CoventorWare® 10 Overview

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June, 2015

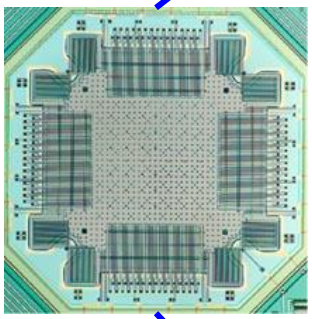
Distributed and supported by ED&C

CoventorWare: Coventor's MEMS Multi-Physics Platform for 10+ Years

COVENTOR

Sensing

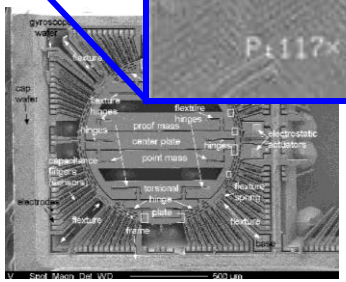
Mechanical→Electrical Tran



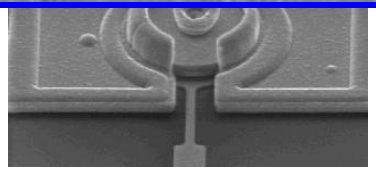
Accelerometers

Hybrids: A

Electrical→



Angular rate
(gyroscopes)



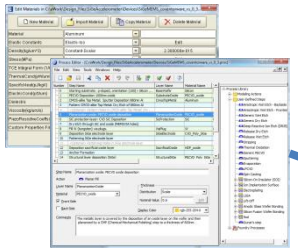
Resonators
(Quartz replacement & RF)

Multi-Physics Simulations

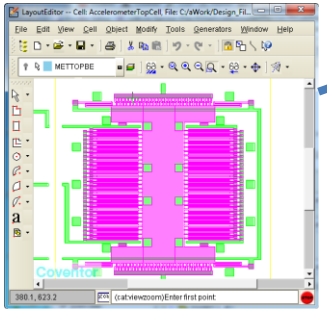
- Structural response
- Electrostatic fields
- Piezoelectric effects
- Piezo-resistance
- Thermal sensitivity
- Gas damping
- Thermo-elastic effects
- Anchor losses,
- …

CoventorWare, from 2D Layout to 3D Simulations

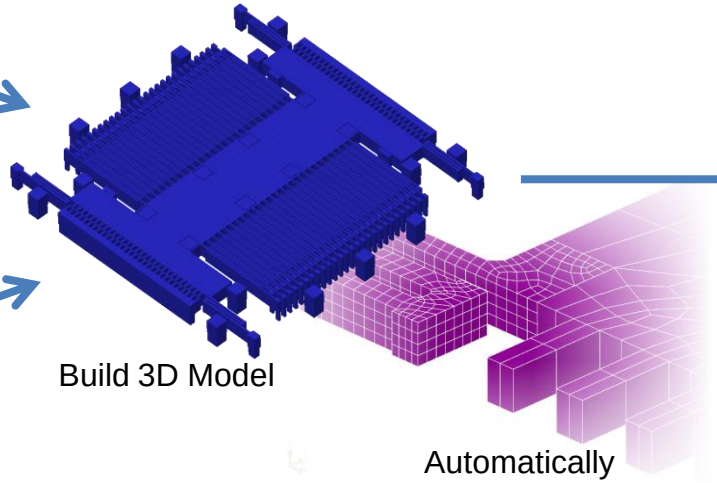
DESIGNER → ANALYZER



Materials & Process

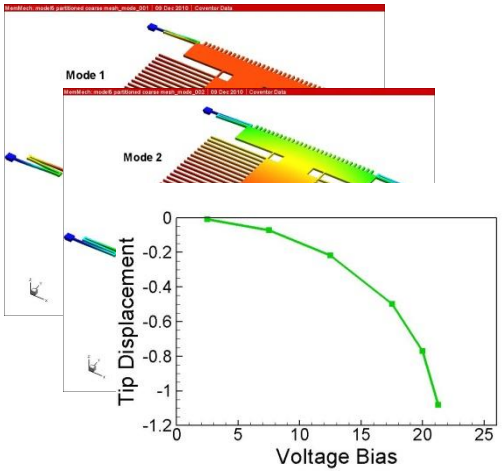


Create 2D Layout



Build 3D Model

Automatically Generate Mesh



Simulate, Visualize, and Analyze

Process-Centric Design Entry

Preprocessing and Mesh Generation Optimized for MEMS Geometry

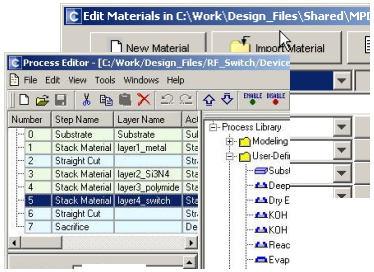
Hybrid FEM/BEM Suite of Multi-Physics Field Solvers

