Design of LCoS devices using high contrast gratings

By

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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.

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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