Organization(s): **Massachusetts Institute of Technology; Georgia Institute of Technology; and Coventor Incorporated**

MTO Composite CAD

Title: New Paradigms for Macromodel Generation of Highly Nonlinear or Strongly Freqency Dependent Integrated Microdevices

Duration of Effort: October 1997 - April 2001

Principal Investigator(s): J. White and S. Senturia (MIT), M. Allen (GIT), J. Gilbert (Coventor)
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Objectives:

Develop algorithmic approaches combined with experimental validation for generating energetically correct and dynamically accurate device macromodels.

Major Accomplishments:

- Developed two fully automatic nonlinear model-order reduction algorithms, one based on a global quadratics and the second based on multipoint linearization. Both schemes provide accurate models of mildly nonlinear devices, using orders of magnitude less computation.
- Developed robust quadrature for curved structures, as well as automated meshing, enabling memHenry to be used in coupled magnetomechanical analysis of complex structures.
- Developed a new photoresist/electroplating process for fabricating both permeable material and Lorentz-force devices, fabricating second generation test structures.
- Developed the first stable surface integral formulation for wideband electromagnetic analysis of problems with finite-sized conductors. Nearly 10x faster than FastHenry for high frequency analysis.
- Extended the CHURN energy-based macromodeling process for assisted development of reduced-order models of highly nonlinear devices to handle magnetic forces and stress-stiffened effects.
- Developed FastMag, an integral equation based solver capable of determining frequency dependent impedances for microfabricated inductors which include magnetic materials. The program's results matched data from GIT's inductors fabricated with magnetic materials.
- Developed two new approaches for near-optimal automatic model-order reduction of strongly frequency-dependent devices (such as spiral inductors). The combined Arnoldi/TBR method and CFADI method both generate models which are as much as 200 times more efficient than Arnoldi-based methods for realistic problems. In addition, Jing Li's work on CFADI was nominated for a FOX prize, a prestigious international award for numerical mathematics.

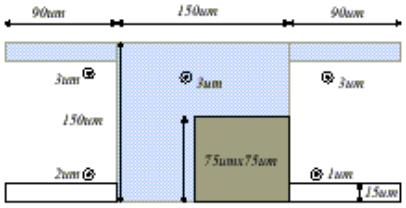
DOD Impact:

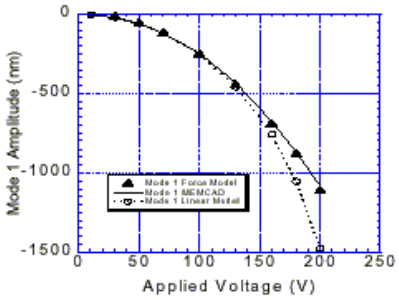
- DOD designers are desperate for better design tools. Now, they have several alternatives.

Technology Transfer/Products:

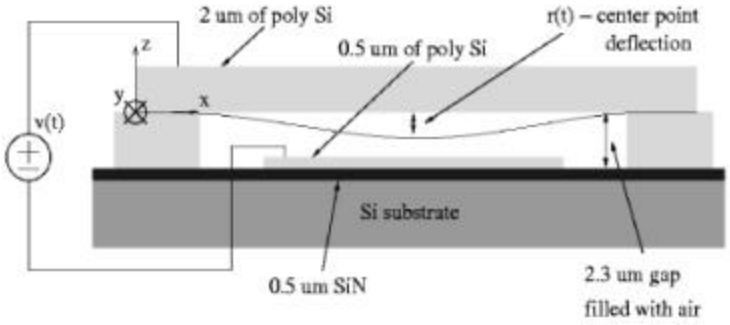
- CFDRC and Coventor currently use some of our macromodeling approaches. Coventer is examing the integral formulation for high frequency analysis.

Massachusetts Institute of Technology

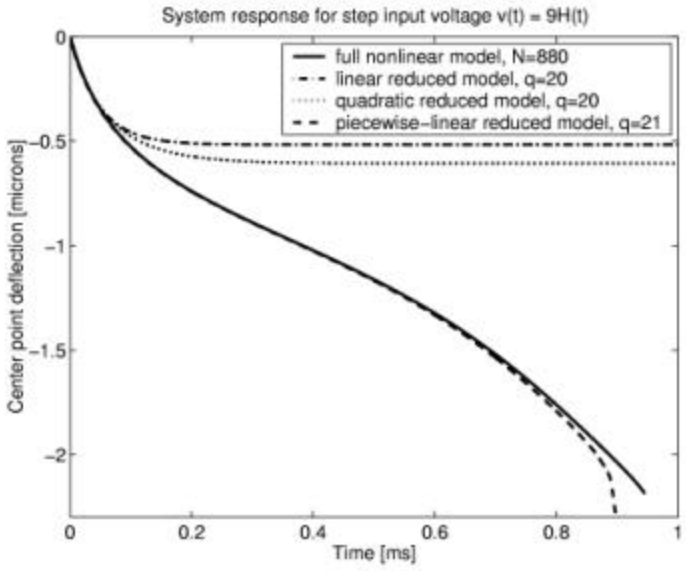




Asymmetrically Supported Plate, electrode 6 microns below plate Model reduction using modified Churn method, note excellent match



Fixed-Fixed Beam with nonlinear voltage/displacement relation



A comparison of the multipoint linear reduction to the exact solution and the Quadratic reduction. Note the much better fit with the multipoint method.