3D MEMS & Semiconductor SOFTWARE

COVENTOR

Coventor Overview

Company Overview

Coventor History:

Founded in 1996

Expertise in 3D modeling and simulation

Initially focused on tools for MEMS design

Focus:

Provide 3D solutions to the MEMS and semiconductor industries that harness compute power to dramatically reduce physical prototyping

Privately Held

- Needham Capital
- Intel Capital

Headquarters — Cary, NC

Development centers

- Waltham, Massachusetts
- Paris, France

Global sales and support

Leadership Team

Highly experienced team, many years at Coventor and serving the MEMS industry

Mike Jamiolkowski
President and CEO, Founder
18 years, founded ISS EDA company

David Fried, PhD
CTO, Semiconductor
2 years +
14 years IBM

Steve Breit, PhD
VP, Engineering
14 years

Gerold Schropfer, PhD
Director, Europe and Foundry Program
13 years

Tom Flynn
VP, Worldwide Sales
4 years +
14 years Ansoft

Ken Greiner
Director,
SEMulator3D R&D
16 years

Gunar Lorenz, PhD
Director,
***MEMS*+ R&D**
14 years

Matt Kamon, PhD
Principal Technologist,
Simulation R&D
16 years

Chris Welham, PhD
Manager,
Applications Eng.
15 years

Serving the World Leaders in MEMS and Semiconductors

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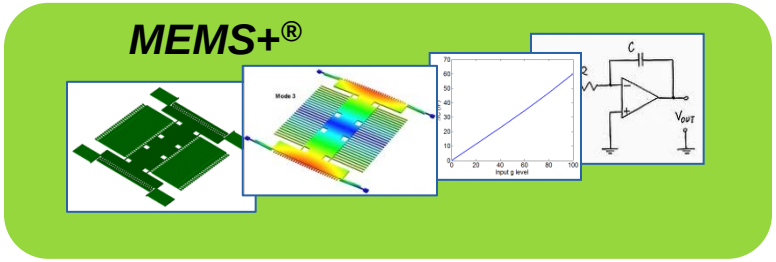
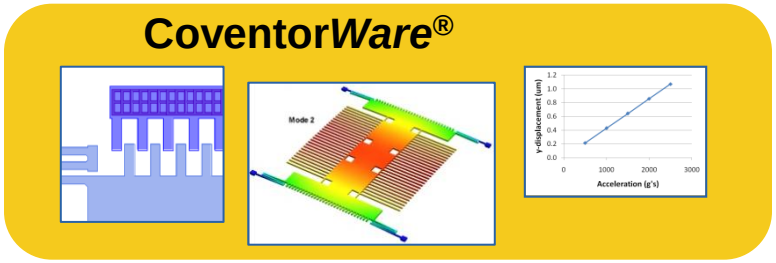
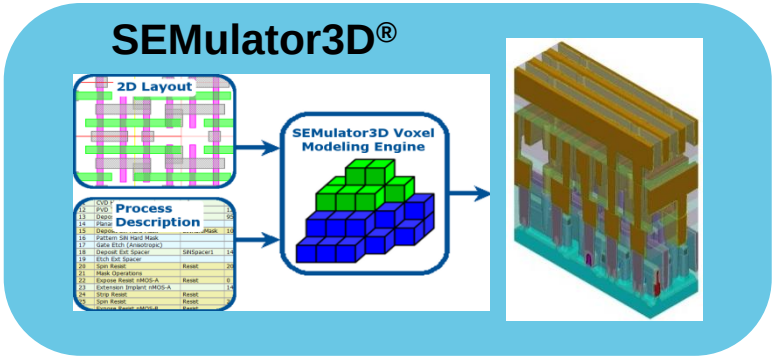
	IDMs	Fabless Companies	Foundries & Others
MEMS	ANALOG DEVICES, TEXAS INSTRUMENTS, ST, hp, Canon, wolfson microelectronics, IDT, OMRON, DENSO, Honeywell, LEXMARK, EPSON EXCEED YOUR VISION	InvenSense, FAIRCHILD SEMICONDUCTOR, RFMD, QUALCOMM, wiSpry Dynamically Tunable RF, mCube, TESSERA, Medtronic, FUJITSU FUJITSU LABORATORIES, Theon sensors, BOEING	XFAB MIXED-SIGNAL FOUNDRY EXPERTS, DALSA, A*STAR Institute of Microelectronics, BSAC, Fraunhofer, NASA, STANFORD UNIVERSITY, TriQuint SEMICONDUCTOR, NIST
Semiconductor	IBM, Micron, intel, SONY, Infineon, Seagate, WD	TOYOTA, HYUNDAI	tsmc, GLOBAL FOUNDRIES, KLA-Tencor, imec, TOKYO ELECTRON

