IntelliSuite

The shortest distance between your MEMS concept & product

IntelliSuite, IntelliFAB, IntelliMask, MEMaterial, AnisE, RECIPE, Synple, Blueprint, IntelliEtch, Hexpresso, WaveRunner, TapeOut, EDA Linker, 3DBuilder, MEMS SoC, Total MEMS solutions, CAD for MEMS and Solutions for the MEMS professional are trademarks of IntelliSense Software Corporation.

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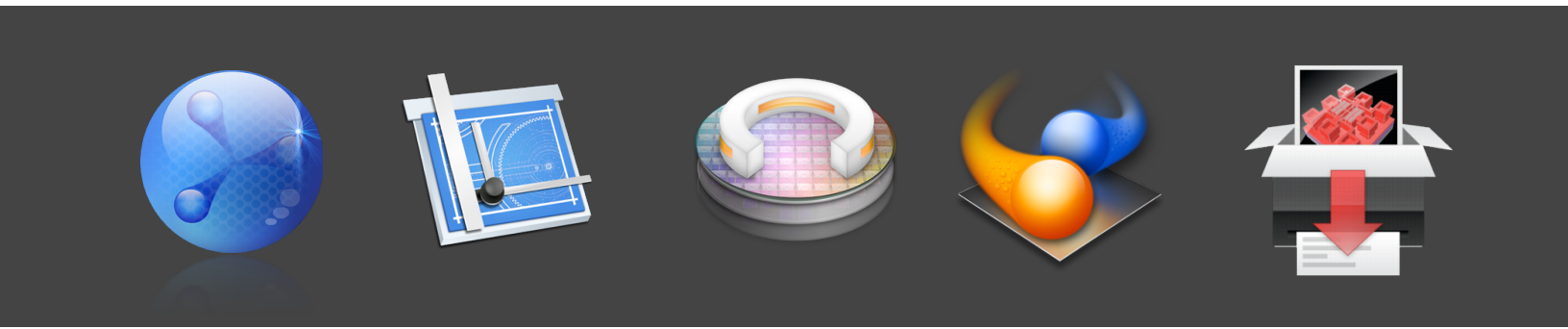


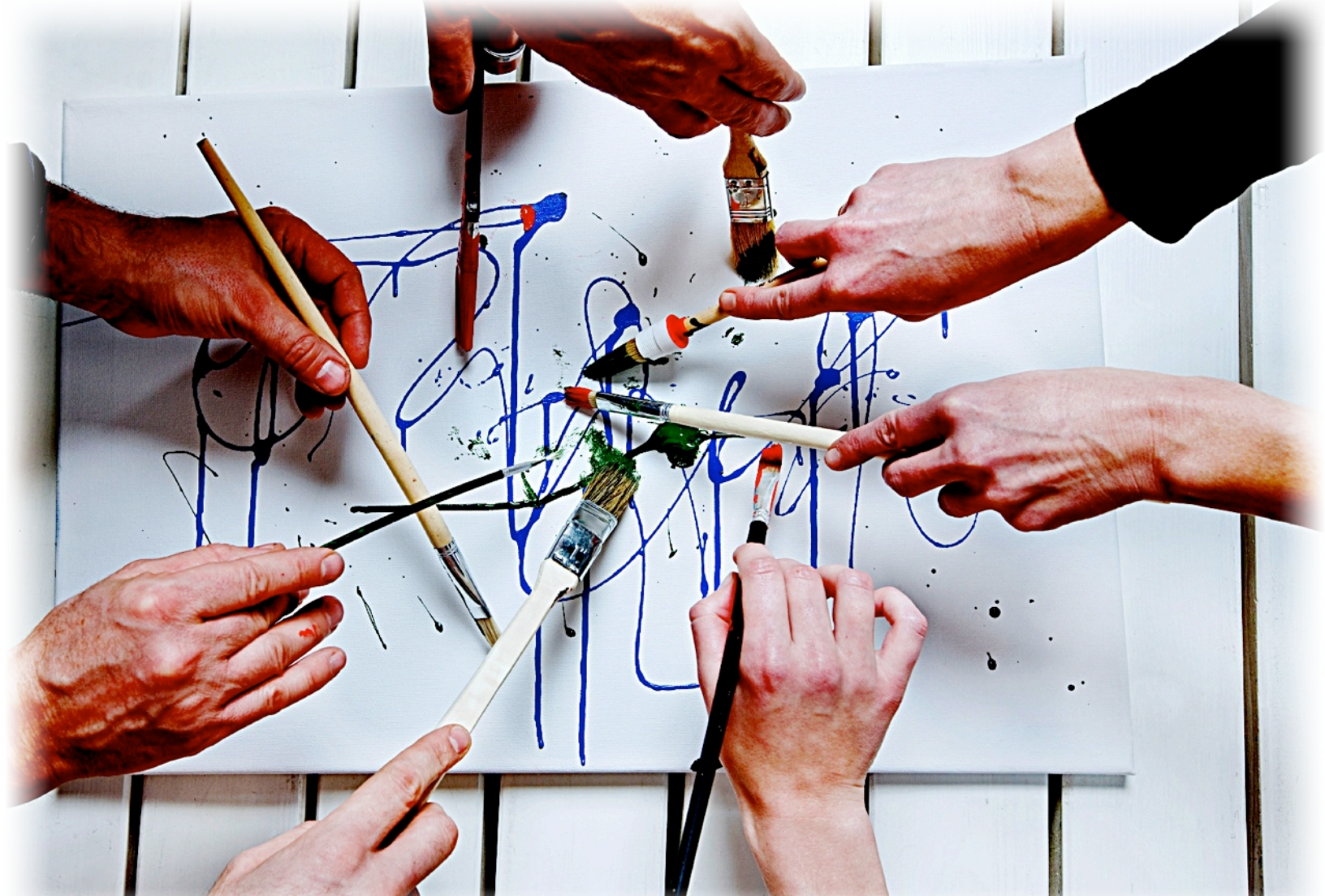
Synple
Schematic capture
Component based
Design exploration
Mesh, Mask and 3D
synthesis

Blueprint
Physical design
Parametric
capabilities
Auto HEX meshing
Layout/DRC
Tape Out

Clean Room
Process flow design
Process debug
Process visualization

Fast Field
Multiphysics solvers
Coupled field analysis
System model
extraction

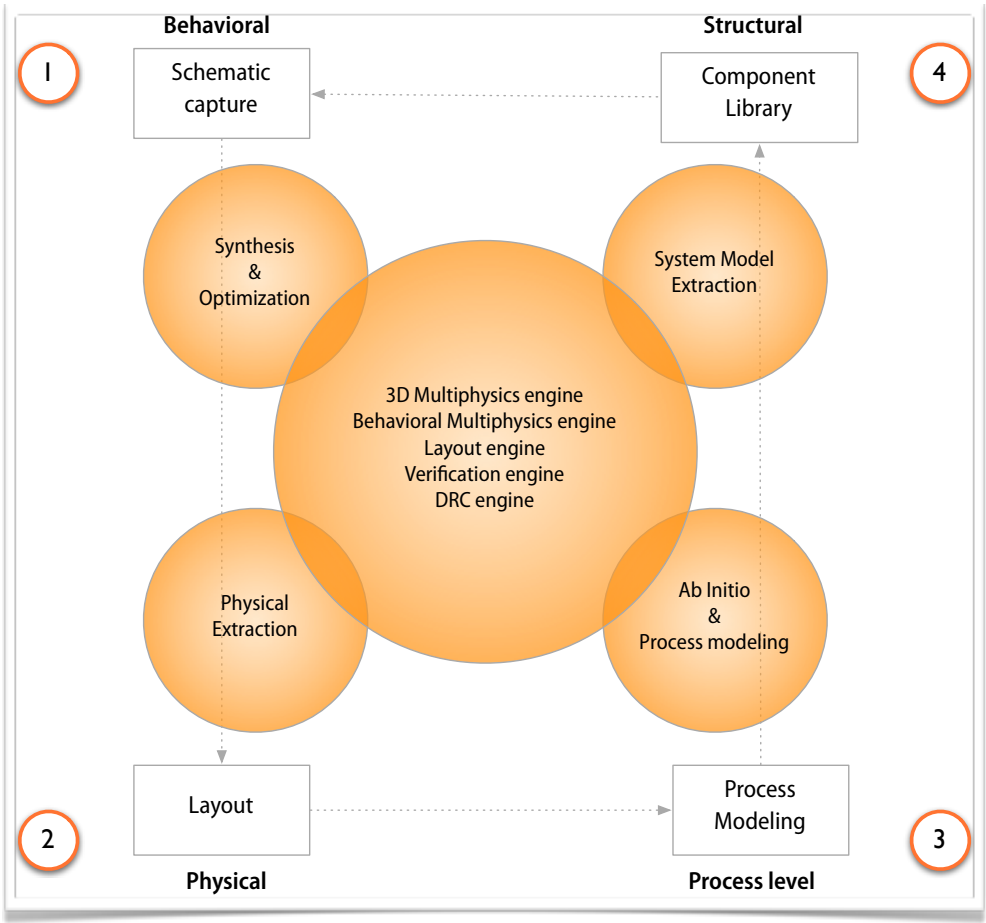
EDA Linker
Link to EDA tools
Cadence, Mentor,
Synopsys, Ansoft,
Mathworks etc…



A living design environment

Used by MEMS professionals worldwide for design, development and manufacturing of MEMS, IntelliSuite has firmly established itself as industry's standard tool. IntelliSense provides MEMS companies and individual users with a complete living design environment to manage their MEMS product through its life cycle.

IntelliSuite is a tightly integrated design environment that will link your entire MEMS organization together. Built to scale from a point tool to an organization-wide tool, IntelliSuite unifies various engineering and manufacturing tasks into a single living design environment.


Behavioral
Structural
1
Schematic capture
Component Library
4
Synthesis & Optimization
System Model Extraction
3D Multiphysics engine
Behavioral Multiphysics engine
Layout engine
Verification engine
DRC engine
Physical Extraction
Ab Initio & Process modeling
Layout
Process Modeling
2
3
Physical
Process level

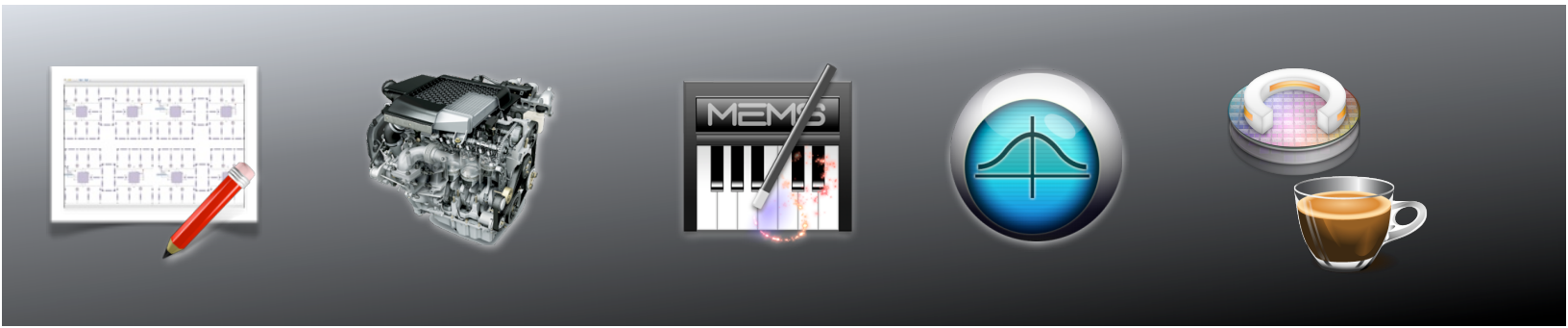
Seamless design flow

IntelliSuite contains a wide range of closely integrated tools to seamlessly go from schematic capture and optimization to design verification and tapeout. A flexible design flow allows you to start your design at either schematic, layout or 3D level.

IntelliSuite consists of a number of advanced tools that work together. For instance, **Synple** allows you to capture your MEMS at a schematic level, much like SPICE for electrical circuits. Your design can then be quickly iterated and optimized at different granularities. Sophisticated **synthesis** algorithms can automatically convert your schematic into mask layout, 3D or better yet a meshed structure for full multiphysics analysis.

Blueprint, is a physical design tool that incorporates advanced layout, design rule check, cross section exploration, and automated mask to hex mesh capabilities. **CleanRoom** process suite allows you to create and debug your process flow and your mask set before you enter the clean room. It allows you to make virtual prototypes to save costly fabrication mistakes. Advanced **Fastfield** Multiphysics tools feature fully coupled electrostatic, mechanical, fluidic, and electromagnetic engines. Advanced Model Order Reduction based **Extraction** techniques capture electromechanical, fluidic and damping behavior into compact models, while EDA Linker seamlessly links IntelliSuite to other leading EDA tools.

