

# MEMS+® 5.0 for MEMS Device Design

Explore Concepts

Optimize Designs

Predict Yield

## The Challenge

MEMS development takes too long...

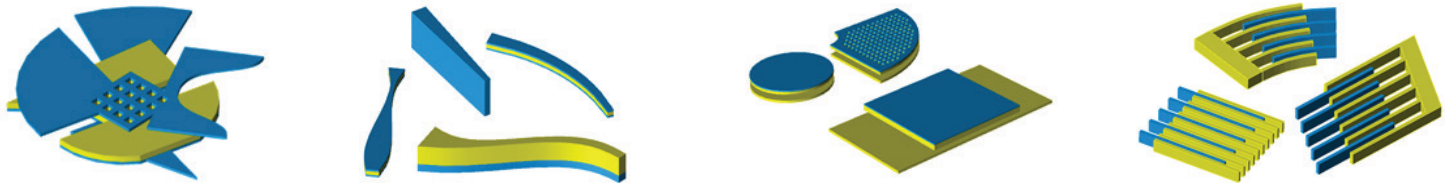
- ◆ Conventional FEA (finite element analysis) is time consuming, even for assessing basic behavior...
- ◆ Full multi-physics coupling is approximated or ignored (this can make or break devices)
- ◆ Transient simulations are often infeasible because they take too long
- ◆ Yield studies are not performed
- ◆ Numerous, time consuming in-fab learning cycles are used in place of simulation
- ◆ Market windows are missed!

## The Solution

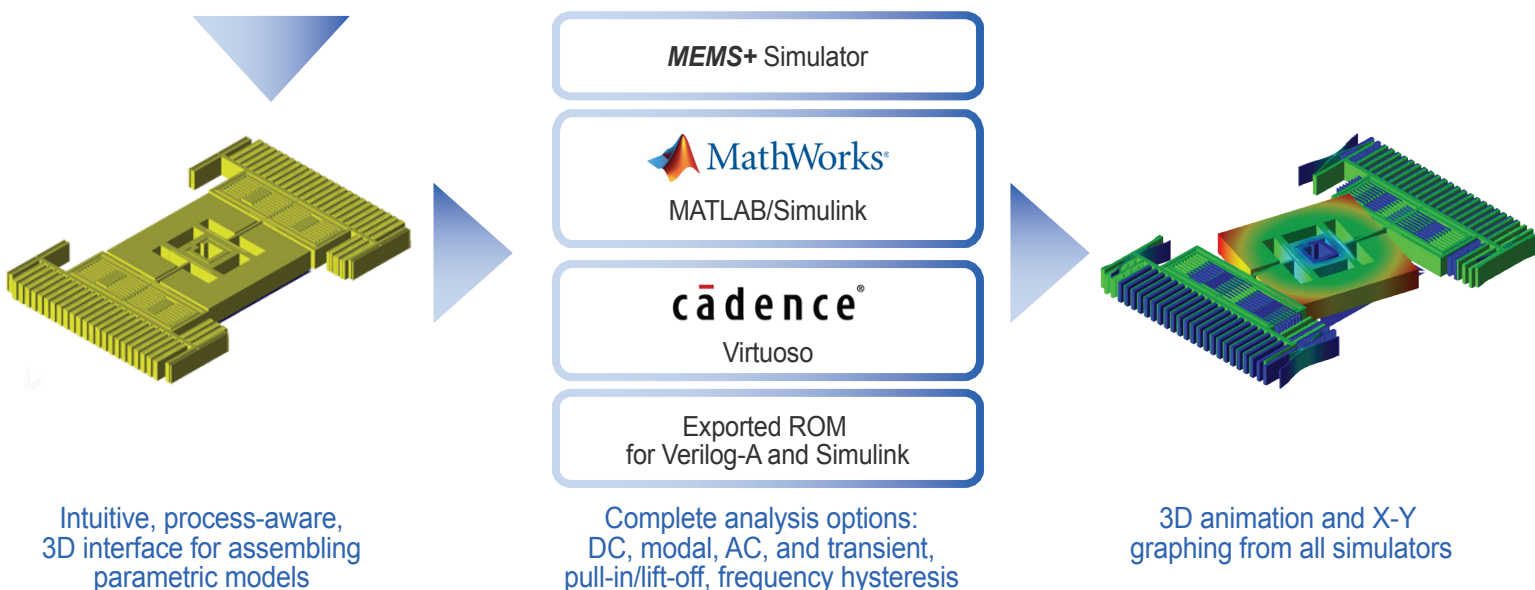
**Reduce development time** using **MEMS+** models

- ◆ Assemble models from a library of MEMS-specific, high-order, parametric finite elements
- ◆ **MEMS+** models are compact (10s to 1,000s unknowns) and simulate really fast (> 100X faster than FEA)
- ◆ The same model runs in multiple simulators: **MEMS+**, MATLAB, Simulink, and Cadence Virtuoso
- ◆ Fully coupled multi physics: mechanics, electrostatics, piezo, thermal, gas damping, packaging and more...
- ◆ Non-linear effects included: mechanical and electrostatic; pull-in, lift-off, spring softening; quadrature, frequency hysteresis, ...

