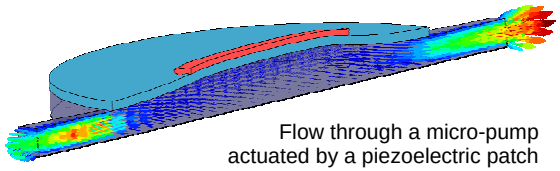
Fluid-structure interaction

The CFD module of the OOFELIE toolkit is well adapted for the simulation of micro-fluidic devices and equipped with adequate boundary conditions for these dimensions.

This fluidic module is also designed in order to provide the most accurate solution for fluid-structure interaction problems and can be coupled with others modules, such as the piezoelectric one (see picture hereunder).

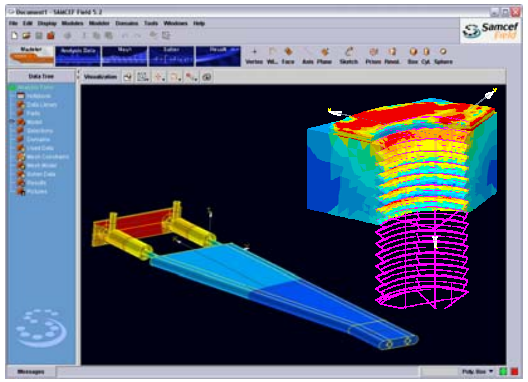


Flow through a micro-pump
actuated by a piezoelectric patch

Modeling environment & optimization

OOFELIE is driven by SAMCEF Field, a user-friendly integrated graphical interface. A CAD modeler, as well as import and **cleaning** capabilities from other leading CAD formats, is integrated for modeling and data preparation.

Parameterized data entry is easily done using contextual menus and pop up boxes, using a wide selection of preprogrammed functions for the definition of varying properties and boundary conditions. These parameters can then be used by our BOSS optimization product. Finally, notice that SAMCEF Field is MEMS Pro (SoftMEMS) compliant.



SAMCEF Field graphical user interface

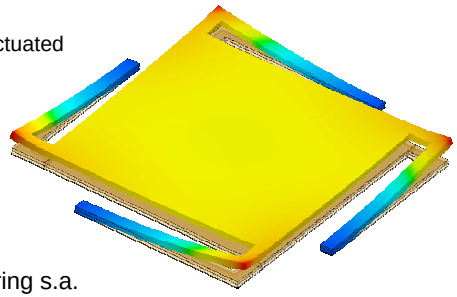
Who we are

Subsidiary of the **Samtech Group**, Open Engineering specializes in Computer Aided Engineering, modeling and numerical analysis aimed at multidisciplinary design and virtual prototyping. Resulting from more than a decade of research, the company delivers state-of-the-art computer modeling capabilities (tools and services) for design and analysis to replace expensive or demanding experimentation, ensure compliance to health, safety or environmental requirements and deliver understanding and insight that lead to improvements in products' and processes' performances at affordable costs.

Open Engineering delivers multi-physics, multi-fields and multi-methods computer modeling tools in a single unified platform and custom-developed software to tackle the most demanding applications.

Most applications involve a combination of several interdependent fields of physics. The traditional approach to solve these problems has generally been based on single physics modules that could be connected in a **weak** way. However, this technique is accompanied by great connection and convergence difficulties and often does not yield a solution. Open Engineering's solution approach is, on the other hand, to use a **strong** coupling, thus to solve directly the physics in a consistent global procedure. In addition to providing better numerical convergence, it has been demonstrated that this is the best way to **accurately** solve coupled dynamics problems.

Electrically actuated
micro-mirror



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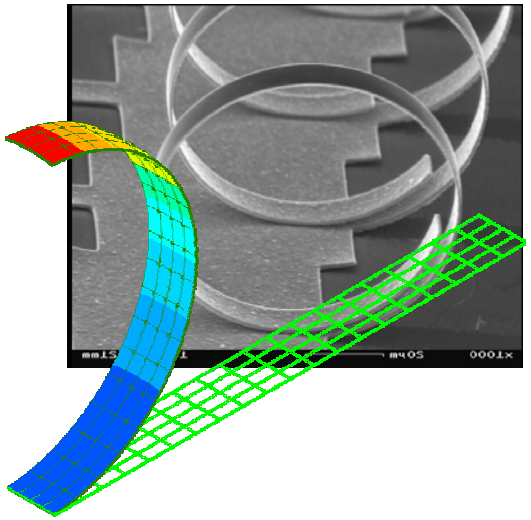
MEMS design using OOFELIE® Multiphysics



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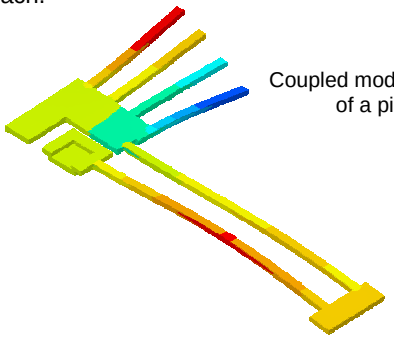
Piezoelectric analysis

The piezoelectric module of OOFELIE allows specific static, modal, harmonic and transient analyses for piezoelectric systems.

