L5: Simulation, Modelling and Computer Aided Design Laboratory

- Mission
- Main areas of expertise
- Research Team
- Specific facilities
- Research interest
- International networks

• ***Mission:*** research, simulation and modelling activities oriented to collaborative research projects, education (short courses, seminars, workshops), services (offering access to hardware and software tools) and consulting (design/ optimization) in the field of micro/bio/nanotechnologies.

• ***Main areas of expertise:*** simulation and design of microfluidic components for biomedical applications, structural analysis, mechanical, thermal analysis, electric and magnetic field analysis, coupled field analysis of MEMS and MOEMS; design development and optimization of MEMS/MOEMS components and device (switches, microgrippers) modelling of opto-electronic devices, neural networks.

• ***Research Team:*** The team has a multidisciplinary expertise in: mathematics, physics, electronic and mechanics (5 senior researchers: 3 PhD, one physicist and one mechanical engineer, 4 PhD students.

Team from left to right: Rodica Voicu; Victor Moagar-Poladian; Oana Nedelcu; Catalin Tibeica; Florina Ravariu; Gabriel Moagar-Poladian; Rodica Plugaru; Irina Codreanu

• ***Specific facilities:***

• Finite element method software COVENTORWARE 2006; • Finite element method software ANSYS 5.4 • Programming tool MatLab 7.0; • Multiprocessor workstation; • Training room equipped with a computer network, used also for design and simulation with specific software packages.

• ***Research interest:*** • modelling and simulation of contact phenomena in MEMS microdevices; • determination of material parameters using FEM simulation for micro and nano materials, modelling and simulation of hard biological tissues, development of new simulation techniques, simulation and optimization of specific technological processes, evelopment and modelling of structures and assemblies for optical computers, modelling, simulation and realization of elastomer based microstructures; • application of simulation techniques to the Design for Manufacturing concept (DfM) in the field of microsystems; • diffusion of mixed fluids in microchannels and study of separation effect, modelling, simulation and characterisation of microfluidic structures as micropumps, microvalves, microchanels; • microliquid handling by electrokinetics; developing nanofluid structures for cooling microsystems obtained by plasma and laser technologies; developing silicon microchips for ADN identification; • modelling, simulation of microfluidic components for lab-on-chip structures; parameter optimization of microsystems design by genetic algorithms analysis;

• ***International networks and projects:*** the laboratory is involved in international projects as: FP6:

- **MI-Lab on chip**- "Lab-on-a-chip implementation of production processes for new molecular imaging agents- STREP (2005-2008), NMP-No 516984
- **ASSEMIC** - Advanced Handling and Assembly in Microtechnology (2004-2007), 2003-504826, Marie Curie Research Training Network - WP 2- Microhandling (Computational fluid dynamics);
- **PATENT** - Design for Micro & Nano Manufacture (Packaging, Test and Reliability Engineering in Micro & Nanosystem Technologies)- NoE No.507255, (2004-2008), - priority 2, IST: WP 2 Modelling and Simulation; Micro Electronic Fluidics Service Clasuter.
- **IPMMAN** - Improvement of industrial Production Integrating Macro, Micro And Nanotechnologies for more flexible and efficient manufacturing FP 6 Project (CA, NMP-CT-033205, 2006-2009)
- **Microteaching** - New teaching and learning methods and basic qualifications in job education Leonardo da Vinci- Microteaching (Contract nr. 146157, 2004-2007)

The laboratory offer simulation, consulting and training services in micro and nano domains; Application areas: microsensors, MEMS, MOEMS, microfluidics, RF MEMS.

Laboratory Head – Dr.Raluca Muller (ralucam@imt.ro)

Raluca Müller received the M.Sc and PhD in Electronics and Telecommunications from "Polytehnica" University of Bucharest. From 1978-1994 she was research scientist with ICCE Bucharest; since 1994 she is with IMT Bucharest.