Behavioral modeling



Schematic Capture
Design Exploration
Optimization
Design for manufacture

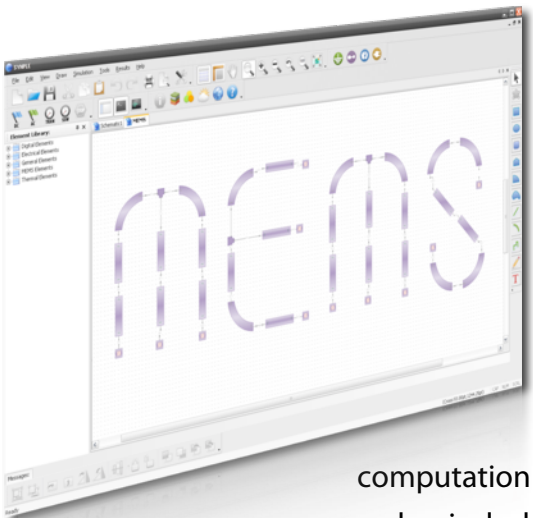
Parallelized Multiphysics Engine
Mechanics
Electrostatics
Damping/Dissipation
Piezo
Mixed Signal
Control Systems
1000X faster than FEA

Synthesis
Schematic to mask
Schematic to 3D
Schematic to mesh

Yield Engineering
DfM
Process Corner studies
Yield prediction

Link to other tools
Automatic meshing
Derive process flow
Link to ModeFrontier™, Phoenix Integration and other optimization tools

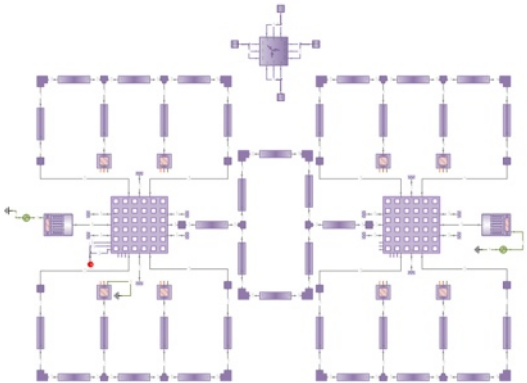
Seamless design flow

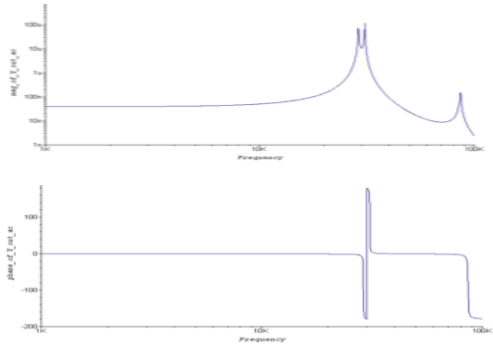


Synple enables schematic based MEMS design capture, design exploration, optimization and system synthesis.

Unlike other tools which give you a warmed over electrical circuit editor, Synple features a sophisticated schematic editor designed specifically for MEMS and Multiphysics modeling. Elements can be wired using a multiphysics bus which carries mechanical, electrical, fluidic and temperature signals across elements. A massively parallel, multi-physics computation engine allows you to perform sophisticated coupled mechanical, electrostatic, fluidic, piezo, analysis along with analog and mixed signal circuit elements (such as transistors, amplifiers, logic, etc) and control elements (such as PID, Sigma-Delta, sliding-mode etc). Synple allows you to optimize your design, explore manufacturability issues and quickly converge upon a robust design for manufacturing.

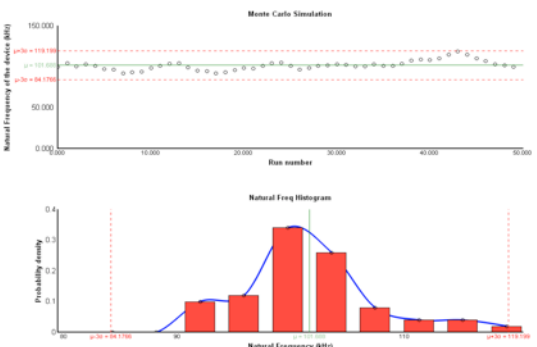
Multiphysics analysis





Compute time: 4 hr (Full 3D) vs 30s (compact)

Schematic based behavioral modeling
Synple places a large array of common MEMS design elements such as straight and curved beams, joints, elastic and rigid plates, frames of references, electrostatic actuating and sensing mechanisms to quickly wire up a complex device in minutes. Compact modeling allows you analyze coupled thermo-electro-mechanical and fluid-structure interaction problems in seconds.

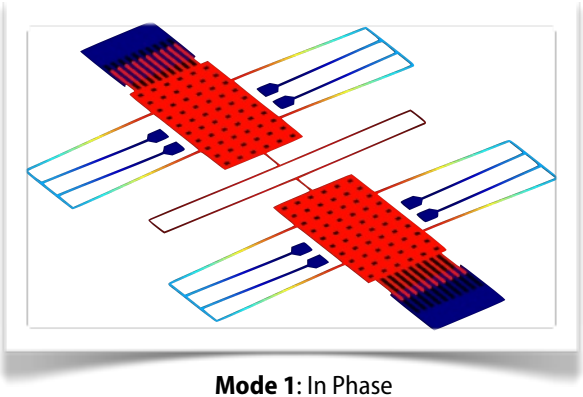


Monte Carlo based process variation analysis

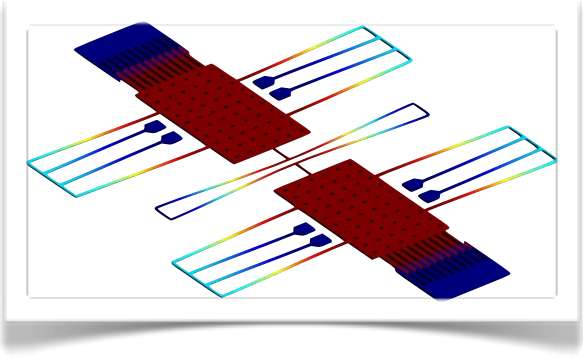
3D result visualization

3D Visualization of Schematic Results
Synple connects to WaveRunner our advanced waveform tool for MEMS, Analog and Mixed Signal analysis.

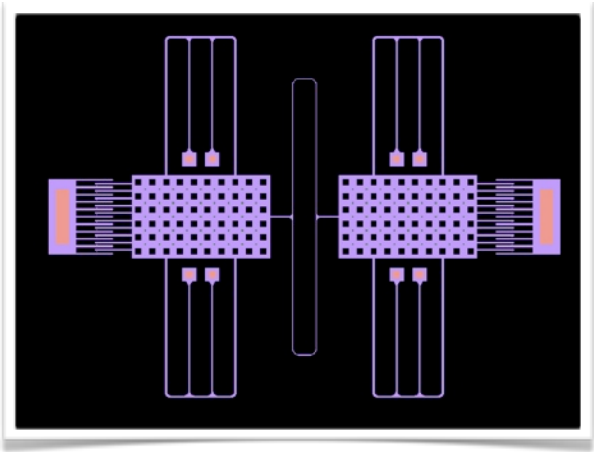
In addition, Synple also connects to VisualEase, IntelliSense's easy to use 3D result analysis tool. Analysis results can be viewed in 3D so that complex motions can be easily visualized.



Mode 1: In Phase



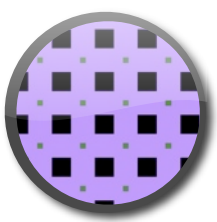
Mode 2: Anti Phase



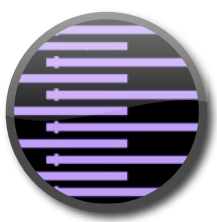
Automated layout synthesis

Attention to detail.
Synple features advanced MEMS placement algorithms to convert schematics into fab-ready layouts. Real world details such as stress relief curves, dimples, bumpers, etch compensation features are automatically generated saving you hours of tedious grunt work.

Stress relief curves



Dimples



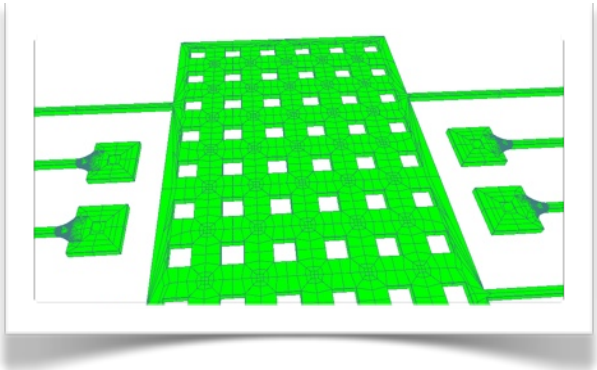
Comb bumpers

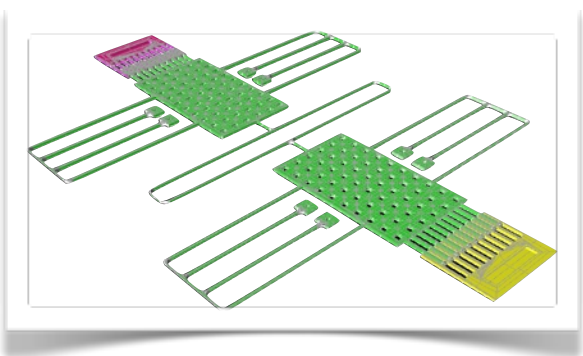
Etch compensation features

Process, 3D and mesh synthesis

Take the pain out of meshing
Synple's synthesis routines can convert the schematic into a process flow that can be used as a basis for your fabrication.

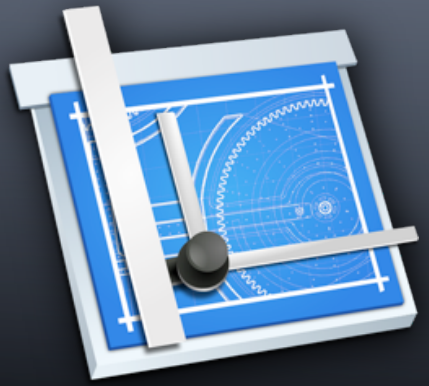
In addition, Synple now integrates our popular HEXPRESSO™ hex meshing tool, automatically converting your schematics into a high-fidelity pure Hexahedral meshes that can be used in Multiphysics analysis.

