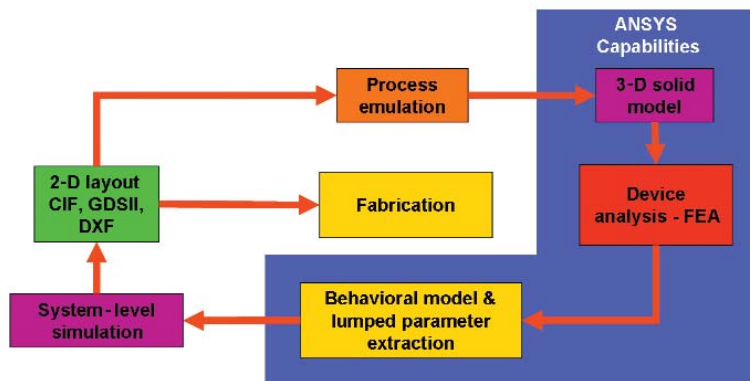


## Simulation Solutions for the Microsystem Design Industry

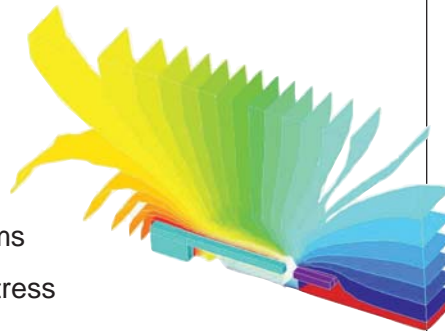
MICROSYSTEM DESIGN

ANSYS, Inc. software provides an extremely broad physics capability directly applicable to many areas of microsystem design. Coupling between these physics enables accurate, real-world simulation of devices such as electrostatic comb drives, thermal-electric actuators and radio frequency (RF) MEMS switches, to name a few. The following diagram explains how ANSYS analysis capabilities fit into a microsystem/MEMS design process.

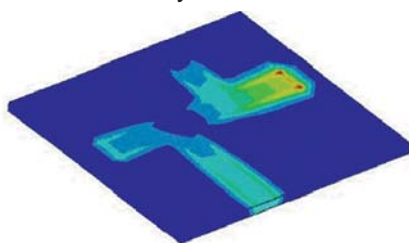


### ANSYS microsystem analysis capability allows users to incorporate:

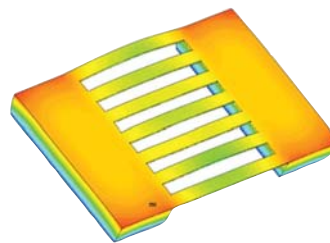
- ▶ Fluid structural damping effects – critical in determining the response time of switches and micro mirrors
- ▶ Electro-thermal-structural effects – employed in thermal actuators
- ▶ Thermo-elastic damping – a critical energy loss mechanism for microsystems
- ▶ Initial or residual stress – mechanical stress resulting from the fabrication process
- ▶ Multiphysics contact – mechanical, thermal, electric and magnetic contact can be handled simultaneously



Electrostatic analysis of comb drive resonator



RF MEMS bandpass filter



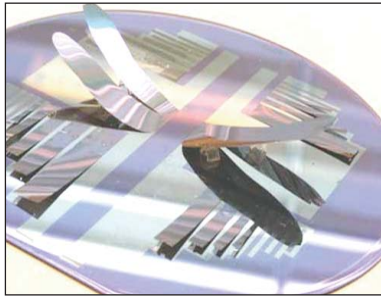
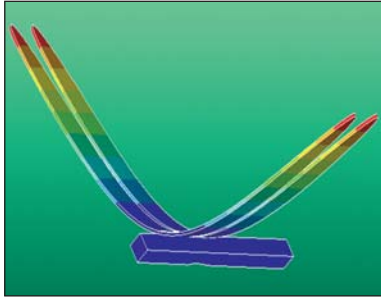
Micromachined interferometer showing initial stress

### ANSYS Simulation Solutions

- ▶ ANSYS® Multiphysics™
- ▶ ANSYS® Emag™
- ▶ ANSYS® Mechanical™
- ▶ ANSYS® CFX®

*“A decisive advantage offered by MEMS technologies is the possibility of implementing sensors and actuators within arrays. This requires knowledge of the different physics for each section of the device required for it to work. ANSYS Multiphysics enables us to couple these physics and accurately predict their performance.”*

– **Patrice Minotti**  
CNRS Research Director  
SilMach S.A.