Currently she is Head of Development in Information Technologies Department and Coordinator of the **Simulation, Modelling and Computer Aided Design Laboratory.**

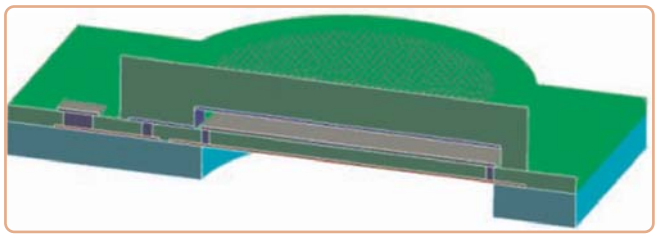
Her main scientific interests include design, modelling and technological processes for micro-electronic devices, integrated optics, microsensors and microsystems. She was involved in teaching activities as associated professor at University "Valahia Targoviste".

She is leader of national research projects and scientist in charge from IMT in international projects as: *IMPACT Project* (FP5) with CNRS – LAAS Toulouse (2003-2004), FP 6: *ASSEMIC- Marie Curie Training Network* (2004-2007)- FP6- *PATENT (Modelling and Simulation cluster)* and *Leonardo da Vinci – Microteaching Project*. She is author of more than 55 scientific papers presented at conferences and published in journals (Sensor&Actuators, J. of Micromechanics and Microengineering, Optical Materials, J. of Microsystem Technologies, etc).

L5: Participation in FP6 projects

Design for Micro & Nano Manufacture

Acronym: **PATENT-DfMM,** NoE-FP6**,** Priority 2 **IST,** Contract No. 507255,
Coordinator – University of Lancaster, UK; **Dr. Andrew Richardson (A.Richardson@Lancaster.ac.uk)**

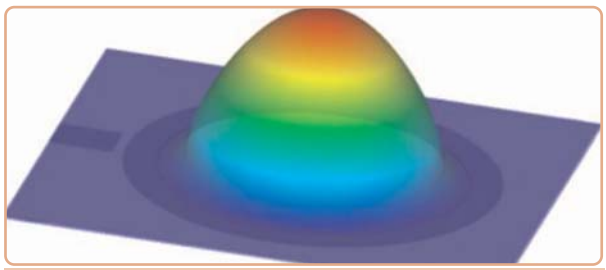


Device modelling-Cross section through the microphone structure

L5 was involved in WP2 - Modelling and Simulation in different proposal Round Robin, Flagships as BioDrop and Hermecity.

Modelling Effects of Packaging on MEMS - Round Robin Modelling Study

Partners: Tyndall National Institute and QinetiQ - leaders, University of Lancaster, HWU - Edinburgh, IMT – Bucharest, BUTE, POLIMI, ULG, WUT, IZM-Berlin



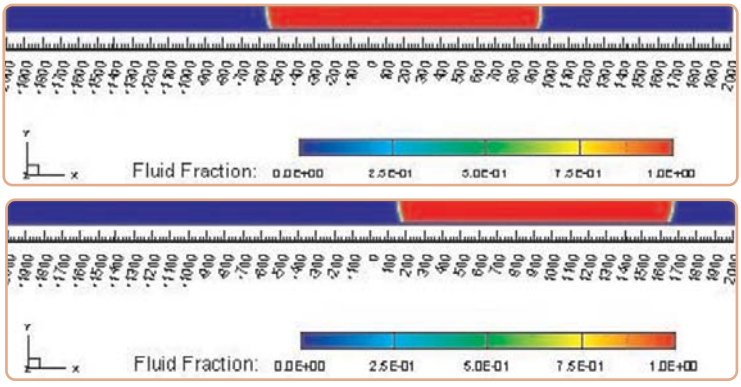
Mechanical simulation-Displacement of the membrane under acoustic pressure (120 dB) (exaggerated displacement)

Objectives: • Compare simulation results across a range of modeling tools and modeling approaches
• Fabrication, test and characterization of three micro-mechanical test structures

Results: Modeling the structures; Simulation of the residual stress effect on the test structures; Simulation of mechanical and electrical behavior under working conditions. **Example** of Capacitive microphone structure.