Growing number of customers purchase both MEMS and semiconductor solutions from Coventor

Our Product Platforms







MEMS Component Design and System Simulation

- Behavioral-level FEA for rapid concept exploration and optimization
- MEMS + IC system design
- Multi-physics FEA of highly non-linear, coupled electro-mechanical, fluidic, and thermal effects

Process Technology Development

- Virtual fabrication MEMS and semiconductor devices
- Predictive, silicon-accurate, 3D structures
- Uses include process development, process integration, physical verification, and technology transfer

The Traditional Approach to MEMS Design

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ASIC Design

MATLAB SIMULINK — Control System Design → Control System Design → Control System Design

cadence — IC Design → IC Design → IC Design

MEMS Design

Hand-crafted

Over-simplified

…ing → Modeling → Modeling → Modeling

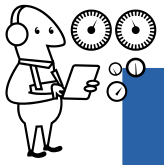
Design-specific

Conventional FEA → Conventional FEA → Conventional FEA → Conventional

Too slow to inform fab cycles

Full coupling infeasible

Fab / Foundry



MEMS Process Learning Cycle → MEMS Process Learning Cycle → MEMS Process Learning Cycle

Consequence: too many "build and test" cycles

MEMS+ is a New Approach

ASIC Design

MATLAB SIMULINK Control System Design

cadence IC Design

MEMS and IC co-design

MEMS Design

Automatically generated, tunable accuracy vs. speed