DESIGNER™

COVENTOR

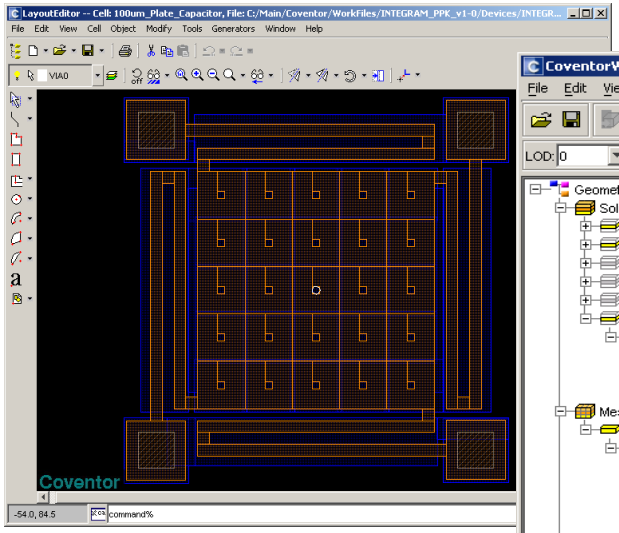
Materials & Process

Customizable for any MEMS process



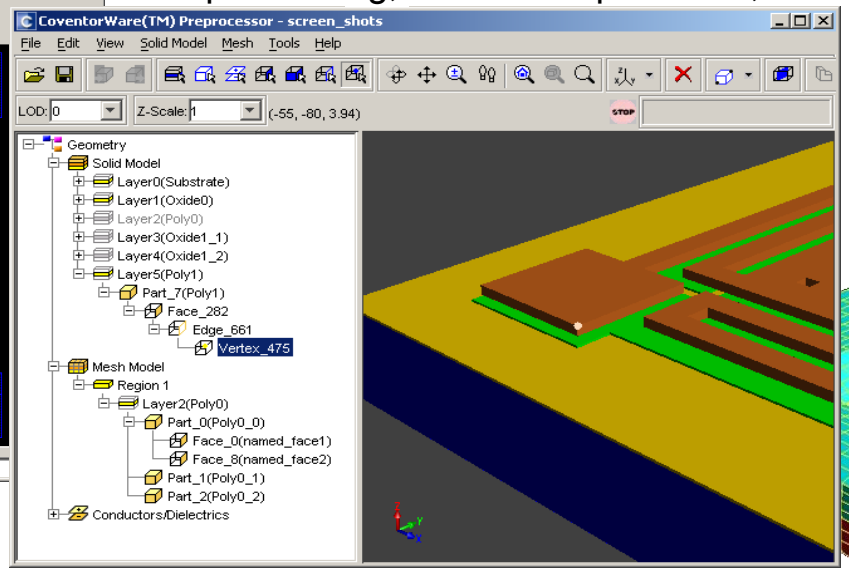
2D Layout Editor

with MEMS-specific features



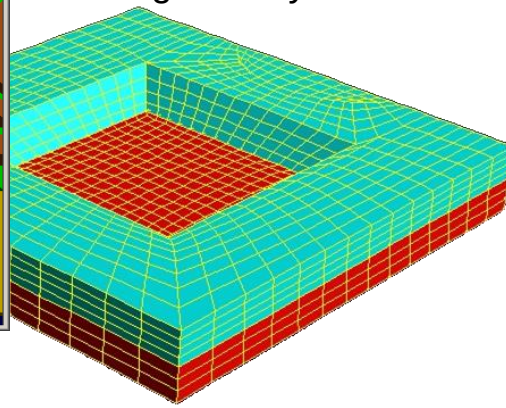
Preprocessor

with partitioning, transform operations,…



Automatic Meshing

meshers optimized for MEMS geometry



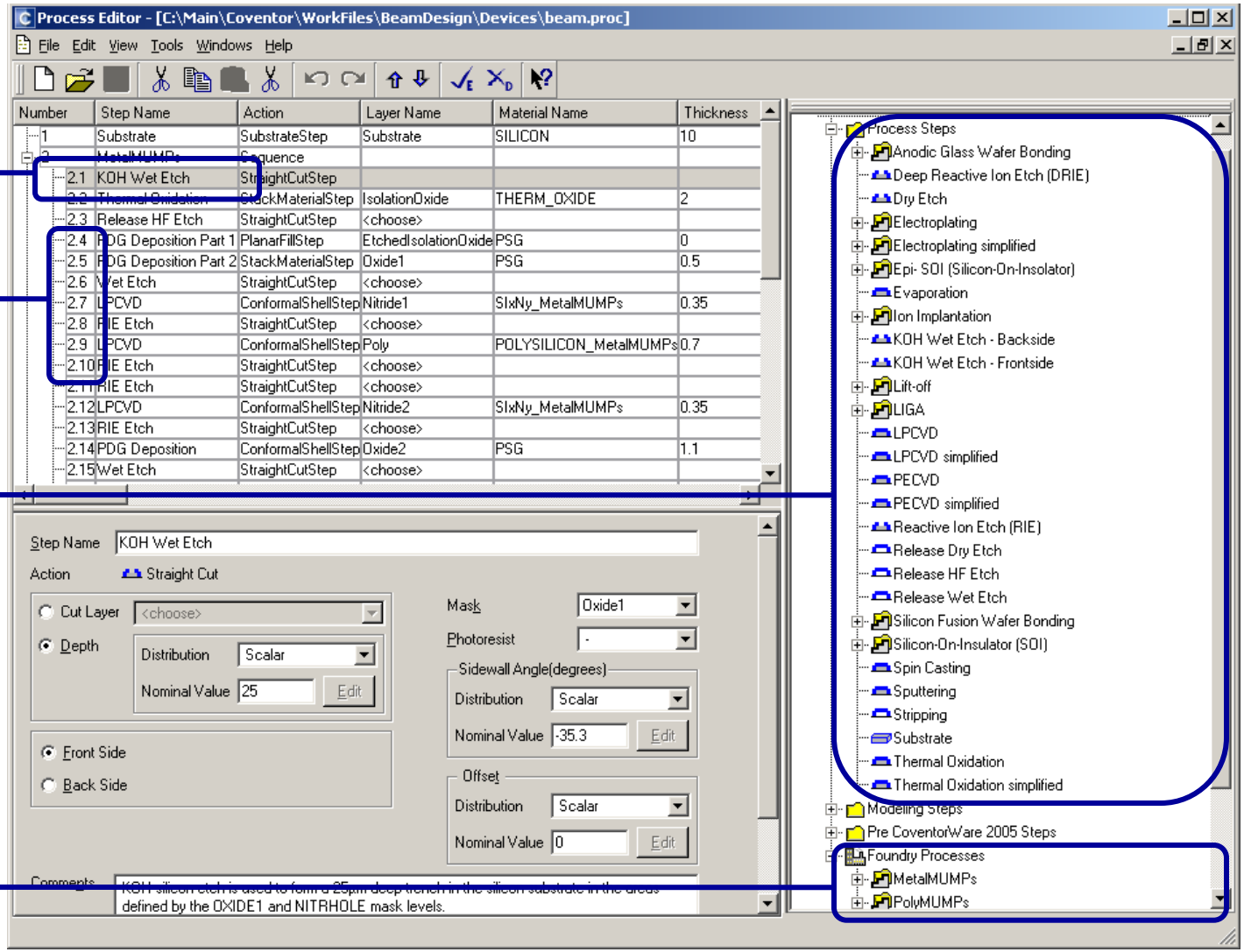
DESIGNER
Process Editor

Descriptive step names

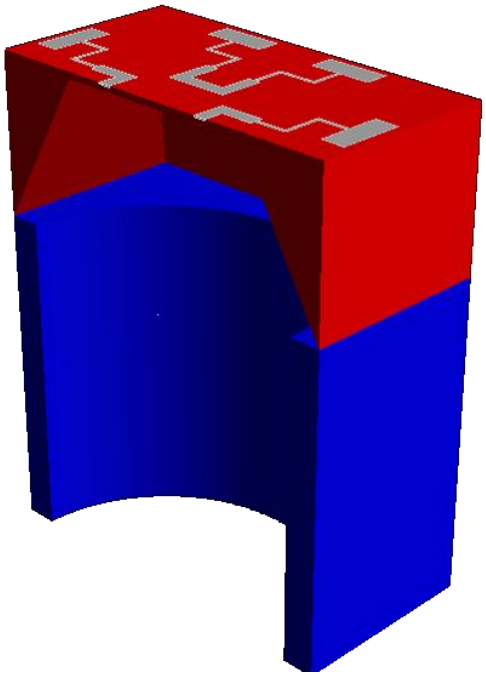