Contact Person IMT: Phys. Catalin Tibeica, PhD Student, catalint@imt.ro;

Droplet-Based Micro-Electronic Fluidic Operations for Production and Evaluation Platform BioMEMS (BioDrop)

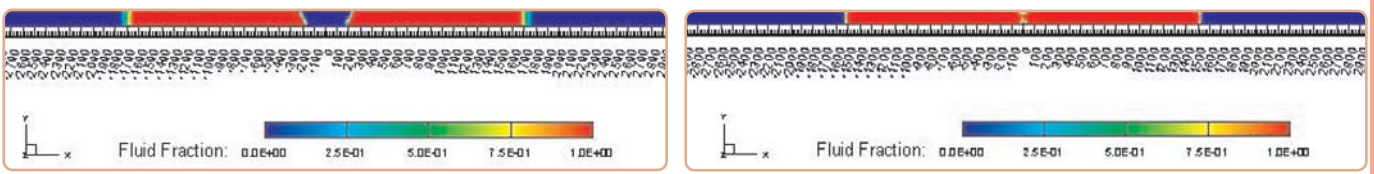


Various steps during the simulation of droplet transportation.

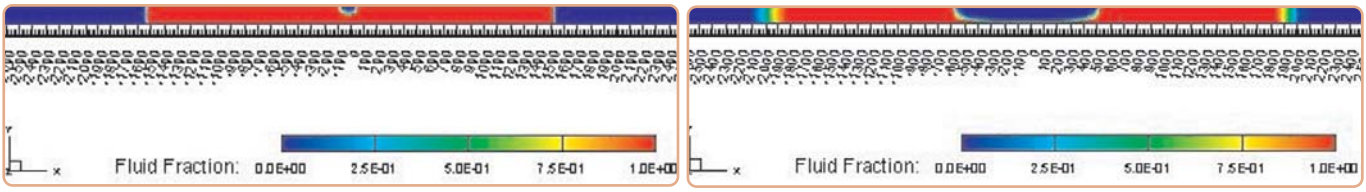
Partners: CTIT University of Twente (NL), CCLRC Daresbury (UK), QinetiQ Ltd, Winfrith (UK), MESA+ Enschede (NL), MultiSynTech GmbH, Witten (G), University of Lancaster (UK), Pepscan Systems BV, Lelystad (NL), LIRMM, Montpellier (F), **IMT-Bucharest** (RO)

The role of IMT-Bucharest, in the frame of the **BioDrop project** consists in study and simulations of simple test structures for droplet fluidic operations, like transportation, merging of droplets and splitting of droplets. The electrical control of small volumes of liquids was performed by electrowetting, which can be used as a very fast and efficient mechanism to deliver and mix micro- or nanoliter volumes of liquid droplets with a relatively low electrical potential and power consumption. We have used the **Bubble-DropSim Module** of the **CoventorWare 2006** simulation software.

We also succeeded to perform simulations for merging two droplets and for splitting a droplet.



Various steps in the simulation of mixing of two droplets.



Various steps in the simulation of the splitting of a droplet in two.

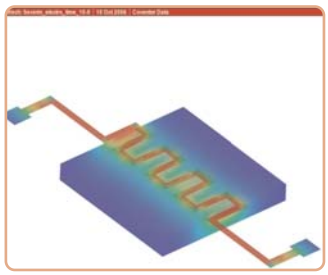
Contact Person IMT: Mat. Irina Codreanu- PhD Student, irinac@imt.ro

