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قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

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AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Engineering Physics and Mathmatics Department

Micro-Cavity Optical Sensors

A Thesis submitted in partial fulfilment of the requirements of the degree of

Doctor of Philosophy in Engineering Physics

by

Mohamed Nabil Ali Mohamed

Master of Science in Engineering Physics

Faculty of Engineering, Ain Shams University

Supervised By

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Prof. Khaled Abdel Wahhab Kirah

Dr. Yasser Mohamed Sabry

Cairo - 2020

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Date:18 May 2020

Statement

This thesis is submitted as a partial fulfilment of Doctor of Philosophy in Engineering Physics, Faculty of Engineering, Ain-Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Thesis Summary

Optical micro-cavities-based sensors are the subject of intensive researches and are expected to revolutionize the sensor market especially in biological and chemical applications. In this context, a proposed form of coupled cavities is presented to enhance the performance of cavity-based sensors in terms of the range of detection and accuracy. Other applications can also use the same concept to enhance the performance like in dye lasers. The basic drawback of these micro-cavities is that they are less tolerable to technological artifacts. A good control of fabrication processes is required for proper operation. The fabrication tolerance is analyzed and experimentally characterized. The proposed coupled cavity was modelled, designed, fabricated on Si wafer based on MEMS compatible technology. Characterization of these cavities revel a widened free spectral range and high quality factor compared to conventional single cavities. In order to further understand the behaviour of micro-cavities, a model based on Fourier optics was built to take into account some effects that were not included in previous models like the small size of the mirrors, verticality, roughness, and mirror shaping. The results of this model explain some of the mismatch between the expected and measured performance. Slotted micro-mirrors are expected to solve some problems found in conventional Bragg mirrors and metallic ones. Therefore, a new model for the slotted micro-mirror was presented to include the effect of mirror small thickness and the expected multiple reflections inside it. The model results are compared to FDTD simulations and good matching was observed.

Key words: Optical sensors, Optical cavities, Coupled cavities, Fabry-Perot cavities, Slotted mirrors

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Mohamed Nabil

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