Customizable step hierarchy

User customizable library of standard process steps (mapped to solid modeling steps)

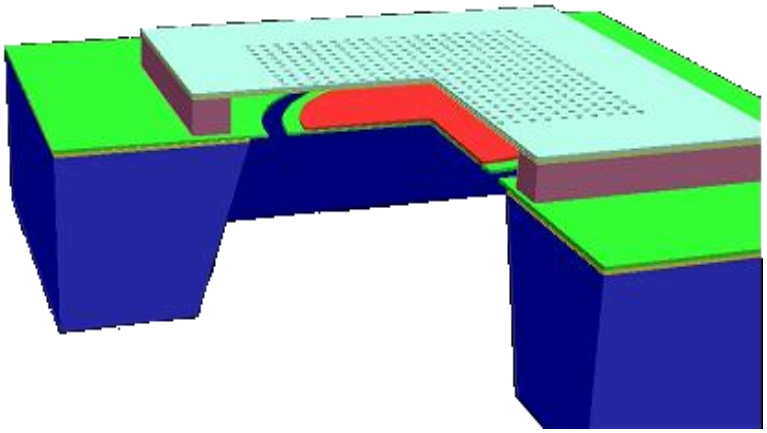
Access to standard foundry processes

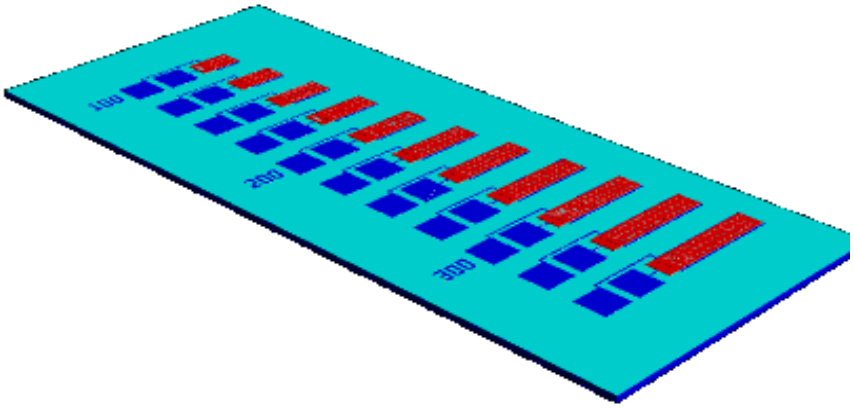


DESIGNER
Solid Modeler



- Employs the 2D layout and fabrication process description to automatically build 3D models (ACIS SAT format)
- Emulates real foundry steps, such as etching through multiple layers or partial backside etching



