

Design of LCoS devices using high contrast gratings

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December 9, 2022

CERTIFICATE OF AUTHORSHIP

I, Sangeeth Soman Thandasseril declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the department of Mathematical and Physical Sciences at the University of Technology Sydney. This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis. This document has not been submitted for qualifications at any other academic institution. This research is supported by the Australian Government Research Training Program.

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*This work is dedicated to my Dad(late), Mother and to my
grandmother (late Kausalya)*

To my partner, my friends and loved ones.

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ABSTRACT

Liquid crystal on silicon (LCoS) technology, existing for more than four decades ago, is facilitating a range of applications in photonics. For example, phase-only LCoS devices (LCoSDs) are now routinely used as switching elements in wavelength-selective switches. A range of different approaches have been considered to improve the performance of conventional LCoSDs. For instance, the diffractive optical losses associated with the pixelated backplane need to be alleviated to enhance the optical performance of LCoSDs. To make the device optically flat, I am using the high-contrast grating (HCG) structures implemented by Finisar Australia Pty Limited in C-Band and optimising the performance in other wavelength regions of operation.

In this thesis, I have numerically investigated HCGs to enhance the performance of LCoSDs. The study was performed using Finite-difference time-domain (FDTD) and rigorous coupled-wave analysis (RCWA) methods. For each significant spectral range (1064 nm, visible range, C-band), HCG parameters have been optimised separately. According to this research, silicon would be a suitable material for near-infrared gratings, while silicon nitride would be a promising material for visible gratings. Furthermore, I have investigated a crosslinked silicon HCG structure to improve the reflectivity of conventional LCoS in the C-Band wavelength range and around 1064 nm, introducing polarisation-independent reflectivity. Finally, I studied Finisar's polarisation-independent LCoSD and optimised the performance using various optimisation techniques. In the future, the results of this research will likely contribute to the design of high-performance wavelength selective switches and WaveShapers.

CONTENTS

1 Chapter 1:Introduction	1
1.1 Introduction to LCoSDs	1
1.1.1 LC electro-optic effects for phase only LCoSDs.....	3
1.1.2 Conventional reflective LCoSDs.....	5
1.2 Motivation of the thesis.....	6
1.3 Thesis structure.....	8
2 Chapter 2:Introduction to diffraction gratings and numerical methods	11
2.1 Introduction to diffraction gratings.....	11
2.2 High index contrast gratings for broad reflectivity	16
2.3 Numerical simulations to calculate the reflectivity of LCoSDs.....	19
2.3.1 Rigorous coupled-wave analysis method	19
2.3.1.1 Reflection efficiency of an LCoS backplane without pixels and with grating using RCWA	31
2.3.2 Finite-difference time-domain(FDTD) method	34
2.3.2.1 Reflection efficiency of a uni-periodic grating using the 2D-FDTD method.....	36
2.3.3 Comparison of the FDTD and RCWA.....	39
3 Chapter 3: Design of high reflectivity LCoSDs without pixels in near-infrared	40
3.1 Introduction to subwavelength HCGs.....	40
3.2 HCG structures for high reflectivity LCoSDs in near infra-red.....	41
3.3 Results and discussion	41
3.3.1 Design of silicon high contrast grating in near infra-red.....	41
3.4 Conclusion.....	48
4 Chapter 4:Design of high reflectivity LCoSDs with pixels and grating in near infrared and investigation of standing waves in pixels	49