Modeling

MEMS+, A Different Kind of FEA

Industrial strength,
Fast AND Accurate,
Full coupling feasible

Conventional FEA

Rapid Design Studies
Optimization
Manufacturability

Complementary, for details and verifying MEMS+

Fab / Foundry

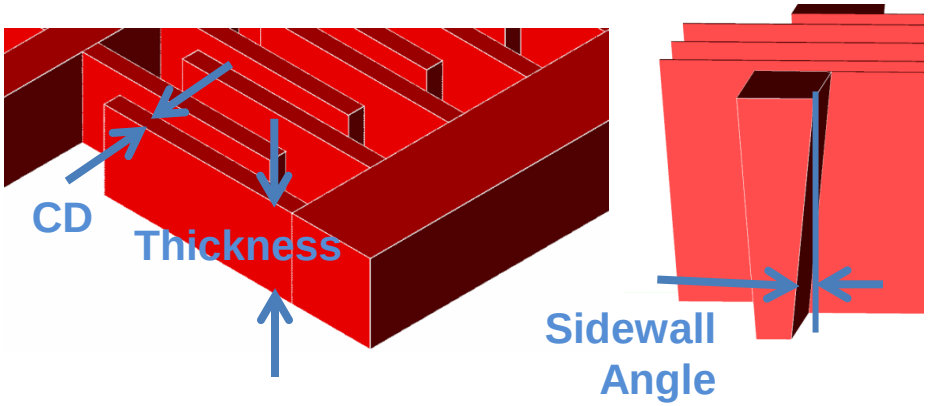
Result: fewer "build and test" cycles

MEMS Process Learning Cycle

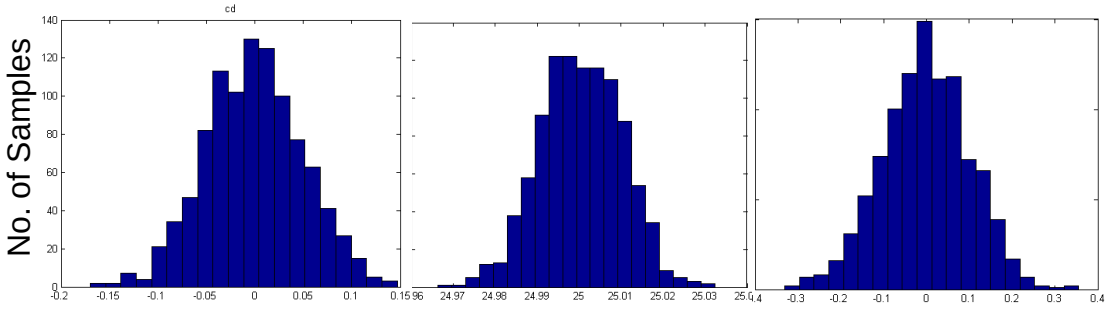
MEMS Process Learning Cycle

MEMS+ Analysis of Manufacturing Sensitivity

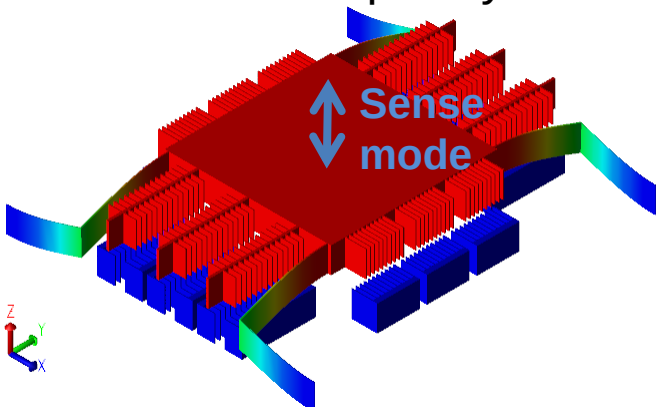
SOI MEMS process, 3 input variables

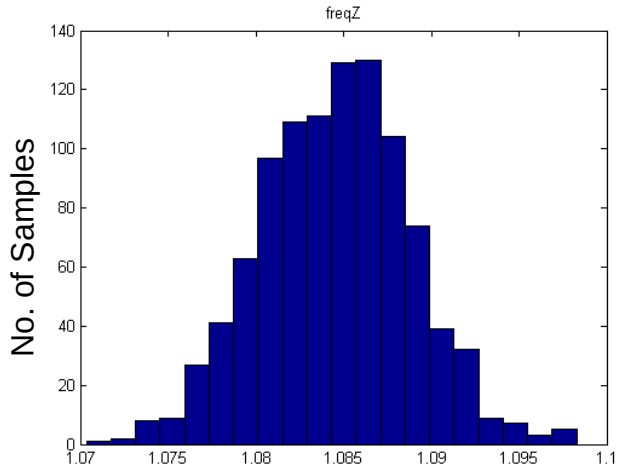


Monte Carlo study, 1000 samples



Functional spec:
sense mode frequency





7 sec per sample, less than 2 hrs total!

MEMS+ Reference - Murata

Tero Sillanpää , Murata ASIC Design Manager:

"The Verilog-A Reduced Order Model (ROM) exported from *MEMS*+ captures second-order effects not seen in basic hand-crafted models without any compromise in simulation performance. We were able to create a Verilog-A ROM of a complex gyro design in just a few minutes, allowing our ASIC team to work in parallel with the MEMS team on further design iterations. Transient simulations in Cadence showed that the model maintained the expected modal frequencies and was stable. The robust model exchange between MEMS and ASIC designers enabled by MEMS+ reduces the probability of design error and can help avoid costly redesign iterations needed to address unexpected behavior."

