

以晶圓接合技術製作 1.5 μm 波長面射型雷射之研究

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摘要

本論文的研究目的是利用晶圓接合技術製作長波長面射型雷射。我們建立了晶圓接合的系統架構與製作流程。在不同的晶圓接合溫度下，我們比較了跨異質接合接面的電阻。由掃描式電子顯微鏡與電壓-電流特性的觀察，得到了可使接面有低電阻且良好的接合介面的晶圓接合溫度。藉由分析 InGaAlAs 多量子井 (MQW) 的螢光光譜強度，得知在晶圓接合過程中對晶體結構所造成的破壞。對於布拉格反射鏡 (DBR) 在經過晶圓接合製程後的反射率頻譜與最大反射率也給與分析及討論。多量子井與布拉格反射鏡的光學特性不會因為經過晶圓接合製程而發生改變。在檢視經過晶圓接合製程的電性與光學特性後，我們利用晶圓接合技術接合了 InGaAlAs 多量子井與 GaAs/AlAs 布拉格反射鏡並鍍覆上 SiO₂/TiO₂ 布拉格反射鏡，構成一面射型雷射之結構。此經過單次晶圓接合製程之面射型雷射，在室溫下以光激發操作的臨界激發光能量密度為 4.5 kW/cm²，受激發光光波長為 1623.5nm。此外，我們也以晶圓接合技術接合 InGaAlAs 多量子井與上部及底部 GaAs/AlAs 兩個布拉格反射鏡，構成一面射型雷射之結構。在室溫下，此經過二次晶圓接合製程之面射型雷射，之臨界激發光能量密度為 5 kW/cm²，受激發光波長為 1527nm。

Study of Wafer Fusion Technique for Fabrication of Long Wavelength Vertical Cavity Surface Emitting Laser

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Abstract

This thesis reports on the fabrication of long wavelength vertical surface emitting laser (LW-VCSEL) with the atomic rearrangement wafer fusion technique. We have setup a wafer fusion system and established the wafer fusion process. The resistance across fused heterojunction under different fusion temperature were compared. The proper fusion temperature for low resistance and well-fused fusion interface observed by scanning electron microscope was obtained. The peak emission wavelength and intensity of the InGaAlAs multi-quantum well (MQW) were analyzed to determine the degradation of the crystal quality during the wafer fusion process. The reflectance spectra and maximum reflectivity of GaAs/AlAs distributed Bragg reflectors (DBR) after the fusion process were also analyzed. The optical characteristics of the MQW and DBR did not alter after the wafer fusion process. After examined the electrical and optical characteristics after the fusion process, a VCSEL structure consisting of the InGaAlAs MQW, a fused bottom GaAs/AlAs DBR and a coated SiO₂/TiO₂ top dielectric mirror has been fabricated. This single fused VCSELs operated at room temperature by optical pumping with the threshold input power density of 4.5 kW/cm² and the stimulated emission wavelength at 1623.5nm. We also demonstrated optically pumped VCSEL structure consisting of the InGaAlAs MQW fused with the bottom and top GaAs/AlAs DBR. The double fused VCSELs operated at room temperature with the threshold pumping power density of 5 kW/cm² and the stimulated emission wavelength at 1527nm.

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Contents

Abstract (in Chinese).....	I
Abstract (in English).....	II
Acknowledgment.....	III
Contents.....	IV
List of figures.....	VI
List of table.....	VIII
Chapter 1 Introduction.....	1
Chapter 2 The operation principles of VCSELs.....	5
2.1 Ingredients of the laser.....	5
2.2 Energy bands in the solids.....	6
2.3 The creation of light.....	7
2.4 The double heterostructures.....	8
2.5 Semiconductor materials for laser diodes.....	9
2.6 Operation mechanisms of VCSELs.....	9
2.7 Output power versus driving current.....	11
2.8 The VCSELs fabricated with wafer fusion technique.....	12
Chapter 3 Wafer fusion technique.....	18
3.1 Introduction.....	18
3.2 Intorduction to wafer fusion methods.....	19
3.3 Key issues in the wafer fusion process.....	20
3.4 The wafer fusion system.....	21
3.5 Experiments for fusion system test.....	21
3.6 Conclusions.....	23
Chapter 4 Design rules and simulation of LW-VCSEL with wafer fusion technique.....	28
4.1 Simulation of DBR reflectance spectra.....	28
4.1.1 The theory of DBRs.....	28

