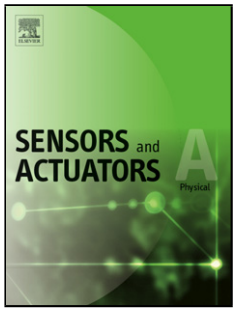

Title: A Fluid-Coupled Transmitting CMUT Operated in Collapse Mode: Semi-Analytic Modelling and Experiments

Author: Martin Pekař Stephan H.M. van Nispen Rob H.B. Fey Sergei Shulepov Nenad Mihajlović Henk Nijmeijer

PII: S0924-4247(17)30394-1
DOI: https://doi.org/doi:10.1016/j.sna.2017.09.055
Reference: SNA 10363

To appear in: *Sensors and Actuators A*

Received date: 27-3-2017
Revised date: 26-9-2017
Accepted date: 29-9-2017

Please cite this article as: Martin Pekař, Stephan H.M. van Nispen, Rob H.B. Fey, Sergei Shulepov, Nenad Mihajlović, Henk Nijmeijer, A Fluid-Coupled Transmitting CMUT Operated in Collapse Mode: Semi-Analytic Modelling and Experiments, *<![CDATA[Sensors & Actuators: A. Physical]]>* (2017), https://doi.org/10.1016/j.sna.2017.09.055

A Fluid-Coupled Transmitting CMUT Operated in Collapse Mode: Semi-Analytic Modelling and Experiments

Martin Pekař[a,b,*], Stephan H. M. van Nispen[c], Rob H. B. Fey[c], Sergei Shulepov[a], Nenad Mihajlović[a], Henk Nijmeijer[c]

[a] *Philips Research, Royal Philips NV, Eindhoven, the Netherlands*
[b] *Thorax Center Dept. of Biomedical Engineering, Erasmus MC, Rotterdam, the Netherlands*
[c] *Dynamics and Control Group, Department of Mechanical Engineering, Eindhoven University of Technology, the Netherlands*

Abstract

An electro-mechanical, semi-analytic, reduced-order (RO) model of a fluid-loaded transmitting capacitive-micromachined ultrasound transducer (CMUT) operated in collapse mode is developed. Simulation of static deflections, approximated by a linear combination of six mode shapes, are benchmarked towards state-of-the-art models and validated with digital holography microscope measurements of a fabricated CMUT device. The dynamic response of a detached single CMUT cell and an array of CMUT cells is predicted and analyzed for the effect of mutual radiation. The step-wise validation shows that our model predicts the static response including hysteresis behaviour of a collapse-mode CMUT with a high accuracy. The dynamic response and frequency-tunability are modelled with a satisfactory accuracy. The developed RO model is computationally efficient and in general faster than finite element methods. It is concluded that the presented RO model allows fast parameter analysis and is a powerful tool for CMUT pre-design.

Keywords: capacitive micromachined ultrasonic transducer, semi-analytic model, collapse-mode, simulations, experiments

1. Introduction

The development of capacitive-micromachined ultrasound transducers (CMUTs) has progressed significantly in the past years [1, 2, 3]. Especially the collapse mode operation of CMUTs has shown a potential for high performance medical imaging [4]. Accurate and fast simulation methods are necessary to guide the

*Corresponding author
Email address: martin.pekar@philips.com (Martin Pekař)