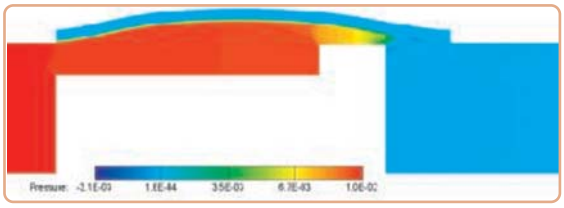
MI-lab on chip-Lab-On-A-Chip Implementation of Production Processes for New Molecular Imaging Agents

Acronym: **MI-lab-on-chip,** STREP-FP6**,** Priority 3 **NMP,** 2005-2008**,** Contract No. 221105

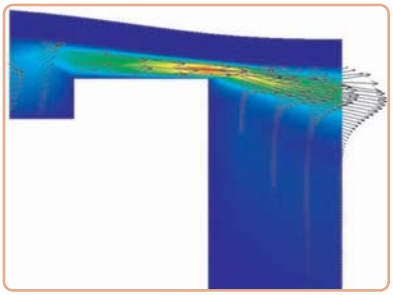
Partners: ***Liege University, Belgium – Leader***; Trasis S.A., Belgium; Bartels Microtechnik GmbH, Germany; IMT-Bucharest, Romania; University Henry Poincare – Nancy I, France.
Objective: Developing multiple steps radio-pharmaceutical chemistry processes at the micro molar scale.

The purpose of this project is to develop multiple steps radio-pharmaceutical chemistry processes at the micro molar scale in disposable, automated and miniaturized systems to be used at the time the products are injected to the patients. The platform will include a smart, single use "lab-on-a-chip" component, in which the process for a given compound is carried out. The chip will integrate and combine microfluidic function and specific chemical functions.
IMT contribution: Workpackage 2: Micro-engineering: Design of the chip functionalities; Validation of performances as function defined specification; **Workpackage 7**: Simulation: Modeling/simulation of functionalities to improve working and performances parameters; **Workpackage 8**: Project Management. **Tool:** *Software package COVENTORWARE 2006 dedicated to MEMS and microfluidic design and simulation.*
Result: • Characterization of pneumatic micopump behaviour; • Characterization of thermal components;

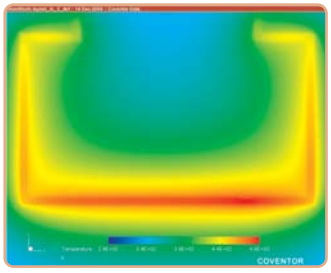




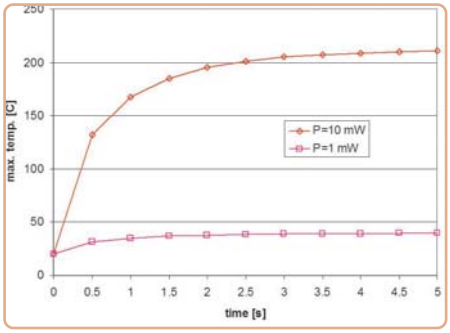
Fluid pressure distribution in the chamber (MPa)



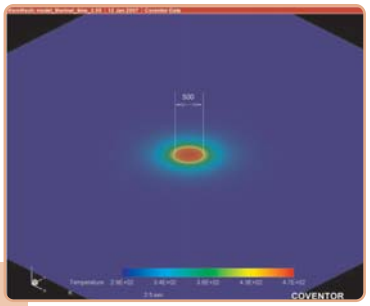
Relative representation of velocity vectors



Fluid-Structure Interaction between fluid and check valve in the pneumatic micropump

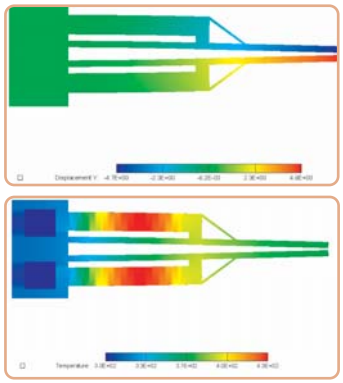


Electrothermal heating: simulation for various resistor geometries - Heating by laser beam



Contact Person IMT: Mat. Oana Tatiana Nedelcu - PhD Student, oanan@imt.ro

Oana Tatiana Nedelcu is mathematician and work in Modelling and Simulation Laboratory as Scientific Researcher. She is also PhD student at "Polytechnica" University of Bucharest. Her scientific expertise refers to computer aided design and simulation for microfluidic structures. She is involved in training activities and technical support in this area.