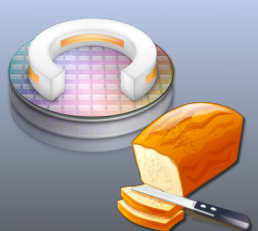




Hexpresso

Physical design & verification



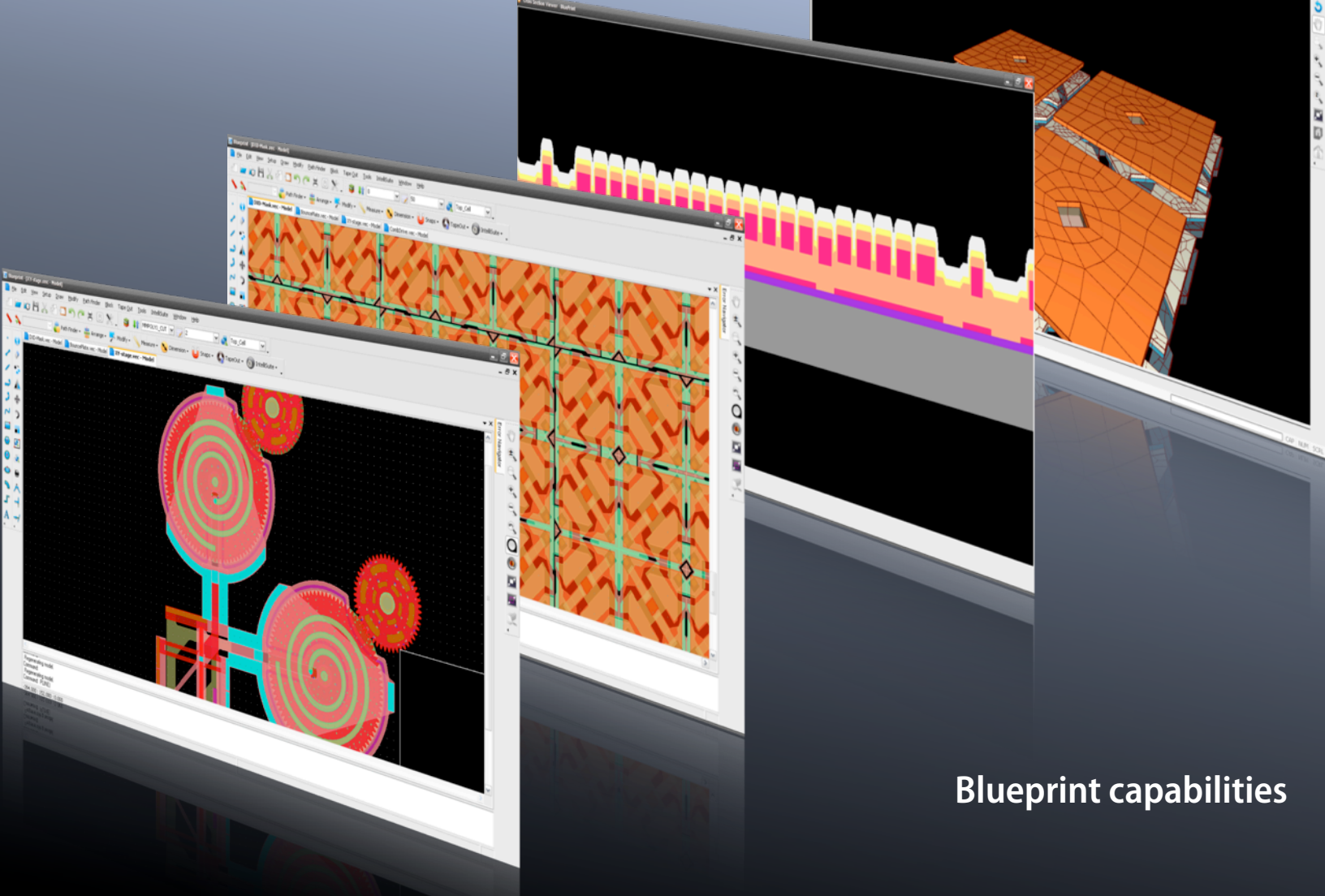


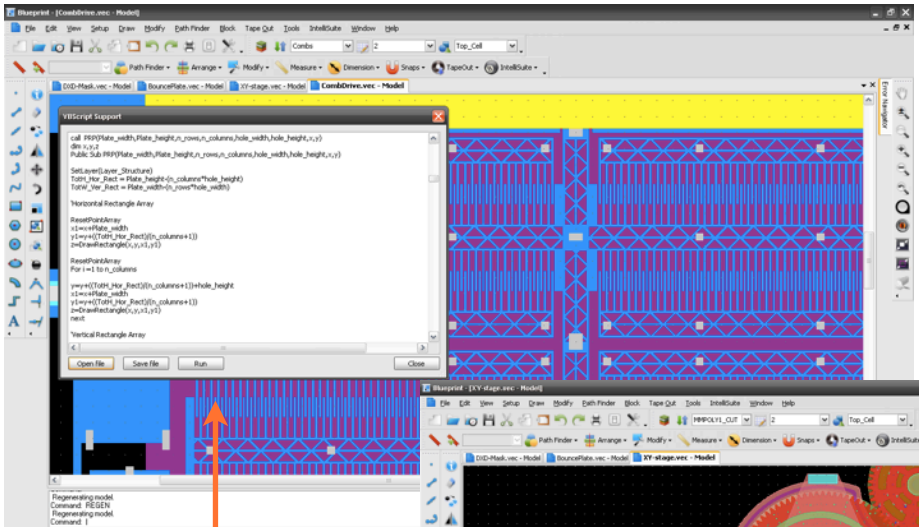
Design capture
Layout optimized for MEMS
AutoCAD™ like interface
Large design library
Hierarchy support
Smart Layers
Pathfinders
Scripting

Design Rule Check
Tape Out DRC Editor
Powerful hierarchical DRC
All angle support
Easy Error Navigator

Layout visualization
Cross section drawing
3D Visualization of layout

Hexpresso
Automated HEX mesher
1 click Mask to Mesh

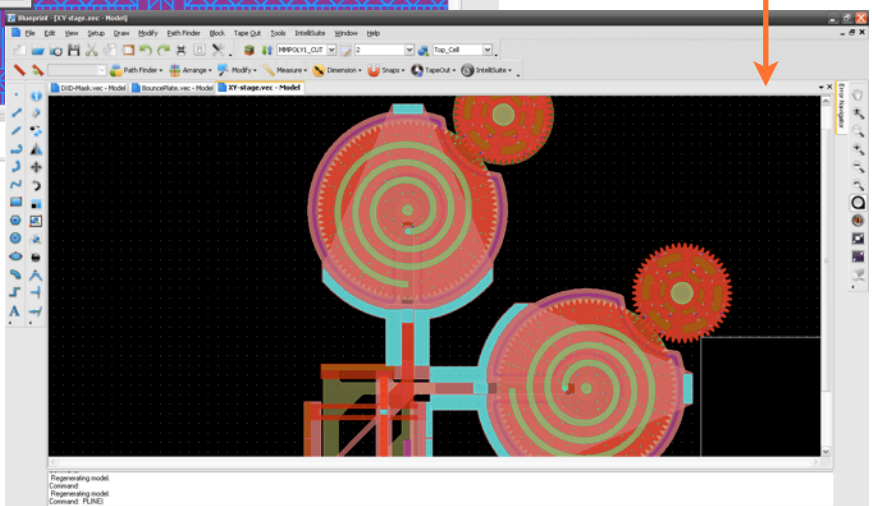

Blueprint capabilities



Mask Courtesy:
Matthew Last, BSAC

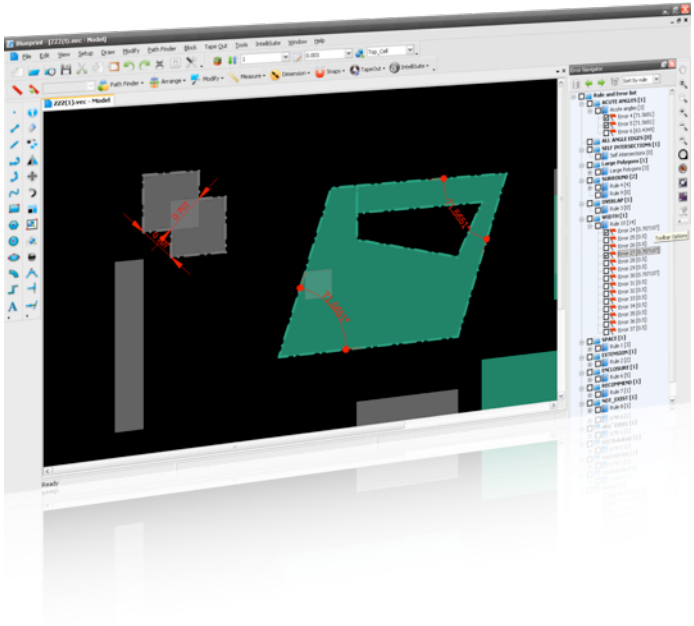
AutoCAD™ like interface makes Blueprint a familiar to new users. Every element of Blueprint from menus to toolbars to keyboard accelerators can be customized to make the interface your own. Layer, view and cell management tools make navigating complex layouts a breeze.

Built in scripting support allows you to automate the creation of complex geometries without breaking a sweat.



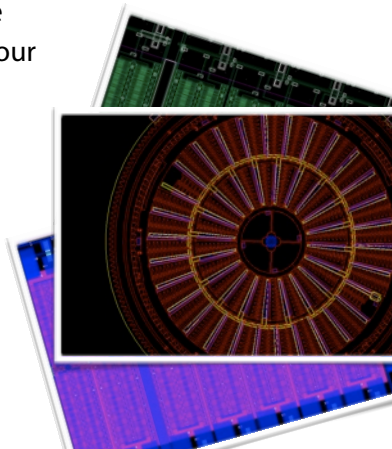
Mask Courtesy:
Prof Tim Dallas, Texas Tech Univ

Layout to TapeOut



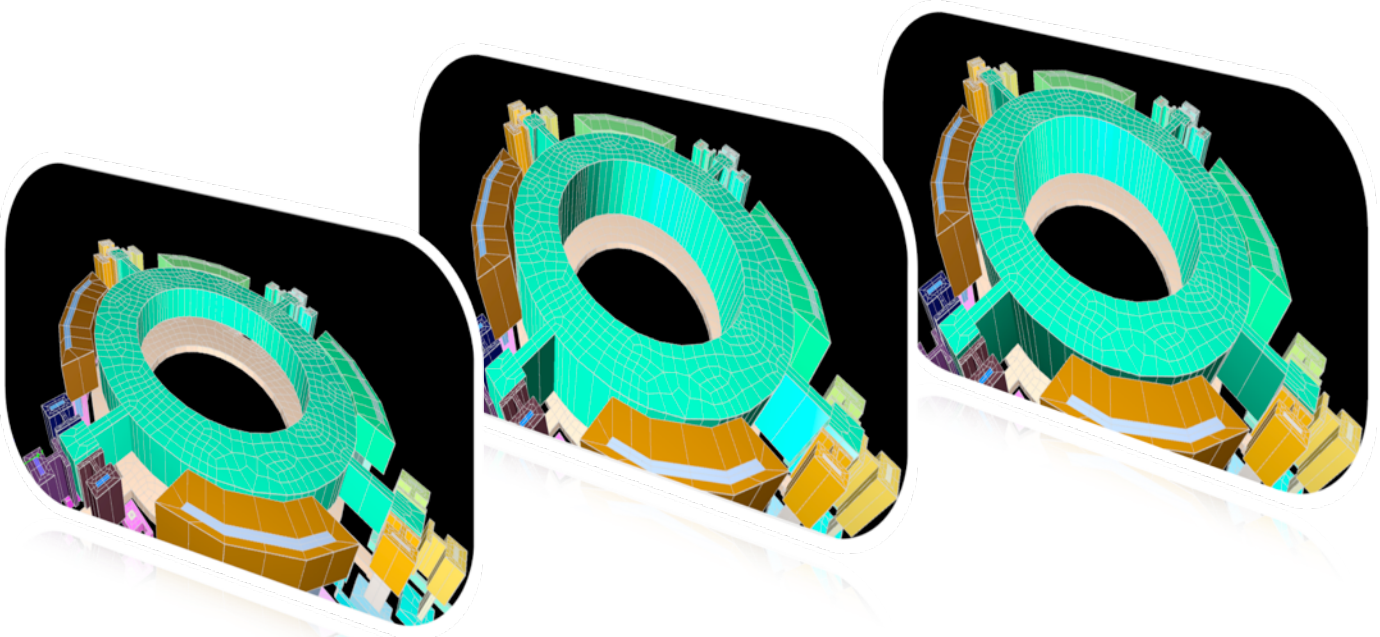
Blueprint is an all-in-one tool for physical design and verification of MEMS.

Blueprint features a layout editor designed for MEMS. An AutoCAD like interface and command line will put most engineers at ease with a feature laden interface. Blueprint integrates a number of technologies that go beyond pure layout. For instance, an integrated cross sectioning tool allows you to examine the process cross section along any line segment. Similarly, built in HEXPRESSO™ support can create pure hexahedral meshes based upon mask layout and process flow. Blueprint also links to TapeOut™, IntelliSense powerful all angle Design Rule Check (DRC) engine to verify your layouts.