**MEMS+** Component Library: MEMS-specific, 3D, high-order, parametric finite elements



Everything needed to assemble multi-physics models of complex, real-world sensor and actuator designs



*The simulation speed of MEMS+ models opens exciting new possibilities for concept exploration, design optimization and yield analysis*

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# MEMS+® 5.0 for MEMS+IC Co-Design

Closed Loop

Corner Cases

Noise Analysis

## The Challenge

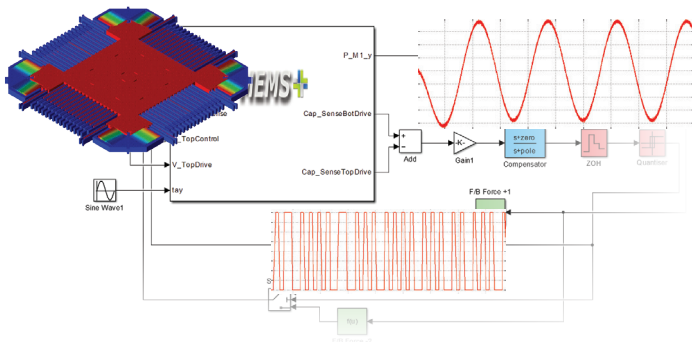
Months are wasted on hand-crafting different MEMS device models for system and IC designers.

- ◆ Different models for different users...
  - System designers use MATLAB/Simulink
  - IC designers use SPICE or Verilog-A
  - MEMS designers use FEA
- ◆ Hand-crafted MEMS models for Simulink, SPICE, or Verilog-A are common practice. These are...
  - Inaccurate due to over-simplification: Degrees of freedom and non-linear effects are neglected
  - Not parametric with respect to design or environment variables
  - Prone to human error and rapidly go out of sync between design groups

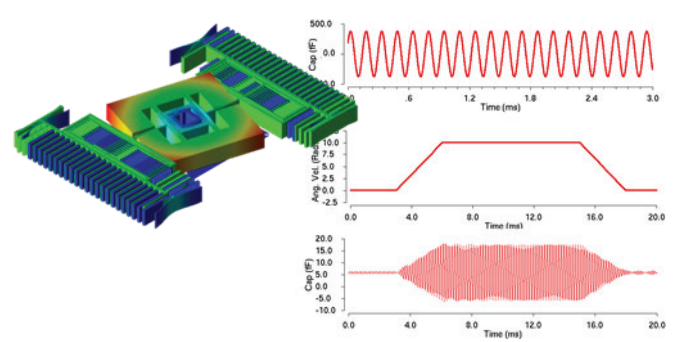
## The Solution

Use **MEMS+** to generate one model for everyone.  
**Save months and avoid design errors.**

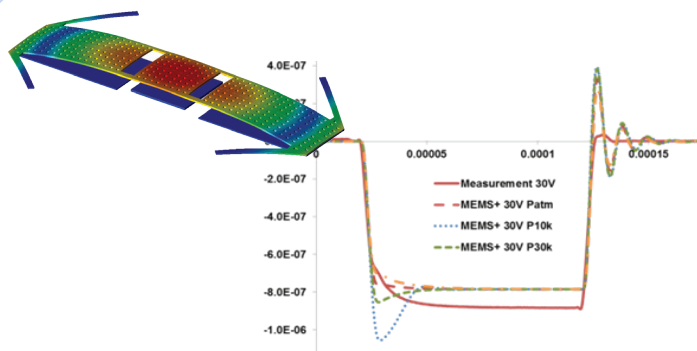
- ◆ A single **MEMS+** model is the source for all formats: MATLAB, Simulink and Verilog-A
  - Redundant modeling effort is eliminated
- ◆ Generated ROMs are tunable for accuracy versus simulation speed
  - Selectively include mechanical degrees of freedom and non-linear effects
  - Selectively expose design and environment variables in system and circuit symbols
- ◆ A source of human error is removed and it's easier for design teams to stay in sync



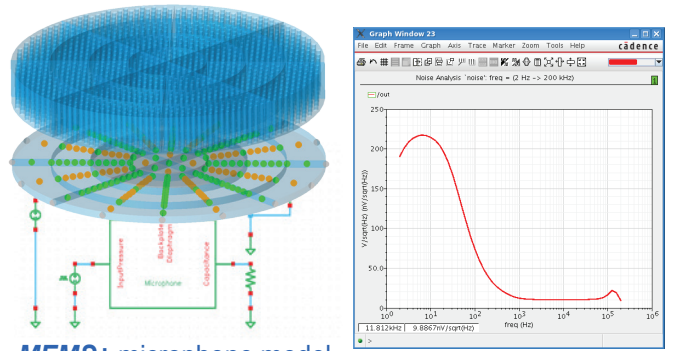
Closed-loop simulation in Simulink and Verilog-A compatible simulators



Gyro transient simulated in minutes



Transient simulation of a Bi-CMOS RF switch closing and opening



**MEMS+** microphone model includes mechanics, electrostatics and fluidics (air) effects

Noise analysis in Cadence Virtuoso

**MEMS+ takes MEMS+IC co-design to a whole new level!**

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