

Micromachined inductive suspensions with 3D wirebonded microcoils



Dissertation zur Erlangung des Doktorgrades
der Technischen Fakultät
der Albert-Ludwigs-Universität Freiburg im Breisgau

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2016

A dissertation submitted in partial satisfaction of the requirements for the degree of

Doktor-Ingenieur
in
Microsystems Engineering

according to the examination regulations at the University of Freiburg for the Ph.D. in Microsystems Engineering of July, 2016.

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Date: June 01, 2016

Microactuators – Design and Technology
edited by Prof. Dr. Ulrike Wallrabe

Volume 11

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Shaker Verlag
Aachen 2017

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

Zugl.: Freiburg, Univ., Diss., 2017

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Printed in Germany.

ISBN 978-3-8440-5450-7

ISSN 2567-0921

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen

Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: www.shaker.de • e-mail: info@shaker.de

Declaration

according to §5(2f) of the examination regulations

I hereby confirm to have written the following thesis on my own, not having used any other sources or resources than those listed.

Freiburg, June 01, 2016

Zhiqiu Lu

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Notation

List of symbols

symbol	meaning	unit
A	overlapping area between two plates	m^2
$\vec{B}$	magnetic flux density generated by input currents	T
B_r	radial component of the magnetic flux density generated by input currents	T
C	capacitance	F
d_{pp}	distance between two SU-8 posts	μm
d_{cp}	distance between SU-8 post and capillary	μm
F_{Lev}	levitation force	N
F_r	radial component of Lorentz force	N
F_p	electrostatic force between two plates	N
f	frequency of input current	Hz
f_c	resonance frequency of a coil	Hz
G_{PM}	proof mass weight	N
g	proof mass thickness	μm
h	levitation height	μm
h_{coil}	coil height	μm
I_0	input current amplitude	A
I_1	inner coil current	A
I_2	outer coil current	A
i	eddy current	A
i_φ	φ -component of eddy current	A
J	eddy current density	A m^{-2}
k_l	vertical stiffness	N m^{-1}
k_s	lateral stiffness	N m^{-1}
k_φ	angular stiffness	N m rad^{-1}

symbol	meaning	unit
$k_{s\varphi}$	cross-stiffness	N m^{-1}
L	inductance of a coil	H
$L_{1,2}$	mutual inductance	H
L_{PM}	proof mass inductance	H
m	mass of proof mass	kg
N	number of windings	
p	pitch between two adjacent windings	μm
r	displacement in the radial direction	μm
R	resistance	ohm
r_1	inner coil radius	μm
r_2	outer coil radius	μm
r_{coil}	coil radius	m
r_{PM}	proof mass radius	μm
t	time	s
V	voltage	V
W	suspension energy	W
Z	impedance	ohm
z	displacement in the vertical direction	μm
δ	skin depth	m
ϵ_0	the free space electrical permittivity	F m^{-1}
ϵ_r	relative permittivity	
μ_0	magnetic permeability	N A^{-2}
μ_r	relative magnetic permeability	
δ	skin depth	m
Ω	volume of the proof mass	m^3
Φ	magnetic flux	Wb
σ	conductivity of the proof mass	S m^{-1}
ω	angular frequency of input current	Hz
ξ	induced electromotive force	V
$\mathcal{L}$	Lagrange function of the suspension	W

List of abbreviations

abbreviation	meaning
2D	two dimensional
3D	three dimensional
AC	alternative current
Al	aluminium
Au	gold
Cr	chromium
Cu	copper
DC	direct current
DRIE	deep reactive ion etching
EDX	energy-dispersive X-ray spectroscopy
EMF	electromotive force
FEM	finite-element method
Fe	iron
IR	infrared
MEMS	micro-electro-mechanical systems
MIS	micromachined inductive suspension
Ni	Nickel
PCB	printed circuits board
PECVD	plasma enhanced chemical vapor deposition
PM	proof mass
PMC	polymer magnetic composite
rms	root mean square
SMD	surface mounted device
Zn	Zinc