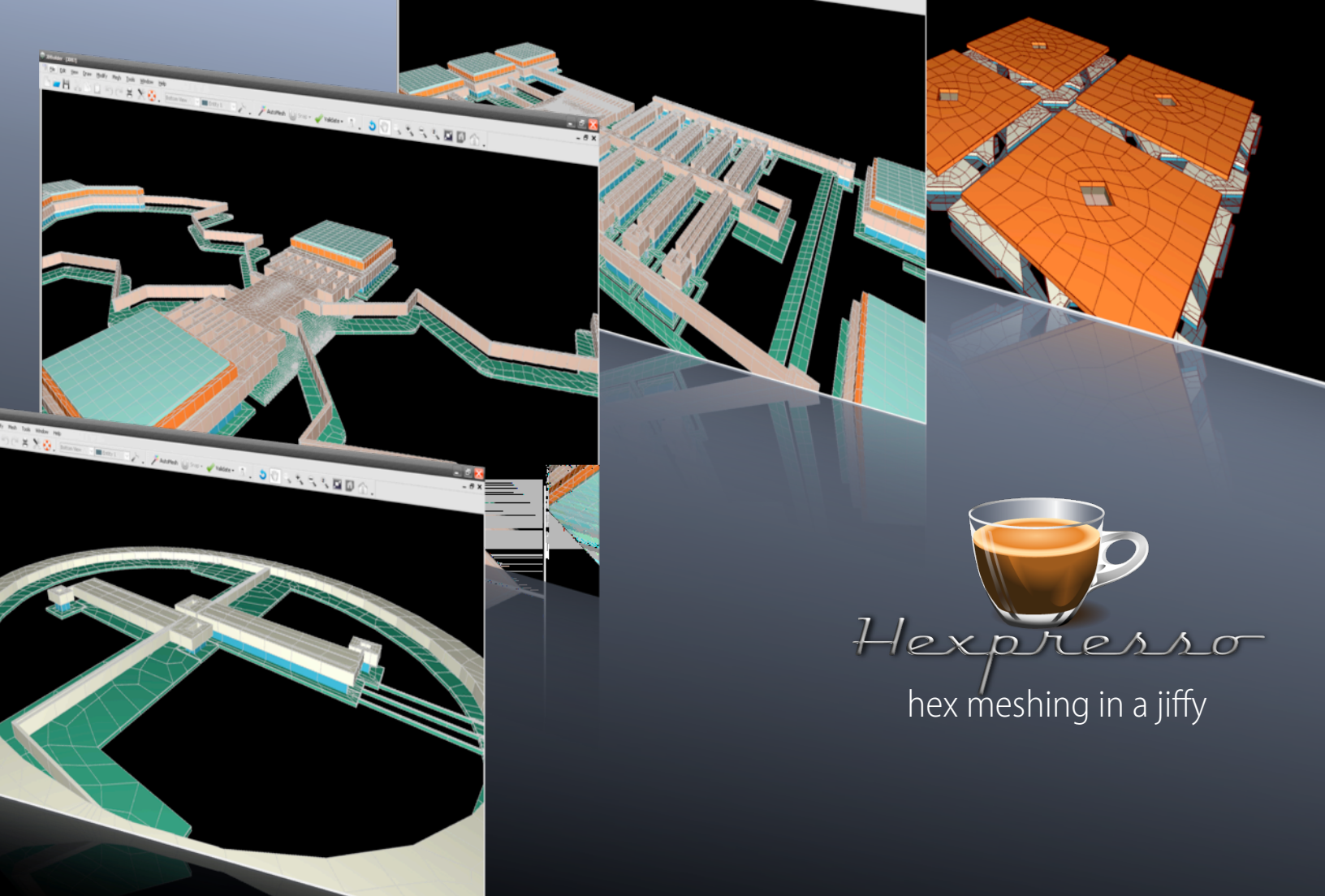
TapeOut & ErrorNav

Blueprint now features a multi-threaded, all angle DRC engine to allow you to verify your designs. An easy to use Error Navigator allows you to identiy and fix errors

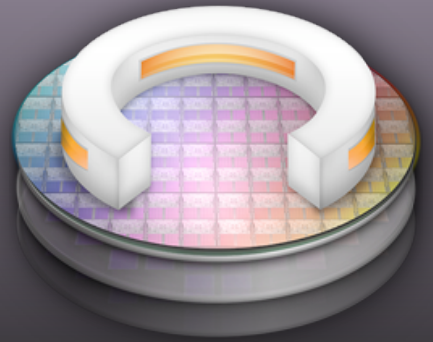


Mesh morphing
Create parametric meshes that can morph across design parameters such as film thickness, electrostatic gaps, sidewall angle and skew, line width offsets without need for remeshing

One click meshing
Use our robust Hexpresso™ engine to go from mask to mesh based upon a process sequence. Hexpresso allows you automatically refine flexures and other high stress areas, account for process flow and process variations .


Hexpresso
hex meshing in a jiffy

Process validation



Process capture
Develop process traveller
Debug traveller
Create process databases

Material databases
Process correlated databases
Material properties

Process simulation
FABViewer: Flow visualization
AnisE - Anisotropic etching
IntelliEtch - ***ab initio*** etching
RECIPE - RIE/ICP etch simulator

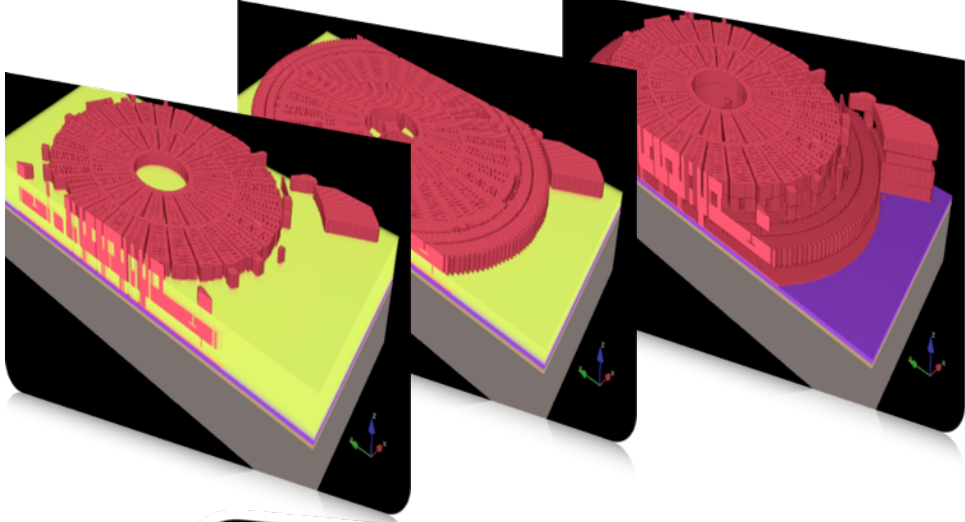
Hexpresso
Automated HEX mesher
1 click Mask to Mesh

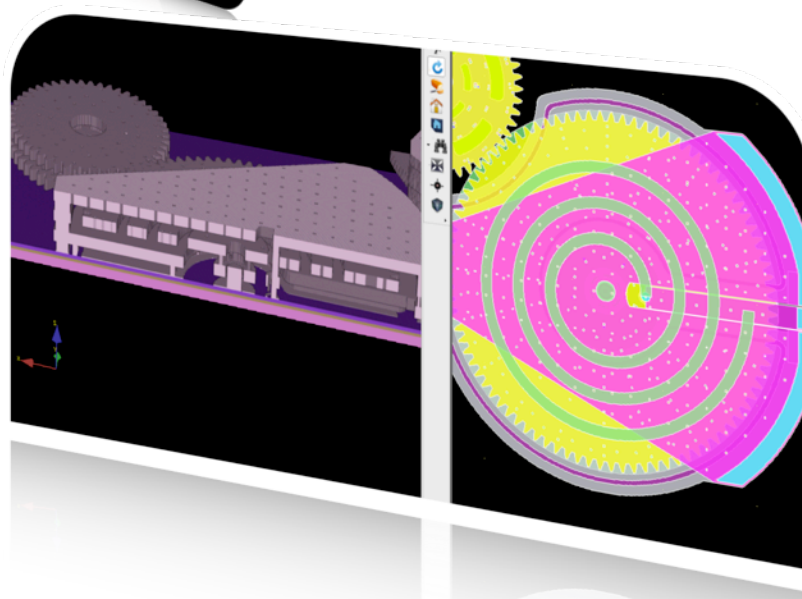
Process traveller based virtual prototyping

IntelliFAB™ allows you to create and debug your process flow and your mask set before you enter the clean room. It allows you to make virtual prototypes to save costly fabrication mistakes.

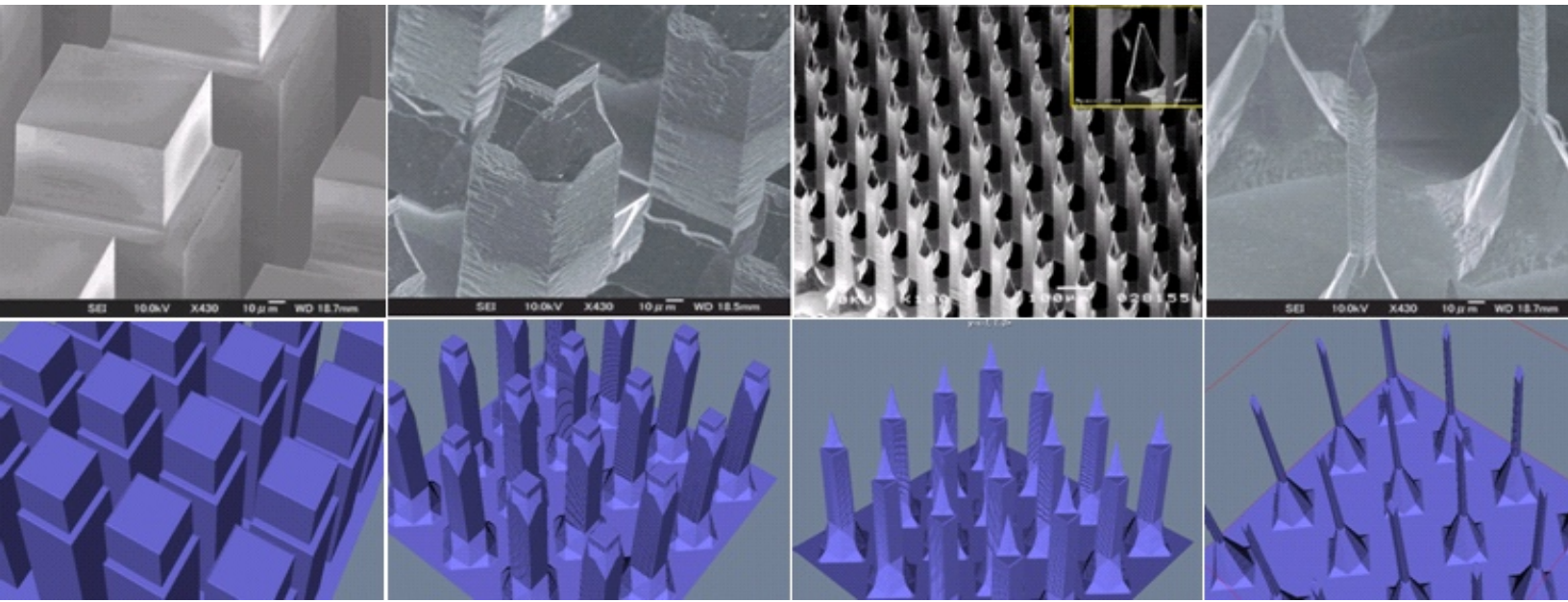
Use IntelliFAB to

- Debug your process traveller
- Visualize your process flow
- Create accurate device models
- Automatically mesh your devices
- Share process flows across the organization
- Capture process knowledge
- Create devices based on foundry templates