To accurately model the behavior of piezoelectric systems, the **strong** coupling between the mechanical and electrostatic problem is considered in the solution approach.



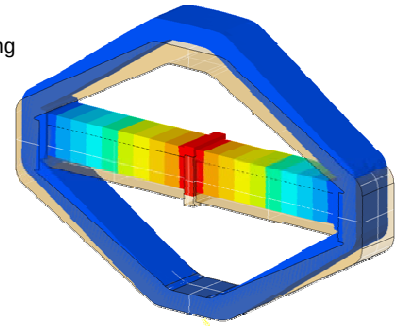
Coupled modal analysis of a piezoelectric resonator

Electrodes can be added, whether “passive” (fixed potential) or “active” (constant but unknown isopotential value, whether in closed or open circuit).

It is also possible to add and connect multiple RLC circuit elements to model the connected circuitry. Specific algorithms are available to adequately address dissipative elements.

Thanks to the strong coupling approach, **model reduction** techniques are available and provide models that can be introduced in other electronics or systems simulators.

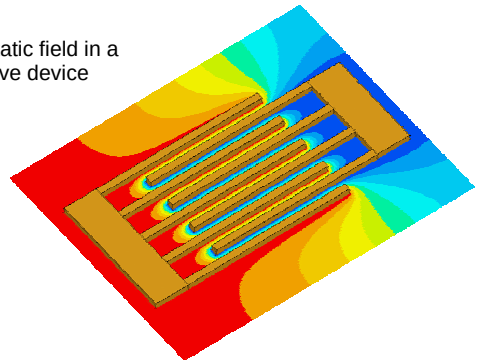
Piezoelectric ring actuator



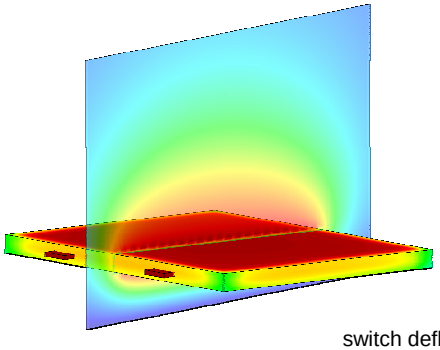
Electrostatic-mechanical analysis

The electrostatic module (developed in collaboration with researchers of Vibrations and Identifcation of Structures from ULg) is dedicated to the modeling of the behavior of electrostatic systems. This simulation tool is very flexible thanks to the use of the conventional finite element method, together with the variational boundary element method (efficient for taking into account the contribution of the outer far field), equipped with **fast multipole method**.

Electrostatic field in a comb drive device



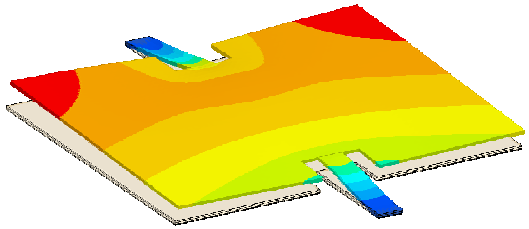
OOFELIE also handles the coupling between the electrostatic and mechanical fields: the static and dynamic, linear and **non-linear**, deformation of the structural parts can also be simulated in a single framework, which is very convenient in the study of micro-actuators or micro-sensors for instance.



Micro-switch deflection and outer electrostatic field

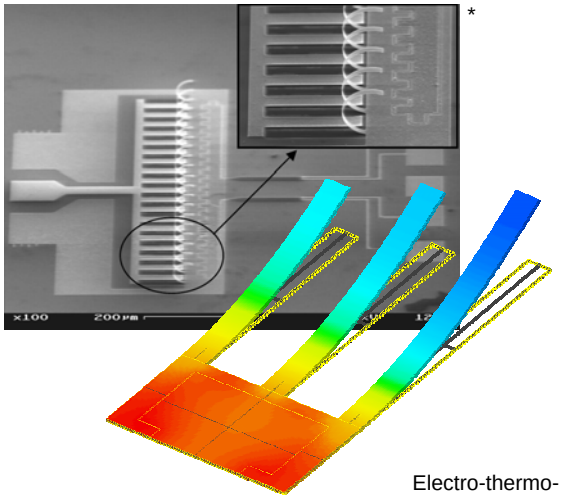
Thermo-mechanical analysis

The coupled thermo-mechanical driver of OOFELIE allows the user to simulate the static and transient, linear or non-linear, thermo-mechanical behavior of MEMS devices.



Micro-mirror thermo-mechanical actuation

The source of the thermal field can be either an imposed heat flux, a convective flux or power dissipated by joule effect (computed using an electrokinetic approach, by means of line, surface or volume conductors submitted to a given electromotive force).



Electro-thermo-mechanical analysis of a bi-layer MEMS actuator *

* Courtesy of Prof. JP Raskin, UCL

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