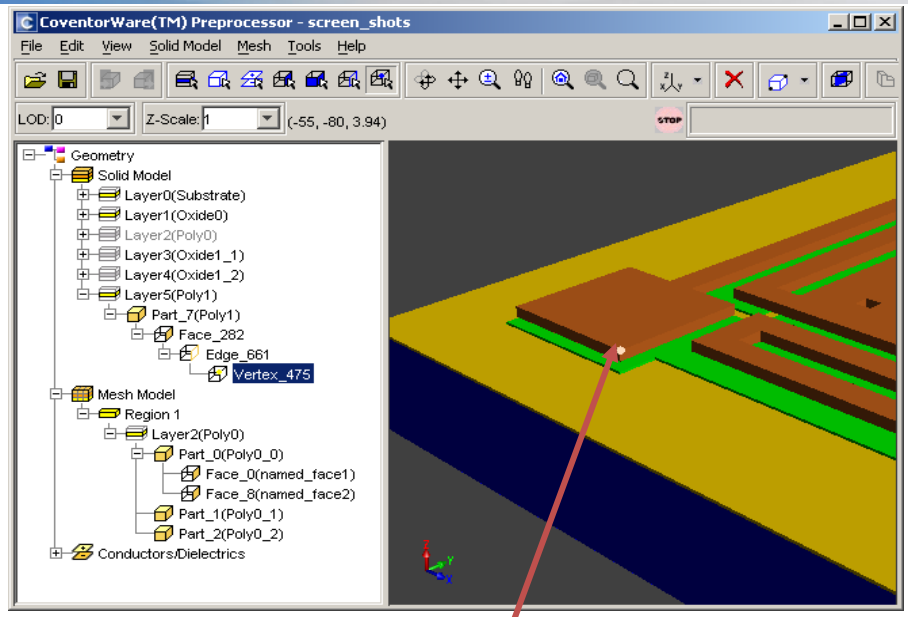


DESIGNER -- ANALYZER Preprocessor

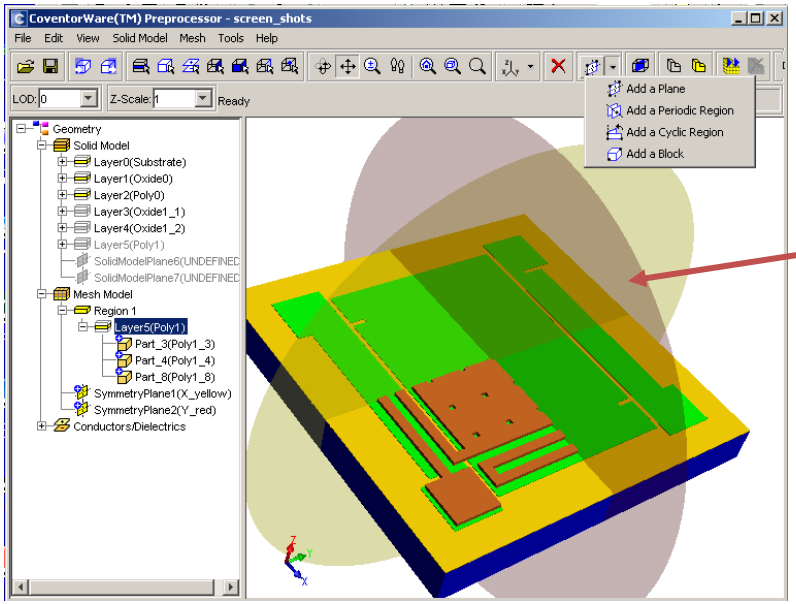
Optimized for MEMs layers

Features include

- Cross-section planes
- Solid model partitioning & transforms
- Automatic layer merging to assure conformal meshes
- Part and face labeling for BCs
- Mesh generation
- Mesh quality checks



Tree expands to show only named or highlighted entities



Same plane can be used as x-section, partition or symmetry.

DESIGNER -- ANALYZER
Meshing

Choose from 5 optimized mesh generators that are ideal for MEMS solid models

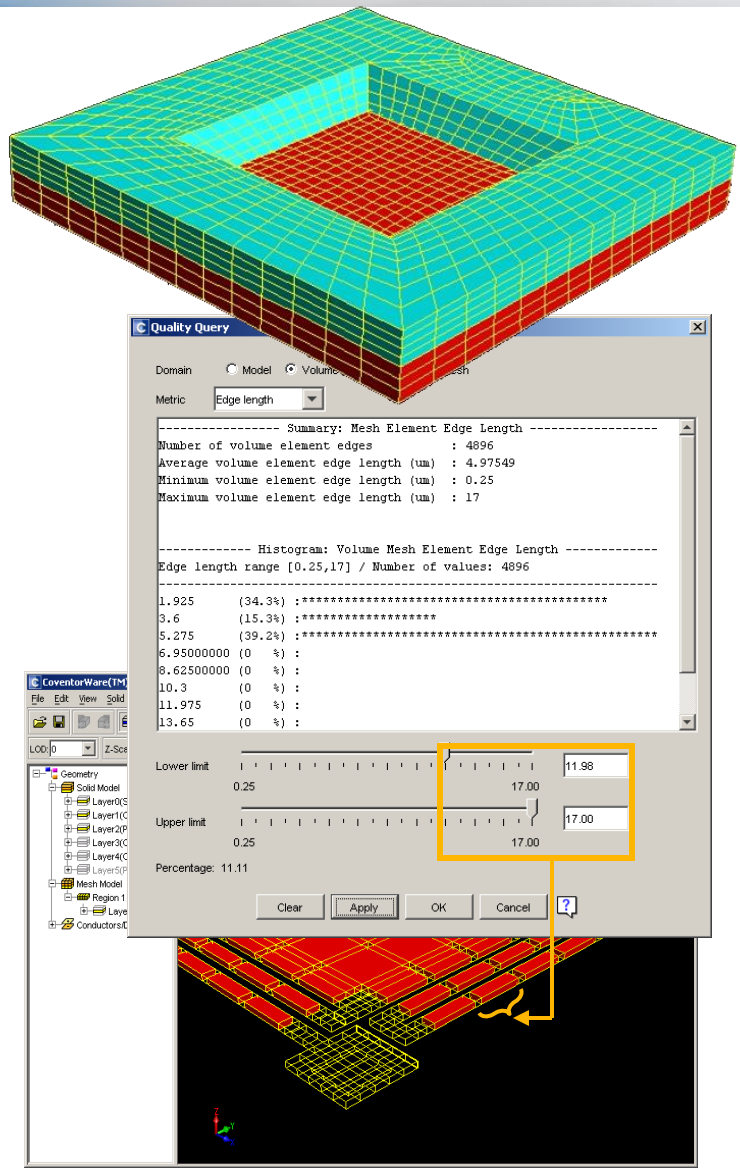
1. Manhattan bricks (hexes) for near orthogonal geometry
2. Extruded bricks for multi-layered non-orthogonal geometry (choose from 3 algorithms)
3. Mapped meshing for 6-sided volumes
4. Tetrahedral meshing for arbitrary shapes
5. Surface meshing (triangles and quadrilaterals) for BEM

Local refinement controls on all model entities (layers, parts, faces, edges, vertices)

Mesh quality checks

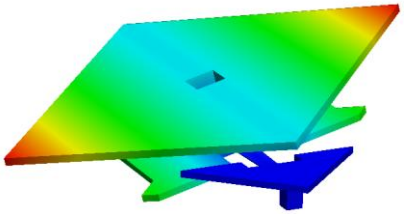
- Easy to read reports
- Highlighted display of “bad” elements