Simulate complex MEMS process flows

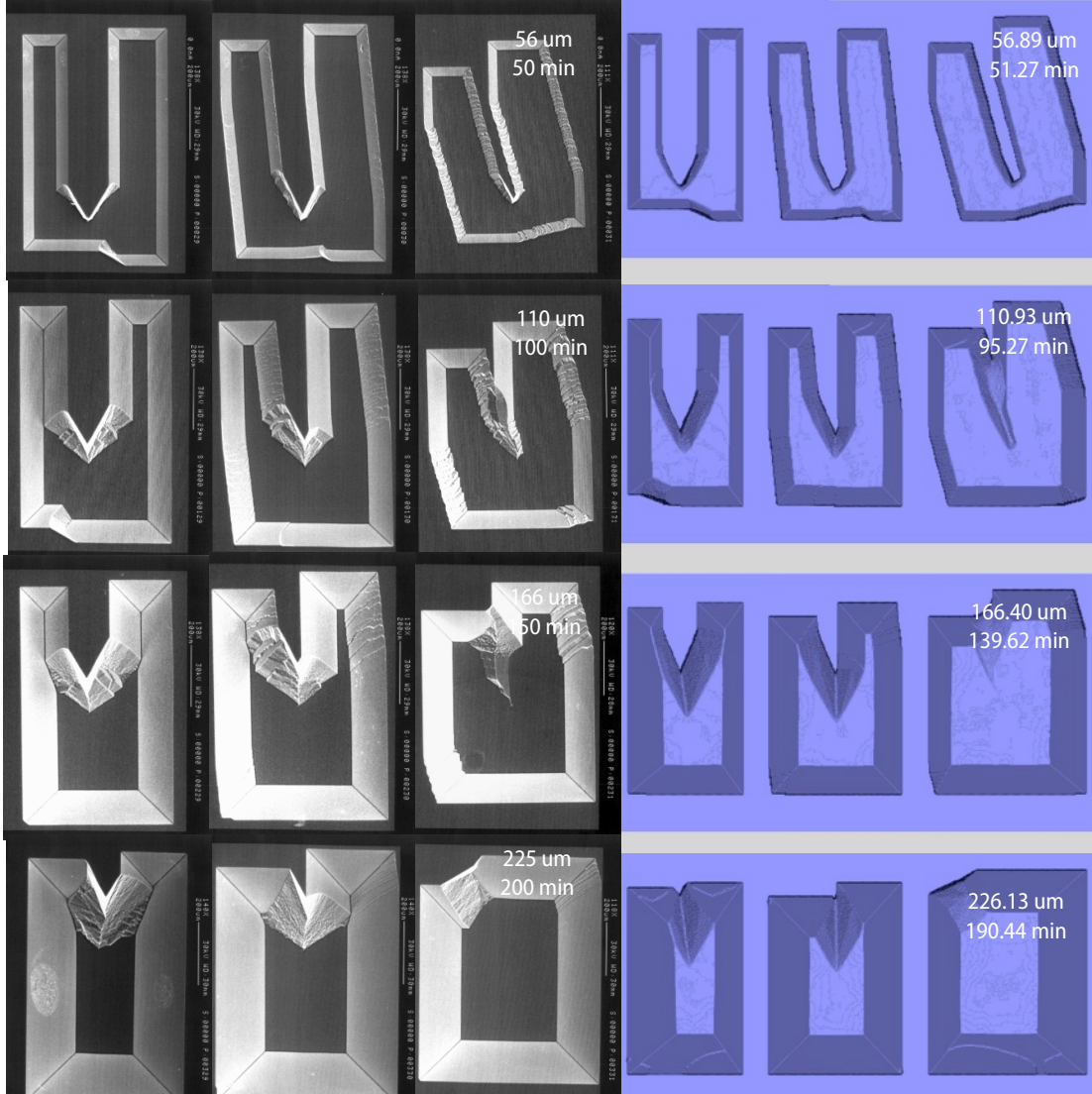


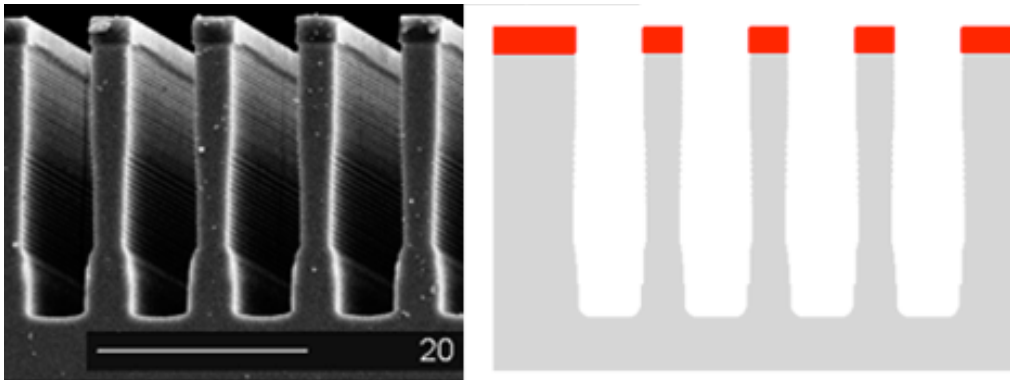
CleanRoom tools allow you to prototype complex process flows. A process flow that combines multi-step mask transfers, oxide and nitride layers, sacrificial layer deposition and wet etching and DRIE processes is shown above.

Composite processes, Shikida Mitsuhiro, J. Micromech. Microeng. 14

Measured vs modeled

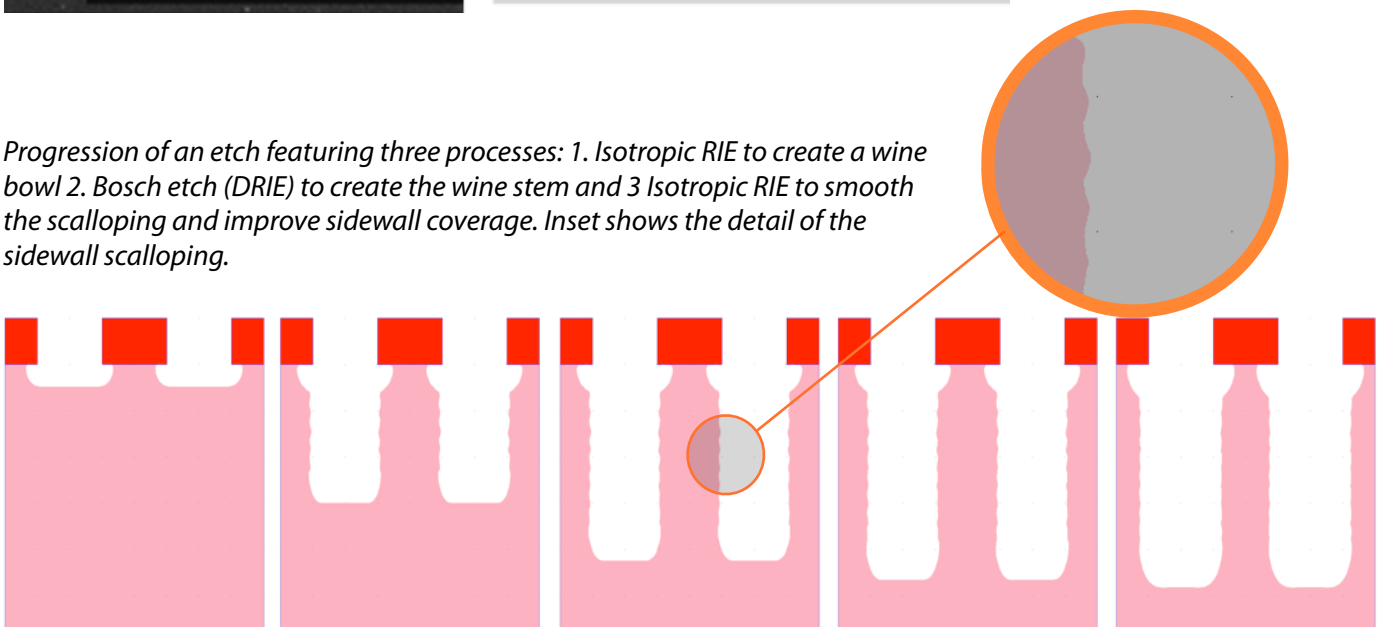
CleanRoom simulation tools are rigorously benchmarked against process studies to ensure first time right design.



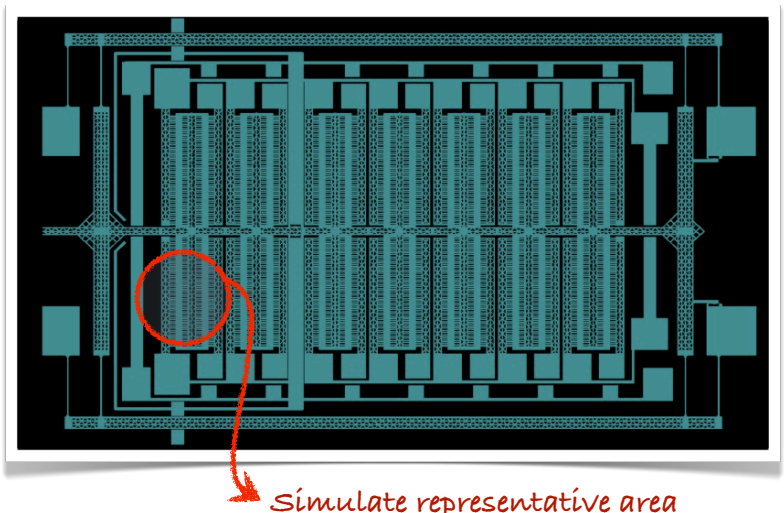


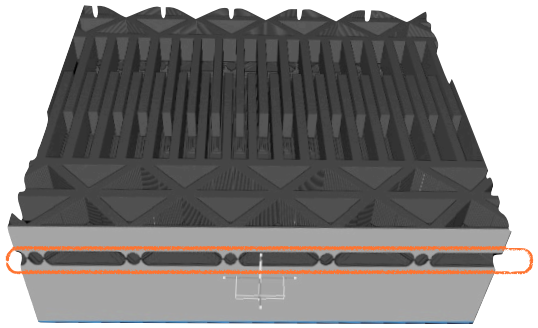
Experimental verification. A RECIPE etch profile (right) is compared with an SEM. A 5µm trench was sequentially etched using a etch/polymerization configuration of 7s/7s, 9s/7s and 5s/7s, each for 5 minutes

Progression of an etch featuring three processes: 1. Isotropic RIE to create a wine bowl 2. Bosch etch (DRIE) to create the wine stem and 3 Isotropic RIE to smooth the scalloping and improve sidewall coverage. Inset shows the detail of the sidewall scalloping.

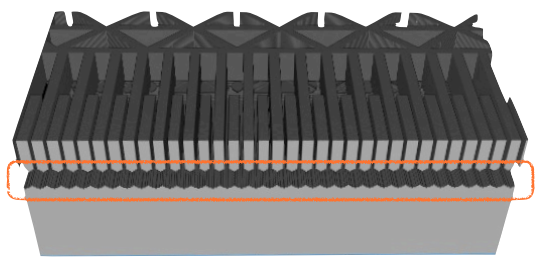


Deep silicon process debug





Unreleased areas



Released structure

Process Debug: RECIPE-3D allows you to fine tune your deep silicon based process flows before entering the fab. In the above example a comb based device is fabricated using the SCREAM process (Single Crystal Reactive Etching and Metallization). The results show areas that are unreleased after the etch (top) and released areas (bottom), indicating that the layout will need some tweaks before entering the fab.

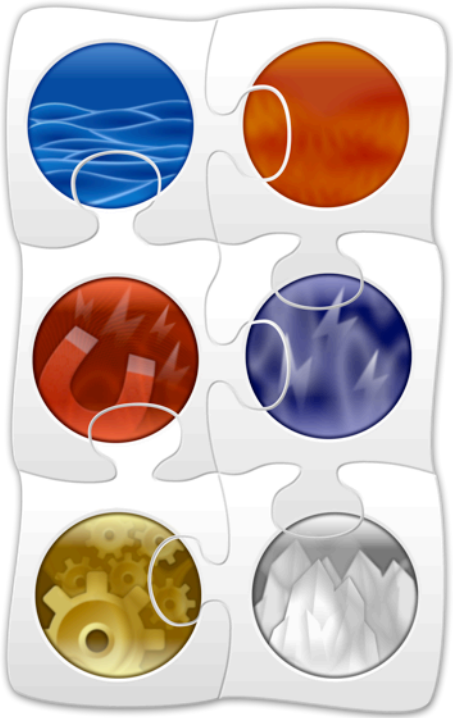
Fastfield multiphysics

Fastfield Multiphysics
Unique FEM-BEM formulation
64 bit multi-processor enabled
5-10X faster than pure FEM

Fully coupled
Thermal
Electrostatics
Mechanical
Fluidics
Contact physics
Piezo
Magnetostatics

Specialized engines
BioMEMS
High frequency EMag

Extraction
Multiphysics capture
Efficient for verification
Lagrangian models
1000X more efficient than FEA



ABAQUS
Integrated Technology

It all fits together

The Thermo-Electro-Mechanical (TEM) analysis module allows you to perform fully coupled thermal, electrical and electrostatic, magnetostatic, fluidic and mechanical analysis.

TEM allows you to perform fully coupled static, dynamic, harmonic, transient, contact and post-contact analyses on linear or non-linear systems. Use TEM for analyzing a wide range of devices based on electrostatic, thermal, piezo, electromagnetic or electrothermal principles.

TEM incorporates many custom MEMS algorithms that are unmatched by other tools.

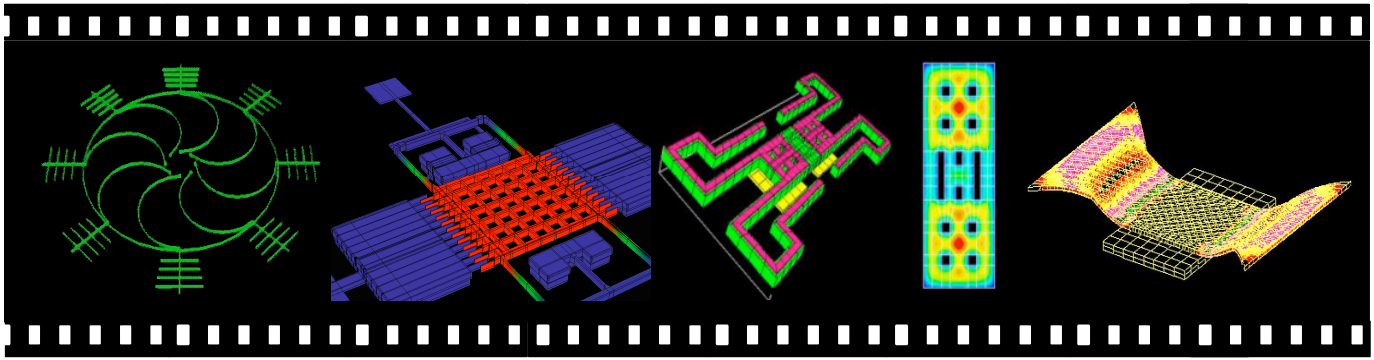
- Full dynamics capability
- State of the art multi-pole accelerated Boundary Element field calculations are 100X faster than comparable FEA tools on the market
- Integrated Fluid Structure Interaction (FSI) for electromechanical, piezoelectric and fast damping extraction calculations

