CAD for Micromechanical Systems

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The activities at the Department of Microsystems and Precision Engineering are focused on the design and application of micromechanical components as well as the evaluation and investigation of methods and tools for the microsystem design flow.

Test and redesign cycles are expensive, because the initial semiconductor fabrication set-up for MEMS is very costly and time-intensive. Therefor the design has to be verified and optimized in advance so that the unit operates with a single round of physical testing. The finite element method has been successful applied for simulation and design on the physical level of abstraction. At the system level, where it is desirable to connect the MEMS device into circuits and to understand the effects of feedback, accurate and energetically correct low-order dynamic behaviour models are needed. Our group uses ANSYS and MEMS Pro. The ANSYS/Multiphysics FEM-Package (ANSYS, Inc.) is well suited for structure, thermal, electrostatic and fluidic design optimisation as well as for coupled field analysis. MEMS Pro (MEMScAP) is practical for system-level simulation and component design.

The Department of Microsystems and Precision Engineering develops new methods for the significant link between the component and system design. A main research is the development of methods an tools for the extraction of reduced order models (ROM) including non-linearity from the expensive physical model to built fast and accurate system models (EKOSAS). Non-linear response by mechanical structures caused by external forces (electrostatic forces, hydrostatic pressure, etc.) and by internal phenomena (plasticity, stress-stiffening effect, etc.) must be considered. Efficient routines to consider interactions with other physical domains are essential. Fig. 1 shows the coupled electrostatic-structural simulation of a micro-mirror-array. Each mirror cell is electrostatic actuated. The simulation of electrostatic actuation involves computation of the electrostatic field to obtain the capacitance and forces. The equilibrium between electrostatic forces and the companion structural reaction forces must be iterative resolved to obtain a consistent solution. Each array cell interacts with adjacent cells by structural, electrostatic and fluidic coupling. Theoretical and experimental investigations of these effects were made in the research project SFB 379/A1.

The response functions of dynamic operated micromechanical devices are primarily shaped by viscose damping effects in the surrounding air. The calculation of the fluid flow and the fluid-structure interactions are necessary. For small air gaps, the Navier-Stokes equation can be simplified to Reynolds squeeze film equation and can be solved with heat flow analogy. Methods and software development to solve this equation is the issue of our part in the REV-Project.

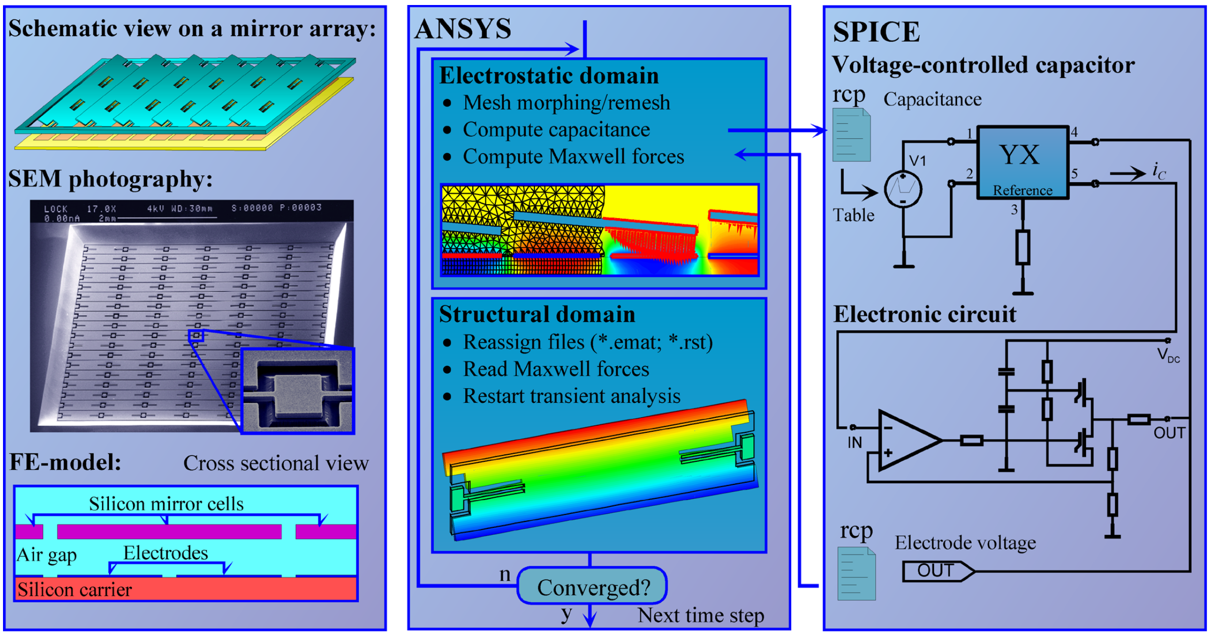

Fig. 1: Coupled electrostatic-structural simulation of Micro-Electro-Mechanical-Systems