MEMS MICRORELAY: DESIGN, MODELING, AND SIMULATION

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UNIVERSITI MALAYSIA PERLIS
2007

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by

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Report submitted in partial fulfillment
of the requirements for the degree
of Bachelor of Engineering

MAY 2007

ACKNOWLEDGEMENT

First of all, I would like to thank my final year project supervisor, Associate Professor Zaliman Sauli and also for lecturers who had given a helping hand during the progress. Thank for their supervision, encouragement, guidance, input and discussions. Thank Mr. Zaliman for appointing me to work on this project, from which I surely got exposed to many things. Thank Mr. Ramzan, Mr Hafiz and Madam Hasnizah in their valuable knowledge sharing and many aspects of care they gave to make me feel at home.

Nevertheless, I feel thankful to Final Year project coordinators of School of microelectronic Engineering UniMAP on their hard works in everything they done for us. Thank also for every level of university managements and academicians including the lab technician, because you I'm here for the degree of Bachelor Engineering in Electronics.

Then, I would like to express my my special thank to Mr. Lau Tong Leong product manager of Meds-Technologies (M) Pte. Ltd. for their technical supports in Samcef_Oofelie CAD software. Next appreciation is to my friends under the same supervisor, and few of my friends from other courses or different study of fields in or out from UniMAP. Thank for their cooperation and encouragement.

Finally, I would like to thanks for my parents especially for those stand by me and give me the full support to raise me up and created an environment in which I can concentrate on pursuing my intellectual pleasures.

Thank you.

APPROVAL AND DECLARATION SHEET

This project report titled MEMS Microrelay: Design, Modeling and Simulation was prepared and submitted by Yap David (Matrix Number: 031030528) and has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Engineering (Electronics Engineering) in Universiti Malaysia Perlis (UniMAP).

Checked and Approved by

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Project Supervisor

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March 2007

MEMS MIKROGEGANTI

ABSTRAK

Satu mikrogeganti baru telah dicipta dengan mengaplikasikan kesan kepiezoelektrikan dan kemudian dimodelkan menerusi perisian MEMS PRO L-EDIT CAD. Seterusnya, model tersebut telah dianalisis dan disimulasi dengan satu lagi perisian iaitu SamCef Field Oofelie FEM CAD dan MathCAD. Struktur jambatannya dan kesan daripada fenomena songsangan piezoelektrik daripada zink oksida membolehkan ia menghasilkan pergerakan menegak dan seterusnya menyambung litar keduanya sebagai fungsi geganti. Dengan voltan pandu 7V beza keupayaannya membolehkan ia menghasilkan pergerakkan sejauh 2μm dalam frekuansi resonannya kira-kira 335.87 kHz. Dengan daya sentuh sebanyak 4μN menghasilkan rintangan tutup litarnya yang rendah iaitu sekitar 0.3Ω. Galangan ciri bagi litar isyaratnya kira-kira 51Ω membolehkan ia mencapai galangan padanan yang baik untuk kegunaan dalam telekommunikasi dengan radio frekuensi, RF. Selain itu, saiz geganti yang halus, sifat-sifatnya yang unik tanpa kesan elektromagnet dan kebolehan berfungsi pada suhu 0˚K membolehkan ia digunakan dalam pelbagai applikasi selain dalam kegunaan RF-nya.

MEMS MICRORELAY

ABSTRACT

A newly design of single pole single throw piezoelectric vertical actuation MEMS microrelay was successfully designed and modeled at the end of this project. This was implemented by using MEMS Pro LEdit CAD Modeler. Then, the finalize bimorph sandwich fixed-fixed model had been simulated and analyzed with numerical analyses by using SamCef Field Oofelie FEM CAD software and some other analyzer created with MathCAD. The design was based on Zinc Oxide phenomena of inverse piezoelectric effect and some other mechanical beam structure considerations. It is capable to be switched in low driving voltage about 7V for 2μm displacement distance at resonant frequency about 335.87 kHz. Its flat-to-flat contact surfaces have a good contact area and given a low on-resistance about 0.3Ω with a contact force about 4μN. Then, its 51.537Ω characteristic impedance of the microstrip line had given a perfect impedance matching. So that, this piezoelectric actuation microrelay is well suited in RF telecommunications due to its tiny size, do not produce magnetic fields nor affected by them, and its ability of piezoelectric effect continue to operate even at temperature close to 0˚K enable it for a broad application area.

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MEMS	Micro Electro Mechanical Systems
CAD	Computer Aided Design
FEA	Finite Elements Analysis
DC	Direct Currents
EM	Electromagnetic
MIC	Microwave integrated circuit
RF	Radio Frequency
CPW	Coplanar Waveguide
App.	Appendix
Proc.	Process
iges	Initial Graphics Exchange Specification, a neutral data format that allows the digital exchange of information among Computer-aided designs (CAD) systems.
s	Total strain (Strain vector)
S	Compliance matrix of transducer
T	Mechanical stress
d	Piezoelectric material constant
E	Electrical field
ε	Permittivity of material

r	Radius of curvature
S_{long}	Longitudinal strain
t_p / t_e	Piezoelectric layer/ Elastic layer thickness
$A / A_e / A_p$	Cross sectional area of the elastic layer/ piezoelectric layer
$E_e / E_p / E_B$	Young's Modulus of the elastic layer/ piezoelectric layer/ beam
$I_e / I_p / I_B$	Elastic layer/ Piezoelectric layer/ Beam cross sectional inertial moment
w	Entire layer width
$\delta(x)$	Vertical displacement at any location (x) of the cantilever
V	Voltage
$\phi(x)$	Angular displacement at any location (x) of the cantilever
l_a, l_b	Partial a or b length of beam
L, W, T	Total Length, width and thickness of the beam
K	Force constant
C	Coefficient constant of beam
F	Force
M	Mass
ω_n	Normalized natural frequency
Q	Quality factor
f_n	Natural frequency or resonant frequency
ρ	Entire material mass density
δ	Skin depth

μ_o	Relativity permittivity
R	Conductance resistance
m	Ramp of the graph