Ministry of Education, Research and Innovation Romania

*National Authority for Scientific Research*

IMT-Bucharest

# Your reliable partner: IMT-Bucharest

## From Technological Services,

## to Scientific Cooperation

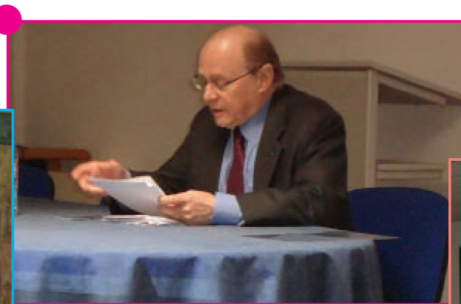
## **IMT-MINAFAB, launched in Brussels** at an event organized by Romania, with the ***participation of the European Commission***.

On **8th of May 2009**, this facility was presented in ***"New Materials, Micro- and Nanotechnologies: discover a good partner in Romania"*** at Brussells, an event organized by ***ROST - Romanian Office for Science and Technology from European Union.***

**IMT-MINAFAB** i.e. **"IMT-Centre for MIcro and NAnoFABrication"** provides scientific and technological support for partners from research, education and industry. It is an "open centre", facilitating easy access in variety of ways.. **IMT-MINAFAB** facilitates R&D common projects and the direct access of the innovative companies to technology. Details about **MINAFAB** services are available on the web page: **http://www.imt.ro/MINAFAB**.

**Dr. Renzo Tomellini**, Head of Unit "Value-added materials", European Commission, DG RTD, DG "Industrial Technologies"

**Mr. Louis Bellemin**, honorary director of the European Commission



**Prof. Alain Pompidou**, President of the French Academy of Technologies, former President of the European Patent Office.

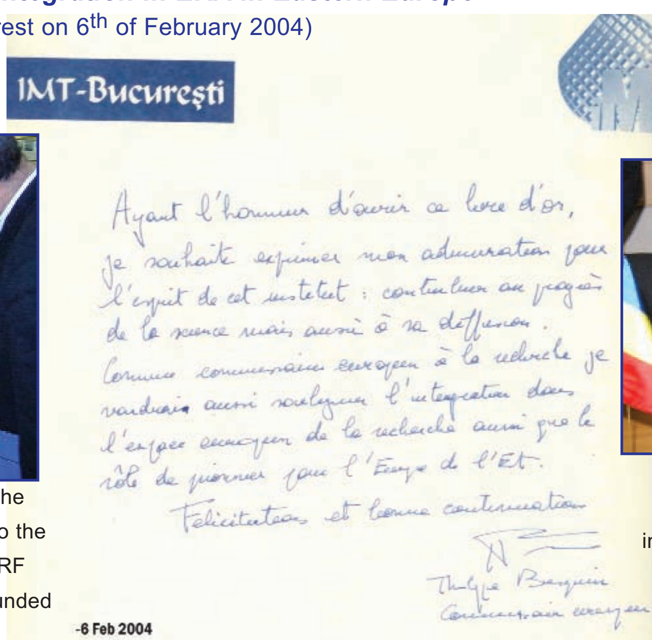
**Mrs Mihaela Ionita**, funding coordinator, INFINEON, Romania

**Dr. Francisco Ibańez**, Deputy Head of Unit "Micro- and nanosystems ICT Programme", European Commission, DG INFSO, DG "Components & Systems"

**Dr. Christophe Bruynseraede**, Business Program Manager, IMEC, Belgium

## ***A visit to remember: Mr. PHILIPPE BUSQUIN,***
the European Commissioner for Research:
***IMT as "... a pioneer of integration in ERA in Eastern Europe"***
(IMT-Bucharest on 6th of February 2004)

Dr. Alexandru Muller, nominated for the Descartes Prize (2002), is presenting to the Commissioner the newest results in RF MEMS obtained with partners which founded AMICOM (NoE financed by FP 6)



IMT-Bucureşti

Ayant l'honneur d'ouvrir ce livre d'or, je souhaite exprimer mon admiration pour l'esprit de cet institut : contribuer au progrès de la science mais aussi à sa diffusion. Comme commissaire européen à la recherche je voudrais aussi souligner l'intégration dans l'espace européen de la recherche ainsi que le rôle de pionnier pour l'Europe de l'Est.

Félicitations et bonne continuation.

Philippe Busquin
Commissaire européen

-6 Feb 2004

The Commissioner appreciated IMT as: "... a pioneer of integration in ERA in Eastern Europe".

# Your reliable partner: IMT-Bucharest

## From technological services, to scientific cooperation

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# IMT in brief

The full name of IMT – Bucharest (or simply IMT) is the **National Institute for R&D in Microtechnologies (http://www.imt.ro)**, a unit coordinated by the National Authority for Scientific Research (Ministry of Education, Research and Innovation, Romania).

The **main competences of IMT are in micro-nanosystems and nanobiotechnology** (see the box below). An interdisciplinary group of laboratories and their top-level equipments is called "Centre of Nanotechnologies", and works under the aegis of the Romanian Academy (of Sciences). Another pair of labs - specialized in microwave and photonics - is grouped as the MIMOMEMS proposal achieved financing by the EC through the REGPOT programme (2008-2011). IMT became visible at the national level, especially by coordinating various projects financed from the National Programme MATNANTECH (New Materials, Micro and Nanotechnologies) (2001-2006). In the period 2003-2009 IMT was involved in approximately 25 European projects (FP6, FP7 and related). **In the landscape of the new member states of UE, IMT is an active actor in RTD**. The investments in equipment (7 millions of euro in 2006-2009) provide an excellent support for the experimental work (details inside this brochure). Through the **Centre for Micro- and Nanofabrication** (**IMT-MINAFAB**) these facilities are available to customers from industry, research and education (**www.imt.ro/MINAFAB**).