Rotary ring gyro
Rate/Coriolis analysis

Draper vibratory gyro
Electrostatic drive

Lockheed inertial device
Squeeze film analysis

Raytheon/TI RF switch
Non-linear contact analysis

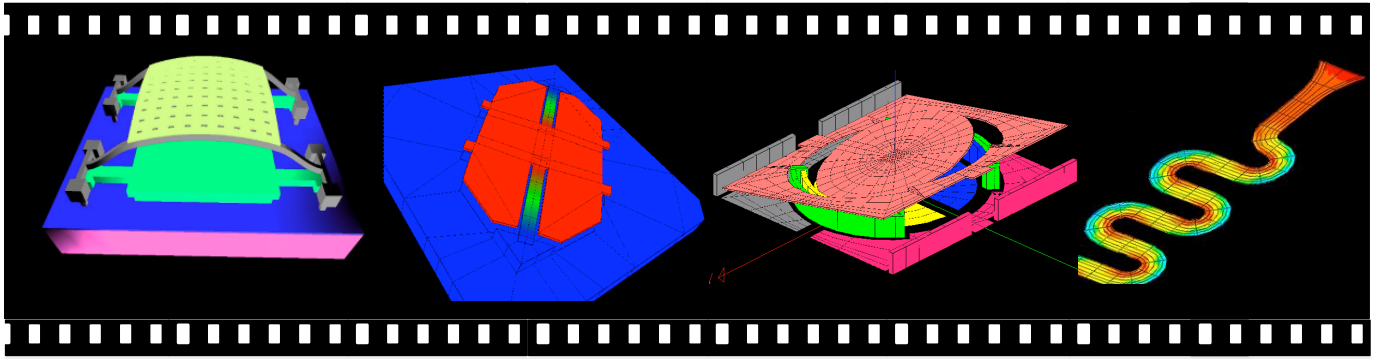


Hitachi
RF Tunable Filter

NASA
Adaptive optics

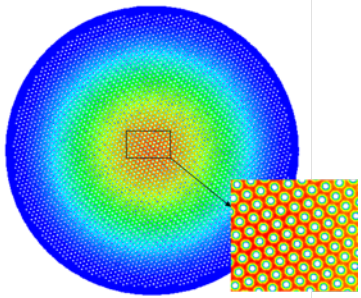
Corning
3D Optical cross connect

NASA
Radiation detectors

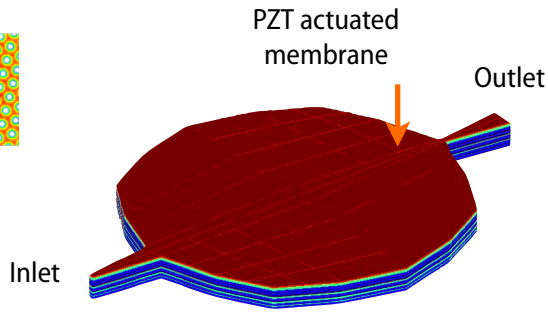


Advanced FSI

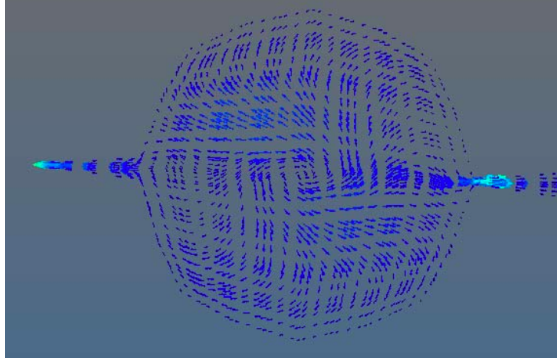
Fastfield technology now supports fully coupled fluid structure interaction (FSI) for electromechanical, piezoelectric and damping (frequency domain) calculations. FSI capability has been widely tested in a number of applications ranging from piezo-pumps to microphone condensers to a variety of MEMS structures.

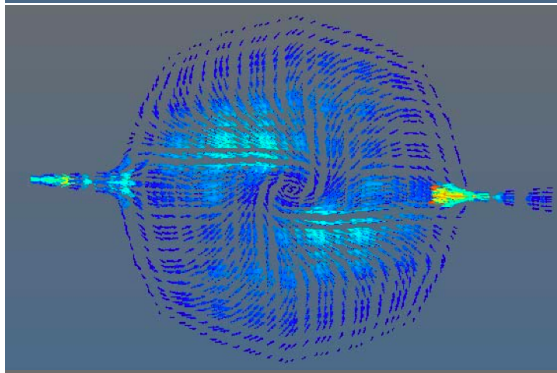


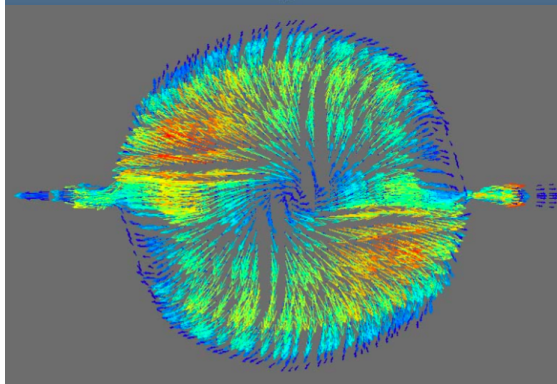
Microphone condenser
Pressure distribution



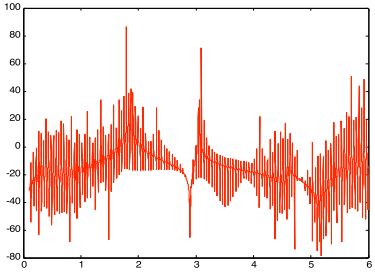
Flow evolution in a piezoelectric membrane micro pump



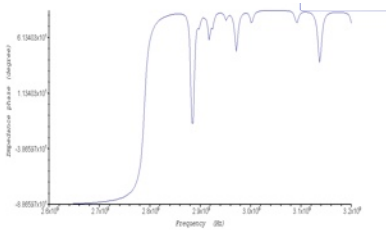




Piezo-Acoustics

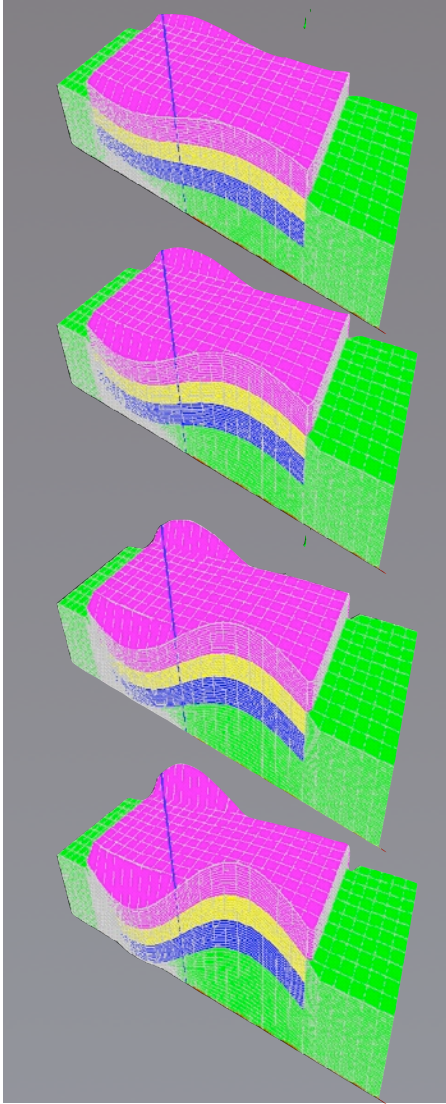


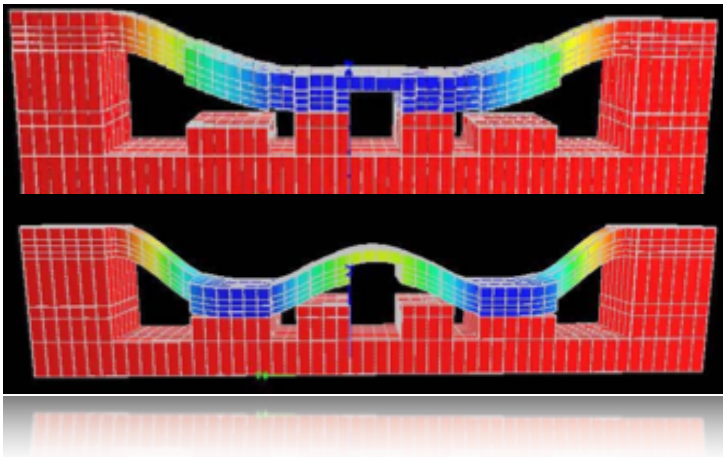
Fast Impedance Extraction

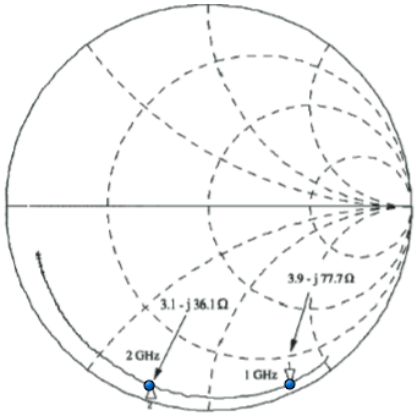


Phase ripple in a BAW device

Multi-processor BAW/SAW simulation
Fast impedance and phase ripple calculations are now a cinch in IntelliSuite





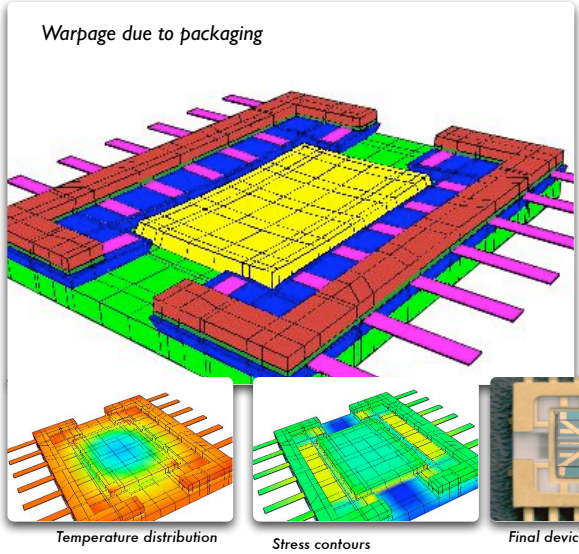


COUPLED ELECTROSTATIC-MECHANICAL-CONTACT PHYSICS & HIGH FREQUENCY (RF) ELECTROMAGNETICS

IntelliSuite ships with a new full 3D FEM based ElectroMagnetics engine optimized for RF MEMS simulation. The Electromagnetics engine is coupled with ThermoElectroMechnaical (TEM) analysis capabilities. FullWave ElectroMagnetic analysis of electro-mechanically deformed structures can be seamlessly simulated for the first time within a single software.

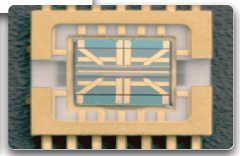
In addition, IntelliSuite ships with several other unique features that allow you to explore phenomenon such as dynamic closure of switches including simulating switch bounce.

Client **Agilent Inc**
Application **Detector chip**
Analysis **Package Thermo-mechanical analysis**

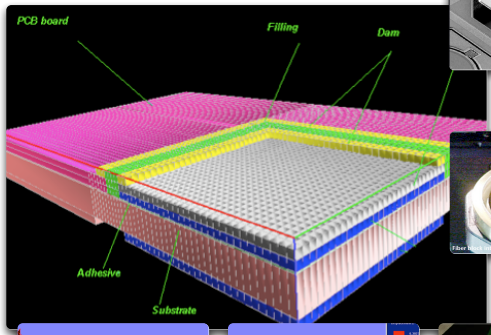


Temperature distribution

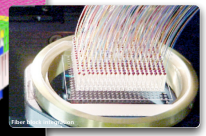
Stress contours

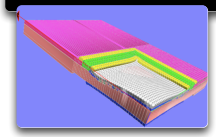

Final device

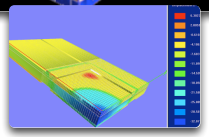
Client **Corning Inc**
Application **Fiber optic switching**
Analysis **Full board level packaging analysis**

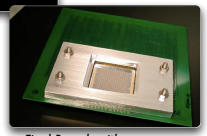


256x256
micro-mirror array


Fiber block integration


Board deformation


Deflection of the mirrors


Final Boards with warpage reduction mechanism

Wrap it up! IntelliSuite includes comprehensive packaging analysis. Stresses, CTE mismatches, shock effects, effects of packaging pressure on device damping, parasitic effects and high frequency electromagnetic effects can all be modeled with ease.

ABAQUS Integrated Technology

Package and board level analyses

IntelliSuite simplifies the packaging of MEMS devices, reducing the cost of packaging development. The tools you need to perform die level and board level packaging analyses come standard with IntelliSuite.

