低維度氮化鎵相關材料發光元件之研究

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摘　　要

本論文旨在於探討氮化鎵族低維度發光元件及結構之製作、材料特性、及光電特性。主要分為四個部分，第一部份為研究氮化銦鎵微米孔發光二極體之光輸出特性，其包含了元件的製作、電性的探討以及光輸出的特性研究，並搭配 TracePro 模擬軟體分析其元件性能的實驗結果。接著，使用有機金屬氣相沈積法在氮化矽奈米孔洞上成長不同大小之零維結構的氮化銦鎵量子點，並利用低溫光激發光譜技術、高解析穿透式電子顯微鏡以及原子力顯微鏡研究此不同大小之氮化鎵量子點的光學、結構特性與探討背後的物理背景，並利用快速熱退火的方式研究熱效應對氮化銦鎵量子點發光機制的影響。接下來介紹直徑約為 60 到 100 奈米的氮化銦鎵多重量子井奈米柱，包含兩種製作方式，一種為直接利用感應耦合式電漿蝕刻方式製作，另一種為透過奈米點狀的鎳金屬作為蝕刻奈米柱的遮罩，並利用光激發光譜技術、高解析穿透式電子顯微鏡以及原子力顯微鏡研究其光學物理及結構特性，並更進一步討論有關存在於氮化銦鎵多重量子井的壓電場在此結構下的影響，以及激子侷限的現象。接下來探討 δ-TMIn 技術在氮化銦鎵多重量子井發光二極體的影響，此 δ-TMIn 為在成長氮化銦鎵磊晶層時在前十分之一的磊晶時間裡的 TMIn 流量為 400sccm，接下來的 TMIn 流量降為 230sccm 完成氮化銦鎵層的磊晶，利用光激發光譜技術研究分析其多重量子井之活化能、載子侷限能及變溫激光光譜等特性，並與以一般成長條件(成長氮化銦鎵全程 TMIn 為 230 sccm)之元件作比較。

Studies of GaN-based Low-Dimensional Light-Emitting Devices

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Abstract

This dissertation explores the fabrication, structural properties, physical features, optical and electronic properties of GaN-based low-dimensional structure and light emitting device. The main focus of this dissertation can be divided into four parts. First, the enhancement in the light output of InGaN-based microhole array light emitting diodes (LEDs) is studied, including device fabrication, electronic properties and light output performance. The experimental results measured from the microhole array LEDs are analyzed with the TracePro simulation. Next, the growth of zero-dimensional structure of InGaN quantum dots (QDs) with different size grown on SiN nanoholes by metal organic chemical vapor deposition (MOCVD) is presented. Their optical and structural properties are investigated by using low-temperature photoluminescence (PL) measurement, high resolution transmission micro (HRTEM) and atomic force microscope (AFM). The photoluminescence spectroscopy was further utilized to study the tuning of confined energy levels in InGaN QDs via rapid thermal annealing. The following part presents the optical properties of InGaN/GaN multiple quantum well nanorods with diameters from 60 to 100 nm. The formation of the nanorods is employed by two methods. One is a directly induced coupled plasma (ICP) etching of InGaN/GaN MQWs LEDs wafer. The other one is ICP etching with self-assemble nickel (Ni) nanomasks formed by rapid thermal annealing. The PL, HRTEM and SEM are employed to study their optical and structural properties. The last part is the effects of delta-trimethylindium (δ-TMIn) flow process on optical properties of InGaN/GaN MQWs LEDs. This part focus on the improvement on light output of the InGaN/GaN MQWs LEDs with δ-TMIn flow process examined by using temperature-dependent PL and HRTEM measurements compared with that of the conventional devices without δ-TMIn flow process. The localization effect and the thermal activation energy by the δ-TMIn process are also studied here.