IMT acts basically as an autonomous, non-profit research company. As far as the participation to national and European projects is concerned, IMT is assimilated to a public research institution. Apart from scientific research and technological development, **IMT is active in technology transfer and innovation**, as well as in education and training. Since 2005, IMT includes an autonomous **Centre for Technology Transfer in Microengineering (CTT-Baneasa)**, and in June 2006, a **Science and Technology Park for Micro- and Nanotechnologies (MINATECH-RO)** was set-up by a consortium with just two partners: IMT (housing most of the park area), and University "Politehnica" of Bucharest. The facilities provided to companies in the park include rooms for working points, priority of access to scientific and technological services provided by IMT, as well as the possibility to install their own equipments in the technological area of IMT. The last possibility is just to be implemented now and opens the way for an exchange of services with IMT, including cooperation in a small-scale production. In 2009 IMT put the basis for the cooperation with important international companies.

**IMT is open for educational activities** in cooperation with universities: undergraduate, M.Sc. and Ph.D. studies, and also for "hands-on training". IMT was active in a Marie Curie training by research network and also in Leonardo programme. Occasional training courses have been provided in IMT by companies and by research partners in European projects. IMT is organizing the **Annual Conference for Semiconductors (CAS)**, an IEEE event (CAS 2009 was the $32^{th}$ edition), now largely devoted to micro- and nanotechnologies. IMT is also organizing within the Romanian Academy the **"National Seminar for Nano-science and Nanotechnologies"** (the 8th edition - in 2009). The institute is editing or co-editing the following publications (all in English): *"Micro- and Nanotechnology Bulletin"* (quarterly magazine, since 2000); **"Romanian Journal for Information Science and Technology"** (since 2008, in the ISI Thomson database), a publication of the Romanian Academy; the series of volumes **"Micro- and Nanoengineering"**, in the Publishing House of the Romanian Academy (12 volumes until 2008).

**Microsystems technologies** are the core of technologies of the IMT Bucharest. Based on these technologies many innovative devices are designed, characterized and fabricated. These devices divided in three main categories:
**(i) RF MEMS** (RF MicroElectroMechanicalSystems) which address the applications of microsystem technologies in the area of microwaves and millimeter waves with applications in advanced communications systems
**(ii) Optoelectronics and photonics** which are dealing with the microsystem technologies at optical wavelengths based on the key concept of MOEMS (MicroOptoElectroMechanicalSystems) The RF MEMS and MOEMES devices are the key concept of the European Center of Excellence MIMOMES financed by UE unifying research forces and equipments in these groundbreaking microsystems technologies covering the electromagnetic spectrum from RF up to infrared wavelengths.
**(iii) Sensors** are key components focussed for a better quality of live of the citizens. Based on the microsystems technologies sensors are the key devices to detect pesticides or herbicides in water or in the food, toxic gases, or to provide an early warning alarm in construction or bridges, or cancer or other harmful illnesses. Microsystems technologies allow the miniaturization of the sensors such that they are integrated in walls, in paper, or other materials conferring them a sort of "intelligence". We are developing smart walls, smart paper and smart dust. The sensor activities are merged in a Center of Research for the Technologies Integration.

# “IMT-MINAFAB” IMT Centre for MIcro and NAnoFABrication

A new infrastructure initiated in 2008, **IMT-MINAFAB**, should be seen as ***an interface which will be created by IMT-Bucharest in order to fully exploit its tangible and intangible assets in micro- and nanotechnologies (clean-room facility, equipments, human resources, partners and clients)***. The so-called **“fabrication centre”** will be in fact **a complex technological platform including also CAD tools, characterization equipments, a mask shop, a reliability lab**. The **fabrication** itself, whenever necessary, is accompanied by specific testing and design, as shown in the following examples:
*(i) the COVENTOR software package for modelling and simulation of microsystems provides design verification, as well as the direct input data for mask fabrication;*
*(ii) the on-wafer RF testing allows immediate testing of experimental RF components;*
*(iii) the nano-plotter and microarray scanner (NanoBioLab, in cleanroom environment) allow on-chip controlled deposition of biological molecules etc.*
The term **“fabrication”** in this context means **“physical realization”** and not necessarily production. In some cases, the equipments can be used for both research and “small-scale production”.

**The role of IMT's R&D laboratories in MINAFAB is twofold**. First, they operate the characterization and design tools, and secondly, they provide multivalent research expertise, from quantum dots to microarrays and from novel CNT applications to micro- and nanofluidics. The majority of the equipments were purchased through the investments taking place recently (approximativelly 6.5 million euro in 2006-2008).

**Clean room facilities**, class 1,000 (200 sqm). The present clean room (class 100 to class 1000) contains a **mask shop** with a DWL 66 (1 mm resolution), **RIE, vacuum deposition system** (E-Beam and sputtering), **double-face alignment, deep pen nanolithography**, etc. A new clean room (to be operational in 2009) will contain *LPCVD, PECVD, APCVD, RTP* equipments, etc.). **Characterization area**, class 100,000 (220 sqm): The **characterization area** (class 100,000) is equipped with S**EM/EBL, nanoengineering workstation** (Raith e_Line), **FEG-SEM, SPM** (AFM, STM etc.), **nanoindenter, X-ray difractometer, Raman Spectrometer, SNOM, WLI**, **electrochemical impedance spectrometer, fluorescence, phosphorescence and lifetime spectrometer, nanoplotter and nanoscanner for microarrays**, etc.

