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IMEMS Modeling

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We describe our modeling toolbox which is tailored for the simulation of integrated micro-electromechanical systems (IMEMS). The toolbox is based on the framework of SESES. Coupled modeling of electrical, thermal and deformation phenomena is provided in a uniform and consistent environment, allowing all boundary and interface conditions required for the correct simulation of the principal IMEMS devices. Our system addresses the essential requirements for a practical IMEMS toolbox: automatic mesh adaptation in 2 and 3 dimensions; near-optimal data structures enabling meshes of about 150,000 finite elements; excellent computational accuracy and efficiency on engineering workstations; consistent treatment of nonlinearities and coupling mechanisms.

1. Introduction

IMEMS[1] building blocks are based on integrated circuit (IC) technology and exploit the interaction of different physical effects to provide controlled actuation, modulation and detection mechanisms. Examples are electrostatic or electrothermal excitation of mechanical displacement, as well as piezoresistive, piezoelectric or capacitive readout, as found in microresonators,[2] electrostatic comb drives[3] and bimorph beams.[4]

The use of integrated circuit fabrication technology for MEMS places narrow limits on new designs, requiring extensive optimization studies. This requires simulation tools which are far superior in terms of efficiency and memory requirements to commercially available solutions. At the Physical Electronics Laboratory, a large number of different IMEMS devices are currently under development. Our toolbox accounts for this with a modular program structure, facilitating the addition of partial differential equations (PDE's), coupling mechanisms and material nonlinearities.[5] The rate at which IMEMS designers