SENSORS AND ACTUATORS MICROSTRUCTURES FOR MICROROBOTIC POZITIONING, MECHANICAL AND BIOLOGICAL MANIPULATION- MEMSAS

The project will contribute to solving problems of micro-assembling, positioning and manipulation. It requires an **interdisciplinary** research, in the area of **micro- and nano- technologies**, focused on the development of some mobile micro-mechanical structures, of optical positioning sensors and of microstructures usable in **biologic material manipulation.** Preliminary results of the simulations for a SU8 polymeric micro-gripper, electro-thermally actuated, using COVENTORWARE 2006 are shown.

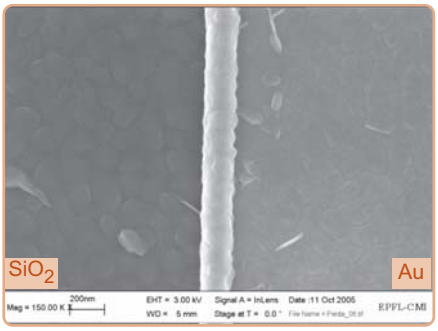
FEM simulation: of the closing arms of the microgripper, when a voltage of 0.2V is applied (scale in μm - top); of the temperatures in the arms of the microgripper when a voltage of 0.2V is apply (rigth)

CEEX (2005-2008); Project coordinator: Dr. Raluca Müller – IMT Bucharest (ralucam@imt.ro)
Contact person: Mat. Rodica Voicu - PhD. Student (rodicav@imt.ro)

UNIT OF ANALOGIC OPTICAL PROCESSING OF IMAGE TYPE INFORMATION

The project continues the previous original research of the project coordinator in the field of optical neurons. The project scope is developing novel algorithms for optical information processing of information and designing the architecture of a such an optical processing unit. What is important is the fact that images are processed by all optical means. The consortium comprises, excepting IMT-Bucharest, two companies and an university.
Project type: CEEX; Project coordinator: Dr. Gabriel Moagar-Poladian – IMT Bucharest (gabim@imt.ro)

ADVANCE STUDIES IN OPTICAL CHARACTERIZATION OF SEMICONDUCTOR NANOMATERIALS AND MANODIVICES



SEM image of the pentacene layer deposited on SiO_2 and the Au contacts. Grains with average size of 150 nm were formed at a deposition rate of 3 Å/min.
Dark output characteristics of (organic FET transistors) OFETs. The channel parameters are: W=500, L=20 and 50 μm. Vg= +15V,-15V. *CAS Conference Proceedings, p. 315.*

The aim of the present project is the theoretic and experimental investigation of optical phenomena in complex inorganic and organic nano-structured systems. Photoluminescence spectroscopy will be used as the most important characterization tool for optical properties investigation.

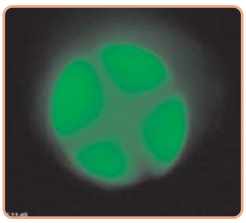
The physical mechanisms of carrier generation and recombination for photoluminescence emission will be investigated in the visible range (200-700 nm) and in the infrared range (800-2200 nm). For spectral analysis of emission in the infrared region acquisition of a photospectrometer working in this range is scheduled in the frame of the project. Experimental measurements will be carried out on Er doped nanocrystalline Si/SiO_2 (nc-Si/SiO_2:Er) films and on organic (pentacene) thin films. The objective is to investigate optimum excitation bands and the energy transfer processes in nanocrystalline semiconductors and organic semiconductors. The impact of light excitation on the characteristics of thin films transistors with organic active layers will be also studied.