**A strategic target for IMT-MINAFAB** is to initiate at the national level a network of complementary facilities in micro- and nanotechnologies. Such a network is planned to be set-up in 2009 starting from the links established between IMT and other RTD institutes in the so-called “technological networks” (financed between 2005 and 2008), as well as in common research projects. IMT intends to exchange services with such partners and mostly elaborate a joint offer of services to third parties. Partnerships with external organizations are also extremely important. Existing partners are LAAS/CNRS, Toulouse, France, and FORTH, Heraklion, Greece, the interaction being financed by twinning activities within the MIMOMEMS centre of excellence.

As far as the **industrial clients** are concerned, IMT is promoting cooperation in two ways: *first, using MINATECH-RO, the science and technology park for micro- and nanotechnologies (whereby, for example, companies can place their own equipment in the technological area); secondly, by facilitating the interaction with other companies and research groups through the network for knowledge and technology transfer with more than 60 partners (the information is exchanged through the Centre for technology transfer in micro-engineering, part of IMT).* Partnership with important foreign companies should be promoted, whenever possible.

**The basic categories of services are: • Partnership in RTD activities**, sharing the IP resulting from common research (with research centres, universities, companies); • **Scientific and technological services**, including design, consultancy, training and education (for universities and companies); • D**irect access to equipments** for “hands-on” activities, after appropriate training (for companies protecting their IP, for postgraduate and postdoctoral students).

## How to access IMT-MINAFAB?

• First, consult the extended information about the equipments and technologies available on the public website at: **http://www.imt.ro/MINAFAB**. You may also e-mail a request for further details to the person in charge with certain equipment (the process engineer or the application scientist).
• If you are ready to order a service, please contact the **IMT-MINAFAB executive team**, by emailing at: **minafab@imt.ro**. Inquires could be also made by fax at +40-21 490 82 38 or by phone at +40-21 490 82 12 ext 19 (Dr. Radu Popa).

# 1. PROCESSING SERVICES

## ❖ Mask manufacturing using Pattern generator - DWL 66fs Laser Lithography System

• **Applications:** It can be used for mask manufacturing or direct exposure on basically any flat material coated with photoresist. Numerous optional features increase the flexibility and make the system suitable for more applications. If one of your applications requires a special technology, it can most likely be implemented in the DWL 66FS.

• **Critical Dimensions Specifications**: The current spec for the critical dimensions is 2 micron with a 0.2 micron tolerance. The CD can be pushed down to 2 micron, but results depend strongly on the layout and are not guaranteed.

• **Mask File Acceptable Formats:** Either CIF of GDSII formats are preferred. DXF is also acceptable, but please verify the pattern with the process engineer before submitting it as we have found incompatibility problems.

• **Available Plates:** We currently have Chrome Soda Lime Masks and the available sizes are 4inch, 5inch, and 6inch (maximum 6 inch, only on command). We DO NOT supply Iron Oxide masks and there is currently no plan to have that kind of masks available in the near future. If you need Iron Oxide, please contact other mask shops.

• **Cost of Mask:** to estimate the cost of the mask, the extents of the pattern have to be specified. The extents are the X and Y dimensions of a rectangle that completely covers all the features of the pattern of the mask. Once you have these dimensions, you can contact the process engineer to obtain the cost of the mask.

• **Mask fabrication time:** depends on the masks design and the number of masks requested. An average time of about 2 day after the file is accepted, for dimensions bigger than 5 microns and for dimensions between 1-4 microns it strongly depends of the area to expose and it can be about 6 days.

**If you want to order a mask please visit www.imt.ro/MINAFAB/** or contact:
**Eng. Gabriela Dragan,** (gabriela.dragan@imt.ro); **Eng. Florentina Gheorghe,** (florentina.gheorghe@imt.ro)

## ❖ Double Side Mask Aligner - MA6/BA 6 (Suss MicroTec)

**Description**
• 4”,5”, fragments >5x5 cm;
• Alignement range: X: ± 10 mm; Y: ± 5 mm ; Θ: ± 5$^{o}$. Mechanical increment resolution: 0.1 µm.
• Top side alignment (TSA)–optical microscope “split field”, 0.5 µm.
• Bottom side alignment – high resolution LCD cameras, 0.1 µm.
• Enhanced Image Storage System (EISS).
• Exposure: contact, vacuum, proximity, flood.
• UV 365 nm, 1000 W (Hg).
• DEEP UV 249 nm 500 W (Hg / Xe).
• UV- NIL

**Applications:**
All standard litography; double side alignment/exposure ()UV, DUV); nanoimprint litography (NIL) for 4’’-6’’.