Import/export ANSYS meshes

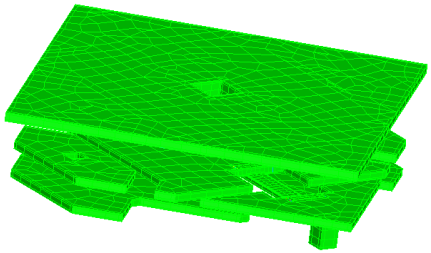


Suite of Field Solvers Optimized for MEMS

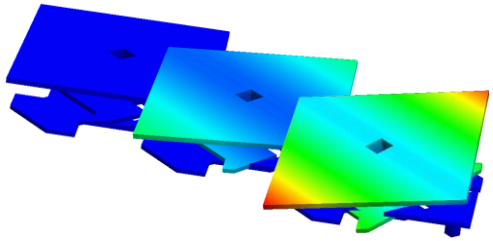
World-class coupled electro-mechanics simulations



Finite element (FEM) non-linear **mechanics**

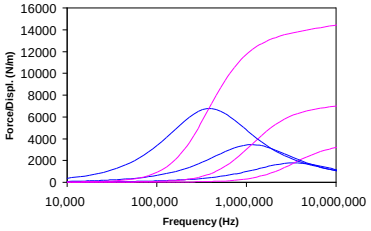


Boundary element (BEM) **electrostatics** – no need to mesh air

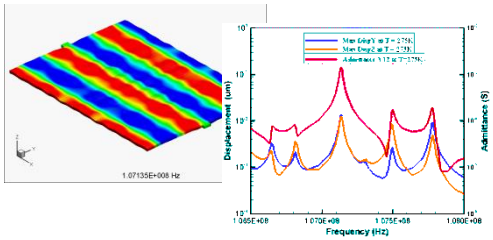


Hybrid FEM/BEM **pull-in/lift-off**

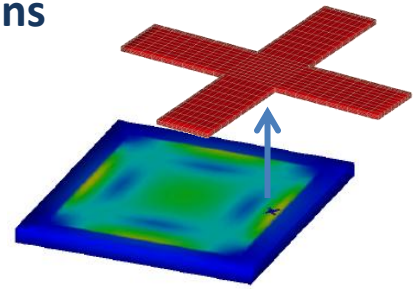
Specialty MEMS physics simulations



Reynolds and Stokes solvers for **gas damping**

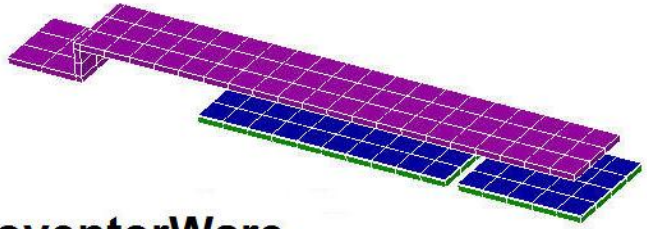


Fast modal harmonic analysis for **piezo (PZE)** resonators

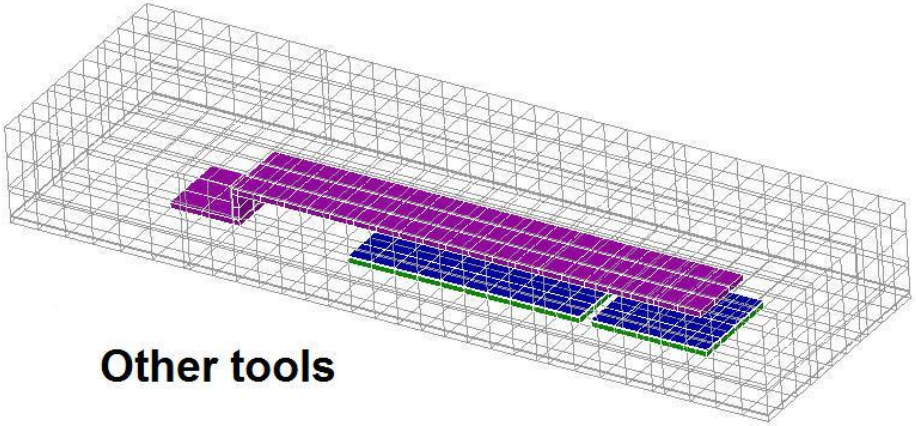


Piezo-resistance (PZR) solver for PZR sensors

Coupled Electro-Mechanics with Hybrid FEM/BEM



CoventorWare

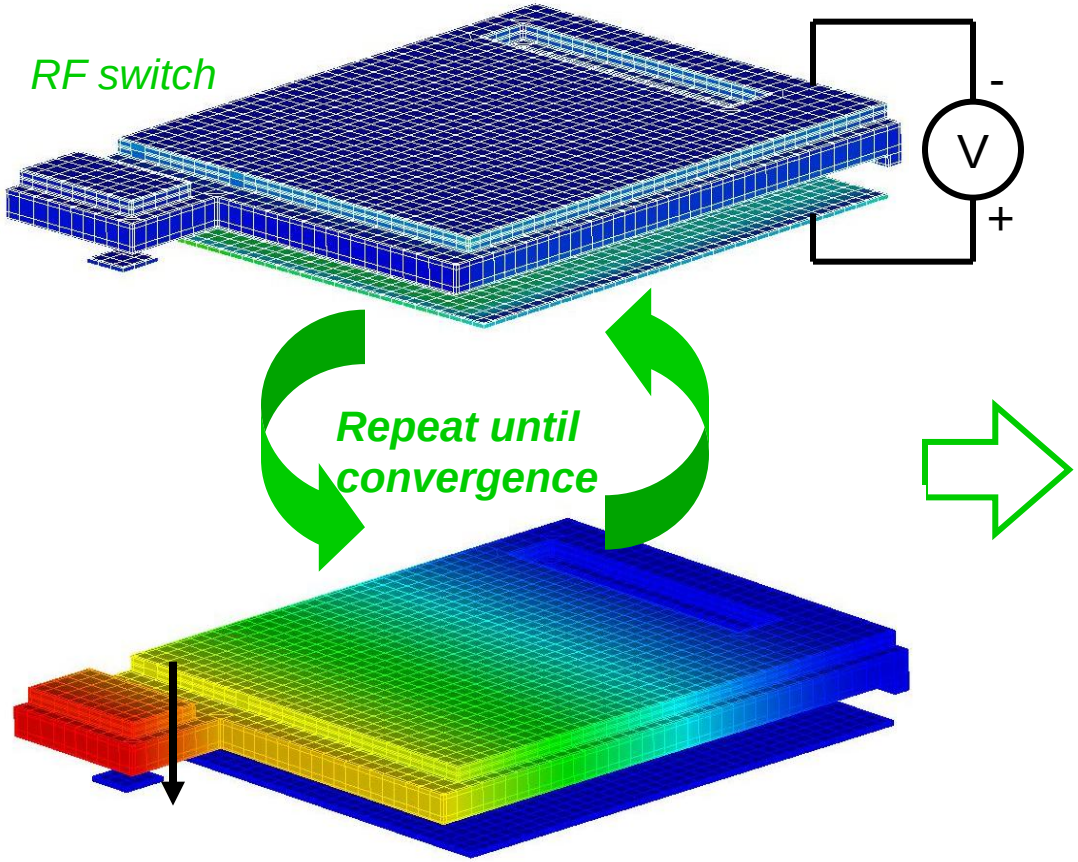


Other tools

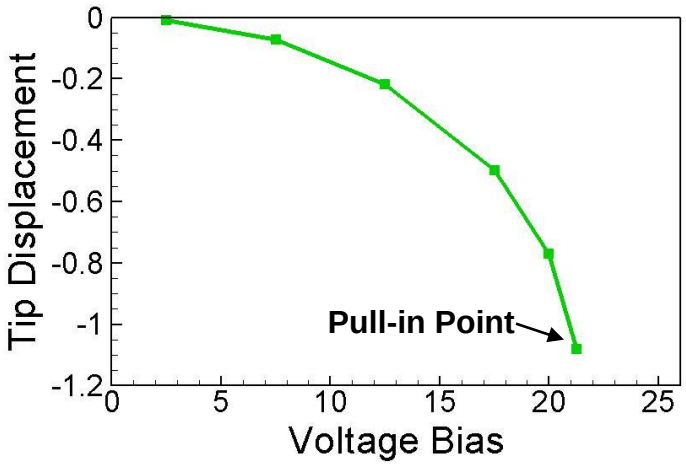
- No mesh required in “air” around moving parts
  - Smaller mesh, faster solutions
  - No need to morph mesh as part moves, especially challenging if gap closes
- Fully captures 3D electrostatic fringing fields that others neglect, critical for derived quantities such as
  - Electrostatic force
  - Pull-in / Lift-off voltage