IntelliSuite solves most complex packaging problems involving linear and non-linear, static, frequency, and dynamic behavior. Stress, strain and warpage calculations, thermal-electrical (joule heating), vibrational analysis including shock testing, damping analysis can all be performed with ease.

Our new package model extraction allows you to model the impact of package stresses at a system level, allowing you to compensate package induced effects in electronics.

This allows you to perform JEDEC, MIL STD, or Belcore tests on packaged devices before costly device fabrication.

Microfluidics

Microfluidics and BioMEMS analysis

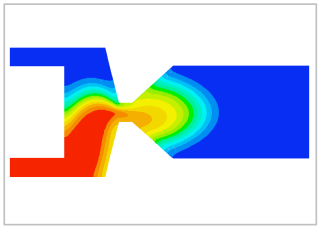
We created a full 3D Navier-Stokes solver optimized for microfluidic applications from the ground up. Simultaneously, we went way beyond the existing code bases by adding support for electrokinetic phenomena, Red-Ox reactions, acids, bases, ampholytes and fluid structure interaction.

An optimized ElectroWetting on Dielectric (EWOD) engine allows you to quickly simulate droplet transport, merging and splitting.

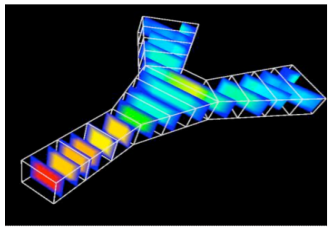
We then added advanced visualization algorithms to look at cross-sectional profiles, velocity vectors, streamlines and transient results.

Our code base is not only faster at solving microfludics problems but is the only MEMS tool for problems from ranging from high frequency dielectrophoresis to isoelectric focusing to electro-osmotically enhanced flow.

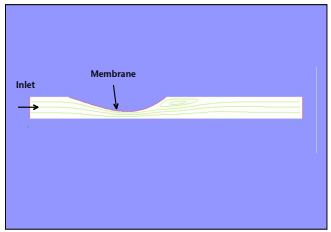
Discover why top BioMEMS companies are choosing the IntelliSense solution.



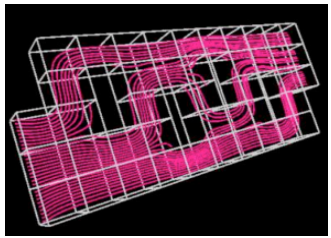
Micro-mixing in a valve
Concentration gradient evolution



Flow mixing
Y combiner

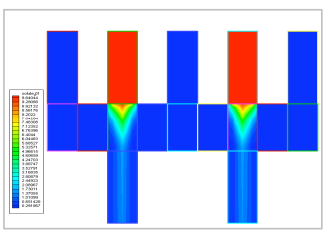


Fluid Structure Interaction
Inlet flow - membrane interaction

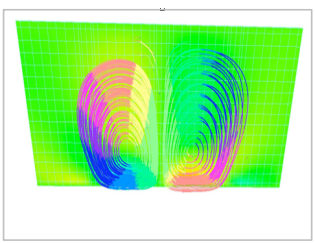


Flow separation device

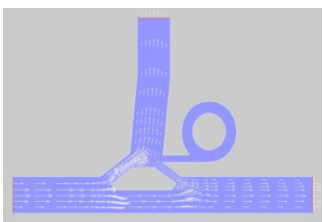
Microfluidics• Electrokinetics • Transport stochiometry • Heat transfer • Electro-Wetting on Dielectric (EWOD) • Digital droplet microfluidics • Free Surface Flow • Fluid Structure Interaction • Electrochemistry Micro-mixing • Electrophoresis • Dielectrophoresis • Capillary flow and electro-separation Electro-osmosis • Electro-hydrodynamics • Micro-pumps



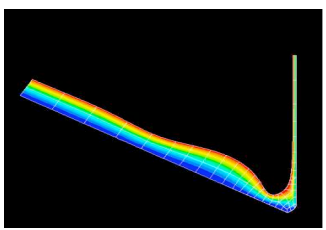
Electrokinetics
Multiplex focusing



Electro-osmotic driven flow
Electrohydrodynamics for cooling



Electrophoresis/Dielectrophoresis
High Frequency Waste separation



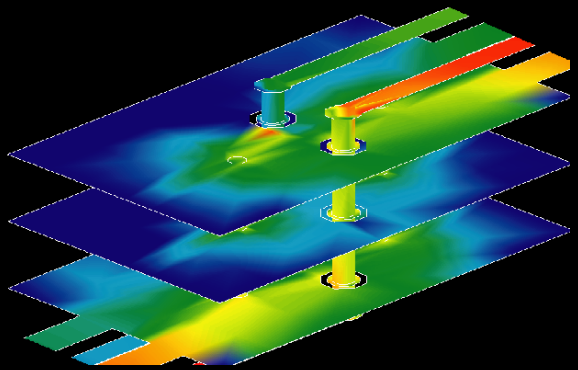
Free surface flow
Slide coater

High frequency electromagnetic analysis

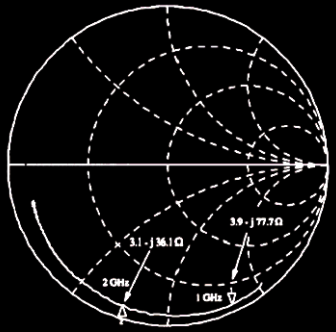
The IntelliSuite electromagnetic analysis module is specifically designed to address the needs of researchers in RF MEMS, microwave, and Optical MEMS by providing fast, accurate, cost-effective solutions for high frequency electromagnetic phenomena.

The Electromagnetics module is the only fully integrated high frequency solver available for MEMS simulation. Traditional high frequency tools are designed for planar or quasi-planar structures, not for the high aspect ratio structures of MEMS. These tools also fail badly when it comes to highly resonant mechanical structures.

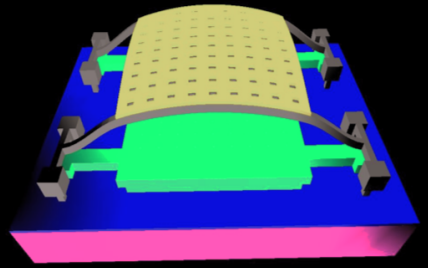
Additionally, we removed more limitations found in most other high frequency tools by adding support for lossy conductors and dielectric discontinuities. Best of all, it tightly integrates with the IntelliSuite environment, providing you with all the tools for your MEMS needs!



Create and model complex geometries such as vias and through feeds with ease. While IntelliSense's multi-pole accelerated impedance extraction algorithms will rapidly compute critical parameters.



IntelliSuite is the only tool on the market that allows you to perform coupled Thermo-Electro-Mechanical & Full Wave ElectroMagnetic analyses— this is particularly useful in designing deformable RF-MEMS such as switches, tunable capacitors and varactors.



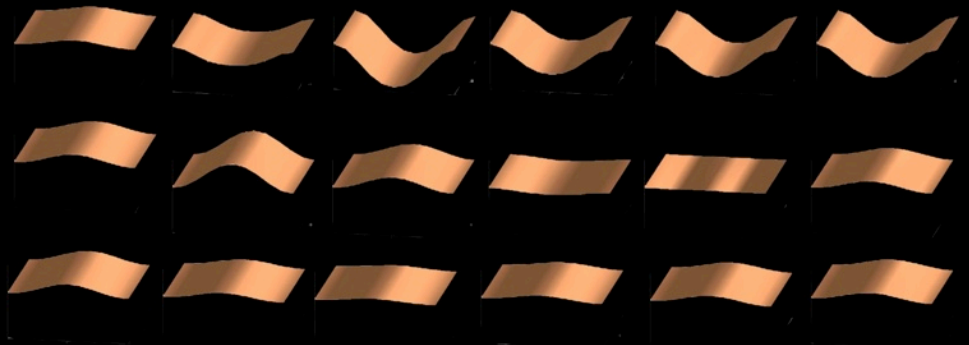
Extraction & verification

System model extractor (SME)

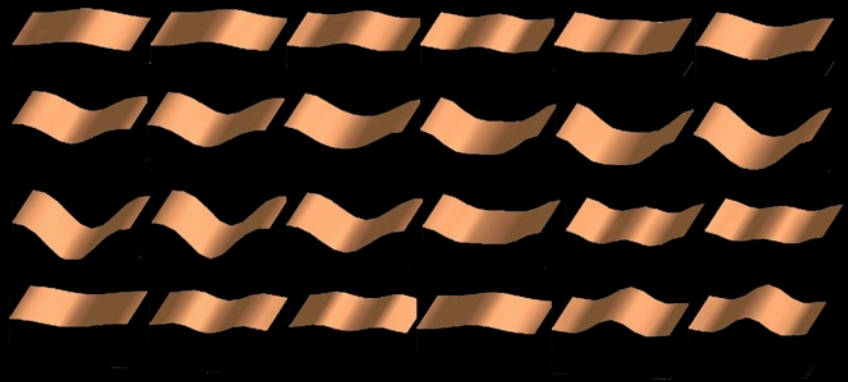
IntelliSense introduces SME for dramatically reducing the computational time to perform accurate dynamic analysis of MEMS. Based upon sub-space model reduction and energy based algorithms, very large non-linear thermo-electromechanical, electrothermal, piezoelectric or piezoresistive FEM models can be reduced into computationally efficient behavioral models.

These behavioral models fully capture the complex non-linear dynamics inherent in MEMS due to electrostatic forces, electrothermal and residual stresses, squeeze film damping, and multiple mechanical degrees of freedom.

IntelliSuite is the only tool that gives you the freedom to create arbitrary degree of freedom compact models. These n-DOF 3D models fully capture all of the harmonic modes of the MEMS enabling you to quickly develop readout or control electronics.



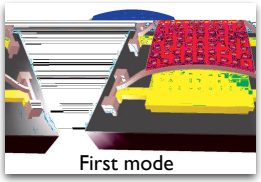
SME allows you to create 3D macro models that accurately capture the dynamic response of MEMS 100-1000x faster than equivalent FEA simulations. The response of a clamped beam driven at 50 kHz (above) and at 3 MHz (left) accurately captures the beam motion.

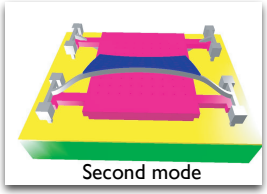


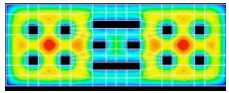
Capture strain energy associated with each mode

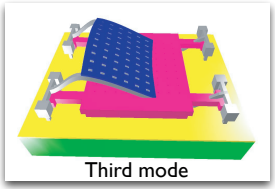
Capture electrostatic energy associated with each mode

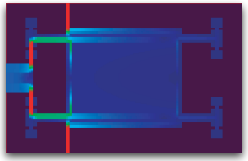
Capture fluid damping characteristics











Arnoldi/Krylov sub-space reduction

N-DOF behavioral model based on Lagrangian formulation

$$\frac{d}{dt}\left(\frac{\partial L}{\partial q_j}\right) - \frac{\partial L}{\partial q_j} = 0$$

HDL

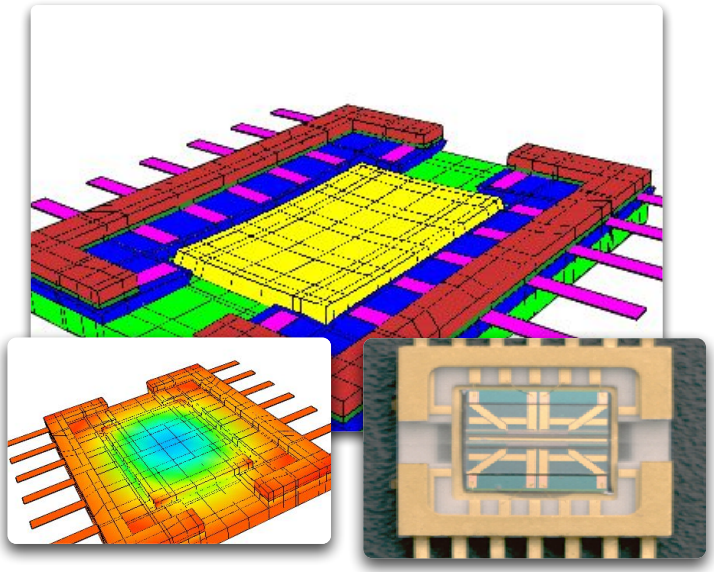
HDL formulation

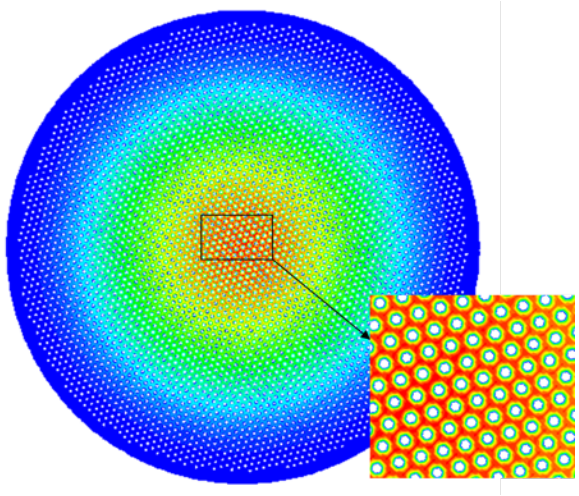
Hardware Description

❶ Capture total energy of relevant mode (Mechanical, Electrostatic, Fluidic, Dissipation) and modal interactions

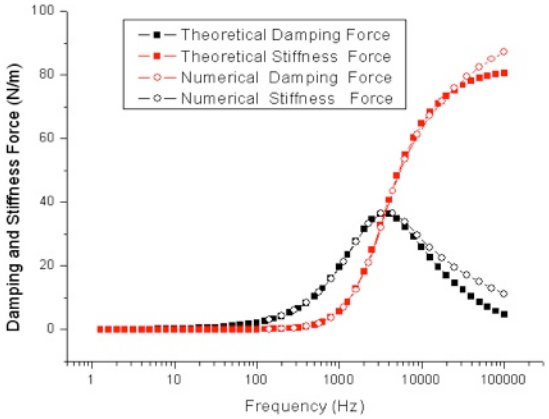
❷ Krylov/Arnoldi subspace methods to generate Lagrangian formulation

❸ Create Lookup table based fast Compact model for system modeling





Extraction algorithms can now capture modal fluid damping, package, and temperature related effects. Modal fluid damping is extracted in the frequency domain to accurately capture variation of fluid film force and damping components with operating frequency. Package warpage and temperature coefficient releated effects are also captured and included in system models.