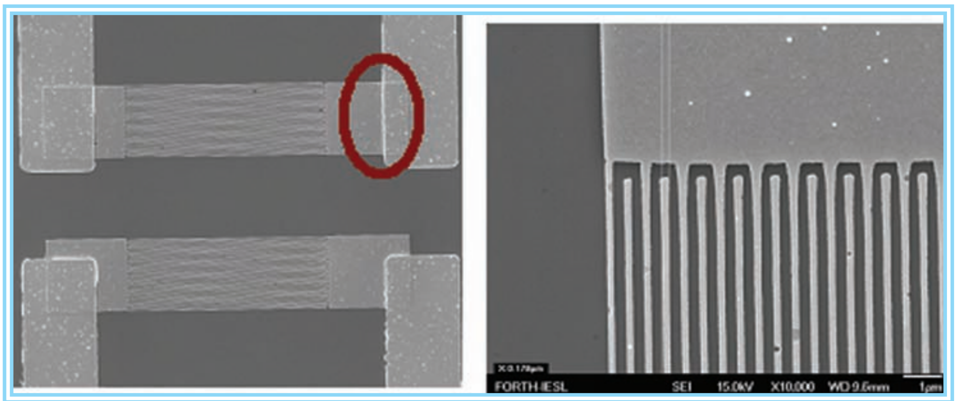
**Contact person: Eng. Adrian Albu,** adrian.albu@imt.ro

## ❖ Structuring at nanoscale range using Electron Beam Lithography and nanoengineering workstation- Raith e_Line from RAITH GmbH

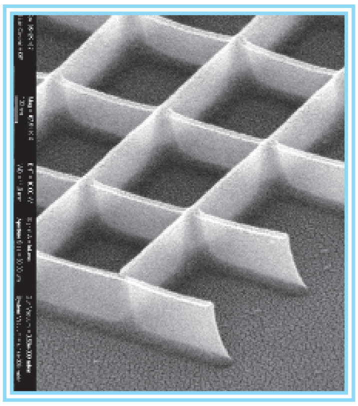
Ultra high resolution EBL (Electron Beam Lithography) and nano engineering workstation Raith e_Line is a versatile electron beam lithography system having complied with the specific requirements of interdisciplinary research, which allow nanoscale structuring. Selected options for nanomanipulation, **EBID and EBIE** expand this system to a nano-engineering workstation.

**Basic hardware features:**
• Thermal assisted field emission gun;
• Minimum line width < 20 nm; Stitching accuracy 40 nm; Overlay accuracy 40 nm; • Cross-over free column with highest beam current density at 2 nm spot size; • Laser interferometer stage with 100 mm by 100 mm travel range and 2 nm resolution achieved by closed-loop piezo-positioning; • 10 MHZ DSP-controlled digital pattern generator; • Optional gas injection system up to five capillaries, nanomanipulators, optical microscope, loadlock, FBMS mode exposure;

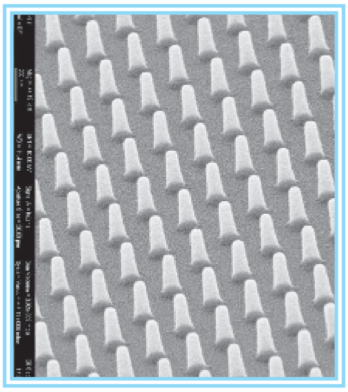
**Applications:** The state-of-the-art e_LiNE electron column matches perfectly with a number of **key applications in:** nanoelectroniccs, photonic crystals (PCs), Difractve Optic Elements (DOE), CNTs interconnects, nanodevices and nanosystems for fundamental research and bio applications. • Nano lithography with sub 20 nm resolution; • High speed devices e.g. HEMT; • CMOS process and device developments; • Resist-less lithography; • E-beam induced deposition and etching (EBID-EBIE); • Imprint template fabrication; • Nano probing and electrical measurements; • Nano and pattern placement metrology; • Gratings, DFB lasers, SAW devices;

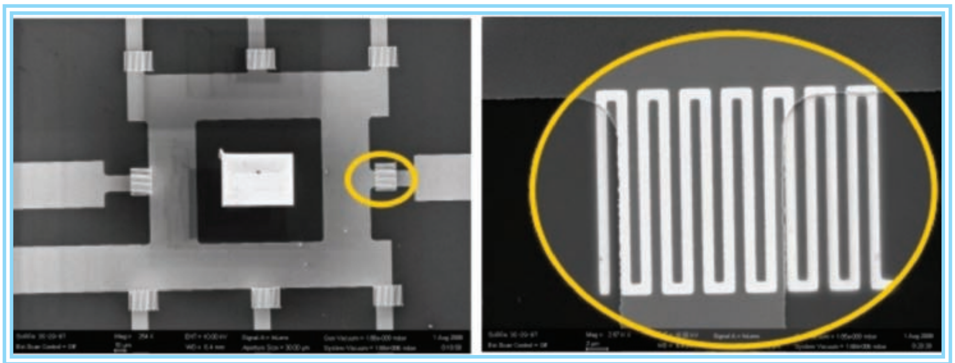



**SAW device for microwave applications obtained using EBL lithography (details of digits and interdigits 150 nm)**



**High aspect ratio (12:1) structures in PMMA with applications in nanotechnology. top: crosslines; bottom nanopilars.**





**Mix-and-match lithography for biomedical applications: optical lithography (left), combined with EBL (right)**

**Partnership: • CATHERINE -** *Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts*, STREP, FP7-ICT, 2008-2011.Project Coordinator: Consorzio Sapienza Innovazione (CSI).
web: http://www.catherineproject.eu/

**Contact person: Phys. Adrian Dinescu**, adrian.dinescu@imt.ro

## ❖ Dry etching processes using Reactive Ion Etching (RIE) Plasma Etcher-Etchlab 200 (SENTECH Instruments, Germany);

Reactive Ion Etching instrument, manual loading, capable of processing wafers up to 6", four process gases: $CF_4$, $SF_6$, $O_2$ and Ar, maximum RF power 600W, equipped with a fore pump and a turbo molecular pump capable of reaching pressures in the reaction chamber down to 10-6 mbar.