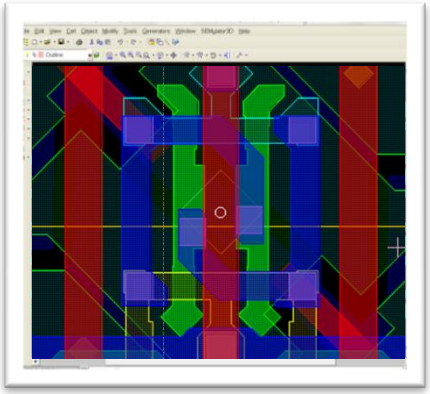
Accelerometers

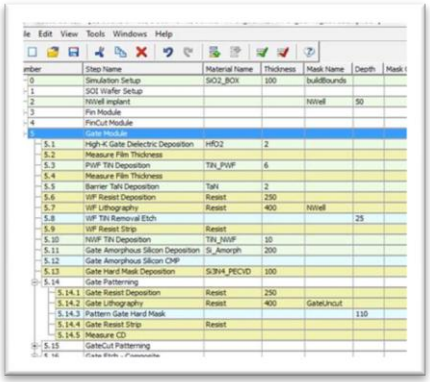
Gyro/accelerometer combo sensors

Pressure sensors

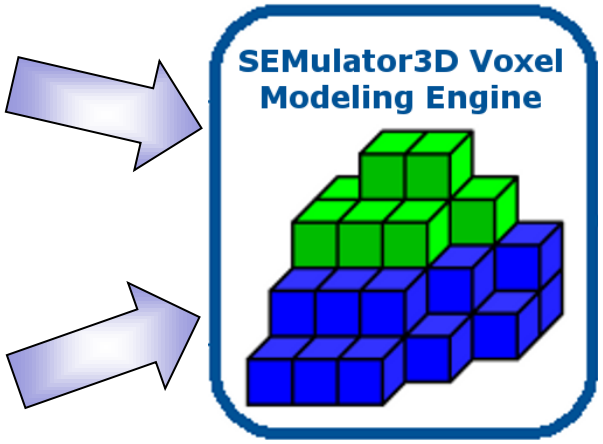
What is SEMulator3D?

A Powerful **Virtual Fabrication Platform** for MEMS and Semiconductors



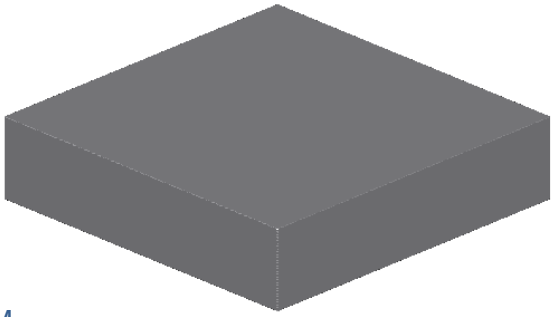


Layout Editor:
Design, OPC,…



Process Editor:
Step-by-Step Process
Behavioral Description

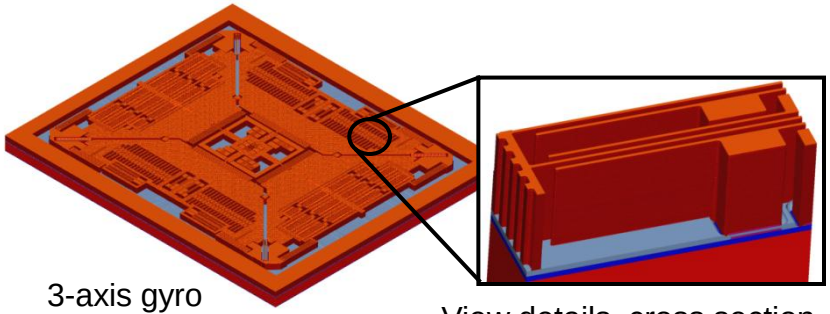
3D Viewer:
MEMS display
mirror on SRAM



- Applicable to <u>any</u> process & <u>any</u> layout
- Handles complete process sequences and large areas
- Provides 3D structural models that are ***accurate***, <u>not</u> idealized
- Provides ***predictive*** insights on design/technology interactions, <u>saving "build-and-test" cycles</u>