4.1.2 Simulation of GaAs/AlAs DBRs.....	30
4.2 Simulation and design concern of active region.....	30
4.2.1 MQW detailed layer structure and design concern.....	30
4.2.2 Simulation of reflectance spectrum of the VCSEL structure.....	32
Chapter 5 Experimental results and discussions.....	37
5.1 Electrical characteristics experiments.....	37
5.1.1 Experimental details.....	38
5.1.2 Results and discussions.....	39
5.2 Optical characteristics experiments.....	40
5.2.1 The influence of distance between fusion interface and active region on active region PL intensity.....	40
5.2.1.A Experimental details.....	40
5.2.1.B Results and discussions.....	41
5.2.2 Comparison of PL spectrum before and after wafer fusion process..	41
5.2.2.A Experimental details.....	41
5.2.2.B Results and discussions.....	42
5.3 Optical pumping of VCSEL structure.....	43
5.3.1 One fused DBR with one dielectric mirror structure.....	43
5.3.2 Double fused DBRs structure.....	44
Chapter 6 Conclusion.....	57
References.....	59

List of figures

Fig. 1.1 Measured loss for typical single-mode silica fibers.....	4
Fig. 1.2 Measured material dispersion for typical single-mode silica fibers.....	4
Fig. 2.1 Two discrete energy level of an atom and the energy bands of a solid.....	14
Fig. 2.2 Electron energy vs. k-vector in semiconductor.....	15
Fig. 2.3 Three kinds of electronic transition between conduction and valencebands..	15
Fig. 2.4 (a) The schematic of the material structure of the material structure; (b) an energy diagram of the p-i-n structure; (c) refractive index profile; (d) the electric field profile for a mode traveling in the z-direction.....	16
Fig. 2.5 Energy band gap vs. lattice constant of some III-V compound.....	17
Fig. 2.6 General VCSEL scheme.....	17
Fig. 3.1 The schematic drawing of the fusion fixture.....	24
Fig. 3.2 The apparatus of wafer fusion system.....	25
Fig. 3.3 Optical microscope picture of GaAs/InP interface.....	26
Fig. 3.4 SEM image of GaAs/InP fused interface.....	26
Fig. 3.5 Current-voltage curve for fused InP/GaAs.....	27
Fig. 4.1 The schematic of a DBR.....	33
Fig. 4.2 Scheme of wave vector normal incident on single dielectric layer.....	33
Fig. 4.3 The reflectance spectra of GaAs/AlAs DBR with different number of pairs.....	34
Fig. 4.4 (a) active region including MQW and InP cladding layers structure details. (b) scheme of standing wave in the resonant cavity.....	35
Fig. 4.5 The structure for reflectance spectrum simulation and measurement.....	35
Fig. 4.6 Comparison of reflectance spectrums between measured and simulated results	36
Fig. 5.1 The layer structure of GaAs and InP.....	46
Fig. 5.2 Sample structure for electrical measurement and measurement scheme.....	46
Fig. 5.3 I-V curve with three different fusion teperatures.....	47
Fig. 5.4 Process for MQW quality experiment.....	48
Fig. 5.5 PL spectra for different InP thickness.....	49
Fig. 5.6 Dependence of the PL peak intensity on the distance from the fusion interface.....	49
Fig. 5.7 Flowchart of MQW/DBR fusion process	50

Fig. 5.8 PL spectra of MQW before and after wafer fusion.....	51
Fig. 5.9 The DBR reflectivity spectra before and after fusion.....	51
Fig. 5.10 VCSE structure for optical pumping.....	52
Fig. 5.11 Scheme of optical pumping / PL setup.....	53
Fig. 5.12 Spectra versus different pumping powers.....	54
Fig. 5.13 L-I curve of optical pumping.....	54
Fig. 5.14 Process flow chart of double fused VCSEL.....	55
Fig. 5.15 SEM image of the double fused VCSEL structure.....	56
Fig. 5.16 The double fused VCSEL output power versus input pumping laser power density characteristics at room temperature.....	56



List of table

Table 2.1 The number of pair for reflectivity=99.5% and thermal conductivity of GaAs/AlAs and InP/InGaAsP DBRs.....	14
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