**Applications:**
- the etching of dielectrics ($SiO_2$, $Si_3N_4$),
- semiconductors (Si),
- polymers and metals (Au, Pt, Ti, Ni).

**Contact person: Dr. Marioara Avram** (marioara.avram@imt.ro)

## ❖ Chemical deposition processes

- **PECVD - LPX-CVD**, with LDS module (STS, UK);
- **LPCVD - LC100** (AnnealSys, France);
- **APCVD - PYROX** (Tempress, UK);

## ❖ Physical deposition using Electron Beam Evaporation an DC sputtering system - AUTO 500 (BOC Edwards, UK);

Front loading thin film system for R&D or pre-production services (500mm x 500mm chamber). Flexible substrate dimensions: 260mm-diameter work-holder plate. Up to 6 coatings in a single vacuum process (4 E-Beam, and 2 DC-sputtering). **Coating materials** using sputtering system: Al, Cr, Au AlSi1%,ITO,Si,Nb,Ti . Up to 250$^{o}$C substrate heating. Optional substrate plasma pre-cleaning. Ultimate vacuum: 7 x $10^{-7}$ mbar. PLC control and thickness monitoring with 0.1 nm resolution.

**Applications:** Vacuum depositions of thin films of Al, Cr, Au,Ti electron-beam evaporation.

**Contact person: Eng. Carmen Iorga**, carmen.iorga@imt.ro

## ❖ Nanoprint (also rapid prototyping regim) using Dip Pen nanolithography System

It allows the drawing of dots and lines with sizes as small as 20 nm under controlled conditions. Complex figures may also be realized. Is a nanolithography system that "prints" an "ink" directly on the substrate. The size of the geometrical features can vary from few tens of nanometers (in best conditions - 20 nm) up to several microns. It allows both a bottom-up approach and a top-down one when constructing the nanostructures. The working principle is that of wetting an AFM-type cantilever with an "ink" and writing down onto a substrate, similar with an ink pen that writes on a paper. The process is serial and is quite slow, but can be highly parallelized by using 2D arrays of cantilevers (55,000 such cantilevers on an array) and thus becomes efficient from the speed and through output points of view. Many materials can be used as "inks", as are solutions of polymers, small organic molecules, sol-gel precursors, macromolecules, nanoparticle colloids.

**Applications:** • surface functionalization (with direct liaison to proteomics, DNA recognition, virus identification); • photolithographic masks correction; • molecular electronics; • realization of master stamps for NIL (Nanoimprint lithography); • novel devices (photonic and electronic);

**Contact Person: Dr. Phys. Gabriel Moagar-Poladian**, gabriel.moagar@imt.ro

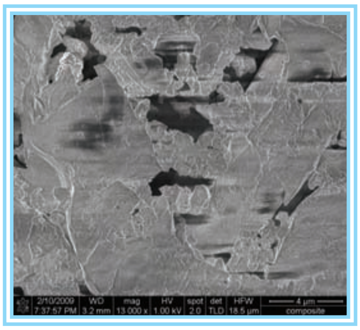
# 2. MICROPHYSICAL CHARACTERIZATION

## ❖ Scanning Electron Microscopy characterization of materials and devices using Field Emission Gun Scanning Electron Microscope (FEG-SEM) - Nova NanoSEM 630 (FEI Company, USA)

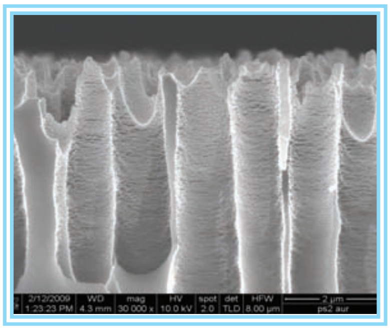
The equipment is a high-quality nanoscale research tool that offers a variety of applications that involve **sample characterization, analysis and prototyping**. It features a superior low voltage resolution and high surface sensitivity imaging in the range of Ultra high Resolution Field Emission Scanning Electron Microscopes (UhR FE-SEM). The Nova NanoSEM 630 presents also low-vacuum imaging capabilities for spectacular nanoscale characterization on charging and/or contaminating nanotech materials. The NovaNanoSEM 630 also offers the most extensive set of tools for nanoprototyping, including an on-board digital pattern generator and dedicated patterning software, a high speed electrostatic beam blanker, gas injection system for direct electron beam writing of nanostructures and its high stability 150 mm piezo stage.

**Basic hardware features:**

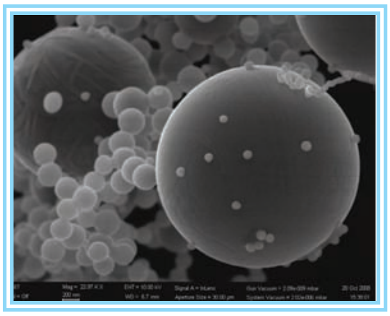
• Ultra-high resolution characterization at high and low voltage in high vacuum: 1.6 nm @ 1 kV;
• Beam deceleration mode with sub-100 V and high surface sensitivity imaging;
• Low and very low kV backscattered electron imaging for compositional characterization in high and low vacuum;
• Novel high stability Schottky field emission gun enabling a beam current up to 100 nA for analysis;
• 150 x 150 mm high precision and stability piezo stage;
• True high resolution low vacuum FESEM, with a resolution of 1.8 nm @ 3 kV;
• The characterization solution for charging and/or contaminating nano-materials/devices;
• Full prototyping solution with on-board 4 k x 4 k digital pattern generator, dedicated patterning software, fast beam blanker and gas chemistries;