  - Electrostatic spring softening effect

Coupled Electro-Mechanics with Hybrid FEM/BEM (cont'd)

BEM solver for electrostatic force due to bias voltage
-- uses surface mesh



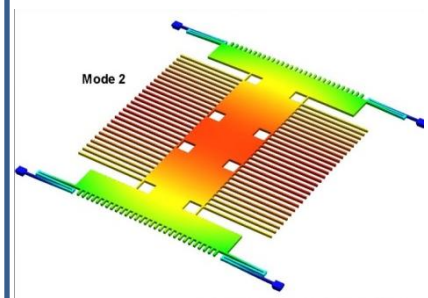
"Pull-in" Result
-- find last stable voltage



FEM solver for solid mechanics displacement
-- uses volume mesh

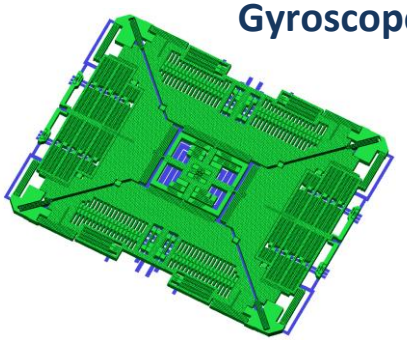
Simulation Capabilities for Wide Range of MEMS

Accelerometers



- Modal analysis
- Freq. response
- Output capacitance
- Pre-stress effects
- Zero-offset from package effects
- Gas damping

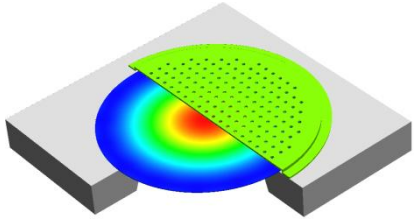
Gyroscopes



Based on ChipWorks teardown

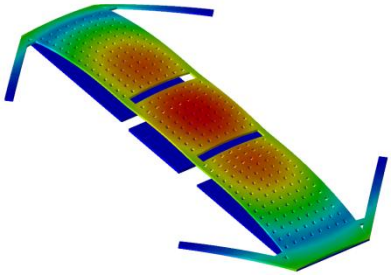
- Pull-in voltage
- Electrostatic drive force
- Output current and capacitance
- Quadrature
- Thermo-elastic damping
- Anchor losses

Microphones



- Freq. response
- Optimize back-plate/membrane perforations
- Electrostatic spring softening
- Pull-in voltage
- Pre-stress

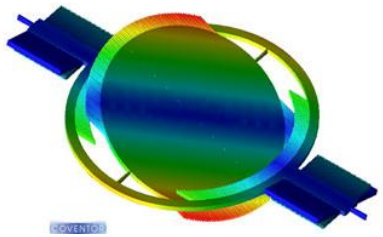
RF Switches & Varactors



- C-V curve
- Actuation (pull-in) and release (lift-off)
- Closed shape
- Contact force
- Pre-stress effects
- High stress areas
- Shock response

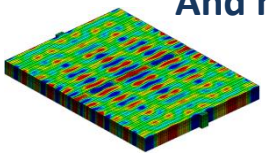
Simulation Capabilities (cont'd)