Virtual Fabrication: Uses for MEMS

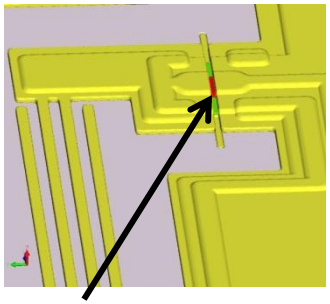
Communication: Visualize, Animate process, Designers←→Fab/Foundry, Tech transfer



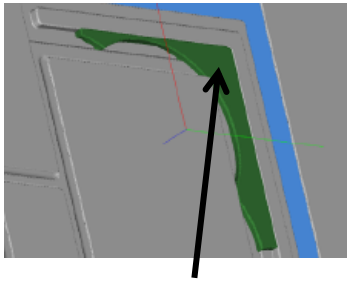
3-axis gyro
from chipworks teardown

View details, cross section

Physical Verification: Check structures, release completion, electrical continuity

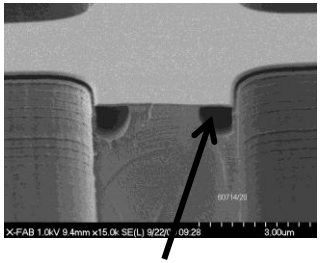


Design error passed 2D DRC

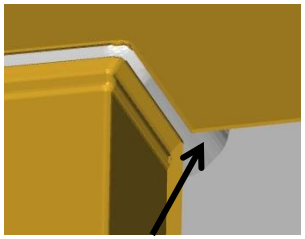


Incomplete release etch

Process Development: Predict/diagnose process problems

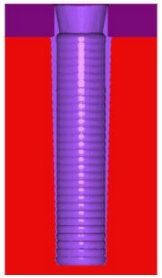


Issue: unexpected voids

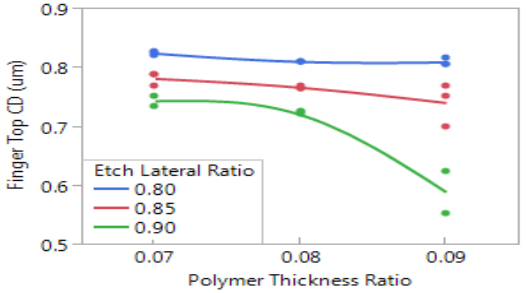


SEMulator3D model confirms root cause

Yield Optimization:

