

# 氮化鎵面射型雷射及微共振腔元件之研究

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## 摘要

本論文主要是探討氮化鎵面射型雷射及微共振腔元件之設計、製作及其發光特性。我們首先利用模擬軟體進行複合式結構的氮化鎵面射型雷射之設計。接著，我們利用有機金屬氣相沉積系統成長具有高反射率氮化鎵/鋁化鎵布拉格反射鏡之  $3\lambda$  氮化鎵系結構，並在此結構上以電子槍蒸鍍機蒸鍍高反射率之介電質反射鏡以完成面射型雷射結構之製作。針對此一結構我們在室溫下以光激發操作時，已觀察到雷射發光的現象，其臨界激發光能量密度為  $53 \text{ MJ/cm}^2$ ，雷射光波長為  $448\text{nm}$ 。此外我們亦針對此雷射之特性做了更深入之探討，諸如：發散角、極化程度、不同操作溫度之影響等…，經由實驗結果得知，我們已成功的製作出光激發氮化鎵面射型雷射。同時，我們亦針對此一結構導入製程以研發氮化鎵微共振腔元件。在充分運用各種半導體製程技術下，諸如：蝕刻、薄膜成長、歐姆接觸電極之蒸鍍等…，我們也成功的製作出氮化鎵微共振腔元件。此一元件在室溫 20 毫安培的電流注入下，發光波長在  $458.5\text{nm}$ ，並具有一窄的光譜半高寬值為  $6.7\text{nm}$ 。此外我們也針對此元件與一般的發光二極體及具下反射鏡之發光二極體元件做變溫操作及變電流操作之發光特性比較，亦發現氮化鎵微共振腔元件具有較佳的波長穩定性。此元件之特性說明了其結構及製程在發展電激發氮化鎵面射型雷射之可行性與潛力。

# Study of Microcavity LED and GaN-based VCSEL

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## Abstract

In this thesis, we report the design, fabrication and emission characteristics of GaN-based VCSEL and GaN-based MCLED. We grew the  $3\lambda$  nitride-based structure with 25 pairs of AlN/GaN DBR by MOCVD, and then deposited 8 pairs of Ta<sub>2</sub>O<sub>5</sub>/SiO<sub>2</sub> DBR by E-gun deposition to complete the full structure of GaN-based VCSEL. The fabricated structure was optically pumped at room temperature and the laser emission was observed. The threshold pumping energy was about 53 MJ/cm<sup>2</sup> and the laser emission peak wavelength was about 448nm. It's evidently that we have successfully fabricated the optically pumped GaN-based VCSEL. Besides, we also discuss the characteristics of optically pumped GaN-based VCSEL such as excitation energy - emission intensity curve (L-I), near field pattern (NFP), far field pattern (FFP), threshold carrier density ( $N_{th}$ ), threshold gain( $g_{th}$ ), degree of polarization (DOP), temperature dependent threshold and characteristic temperature ( $T_0$ ). We also fabricated the GaN-based MCLED following the success of optically pumped GaN-based VCSEL. The device showed the emission wavelength of 458.5nm and the narrowed spectral FWHM of 6.7nm at 20mA injected current. The MCLED also showed stable emission peak wavelength, while varying the injected current density and operating temperature. It indicated that a good resonant cavity was fabricated. Such MCLED could be the basis for electrically injected GaN-based VCSEL.

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# Contents

**Abstract (in Chinese)**

**Abstract (in English)**

**Acknowledgement**

**Contents**

**Table Contents**

**Figure Contents**

<b>Chapter 1</b>	<b>Overview.....</b>	<b>1</b>
1.1	Introduction.....	1
1.2	GaN-based Surface Emitting Devices.....	2
1.3	Objective of the Thesis.....	2
1.4	Outline of the Thesis.....	3
<b>Chapter 2</b>	<b>Fundamentals of VCSEL and Fabry-Perot Resonator.....</b>	<b>4</b>
2.1	Introduction to VCSELs.....	4
2.2	The Theory of DBRs.....	7
2.3	Fabry-Perot Resonator.....	11
2.4	The Finesse and the Quality Factor of Resonant Cavity.....	12
2.5	Operation Mechanism of VCSEL.....	13
<b>Chapter 3</b>	<b>Optically Pumped GaN-based VCSEL.....</b>	<b>20</b>
3.1	Recent Status.....	20
3.2	The Design of GaN-based VCSEL.....	21
3.2.1	The Simulation of Ta <sub>2</sub> O <sub>5</sub> /SiO <sub>2</sub> and Nitride-based DBRs.....	21
3.2.2	The Design of Active Region.....	25
3.3	The Fabricated GaN-based VCSEL Structure.....	26
3.3.1	Fabrication of GaN-based VCSEL.....	26
3.3.2	Reflectance Spectrum and Photoluminescence.....	27
3.3.3	The Finesse and the Quality Factor.....	29
3.4	Optical Pumping Experiment.....	29
3.4.1	Optical Pumping System.....	29

3.4.2	Characteristics of Optically Pumped GaN-based VCSEL.....	30
3.5	Summary.....	36
<b>Chapter 4</b>	<b>Fabrication and Characteristics of GaN-based MCLED.....</b>	<b>37</b>
4.1	Recent Status.....	37
4.2	Fabrication of GaN-based MCLED.....	38
4.2.1	Wafer Preparation.....	38
4.2.2	Process Procedure.....	41
4.3	Characteristics of GaN-based MCLED.....	47
4.3.1	Electrical Characteristic of GaN-based MCLED.....	47
4.3.2	Optical Characteristic of GaN-based MCLED.....	49
4.4	Summary.....	53
<b>Chapter 5</b>	<b>Conclusion and Future Work.....</b>	<b>54</b>
<b>Reference.....</b>		<b>56</b>



