結構。

Figure Captions

Table Captions