4.1	High reflectivity LCoS with pixels and grating.....	49
4.2	Methods, results and discussion	51
4.2.1	Design of high reflectivity LCoS with pixels and grating in near-infrared and fabrication tolerances	51
4.2.2	Two-dimensional grid optimisation and fabrication tolerance of grating parameters.....	54
4.3	Numerical investigation of standing waves in pixelated backplane....	56
4.3.1	Simulation method.....	57
4.4	Results and discussion.....	58
4.4.1	Near optical field analysis using FDTD.....	58
4.5	Conclusion	60
5	Chapter 5: Design of LCoSDs in visible wavelengths	62
5.1	Introduction to silicon nitride HCG	62
5.2	Design of silicon nitride HCG LCoS in the visible wavelengths.....	63
5.3	Optimisation methods	64
5.3.1	Genetic algorithm to set initial grating parameters for optimisation in the visible wavelength.....	64
5.4	Results and discussion.....	65
5.4.1	Four parameter optimisation of R_s using genetic algorithm at 800 nm	65
5.4.2	Fabrication tolerance analysis of silicon nitride grating without pixels at 800 nm.....	66
5.4.3	Four parameter optimisation of R_s using genetic algorithm at 532 nm	69
5.4.4	Fabrication tolerance analysis of silicon nitride grating LCoS without pixels at around 532 nm	70
5.4.5	Design of silicon nitride grating on top of conventional LCoS pixels.	72
5.4.6	Optimisation of Si_3N_4 subwavelength grating LCoS using two- dimensional grid optimisation at 800 nm	75
5.5	Conclusion	76
6	Chapter 6: Polarisation independent HCGs for high reflectivity LCoSDs	77

6.1	Polarisation-independent HCGs for high-reflectivity LCoS in near-infrared	77
6.1.1	Introduction	78
6.1.2	Polarisation-independent high contrast grating	78
6.2	Results and discussion	79
6.2.1	Numerical simulation	79
6.2.2	Conventional LCoS backplane	81
6.2.3	Two-dimensional grid optimisation and fabrication tolerance	82
6.3	Conclusion	87
7	Chapter 7: Metal-dielectric grating for polarisation independent LCoSDs	88
7.1	Introducing anisotropic structure via uni-periodic metal-dielectric grating.....	88
7.1.1	Working principle of the metal-dielectric subwavelength grating.....	93
7.2	Results and discussion	97
7.2.1	Polarisation independent LCoS optimisation at 1550 nm.....	97
7.2.1.1	The Optimisation of uni-periodic metal-dielectric structure using surface plots and pseudo-colour plots	97
7.2.2	Polarisation independent LCoS optimisation at 1064 nm.....	101
7.3	Conclusion.....	109
8	Chapter 8	110
8.1	Conclusions and outlook.....	110
	Appendix A:Grating Diffraction Calculator(GD-Calc)	113
A.1	Implementation of GD-Calc.....	113
A.1.1	GD-Calc software interface overview	114
A.1.2	Constructing grating in GD-Calc	115
	Appendix B:Genetic algorithm optimisation	122
B.1	Genetic algorithm optimisation and implementation	122
	Bibliography	125

ILLUSTRATIONS

Figure 1.1. LCoS based Wavelength selective switch (WSS) design from Finisar.....	3
Figure 1.2(a,b). (a)A schematic of LC molecular birefringence grating (b) Schematic of zero-twisted configuration in electrically controlled birefringence(ECB) with small tilt angle.....	5
Figure 1.3. Illustrated schematically conventional reflective LCoS without grating....	6
Figure 2.1. Example of a uni-periodic one-dimensional grating.....	13
Figure 2.2(a, b). Example of one-dimensional multilayer dielectric Bragg grating. (a) Illustrates the grating region with a periodic variation of refractive indices between n_1 and n_2 with a periodicity of d . (b) Showing the reflectivity spectra of different Bragg gratings with a central Bragg wavelength of 1310 nm.....	15
Figure 2.3(a,b). Schematic of the subwavelength high contrast grating reflector. (b) Front view of the subwavelength HCG with waveguide array modes.....	17
Figure 2.4. Ultra-broadband reflectivity for light polarised perpendicular to the grating lines at a centre wavelength of 1550 nm using RCWA.....	18
Figure 2.5. Biperiodic grating structure.....	20
Figure 2.6. The period of bi-periodic grating illustrated the stratum-specific vectors.	22
Figure 2.7. The distribution of electromagnetic field's tangential spatial frequencies.	28
Figure 2.8. Illustrated an example of grating stratum with stripes and block.....	31
Figure 2.9. Illustrated an LCoS backplane without the pixels and uni-periodic silicon rectangular subwavelength gratings with stripes and fundamental grating periods in the RCWA platform.....	32

