國立交通大學

光電工程研究所

博士論文

奈米製程技術在氮化鎵相關發光元件之研究
Study of Nano-Processing Techniques for GaN-based Light Emitting Devices

研究生：　黃泓文
指導教授：　王興宗 教授
　　　　　　郭浩中 教授

中華民國九十六年五月

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研究生：黃泓文	Student：Hung-Wen Huang
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郭浩中 教授	Prof. Hao-Chung Kuo

國立交通大學 電機學院
光電工程研究所
博士論文

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Doctor of Philosophy
in

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Hsinchu, Taiwan, Republic of China

中華民國九十六年五月

國立交通大學

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Hsinchu, Taiwan, R.O.C.

Date : 5/24/2007

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論文名稱：奈米製程技術在氮化鎵相關發光元件之研究

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奈米製程技術在氮化鎵相關發光元件之研究

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摘　　要

本論文旨在於探討氮化鎵族奈米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鎵銦表面奈米粗化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ASAP模擬軟體分析其元件性能的實驗結果。接著，使用TiO_2 particles在氮化鎵發光元件平台之側壁做粗化製程，並搭配ASAP模擬軟體分析其元件性能的實驗結果。接下來介紹直徑約為50到250奈米的氮化鎵銦多重量子井奈米柱，包含兩種製作方式，一種為利用奈米點狀的鎳金屬作為蝕刻奈米柱的遮罩，另一種為透過奈米點狀的鎳金屬/氮化矽（Si_3N_4)薄膜作為蝕刻奈米柱的遮罩，並利用光激發光譜技術以及高解析穿透式電子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鎵銦多重量子井的壓電場在此結構下的影響。最後，更利用光增強型化學式蝕刻技術，將氮化鎵銦多重量子井奈米柱作成電激發發光元件，並利用高解析穿透式電子顯微鏡研究其結構特性，以及分析其多重量子井之光激發光譜及電激光光譜等特性，並與一般氮化銦鎵之元件作比較。

Study of Nano-Processing Techniques for GaN-based Light-Emitting Devices

Student: Hung-Wen Huang

Advisor: Prof. Shing-Chung Wang
Prof. Hao-Chung Kuo

Institute of Electro-Optical Engineering
National Chiao Tung University

Abstract

This dissertation explores the fabrication, structural properties, physical features, optical and electronic properties of GaN-based nano-processing light emitting devices. The main focus of this dissertation can be divided into four parts. First, the enhancement in the light output of GaN-based top-surface nano-roughened light emitting diodes (LEDs) with self-assemble nickel (Ni) nanomasks formed by rapid thermal annealing is studied, including device fabrication, electronic properties and light output performance. The experimental results measured from the top-surface nano-roughened LEDs are analyzed with the ASAP simulation. Next, the enhancement in the light output of GaN-based sidewall nano-roughened light emitting diodes (LEDs) with nano-masks by TiO_2 particles also is studied. The following part presents the optical properties of InGaN/GaN multiple quantum well nanorods with diameters from 50 to 100 nm. The formation of the nanorods is employed by ICP etching with self-assemble nickel (Ni) nanomasks formed by rapid thermal annealing. The optical and structural properties are investigated by using varied temperature photoluminescence (PL) measurement, high resolution transmission microscope (HRTEM) and scanning electron microscope (SEM). The last part is fabrication of InGaN/GaN nanorod LEDs with self-assemble nickel (Ni) nanomasks and photo-enhanced chemical (PEC) etching. This part focus on the fabrication, optical and electrical properties are investigated on the InGaN/GaN nanorod LEDs by using room temperature PL, EL (electroluminescence) and HRTEM measurements compared with that of the conventional devices.

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泓文　　于 96 年6 月 14 日
交通大學光電所

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