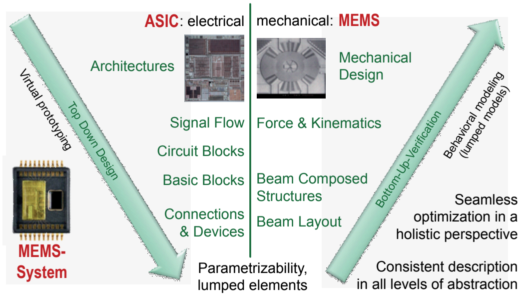
Project Outline

The project opens up innovations in mechanical and process plant engineering by using powerful sensor and actuator systems in all physical domains (e.g. pressure, acceleration) based on groundbreaking MEMS and chip technologies.

Besides the supply of processes and process data for MEMS the substantial benefit of the MEMS2015 project is the development of a universal and modular design methodology for MEMS. This will be created by joining the successful design flow of microelectronic circuits and a new design flow for micromechanical structures. The latter one will be derived from the basic concepts already used in microelectronics design.



In the end this leads to a seamless, Lego-brick-style designflow for heterogeneous systems, offering enormous simplicity. Electrical and mechanical systems can be simultaneously described, simulated and designed in one model, leading to a faster development of the final application.

By using such a type of modular system derived from microelectronics, the MEMS2015 researchers aim to plug the gaps between chip and sensor manufacturing on the one hand and the subsequent integration of the modules into products on the other. Hence, the MEMS2015 project raises the bar when it comes to the quality and especially the productivity of MEMS design. The following technical goals are in the focus of the project:

- ASIC compatible modeling of all electrical and mechanical properties of MEMS as a whole
- Extraction of electrical and mechanical parasitics
- Development of MEMS verification tools
- Elimination of the MEMS-ASIC tool gap
- Definition of an interface between MEMS design and manufacturing
- Verification of the design methodology by real life demonstrators

To reach all these goals representatives of the whole value chain work together as project partners, including universities, a research organization, an EDA supplier, a system- and semiconductor company, a foundry and two ODMs.

Partners

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Schematic-Based Design of MEMS for Applications in Optics and Robotics

a public funded EDA research project

Runtime: 07/2012 - 06/2015

Project Benefit

The project's new development methods for MEMS will allow innovative sensor and actuator systems to be developed – providing robots, for instance, with more effective sight and touch in the future. What is more, the potential market for MEMS stands to increase by up to 50 percent as a result. Using a modular system the new methods will substantially increase the opportunities for widespread use of MEMS. Furthermore the project's results will also allow small and medium-sized enterprises to design MEMS and integrate them into their products much more often, as well as in a wider range of configurations than at present.

Abstract

Within the research project "Schematic-Based Design of MEMS for Applications in Optics and Robotics" – or MEMS2015 for short – experts from research institutions and industry are investigating entirely new methods for developing Micro Electromechanical Systems (MEMS). The aim is to develop the first ever universal design methodology for MEMS to close the gap between electronics and mechanics design, manufacturing, and subsequent integration into products.

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Structure

Structure of MEMS2015

MEMS2015 comprises three work packages (WP) named
WP1: "MEMS Modeling"
WP2: "System Design and Methodology"
WP3: "Demonstrator and Application of MEMS"

which are divided into several tasks, shown on this page. While WP1 and WP2 deal with fundamental design elements like modeling and synthesis, WP3 is focused on the demonstration of the feasibility of the methods developped in WP1 and WP2.

WP1: MEMS Modeling

Task 1.1 MEMS Modeling with Constraints
(Cadence, Carl Zeiss SMT, IMMS)
Task 1.2 Abstraction levels and Model Verification
(Bosch, TU München, X-FAB)
Task 1.3 Backannotation of MEMS Structures
(Bosch, IMMS)

In work package 1 (WP 1) proven modeling methods from ASIC design will be transferred in the design of micromechanics and at the same time will be adapted to their specific needs by modification or enhancements. This will allow the simulation of electrical circuits joint together with mechanical elements considering both, the electrical and the mechanical aspects. An additional difficulty of this task has to be derived from the high coupling of elements in micromechanics and the high stress-dependent electrical properties in that domain.

