ABSTRACT

Silicon-on-insulator (SOI)-based sensors are attractive for sensing applications in environmental safety, oil and gas, medical research, and clinical applications. Since these devices are typically developed using Complementary metal-oxide-semiconductor (CMOS)-compatible multi-project-wafer (MPW) shuttles, they bring the potential for having sensing systems on chips (SSOCs), and for mass fabrication and low cost production. The objective of this thesis is to improve the sensitivity, accuracy, and repeatability of sensors fabricated on the SOI platform. Such sensors have the potential to be the key components of an SSOC.

One can increase the sensitivity of a resonator sensor by increasing the interaction between the evanescent field of the guided mode and the analyte. In this thesis, two methods for increasing this interaction in micro-ring resonator-based sensors are investigated: 1) using the transverse electric (TE) guided mode in ultra-thin strip waveguides and 2) using the quasi-transverse magnetic (TM) guided mode in thin strip waveguides. Using analyses and simulations, micro-ring sensors were designed to be fabricated within the constraints of a MPW CMOS-compatible process. Using the TE sensors, the temperature-induced errors were reduced by a factor of three; and the TM sensors exhibited twice the sensitivity of the best SOI micro-ring resonator-based sensors reported to date.

Moving towards the actual implementation of an SSOC, a system of sensors was designed to correct for unwanted variations in the measurements. This system drew on multivariate techniques to achieve improvements that resulted in measurements that were more repeatable and more accurate in the presence of environmental variations. The capability of this system is investigated by designing a cascade of previously developed micro-ring sensors with various waveguide thicknesses. With this system of sensors, we achieved an $R^2$ value of predictions over 0.996 in the presence of a 2 K temperature drift. This approach significantly improved the repeatability and reliability of the measurements in the presence of undesirable variations and drifts. In another move towards achieving an SSOC, integrating photodetectors in resonator sensors was investigated. To accomplish this, ion-implantation on micro-ring sensors was used. Such integrated photodetector-sensors were designed, fabricated, and tested. Their measured sensitivities were within 95% of the expected values.

BIOGRAPHICAL NOTES

Academic Studies: M.A.Sc., The University of British Columbia, 2008  
B.Sc., Carleton University, 2006

GRADUATE STUDIES

Field of Study: Biomedical Engineering, MiNa group  
Department of Electrical and Computer Engineering

Courses

<table>
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<tr>
<th>Instructor(s)</th>
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<tr>
<td>EECE 571C LASERS &amp; APPLS</td>
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<td>APSC 512 Intellectual Property Management and Technology Commercialization</td>
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<td>APSC 571T Biophotonics</td>
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<td>APSC 540 Business Decisions for Engineering Ventures</td>
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<td>APSC 530 Biomedical Equipment, Physiology and Anatomy</td>
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AWARDS

- Four-Year Fellowships (FYF) For Ph.D. Students  
- NSERC PGS Scholarship  
- Faculty of Applied Science Graduate Award  
- BCIC Innovation Scholarship  
- NSERC CGS M Scholarship  
- Faculty of Applied Science Grant Supplement Award  
- Ph.D. Tuition Fee Award  
- Graduate Entrance Scholarship  
- Faculty of Applied Science grant supplement award  
- Governor General’s Medal for academic achievement  
- USRA-NSERC  
- Professional Engineers Foundation award  
- David C. Coll Scholarships in Communications Engineering  
- Dean’s Honor List of Distinguished Students  
- Carleton's Entrance Scholarships
SELECTED PUBLICATIONS


SELECTED PRESENTATIONS


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The Final Oral Examination
For the Degree of

DOCTOR OF PHILOSOPHY
(Biomedical Engineering)

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“Optical Resonator Sensors and Systems”

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