# Table Contents

Table 4.1 Process flowchart.....46



## Figure Contents

Fig. 2.1 Schematic diagram of (a) an EEL and (b) a VCSEL.....	4
Fig. 2.2 Typical structures of VCSEL and DBRs.....	5
Fig. 2.3 Schematic diagram of the light reflected from the top and bottom of the thin film.....	7
Fig. 2.4 Schematic diagram of DBRs.....	9
Fig. 2.5 A schematic diagram of a Fabry-Perot cavity with two metallic reflectors with reflectivity $R_1$ and $R_2$ .....	11
Fig. 2.6 The transmission pattern of a Fabry-Perot cavity in frequency domain.....	13
Fig. 2.7 Reservoir with continuous supply and leakage as an analog to a DH active region with current injection for carrier generation and radiative and nonradiative recombination.....	14
Fig. 2.8 Schematic diagram of VCSEL.....	17
Fig. 2.9 Illustration of output power vs. current for a diode laser.....	18
Fig. 3.1 The reflectance spectrum of 25, 40, 60, and 80 pairs of $\text{Al}_{0.25}\text{Ga}_{0.75}\text{N}/\text{GaN}$ DBR.....	22
Fig. 3.2 The reflectance spectrum of 25, 30, 40, and 50 pairs of $\text{Al}_{0.35}\text{Ga}_{0.65}\text{N}/\text{GaN}$ .....	22
Fig. 3.3 The reflectance spectrum of 5, 10, 15, and 25 pairs of $\text{AlN}/\text{GaN}$ DBR.....	23
Fig. 3.4 The reflectance spectrum of three different nitride-based DBRs with high reflectivity.....	24
Fig. 3.5 The reflectance spectrum of 3, 5, and 8 pairs of $\text{Ta}_2\text{O}_5/\text{SiO}_2$ DBR.....	25
Fig. 3.6 The EFI and the refractive index relative as the functions of the distance from top layer.....	26
Fig. 3.7(a) The SEM image of the MOCVD grown structure (b) The SEM image of the overall VCSEL (c) The schematic diagram of the overall VCSEL structure.....	27
Fig. 3.8 The reflectance spectrum of $\text{AlN}/\text{GaN}$ DBRs and $\text{Ta}_2\text{O}_5/\text{SiO}_2$ DBRs.....	28
Fig. 3.9 PL emission of MOCVD grown structure and overall VCSEL structure.....	29
Fig. 3.10 Optical pumping system.....	30

Fig. 3.11 The excitation energy - emission intensity curve (L-I).....	31
Fig. 3.12 The stimulated emission spectrum of the VCSEL at room temperature and the inset shows the stimulated emission image.....	31
Fig. 3.13 The stimulated emission image at different excitation energy.....	32
Fig. 3.14 The stimulated emission intensity as a function of the distance from the center of the emission spot.....	33
Fig. 3.15 The stimulated emission intensity as a function of the angle along the optical axial of the stimulated emission.....	33
Fig. 3.16 The normalized intensity as a function of the angle of the polarizer.....	34
Fig. 3.17 The temperature dependent threshold excitation power.....	35
Fig. 3.18 The emission intensity-excitation energy curve at 120K, 200K, and 300K.....	36
Fig. 4.1 The schematic daigram of nitride heterostructure of GaN-based MCLED grown by MOCVD.....	39
Fig. 4.2 The reflectivity spectrum of the 25 pairs of GaN/AlN DBR structure measured by n&k ultraviolet-visible spectrometer with normal incident at room temperature.....	39
Fig. 4.3 The PL spectrum of the MOCVD grown structure.....	40
Fig. 4.4 The reflectivity spectrum of 6 pairs of SiO <sub>2</sub> /TiO <sub>2</sub> DBR.....	41
Fig. 4.5(a) The 3D schematic diagram of nitride structure of MCLED grown by MOCVD (b) The 2D schematic diagram of nitride structure of MCLED grown by MOCVD....	43
Fig. 4.6 First step of process: mesa. (a) 3D schematic diagram (b) 2D schematic diagram....	43
Fig. 4.7 Second step of process: passivated (a) 3D schematic diagram (b) 2D schematic diagram.....	44
Fig. 4.8 Third step of process: TCL. (a) 3D schematic diagram (b) 2D schematic diagram...	44
Fig. 4.9 Fourth step of process: N-contact. (a) 3D schematic diagram (b) 2D schematic diagram.....	44
Fig. 4.10 Fifth step of process: P-contact. (a) 3D schematic diagram (b) 2D schematic	



diagram.....	45
Fig. 4.11 Sixth step of process: DBR (a) 3D schematic diagram of completed MCLED (b) 2D schematic diagram of completed MCLED.....	45
Fig. 4.12 Electrical and optical measurement system.....	47
Fig. 4.13(a)The photograph of MCLED tested at probe station. (b)Top view photograph of MCLED arrays. (c)Top view photograph of MCLED at 20ma current injection at room temperature.....	48
Fig. 4.14 L-I-V characteristics of GaN-based MCLED.....	48
Fig. 4.15 (a)GaN-based MCLED (b)GaN-based MCLED without top DBR (c)GaN-based conventional LED.....	50
Fig. 4.16 EL of GaN-based MCLED.....	51
Fig. 4.17 The emission peak wavelength of GaN-based MCLED, GaN-based MCLED without top DBR, and GaN-based conventional LED as a function of injection current density.....	52
Fig. 4.18 The emission peak wavelength of GaN-based MCLED, GaN-based MCLED without top DBR, and GaN-based conventional LED as a function of operating temperature.....	53