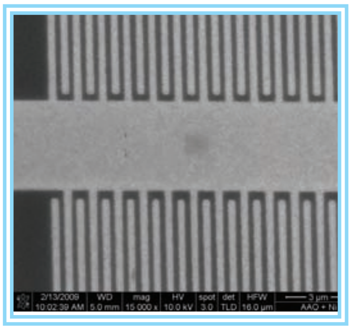
**The structure of an composite material used in aeronautics-sample from INFN Italy**



**Porous alumina membrane covered with Ni catalyst used as template for CNTs growth**



**Micro and nanospheres produced in the process of CNTs growth.**



**Detail of a SAW structure patterned with e-beam lithography**

**Applications:** microphysical characterization of a variety of **challenging nanotechnology** materials such as metals, magnetic materials, nano-particles and powders, nano-tubes and -wires, porous materials (e.g. silicon), plastic Electronics, glass substrates, organic materials, diamond films, cross-sections, **microdevices** etc.

**Targeting:** • **RESEARCH**: Materials Qualification; Materials&Sample Preparation; Nanoprototyping; Nanometrology; Device Testing and Characterization;
• **INDUSTRY**: Macro Sample to Nanometer Metrology; Particle Detection and Characterization;

**Partneship: CATHERINE**- *Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts*, STREP, FP7-ICT, 2008-2011, Project Coordinator: Consorzio Sapienza Innovazione (CSI).
web: http://www.catherineproject.eu

**Contact Person: Phys. Adrian Dinescu,** adrian.dinescu@imt.ro

## ❖ Scanning Electron Microscopy characterization of materials and devices using Scanning Electron Microscope - Vega II LMU @ Pattern Generator - PG Elphy Plus (TESCAN s.r.o , Czech Republic @ Raith, Germany)


SEM-General purpose scanning electron microscope, tungsten heated filament. Maximum resolution 5nm@30kV, SE and BSE detectors, low vacuum working mode up to 250Pa, movements: X= 80mm - motorized Y=60mm -motorized Z= 47mm -motorized PG- 6 MHz high-speed pattern generation hardware, 16 bit DAC vector scan beam deflection, 2ns writing speed resolution, TTL and 100V blanking signal drivers.

**Applications:** • general purpose SEM imaging using secondary electrons (topography) and backscattered; • electrons (composition); • electron beam lithography with sub-50nm resolution;

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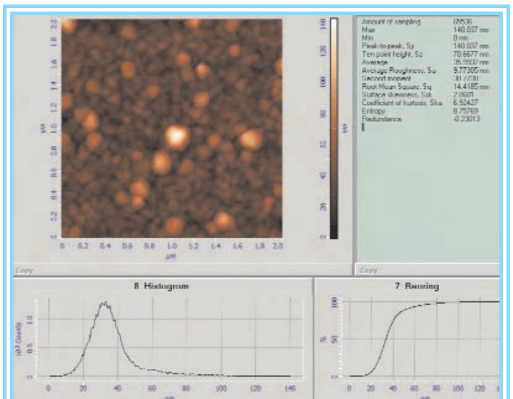
## ❖ Scanning probe characterization using Scanning Probe Microscope NTEGRA Aura (NT-MDT Co., Russia)

The equipment enables several related techniques (AFM, STM, EFM, MFM, SKPM, Conductive AFM etc) for high resolution imaging and measuring of various surface properties. ***A very wide range of surfaces could be investigated***, covering metallic, ceramic, polymeric and semiconducting materials, no matter of sample conductivity. Samples could be measured in various environments (normal ambient, controlled gaseous, liquid, low vacuum - $10^{-2}$ torr).

The common applications are in the field of **surface metrology**, due to the unique capability to provide surface morphology maps together with 3D dimensional measurements from surface roughness to nanometer-sized features. Moreover, depending on the selected technique, it could ***simultaneously provide other sample characteristics***, such as the surface potential, distribution of local mechanical or electrical properties. This makes SPM a powerful characterization tool for researching the physical properties of surfaces on a scale from microns down to the nanometric level.



AFM topography map (2x2 μm area) of a thin Al film deposited on Si, together with statistical analysis of surface morphology

***Technical specifications:*** • Max. scan area: 100x100 microns;
• Non-linearity, XY with closed-loop sensors < 0.15%;

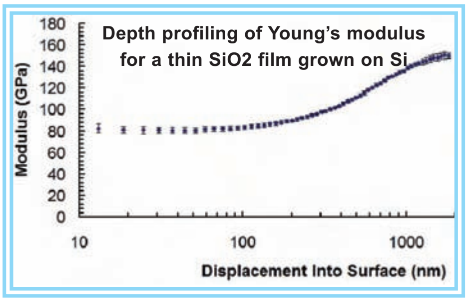
**Application fields:** • High-resolution surface profilometry;
• Evaluation and optimization of thin film coatings for various applications (optical, packaging, paintings, wear-resistant etc);
• Grain and particle size analysis;
• Surface cleaning and polishing studies (characterization of optical surfaces roughness, electro-polished metal surface evaluation etc);
• Determining process effects (e.g. plasma treatment) on surface properties;
• Examining the impact of surface roughness on surface properties as adhesion or haze;
• Microstructural studies (Pharmaceutical, Polymers);
• Morphological studies of biological and biocompatible materials;
• Virtually any other field where nanometer-sized surfaces are concerned;

AFM image of patterned Si. Individual stairs (15 nm height ) feature monoatomic steps.

