Ain Shams University
Faculty of Engineering
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MEMS Fabry-Perot Spectrometer

A Thesis
Submitted in partial fulfillment of the requirements of a Master of Science degree in Electrical Engineering

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Cairo, 2017

Faculty of Engineering – Ain Shams University

Electronics and Communications Engineering Department

Thesis Title: **“MEMS Fabry-Perot Spectrometer”**

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Degree: **Master of Science in Electrical Engineering**

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Date: 21 /10 /2017

Statement

This dissertation is submitted to Ain Shams University for the degree of Master of Science in Electrical Engineering (Electronics and Communication Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communication Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ACKNOWLEDGEMENT

All praise is due to Allah, Most Merciful, the Lord of the Worlds, Who taught man what he knew. I would like to thank God Almighty for bestowing upon me the chance, strength and ability to complete this work.

My sincere gratitude goes to my parents, my sisters, my brother and the rest of my family. This work would not have been possible without their continuous encouragement, patience, support and assistance.

My words can’t express my gratitude to my advisor Prof. Diaa Khalil, who introduced me to the world of optics and guided me through my research and career to the best. I wouldn’t be able to finish this work without his support, guidance, encouragement and confidence in me. I’d like also to thank my co-advisor Dr. Yasser Sabry for his continuous help, discussions and flexibility to accept my ideas and refine them to reach better results.

Special thanks go to Prof. Mahmoud Hannafi who accepted me as member of the research team at Optical Communications and Lasers Lab (LLOC), Ain Shams University.

I would like to extend my deep gratitude to Si-Ware Systems, particularly the Optical MEMS division for sponsoring the Master and providing me with many facilities to complete this work.

Yomna Eltagoury
Cairo, Egypt
October, 2017

THESIS SUMMARY

This thesis aims to study and develop MEMS spectrometers based on Fabry-Perot (FP) interferometers and electrostatic actuators. For this purpose, we developed high speed electrostatic actuators and compared between different architectures. A novel Fourier Transform InfraRed (FT-IR) spectrometer architecture based on cascaded FP interferometers was introduced and analyzed thoroughly. Two designs for the cascaded FP FT-IR spectrometers based on Deep-Reactive-Ion-Etching (DRIE) technology over Silicon-On-Insulator (SOI) wafer were proposed and implemented. Successful demonstration of the spectrometer based the proposed designs was realized. The proposed MEMS spectrometer has the advantage of ultra-compact optics and high resolving power compared to the conventional architecture.

The thesis is divided into six chapters as listed below:

<u>Chapter 1:</u> gives a brief introduction of the motivation, objectives, major contributions and organization of the thesis.

<u>Chapter 2:</u> introduces a review on the types of optical spectrometer, namely, diffraction grating, tunable filter and FTIR spectrometers. An overview on the MEMS technology and the electrostatic actuation is briefly given. The FT-IR spectrometer theory of operation and the main system specifications are discussed. Finally, a brief comparison of the state-of-the-art miniaturized spectrometer is presented.

<u>Chapter 3:</u> reports the design, fabrication and characterization of high-speed MEMS actuators with in-plane motion; achieving the highest product of the travel range and frequency under atmospheric pressure. Two actuators are reported having resonance

frequencies of about 26.1 kHz and 93.5 kHz and achieving a single-side travel range of about 9.1 µm and 2 µm. An opto-mechanical characterization method is applied accounting for the diffraction effect in the microscale. The experimental results are compared to the theoretical analysis.

Chapter 4: introduces and analyzes the system of FTIR spectrometer based on cascaded interferometers. The system is analyzed for different combinations of interferometers by studying in details the overall transfer function and the generated interferogram and the corresponding spectrum. Two architectures based on FP interferometers are studied and optimization study for the different design parameter is carried out.

Chapter 5: presents two designs of the FP-FTIR spectrometer. The designs are modeled using Fourier optics to account for the diffraction effect. The implementation of the designs using DRIE technology on SOI is explained. Finally, the experimental results of the developed spectrometer are presented, demonstrating the success of the ultra-compact optics and the high resolving power compared to the conventional architecture.

Chapter 6: gives the conclusion of this thesis and introduces several recommendations and suggestions for the future work.

Key words:

Fabry-Perot interferometer, Micro-electro-mechanical systems (MEMS) technology, High speed actuators, Fourier transform spectroscopy, Dispersion, Micro-optical bench technology, Near-infrared (NIR) spectrometer, Fourier optics.

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