Figure 2.10 (a, b, c, d, e). Reflectivity of LCoS without pixels and with grating and convergence analysis.....	33
Figure 2.11. Schematic representation of Yee cell.....	36
Figure 2.12. Schematic diagram of the LCoS backplane with one-dimensional uni-periodic silicon high contrast subwavelength grating.....	38
Figure 2.13(a,b). (a) Convergence analysis of LCoS backplane with one-dimensional uni-periodic silicon HCG using FDTD method (b) Comparison of the reflectivity using FDTD and RCWA.....	38
Figure 3.1. Schematic view of one-dimensional uni-periodic Si-high contrast grating structure without pixels and with Al layer.....	42
Figure 3.2 (a, b). Broad high reflectivity in near-infrared wavelengths.....	43
Figure 3.3 (a, b, c, d). Optimisation and fabrication tolerance of LCoS without pixels and with grating.....	45
Figure 3.4 (a, b, c, d). Optimisation and fabrication tolerance of LCoS without pixels and with grating at around 1064 nm.....	47
Figure 4.1. Sectional side view of the liquid crystal on silicon with pixels and grating.....	50
Figure 4.2 (a, b, c). Schematic diagrams of the conventional LCoS pixels.....	51
Figure 4.3 (a, b). Schematic diagram of the HCG integrated on top of LCoS pixels..	53
Figure 4.4. Reflectivity comparison between LCoS with grating and pixels and conventional LCoS.....	53
Figure 4.5 (a, b, c, d). Optimisation and fabrication tolerance of LCoS with grating and pixel at around 1064 nm.....	55
Figure 4.6 (a, b). (a) Broad reflectivity of conventional LCoS simulated to observe local minima and maxima (b) Schematic diagram of Pixelated LCoS.....	57

Figure 4.7. Schematic diagram of the 3D-FDTD simulation.	58
Figure 4.8 (a, b, c, d). Near field optical analysis of conventional LCoS pixels.....	59
Figure 5.1 (a, b). Schematic diagram of Si ₃ N ₄ grating LCoS without pixels.....	63
Figure 5.2 (a, b). Genetic algorithm optimisation and broad reflectivity corresponding to optimal parameters.....	66
Figure 5.3 (a, b). Optimisation and fabrication tolerance analysis of Si ₃ N ₄ grating LCoS without pixels at around 800 nm.....	68
Figure 5.4 (a, b). Genetic algorithm optimisation and broad reflectivity corresponding to optimal parameters.....	70
Figure 5.5 (a, b). Optimisation and fabrication tolerance analysis of Si ₃ N ₄ grating LCoS without pixels at around 532 nm.....	71
Figure 5.6 (a, b). Schematic diagram of LCoS with Si ₃ N ₄ grating and pixels.....	73
Figure 5.7 (a, b). Convergence plot and broad reflectivity comparison at around 800 nm.....	74
Figure 5.8 (a, b). Two-dimensional grid optimisation in log scale.....	75
Figure 6.1 (a, b). Schematic diagram of the crosslinked grating on top of LCoS pixels and unit cell.....	79
Figure 6.2 (a, b). Cross-linked 2D grating with periodic boundary conditions along x and y, reflectivity simulated in C-Band.....	80
Figure 6.3 (a, b). Schematic diagram of the conventional LCoS backplane with equal periodicity.....	81
Figure 6.4 (a, b). Comparison of reflectivity in C-band and at around 1064 nm.....	82
Figure 6.5 (a, b, c, d). Two-dimensional grid optimisation and fabrication tolerance at around 1550 nm.....	84
Figure 6.6 (a, b, c, d). Two-dimensional grid optimisation and fabrication tolerance at around 1064 nm.....	85