**Contact Person: Phys. Raluca Gavrila** (raluca.gavrila@imt.ro)

## ❖ Nanomechanical characterization using Nano Indenter G200 - Nanomechanical Characterization Equipment Agilent Technologies

**G200** is a nanomechanical characterization equipment which provides access to various mechanical properties of **small-volume samples**, such as thin films, but could be equally applied to investigate bulk samples. The Nano Indenter G200 enables users to measure Young's modulus and hardness **in compliance with ISO 14577 and ASTM 2546 standards.** The patented CSM technique yields **the elastic modulus and hardness values as a function of depth in a single measurement** (especially useful for thin films) and allows characterization of the time dependent mechanical behavior of samples (e.g. polymers).

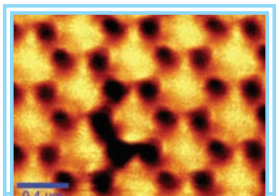



**Applications:** High resolution mechanical characterization of a wide variety of materials (metals, semiconductors, ceramics, biocompatible materials), especially in the form of thin films, coatings etc. The characterized properties include hardness, Young's modulus, film adherence, wear behaviour, dynamic testing of polymers.

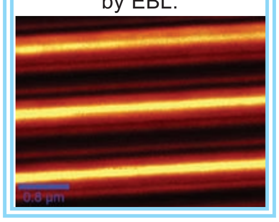
**Contact Person: phys. Raluca Gavrila**, raluca.gavrila@imt.ro

## ❖ Microphysical characterization using Scanning Near-field Optical Microscope - SNOM (Witec alpha 300S, Witec, Germany)

The Alpha300S System is a Scanning Near-field Optical Microscope that combines the characterization methods of SNOM, Confocal Microscopy (CM) and Atomic Force Microscopy (AFM) in a single equipment. The Alpha300S uses patented micro-fabricated SNOM cantilever sensors (aperture size typically 100nm) for optical microscopy with spatial resolution below the diffraction limit (optical resolution of 50-100 nm).
**Operating modes:** *Near field optical microscopy*: transmission, reflection, collection, fluorescence; *Confocal microscopy:* transmission, reflection, fluorescence, can be upgraded with a Raman spectrometer; *Atomic force microscopy*: contact and AC–Mode. The flexibility of this equipment and its operation modes allows a ***large variety of applications in nanotechnology and nanosciences***. It allows the optical characterization (in transmission and reflection mode) of various samples (nanostructures, biological samples, polymers) with a resolution of 50-90 nm in visible spectral range with the possibility of extension in the IR range. Working in the collection or photon scanning tunnelling microscope (PSTM) mode the SNOM allows the imaging of propagating optical field in various metallic and dielectric waveguides providing a powerful method to characterize and investigate nanophotonics and nanoplasmonic structures and devices. The AFM module working in both contact and alternative contact modes (with possibility of extension to magnetic force measurements and pulsed force mode) allows the topographical and chemical characterization of various surfaces and nanostructures.



**Nanostructure characterized on SNOM:** **top** - transmission mode image of a hexagonal array of Al regions deposited on a glass substrate (Fisher pattern). **bottom** - reflection mode image of an array of polymer stripes realized by EBL.



**Applications:** Imaging the optical properties of a sample with resolution below the diffraction limit with applications in nanotechnology, nanophotonics, nanooptics and plasmonics; Materials research and polymers; Single molecule detection; Life sciences;

**Partnership:** • **MIMOMEMS** - European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors (FP7-Capacities) 2008-2010; *Coordinator: IMT-Bucharest*. web: http://www.imt.ro/mimomems/
• **FLEXPAET -** Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology (IP- FP7/NMP) 2008-2010; *Coordinator: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. Fraunhofer Institut für Produktionstechnolgie (IPT).* web: http://www.e-squizoide.com/flexpaet/project.php

**Contact Person: Dr. Cristian Kusko** (cristian.kusko@imt.ro)

## ❖ Investigations of *electrochemical active surfaces* using Scanning Electrochemical Microscope - ElProScan (HEKA, Germany)

The HEKA ElProScan is an Electrochemical Probe Scanner used to characterize processes and structural features of the samples. The scanning electrochemical microscopy (SECM) resembles the scanning tunneling microscopy (STM) technique in its use of a tip to scan over a substrate surface, the fundamental difference in principles of operation being determined by the nature of recorded currents: in SECM the current is carried by redox processes at tip and substrate in solutions.

**System components:**

• Bipotentiostat/Galvanostat PG340 with two low current Preamplifiers.

• High precision real time controlled positioning system with 3 stepper motors mounted on a stable holder made of granite and a piezo translator; resolution in XY: 100 nm or 15 nm stepper motors, resolution in Z: 100 nm stepper motor + Fast real time controlled Z-piezo with 5 nm resolution and 100 mm scan range, closed loop regulated.

• Real-Time Computer System with real-time processing boards, counter and data acquisition modules - software POTMASTER with SCAN extension.

**Applications:**

• **Surface science**: SECM is not only able to reveal the topography (3D images) of samples in solution, but it may also detect and visualise local variations in the conductivity and electro-chemical reactivity of the investigated samples. For example, measuring the catalytic activity of microelectrode arrays directly and local distribution of feedback currents allows a quality control of microsensor production.

