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Ain Shams University
Faculty of Engineering
Electronics and Electrical Communications Engineering Department

Modelling and Enhancement of Vertical Mirrors in MEMS Spectrometers

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

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Cairo, 2021

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Thesis Title: **“Modelling and Enhancement of Vertical Mirrors in MEMS Spectrometers”**
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Degree: **Master of Science in Electrical Engineering**

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Statement

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

The work included in this thesis was carried out by the author at the Electronics and Communications 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, Lord of the Worlds, Who taught man what he knew. I would like to thank Allah Almighty for bestowing upon me the chance, strength and ability to complete this work.

My sincere gratitude goes to my wife, my parents, and my family especially my brother Mo'men. This work would not have been possible without their continuous encouragement, patience, support and assistance.

I would like to thank Prof. Diaa Khalil and Dr. Yasser Sabry for their continuous support and guidance through my master's study, and even before the start of thesis work when they introduced me to the post graduate study at Ain Shams University. The work I have achieved wouldn't have been possible without their support.

Thanks to Si-Ware for enabling access to facilities to complete this work as well as financial co-sponsoring for my master's work. In this regard, I would like to thank Sebastien Nazeer for all the physical characterizations he have done, as well as Ahmed Shebl for the support on the optical characterization, both contributions were from the main pillars in my master's work.

I would like also to thank all my colleagues at Si-Ware systems for our fruitful discussions, ideas and suggestions, specifically Mohamed Sakr and Alaa Fathy. I would like also to thank my manager at Si-Ware Yasseen Nada for his understanding and support that made me able to finish this work.

Finally, thanks to all my friends who accepted my many apologies during the master's degree work.

Moez ElMassry
Cairo, Egypt
September 2021

ABSTRACT

Optical MEMS applications such as on-chip spectrometers, optical switches, and optical scanners require high reflectance vertical metallized micromirrors. The quality of the metal film sputtered on vertical micromirrors behaves differently than horizontal surface, and thus, affecting the optical reflectivity. In this thesis, vertical micromirrors fabricated using deep etching of silicon followed by metal sputtering are studied. Physical parameter extraction methodology, image processing, machine learning and discrete element analysis are used to extend the easy-to-take scanning electron microscope images into 3-D topographical information, that are usually obtained using atomic force microscope and transmission electron microscope. The experimental results show that vertical micromirrors surface quality has a granular nature showing degraded performance and a different optical response with respect to the bulk metal. A physical model is developed and validated by comparing the measured reflectivity of the fabricated micromirrors with a multi-layer reflectivity optical model based on the effective medium theory fed by the extracted physical parameters. In agreement with the experimental results, the model predicts a reflectivity of about 60 % for a sputtered aluminum thickness of 50 nm, compared to 97.5% reflectivity predicted by the bulk metal model.

Keywords: Vertical micromirrors, aluminum reflectivity, transfer matrix method, metal thin film grains, Micro-Electro-Mechanical-System, Silicon, Deep-Reactive-Ion-Etching.