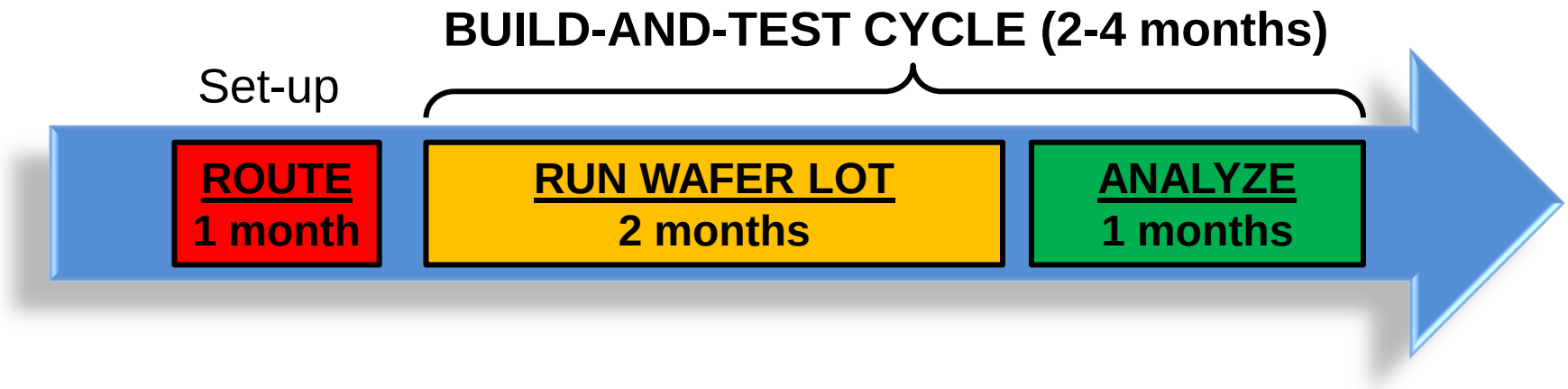


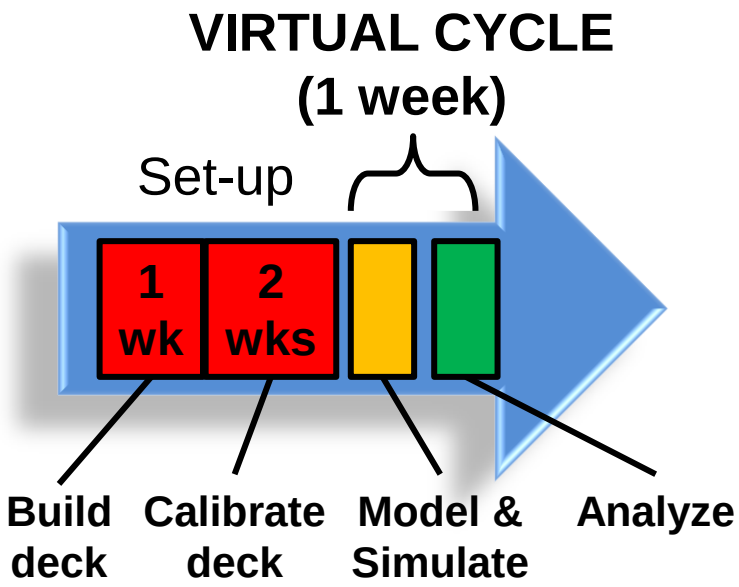
DRIE



Quantify sensitivity of structure CDs to process parameters

Virtual Fabrication vs. "Build and Test"





Benefits:

- Faster time to production
- More experiments ➔ higher yield
- Lower development cost

Virtual Fabrication for MEMS Foundries

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MEMS foundries use SEMulator3D for:

- **Process development:** Predict and diagnose process issues and improve yield
- **Physical design verification:** Verify structures, release and electrical continuity before tape out
- **Customer support:** communicate process and design and information with customers
- **Failure analysis**

DALSA

"SEMulator3D gives engineers the ability to do virtual test runs to verify that a device design is compatible with the manufacturing process, and that the 3D result is as expected. Design mistakes and shortcomings can be identified, even if they are compatible with 2D layout rules."

X FAB
MIXED-SIGNAL FOUNDRY EXPERTS

"The benefits of visualizing accurate 3-D virtual MEMS prototypes include increased probability of achieving first-time success by minimizing analysis errors, increased design efficiency by identifying process errors early, avoiding undesired effects that would have reduced yield, and more efficient communication between design engineers and outside groups."

In Conclusion:

Most MEMS industry leaders are Coventor customers

- IDMs, Fabless, Foundries, R&D Organizations, Universities

Coventor's unique product platform speeds time to market

- ***MEMS+*** enables rapid design exploration, optimization, and automated hand-off between MEMS and IC designers
- **CoventorWare** for specialized coupled physics challenges
- **SEMulator3D** for process development and sign-off

Coventor is well positioned to enable industry trends

- Continued growth from mobile and consumer applications
- New devices and new applications (passive displays, IR imaging,…)
- Growth of the Fabless/Independent Foundry business model