Integration of TCAD Tools into CAD Tools for MEMS

Nathan M. Wilson[1], Robert W. Dutton[2]

Departments of Mechanical Engineering[1] and Electrical Engineering[2]
Division of Mechanics and Computation and TCAD group
Stanford University, Stanford, CA 94305-4075
[1] Correspondence author: nwilson@stanford.edu

Micro-Electro-Mechanical Systems (MEMS) offer dramatic new functional capabilities. Analysis of MEMS is a challenge; the structures are geometrically complicated, electromechanically coupled, and inherently three-dimensional. The multi-domain physics for MEMS includes electrical, mechanical, and fluidic interactions. Effects of each domain need to be accurately simulated to correctly predict device performance. In addition, IC-based fabrication techniques require the modeling of complex material behavior and processing such as oxidation, etching, deposition, and diffusion.

Two quite different modeling methodologies are being pursued among the MEMS community. The "homogeneous" approach is to develop tightly integrated component simulation tools and design methodology. Alternatively, a "heterogeneous" approach is one that wraps distinctly different end-user software packages to create a "meta" tool. Currently available implementations have limitations especially in the area of creating and utilizing complex geometry. A geometry server under development at Stanford will be discussed, built on top of the solid modeling kernel Shapes [1], that permits the efficient integration of process simulation results into a portable geometric model.

Many commercial and academic systems for MEMS analysis rely on purely geometric operations to create device geometry. While Technology CAD (TCAD) tools exist for creating geometry for the VLSI community, there are unique challenges posed by MEMS. Modeling challenges include the size (and aspect ratios) of typical structures, residual stresses which create initial curvature in ideally flat devices, and effects of the materials used. If 3-D process simulation for the entire device were performed to predict geometry, it would require excessive amounts of computing resources including time and memory that exceed current limitations of software and hardware. In addition, due to some of the features of typical devices, much of the device does not gain geometric accuracy from 3-D simulation compared to using 2-D typical cross-sections. This motivates the novel method to be discussed which utilizes existing tools in a computationally efficient method to achieve accurate and practical geometry. A technique referred to as "domain decomposition" will be presented that utilizes a combination of 1-D, 2-D, and 3-D process simulation to build physically accurate geometry of MEMS for simulation [2,3]. The domain decomposition technique is an automated process that uses process flow, mask layouts, and a set of heuristics to determine which regions on the wafer require 1-D, 2-D, and 3-D simulation. The appropriate order of simulation is then performed and the results are automatically combined to create a useful geometry that can be used for simulation of device behavior.

References

[1] Shapes, by XOX, Inc., http://www.xox.com

[2] N. M. Wilson, R. W. Dutton, and P. M. Pinsky, "Utilizing Existing TCAD Simulation Tools to Create Solid Models for the Simulation Based Design of MEMS Devices", Proceedings of *International Mechanical Engineering Conference and Exposition*, November 15-20, 1998, pp. 565-570.

[3] N. M. Wilson, S. Liang, P. M. Pinsky, and R. W. Dutton, "A Novel Method to Utilize Existing TCAD Tools to Build Accurate Geometry Required for MEMS simulation", Proceedings of *Modeling and Simulation of Microsystems*, April 19-21, 1999, pp. 120-123.