#### CASE-IN-POINT

Silmach S.A. uses ANSYS Multiphysics to develop advanced microsystem sensor and actuator arrays, which the company recognizes as providing a decisive advantage among MEMS technologies. Developing such MEMS arrays requires an understanding of the different physics acting in each section of the device required for it to work properly. The company reports that using multiphysics enables them to effectively couple these physics and accurately predict their performance. In this way, ANSYS Multiphysics enables Silmach to create a more efficient MEMS device. The technology played a key role in the development of an electromagnetic actuator, for example, that has a power output of 100 Watt/gram compared to 1 W/g for standard devices, a 100-fold performance.

#### ANSYS Microsystem Analysis Capabilities

- ▶ Structural static, modal, harmonic, transient mechanical deformation
- ▶ Large deformation structural nonlinearities
- ▶ Multiphysics contact
- ▶ Linear and nonlinear materials
- ▶ Buckling, creep
- ▶ Material properties: temperature-dependent, isotropic, orthotropic, anisotropic
- ▶ Loads/boundary conditions: tabular, polynomial and function of a function loads
- ▶ Plasticity, viscoplasticity, phase change
- ▶ Electrostatics and magnetostatics
- ▶ Low-frequency electrics
- ▶ Low-frequency magnetics
- ▶ High-frequency electromagnetics (full wave, frequency domain)
- ▶ Circuit coupling: voltage and current-driven
- ▶ Acoustic-structural coupling
- ▶ Electrostatic-structural coupling
- ▶ LCG lumped parameter extraction
- ▶ Fluid structural capability to evaluate damping effects on device response time
- ▶ Microfluidics: Newtonian and non-Newtonian continuum flow
- ▶ Free surface VOF
- ▶ Charged particle tracing in electrostatic and magnetostatic fields
- ▶ Electro-thermal-structural coupling
- ▶ Piezoelectric and piezoresistive transducers: direct coupled structural-electric physics; full isotropic, orthotropic parameters
- ▶ Advanced thermoelectric effects: Seebeck, Peltier and thermocouple

#### ANSYS Multiphysics can be applied to a broad range of microsystem/MEMS analysis:

- ▶ Inertial devices – accelerometers and gyroscopes: structural modal, static, transient, electrostatic-structural, reduced-order macro modeling for system level
- ▶ Inkjet printheads – piezo and thermal actuation: thermal-electric and electric-structural coupled physics
- ▶ Pressure transducers
  - capacitance-based: electrostatic structural coupling
  - piezoresistive-based: electric-structural coupling
- ▶ RF MEMS – high-frequency electromagnetics and coupled HF emag-thermal

#### The ANSYS Advantage

ANSYS software provides customers with a competitive advantage:

- ▶ Ability to factor in more than one physics with ANSYS Multiphysics
- ▶ ANSYS® Workbench™, which provides a unified product development environment offering integration across a wide range of design processes — ranging from geometry modeling and editing, meshing and pre-processing, advanced analysis (structural, thermal, electromagnetics, CFD, etc.) and robust design optimization
- ▶ Industry's broadest range of physics capability in one integrated analysis environment
- ▶ Advanced meshing solutions to efficiently address high-aspect ratio geometry commonly associated with microsystem devices
- ▶ Advanced fluid dynamics for microfluidic and fluid damping applications



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