Mechanics of mems: a review of modeling, analysis and design

Ephrahim Garcia[1a], Nicolae Lobontiu[a], Yoonsu Nam[b]
[a]Sibley School of Mechanical Engineering, Cornell University, Ithaca, NY USA 14853
[b]Department of Mechanical and Mechatronics Engineering, Kangwon National University
192-1 Hyoja 2 dong, Chunchon, Kangwon KOREA 200-701

ABSTRACT

The paper provides a review of the literature dedicated to existing modeling, analysis, synthesis and optimization tools, together with the associated design procedures for MEMS applications, by looking at the approximate analytical algorithms and finite element procedures in the static, dynamical and coupled-field domains as applied to a large compartment of compliant members and their corresponding devices. The paper gives a classification of MEMS according to their structure and another classification as a function of their function. Main architectures of compliant microdevices are also reviewed, including torsion mirrors, bending mirrors, bimorph/multimorph transducers, accelerometers, gyroscopes, scratch drives, out-of-the-plane microcantilevers, sensing devices, resonators, switches or filters. Attention is dedicated to operational means of actuation, such as thermal, electrostatic, magnetic, electromagnetic, piezoelectric or shape-memory-generated, and to their integration into the overall microsystem design. Numerical modeling techniques, such as finite or boundary element model algorithms/codes that are utilized in the analysis and design of MEMS are also presented.

Keywords: MEMS, mechanics, modeling, analysis, design

1. INTRODUCTION

This paper gives a brief review of the literature dedicated to the methods of modeling, analyzing, synthesizing and designing of microelectromechanical systems (MEMS) mostly from a mechanical engineer's viewpoint. As it is virtually impossible to address all relevant MEMS-related publications, the paper has its inherent limitations mainly posed by subjectivity and dimension boundaries, and therefore the titles included here are just a small sample of the vast body of dedicated literature. A schematic of the topics covered here is shown in Fig. 1. where the MEMS typology is first discussed in terms of structural and functional criteria, followed by the main domains of MEMS design (and which are the static/quasi-static domain and the dynamic one – with its core of modal response) and eventually the methods of MEMS design, including analytic, finite element and experimental procedures. The important issues of materials, microfabrication, packaging, and final characterization, which are natural points of interest in MEMS design, have not been included in the present discussion.

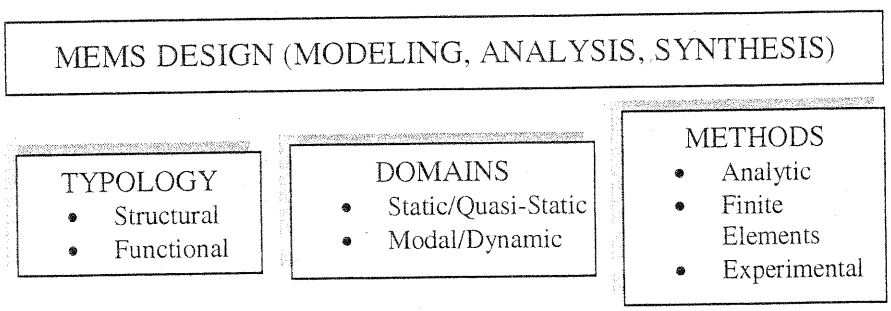

Figure 1. Main aspects in the mechanical-based design of MEMS

[1] eg84@cornell.edu, phone: 607 255 4366, fax: 607 255 1222

Smart Structures and Materials 2004: Smart Structures and Integrated Systems,
edited by Alison B. Flatau, Proc. of SPIE Vol. 5390 (SPIE, Bellingham, WA, 2004)
0277-786X/04/$15 · doi: 10.1117/12.540070