Figure 7.1. Conventional LCoS with pixelated backplane embedded on the silicon CMOS panel.....	89
Figure 7.2. Schematic diagram of standard LCoS made polarisation insensitive by double passing the optical signal into the quarter-wave plate.	90
Figure 7.3. Illustration of Fabry-Perot resonance in a twisted nematic liquid crystal cell.....	91
Figure 7.4. X-Z view of the uni-periodic subwavelength structure with a periodicity of 0.75 microns.....	93
Figure 7.5. Exploded perspective view of polarisation independent LCoS having uni-periodic metal-dielectric grating embedded on pixels.....	95
Figure 7.6. Side exploded perspective view of polarisation independent LCoS showcasing the polarisation modification process.....	96
Figure 7.7 (a, b, c). Grid optimisation to observe the grating parameters dependence on phase difference.....	98
Figure 7.8 (a, b, c). Pseudo colour optimisation of phase difference and reflectivity difference.....	99
Figure 7.9 (a, b, c). Pseudo colour optimisation of phase difference and reflectivity difference, i.e., period=392 nm and width=65 nm.....	100
Figure 7.10 (a, b). Broad reflection efficiency from the optimised parameters. (b) phase difference simulated from 1450 nm to 1650 nm with the optimised parameters.....	101
Figure 7.11 (a, b, c). Pseudo colour optimisation of phase difference and reflectivity difference.....	102
Figure 7.12 (a, b, c). Pseudo colour optimisation of phase and reflectivity difference associated with linear polarisation components of the input light.....	103
Figure 7.13 (a, b, c). Pseudo colour optimisation of grating parameters.....	104

Figure 7.14 (a, b, c). Pseudo colour optimisation of phase and reflectivity difference associated with linear polarisation components of the input light.....	105
Figure 7.15(a, b, c). Pseudo colour optimisation of phase and reflectivity difference associated with linear polarisation components of the input light.....	106
Figure 7.16 (a, b, c). Pseudo colour optimisation of phase and reflectivity difference associated with linear polarisation components of the input light with optimal parameters.....	107
Figure 7.17 (a, b). Broad reflectivity and phase difference correspond to the optimal parameters.....	108
Figure B.1. Basic algorithm of genetic optimisation.....	123
Figure B.2. Algorithm of the genetic optimisation implemented in section 5.3.1....	124

TABLES

Table 3.1. Optimised parameters and fabrication tolerances at around 1550 nm.....	45
Table 3.2. Optimised parameters and fabrication tolerances at around 1064 nm.....	48
Table 4.1. Optimised parameters and fabrication tolerances of LCoS with grating and pixels at around 1064 nm.....	56
Table 4.2. The table illustrates the maximum electric field $ \mathbf{E}_y $ of the standing waves.....	60
Table 5.1. Summary of optimisation at around 800 nm.....	69
Table 5.2. Summary of optimisation at around 532 nm.....	72
Table 5.3. Summary of optimised parameters of the LCoS with pixels and Si_3N_4 grating.....	76
Table 6.1. Summary of optimisation at around 1550 nm.....	84
Table 6.2. Summary of optimisation at around 1064 nm.....	86

ABBREVIATIONS

LCoSDs: Liquid crystal on silicon devices

CMOS: Complementary metal-oxide-semiconductor

LC: Liquid crystal

SLM: Spatial Light Modulator

WSS: Wavelength Selective Switches

AWG: Arrayed Waveguide Gratings

ROADM: Reconfigurable Optical Add-Drop Networks

HCG: High Contrast Grating

FDTD: Finite Difference Time Domain

RCWA: Rigorous Coupled Wave Analysis

VCSEL: Vertical-Cavity Surface-Emitting Lasers

FEM: Finite Element Method

GD-Calc: Grating Diffraction Calculator

RI: Refractive Index

TE: Transverse Electric

TM: Transverse Magnetic

2D: Two-Dimensional

PML: Perfectly Matched Layer

DBR: Distributed Bragg Reflector

RHCP: Right-Handed Circularly Polarised