EDA-Linker — Integrate MEMS + ASIC design flows

Seamless integration with your preferred EDA Workflow

EDA Linker allows you to incorporate IntelliSuite directly into your EDA workflow. Whether you are using a Cadence, Mentor, Synopsys, Matlab or Tanner environment, or a mixed tool environment IntelliSuite will fit right in.

EDA Linker allows you to co-simulate your micro-devices along with the electronics in your favorite mixed signal or system level environment.

Automated code generation

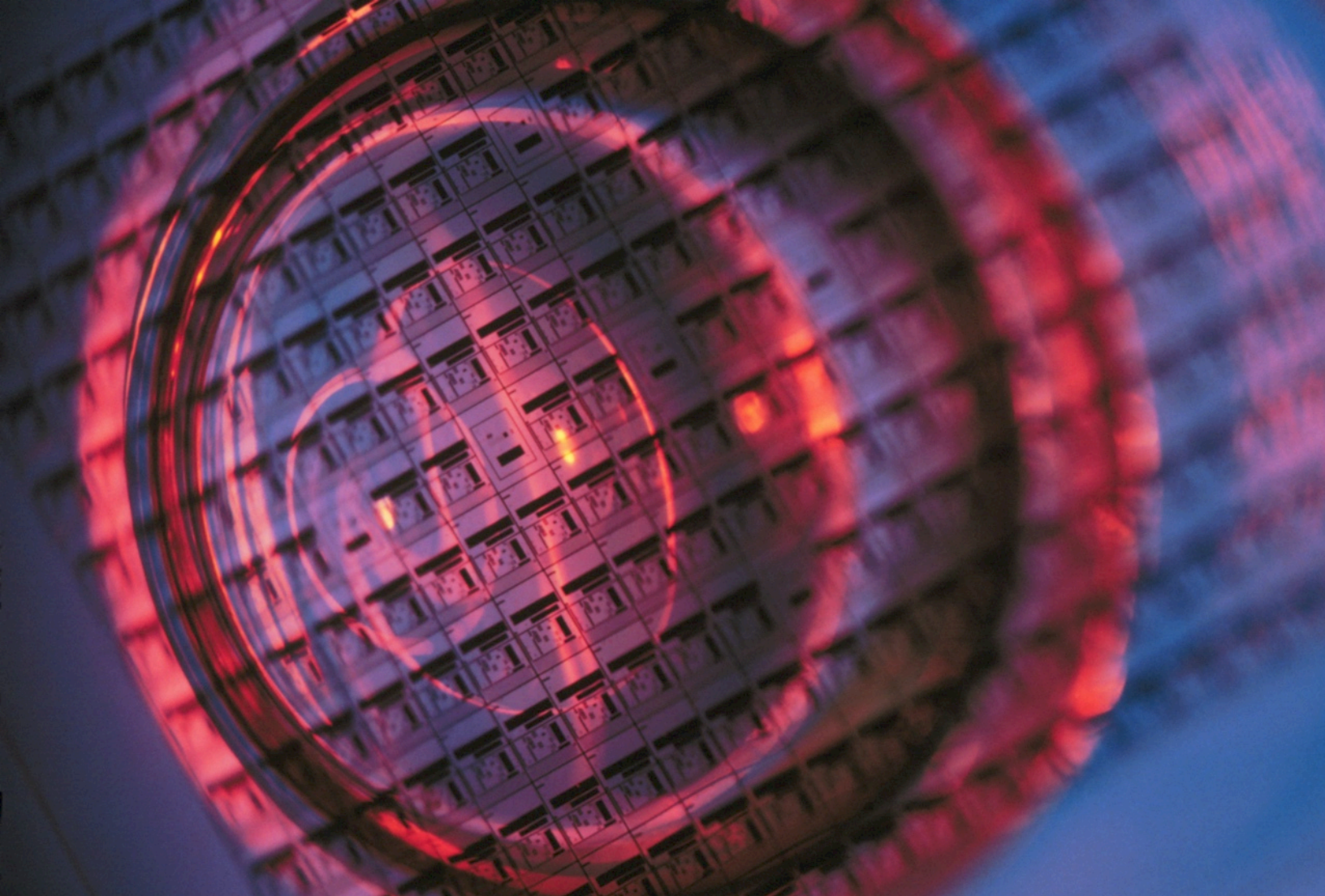
Users can easily convert complex electro-mechanical devices such as gyroscopes, resonators, switches etc into an equivalent hardware description language with the click of a button. EDA Linker supports, VHDL-AMS, Verilog-A, HSPICE, PSPICE, Simulink MEX based flows.

Open standards based exchange

Physical layout	GDS, DXF, CIF, GERBER, RS-247, EMK, HOLES
Structural and 3D	IGES, SAT, VRML, GEOM, DXF
Analysis and mesh structure	UNV, PAT, CDB, SAT (Ansoft, Ansys, ABAQUS, Patran, Nastran, Simulia)
System and circuit level	VERILOG-A, VHDL, PSPICE, HSPICE, SIMETRIX, SIMULINK (MEX), TOUCHSTONE
Result files	ASCII, CSV (Excel), Touchstone, PLT (Tecplot)

IntelliSuite provides compatibility with many of the existing tools in your toolbox. At the physical layout level it provides seamless data exchange with L-Edit, Virtuoso, AutoCAD and other popular layout editors; at the solid model level you can exchange data with any SAT or IGES based tool such as SolidWorks, CATIA, ProE. At the analysis level you can exchange data with Abaqus, Ansys, Ansoft, Comsol, Nastran or Patran; at a mixed signal or system level you can export directly to ADS, Ansoft, Cadence, Mentor, Mathworks Simulink, Synopsys or Tanner based workflows. Additionally, all result files can be visualized in any Tecplot compatible tool.

Design to device services



Engineering services

Design services

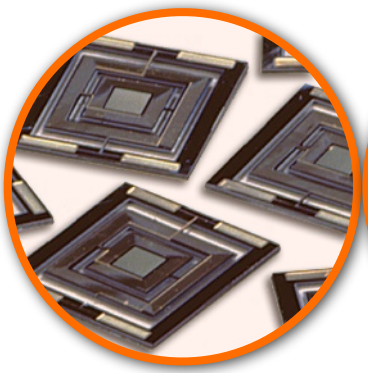
IntelliSense has a strong background in offering design services for MEMS. In fact, we have been involved in many a MEMS program since 1991. IntelliSense offers a wide range of design services ranging from traditional work for hire to specialized IP development.

Turnkey MEMS fabrication services

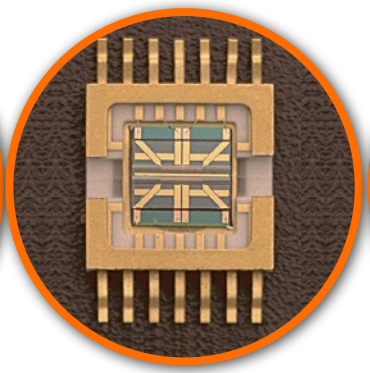
IntelliSense operates as a fabless MEMS company and offers design/prototyping/ manufacturing, IP licensing and consulting services. IntelliSense has formed strong affiliations with established MEMS foundries and research institutions throughout the United States and the world. Our partnerships across the value chain allow IntelliSense to prototype and transfer MEMS based components into production at the lowest cost.

Consulting services

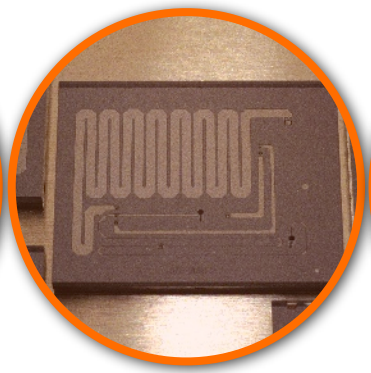
Although we are extremely discrete about our clientele you will find that we have worked with the top names in the world. We have tackled some of the most challenging MEMS problems over the years. Be it solving manufacturability issues or process technology recommendations we are ready to take on your problem.



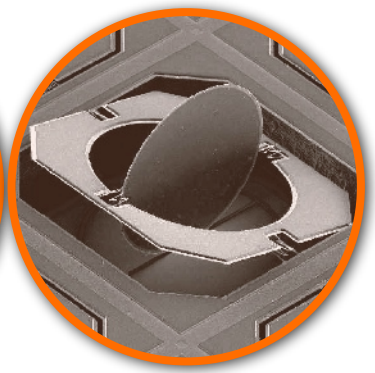
Microsensors



RF MEMS



Microfluidics



Optical MEMS

Design to Device Services

Supply chain management

IntelliSense has formed strong affiliations with established MEMS foundries and research institutions throughout the United States and the world. Our partnerships through out the value chain allow IntelliSense to prototype and transfer MEMS based components into production at the lowest cost.

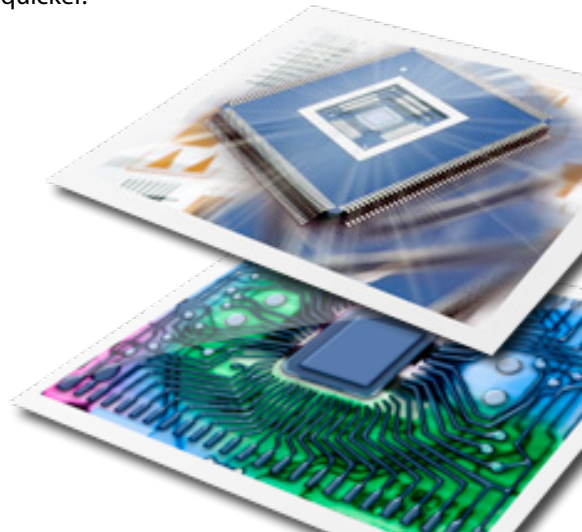
Prototype to manufacturing

It is important for custom MEMS design that design and process development engineers work closely together. That is why IntelliSense has formed strategic partnerships with the leading MEMS foundries. Prototype development, including packaging and test, is done with these partners. Pilot-line manufacturing can be completed with these local foundries as well. To reduce cost, higher volume manufacturing can be done in our overseas partners' facilities.

We can help you drive down MEMS, BioMEMS and opto-electronic packaging costs, reduce your risk in the development cycle, and smooth the path through pilot scale to high-volume manufacturing.

Reducing risk

Our strategic partnerships gives you access to the right vendor for the right job. By working with several vendors, we closely keep track of their evolving expertise and competence in different areas. This allows us to put together the right partnerships to get your devices to market quicker.



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Total MEMS Solutions

IntelliSense ignited the MEMS industry in the early 1990s with its IntelliSuite® family of innovative CAD/EDA tools — and is now the leading innovator and supplier of design and development solutions for the MEMS professional. With users in more than 30 countries, IntelliSense offers software tools and custom design, consulting and market research services to universities, blue-chip companies and start-ups worldwide.

What's more, IntelliSense has formed strong affiliations with dozens of leading MEMS foundries and research institutes worldwide, which allow us to prototype and transfer MEMS-based components into production at the lowest cost. As a fabless MEMS company, IntelliSense also offers design, IP licensing and consulting services.

www.intellisense.com