Micro-mirrors

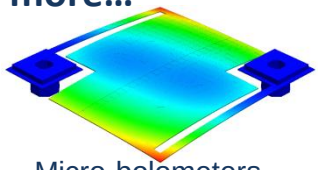


- Analog (scanning): electro-static drive force & response
- Digital display: Actuation (pull-in) and release (lift-off)
- Modal analysis
- Hinge stress
- Gas damping

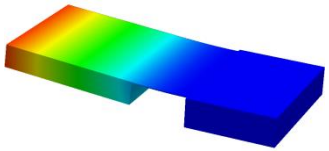
And much more…



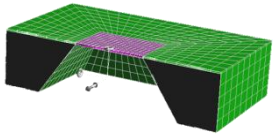
Piezo-MEMS (PZE)



Micro-bolometers



Energy harvesters



Piezo-resistive (PZR) sensors

CoventorWare 10 Highlights

- "FastPZE", a new scripted solution for fast analysis of piezoelectric bulk acoustic resonators (FBAR, LVR,…)
  - Usage is covered by a new piezo-resonator tutorial
- Other new tutorials
  - Micro-mirror tutorial now includes Stokes solver for gas damping
  - All-new microbolometer tutorial
- Numerous minor enhancements and bug fixes in Console, Preprocessor and MemMech
- RHEL 6 is supported (available as update for CoventorWare 2014)

Released in February, 2015

Motivation for FastPZE: RF Filters Need "MEMS"

Exhibit 12

Filter content in different segments of smartphones

	Typical 3G	Regional LTE	Global Roaming LTE
SAW Filters	$1.25	$2.25	$3.00
BAW Filters	$0.00	$1.25	$3.50
Power Amplifiers	$1.25	$1.75	$2.00
Switches / ASMs	$0.75	$0.75	$1.00
Wi-Fi	$0.50	$1.00	$1.00
Total RF Content	$3.75	$7.00	$10.50 +

Source: TriQuint Semiconductor, Morgan Stanley Research

http://blogs.barrons.com/techtraderdaily/2013/11/25/avago-rf-filter-biz-to-benefit-from-cheap-smartphone-growth-says-morgan-stanley/

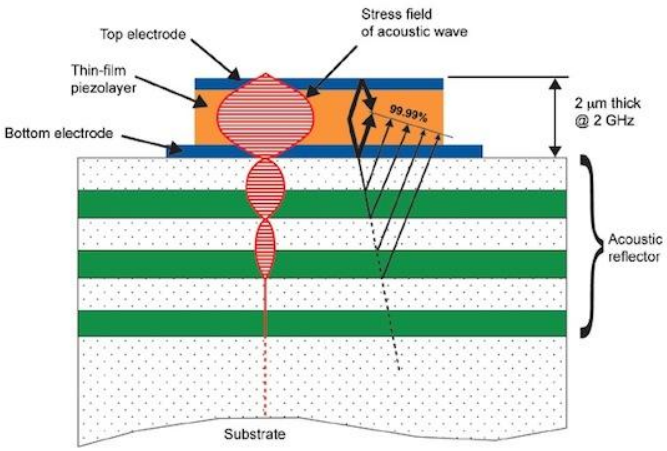
BAW filters are "MEMS-like", but not our typical customers

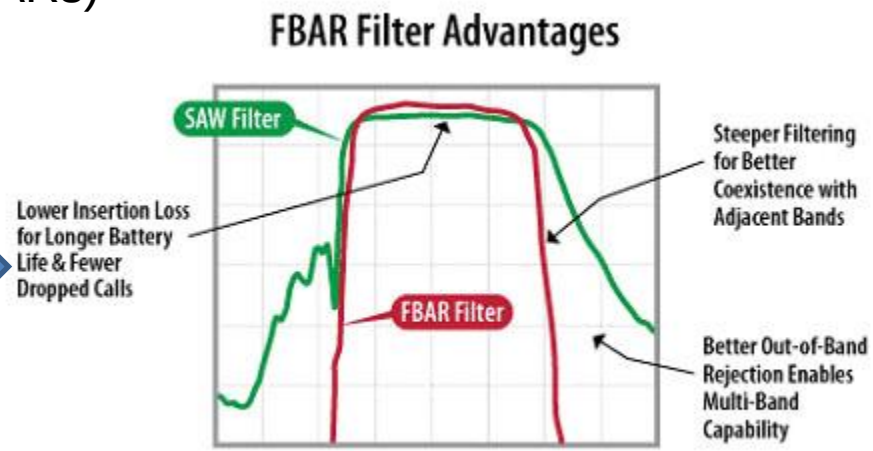
They use **piezoelectric** materials to make mechanical filters for RF signals

The mechanical filter is an **acoustic** resonance (the "A" in BAW and SAW)

Common Types of BAW Resonators

Thin-Film Bulk Acoustic Resonators (FBARs)

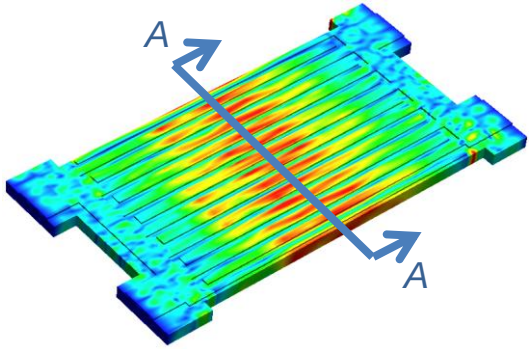


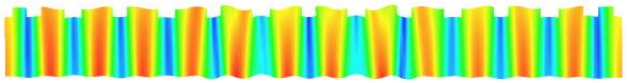


http://www.edn.com/design/wireless-networking/4413442/SAW--BAW-and-the-future-of-wireless

http://www.avagotech.com/pages/en/rf_microwave/fbar_filters/

Laterally Vibrating Resonators (LVRs)