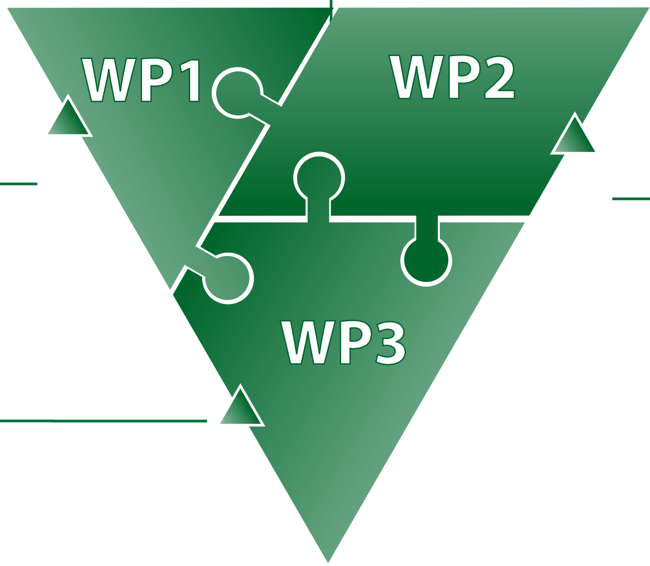
The modeling task in micro-mechanics will be solved by using electrical equivalent circuits. Those models can be used in an overall system simulation to achieve a sufficient accuracy as all relevant physical effects are considered in micro-mechanics. At the same time the models allow the consideration of parasitic effects on the individual systems already in the design phase. In addition, the transition from a simulated micromechanical structure into the production will be observed (LVS for mechanics).

WP2: System Design and Methodology

Task 2.1 Interface between MEMS and ASIC
(Bosch, X-FAB)
Task 2.2 MEMS System Design
(Cadence, IMMS)
Task 2.3 System Optimisation
(Bosch, IMMS, U Bremen)
Task 2.4 PDK as Interface between Foundry and Customer
(Cadence, IMMS, X-FAB)

In work package 2 (WP2), a seamless design flow of complete MEMS systems (consisting of micromechanics and electronics) is implemented. This will be realized by transferring the design methodology for integrated circuits to the micro-mechanical design. Therefore, the detailed micro-mechanical models developed in WP1 are involved in two steps into the new design flow: First, the models are simplified and parameterized (in cooperation with WP1) before they are incorporated into the design environment for high-performance simulation. This is partially performed with commercial solutions such as those of Coventor, but also by using proprietary "in-house solutions".

The electrical equivalent circuit diagrams or models developed in WP1 also contain geometrical parameters of the micromechanics, which can be dimensioned in the same way as electronic parameters. In this way, proven IC design methods such as parametric simulation, optimization, symbolic analysis and model simplification can be applied to the MEMS system design. Based on this, new tools will be developed and existing ones will be extended to obtain a continuous chain of tools at the end of the project, which transmits the MEMS design into the existing IC design flow. This makes it possible to simulate and optimize complete MEMS systems.



WP3: Demonstrator and Application of MEMS

Task 3.1 Demonstrators
(Bosch, Cadence, X-FAB)
Task 3.2 Verification of the Methodology
(Bosch, Carl Zeiss SMT, IMMS, X-FAB)
Task 3.3 Application of MEMS
(Carl Zeiss SMT, IMMS, Tetra)

As part of work package 3 (WP3) designs are verified and sensors are manufactured that are required for calibration of the models created in WP1 and for the verification of the methodology developed in WP2. Thereby, the methods developed in WP1 and WP2 will be employed exemplary for the design cycle of inertial, pressure and force sensors as well as for micro-mirrors. At the same time, their applicability will be evaluated. All this is done for example, by the comparison of simulation results and measurements.

Besides silicon demonstrators that are designed and manufactured using the developed new design flow, also the prototypical implementation of various software demonstrators is part of WP3. In addition, the methodology for bridging the gap between foundry, MEMS designer and MEMS system integrator is prototypically realized for a foundry PDK. This PDK facilitates the use of MEMS for all foundry customers, especially SMEs. Further content of WP3 is the definition of requirements for model tests related to technical and scientific performance and the evaluation of test results from a MEMS user's perspective.

Demonstator Example: 100g Sensor

The picture below shows an extract of the X-FAB100g sensor