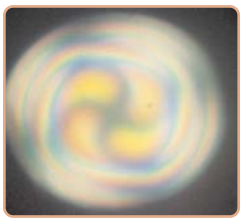
Project type: CEEX II Research projects for researchers reintegration
Project coordinator: Dr. Rodica Plugaru – IMT Bucharest (rodicap@imt.ro)

NON-CONVENTIONAL MATERIALS FOR MICROTECHNOLOGY – RESEARCH AND EXPERIMENTATOPN OF ELASTOMER -BASED MICROSTRUCTURES FOR APPLICATIONS IN THE FIELD OF MICROSYSTEMS

Photo of an experimental model of the reflective conoscope, developed in cooperation by IMT-Bucharest and S.C. ProOptica S.A.

In 2006 it was made and tested successfully the experimental model, in cooperation with S.C. ProOptica S.A. It is based on an idea developed by dr. Gabriel Moagar-Poladian and patented by IMT-Bucharest, the invention receiving the Silver Medal at the Bruxelles Fair of Invention in 2004. The reflective conoscope prototype is made under a national project aimed at realizing elastomer based microstructrures, project led by dr. Gabriel Moagar-Poladian from IMT-Bucharest. Attached are some images of the experimental model as well as of some reflective conoscopic images obtained with the experimental model. Now is under realization and certification **a prototype of a reflective conoscope.** Attached is also a brochure regarding the reflective conoscope and its applications. We succeeded in obtaining the reflective conoscopic image of a 190 microns thick quartz sample, quartz being known as having a small birefringence.





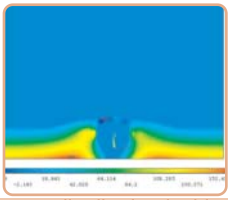
Main application domains: Integrated optics and optoelectronics, integrated ferroelectrics and piezoelectrics, materials science and engineering, process monitoring in optoelectronics and integrated optics technology , -geology and mineralogy gemology.

Project type: CEEX No.15I/2005, (2005-2008); IMT-Bucharest (coordinator), S.C. ProOptica S.A. (Laboratory of Optical Measurements) . Project coordinator: Dr. Gabriel Moagar-Poladian – IMT Bucharest (gabim@imt.ro)

KNOWLEDGE BASED ECOLOGICAL MATERIALS FOR FIRE PROTECTION, WITH SECTORIAL AND INTERSECTORIAL APPLICATIONS–ECOMAF

Experiment for measuring the insulating effects of paint; the foaming of the paint exposed to high temperature

Objective: The aim of this project is to develop a highly protective paint against the heating of fire. This paint will cover structures like metallic reinforcements for buildings, walls, gas tanks, etc. providing enough thermal insulation for certain time (until the fire is extinguished). The principle of this protectiv paint is to develop bubbles of gas when the paint is exposed to the fire. This way the thickness of the layer will become considerable, and the thermal conduction will be reduced due to its porous structure. Due to the complexity of phenomena, the ANSYS simulation was carried out by IMT with only one bubble of gas in the layer of protective paint.



Pressure distribution inside the gas bubble (ANSYS)

CEEX project (2005-2007). Coordinator ICEMENERG, IMT-Bucharest partner, Eng. Phys. Victor Moagar-Poladian (victorm@imt.ro)

COMPUTER AIDED DESIGN OF MICROFLUIDIC COMPONENTS

Main Objectives 2006: • Design of actuating microcomponents to optimize the fluid handling: microvalves and micropompes; • Study of ionic liquids to be used in biomedical applications

Main Results: • Design of actuating microfluidic components with various actuation principles; • Studies on Multilayer Soft Litography technology to obtain microfluidc components; • Studies on ionic liquids: properties and applications in biomedical applications;

National basic funding project-2006-2008; Coordinator: Mat. Oana Tatiana Nedelcu- PhD Student- oanan@imt.ro