Modal displacement at A-A

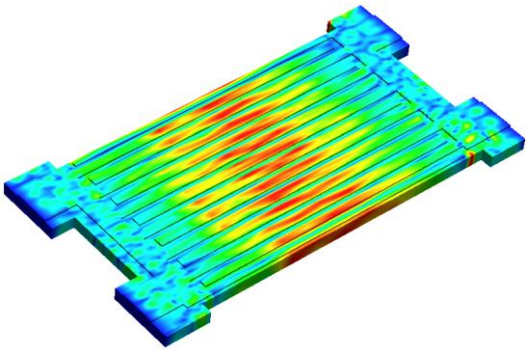
LVR advantage: peak frequency is determined by lithography, not thin-film process as in FBARs

FastPZE in CoventorWare 10

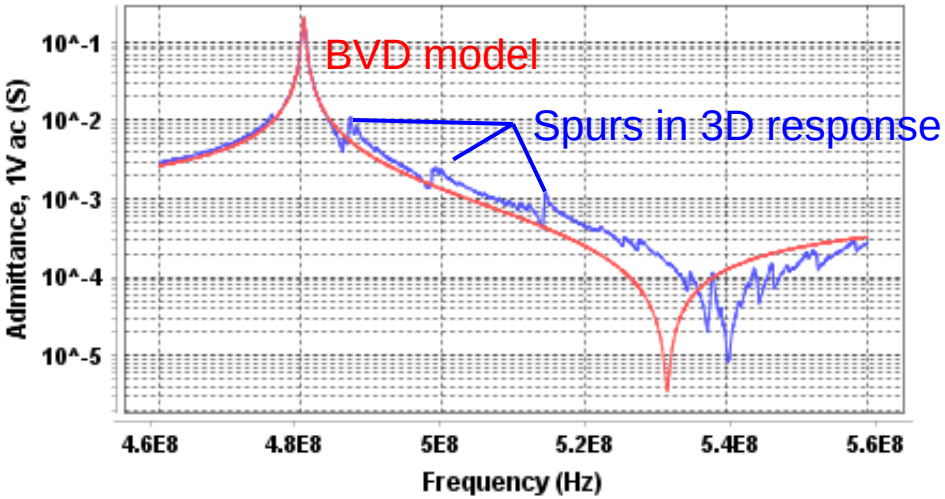
The FastPZE fast-frequency-sweep algorithm is **unique in the industry**

- Up to 30X faster than competing tools (a couple hours vs. days), allows analyzing many designs in **one day instead of weeks**
- Includes **automated multiport filter analysis**: setup and post processing
  - Displays frequency response plots: admittance, charge and *S* parameters
  - Exports *S* parameters in Touchstone format (for ADS and other RF simulators)
  - Computes BVD model parameters

New Piezoelectric Resonator tutorial fully explains this new capability



Peak response mode of LVR



FastPZE vs. Conventional Simulation Performance

No. of Mesh Nodes	DoF	No. of Frequencies	Simulation Time	
			Conventional Frequency Sweep (estimated)	FastPZE Fast Frequency Sweep
~18k	67k	1680	*~ 7 hrs*	**15 min**
~90k	350k	1900	*~74 hrs*	**2 hrs 20 min**

~30X faster!

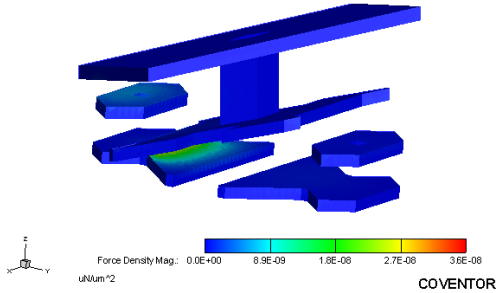
Type of mesh: Parabolic hex

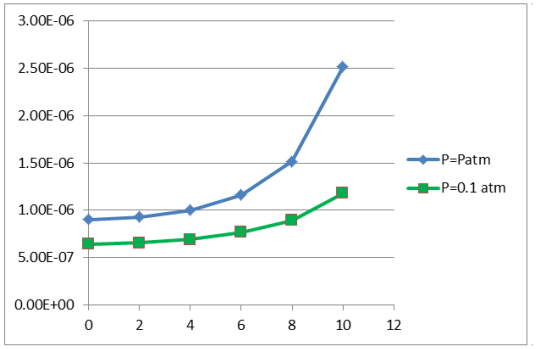
Frequency range: 0.4GHz to 0.6GHz

CPU info: 2.7 GHz, 8 cores

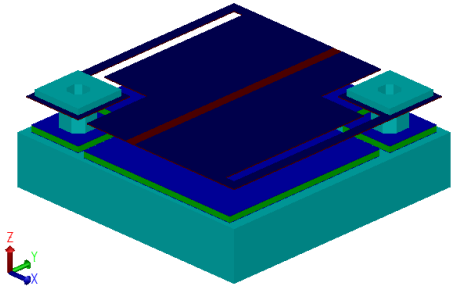
Other New Tutorials

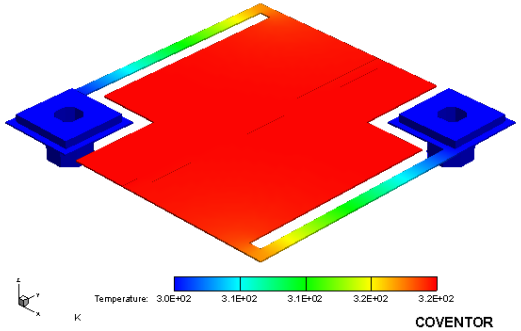
Display Mirror tutorial has added section on gas damping with the Stokes solver in DampingMM





Microbolometer tutorial is completely new, based on a typical device design and covers simulation of key design parameters





Supported Platforms = Operating Systems

Supported “desktop” platforms, 64-bit only

- Windows 7 Pro 64-bit
- Windows 8.1 64-bit
- Red Hat Enterprise Linux Desktop 5
- Red Hat Enterprise Linux Desktop 6

Support multiple users and remote 3D graphics via free TurboVNC

The following previously supported platforms are <u>not</u> supported

- Windows XP Pro 32-bit
- Windows XP 64
- Windows 7 Pro 32-bit
- Red Hat Enterprise Linux Workstation 4

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