• **Two dimensional mapping of reaction rates**: spatially resolved imaging of dc and ac transport properties by nanoimpedance spectroscopy (NIS) technique allows the correlation of average transport properties with individual microstructural elements. Therefore, Nanoimpedance Microscopy/Spectroscopy (NIM) has both imaging and spectroscopic modes that differentiate processes at interfaces and defects by the time constants associated with local relaxations.

• **Bioelectroanalysis**: SECM is a powerful approach for imaging chemical gradients in the diffusion layer surrounding cell and tissue, the catalytic activity of immobilised enzymes/antibodies, or hybridisation events on DNA microarrays.

• **Characterization of hybrid interfaces** and interfacial processes with high spatial and temporal resolution, including: study of charge transport at the interface between two immiscible electrolyte solutions (ITIES), molecular transport across membranes, heterogeneous electron-transfer reactions, adsorption/desorption processes, corrosion processes. For example, polyelectrolyte, electronically conductive polymers, passivation films on metals and dissolution processes.

• **Micropatterning:** is a convenient tool for local surface derivatization due to its ability to generate micrometric sources of a broad range of reactive chemical species. By means of SECM, it is possible to induce a local polymerisation process under the positioned micro-electrode resulting in a well-defined functionalised polymer spot at which enzymes, e.g. glucose oxidize, could be covalently immobilized and moreover the surfaces can also be local structured with different thiol monolayer by means of micro-contact printing with high reproducibility.

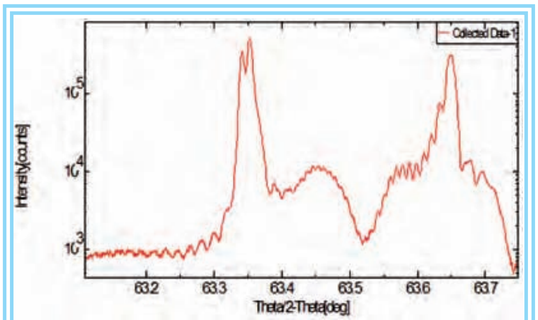
**Contact Person: Dr. Mihaela Miu,** mihaela.miu@imt.ro

## ❖ X-ray Metrology in Semiconductor Industry using Ultra High TrIple Axis Rotating Anode 9kW X-ray Thin Film Diffraction System, Rigaku SmartLab, (Rigaku Corporation, Japan)


**Main technical characteristics** are:
• 9kW rotating anode (45kV, 200mA), up 200mm wafer samples, triple axis, vertical goniometer, independent theta - theta arms, horizontal sample mount, Euler cradle (chi, phi, omega independent axis), in-plane arm, DTexUltra 1D high speed real time detector (SSD–Silicon multistrip);
• Automatic software alignment (or manual user computer controlled alignement) of the optics modules and sample for each measurement;
• Bragg-Brentano (+1D DTexUltra SSD detector), parallel beam (multilayer mirror), different monochromators/analyzers (Ge(220) crystals with two and four bounce reflections, Ge(440) four bounce reflection, graphite C(0002) analyzer bent/flat,etc.), X-Y micro area mapping unit-phase composition, strain&stress, tilt&twist, lattice parameter modifications/values $\Delta d/d=10^{-7}$–$10^{-9}$, depth distributions of phase composition, strain, etc;

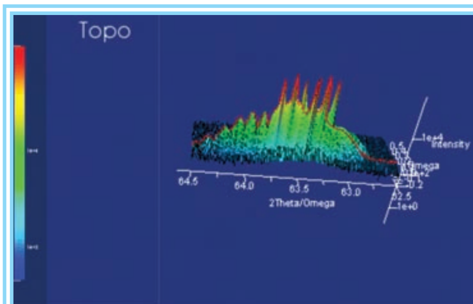
SmartLab makes thin films analysis more flexible. SmartLab approach is to aid users in choosing the specific measurement conditions, experimental geometries and application methods best suited to their particular sample. The system is multimodular (quick alignment computer aided, small measurement time), X-ray sources 9kW rotating anode, real time ultraspeed detectors and diffraction data processing (software, databases, etc).

The system offers **multiple measurement techniques**:
• X-ray Powder Diffraction (XRPD), can use DTexUltra high speed SSD;
• High resolution Powder Diffraction (polycrystals) - HRXRPD, using expanded range of monochromators: Ge (220) 2/4 bounce Ge(440) 4 bounce and the and the new CALSA analyzer - Ge(111) high performance compact multi-crystal single reflexion analyzer;
• High resolution X-ray diffraction (HRXRD) (including multiple reflection HR-MRMCXRD Ge(220) 2/4 bounce monochromator, Ge(440) 4 bounce monochromator, Ge(220) 2 bounce analyzer, focussing/flat diffracted beam monchromator);
• X-ray reflectometry (XRR, including HRMR XRR);
• Grazing incidence diffraction (GIXRD);
• Transmision diffraction&SAXS measurements;
• In-plane grazing incidence diffraction (IPGID);
• Small angle X-ray scattering (SAXS, USAXS);
• Single crystal diffraction (SCD);




**High resolution (Ge (220) 4 bounce mono) and ultra high resolution X-ray diffraction spectra (Ge(220) 4 bounce mono and Ge (220) 2 bounce analyzer**

Some of **the characterized structure parameters** are:
• multilayer structure&thickness&composition (1~103nm), density ($H_2O$~Heavy metals), roughness (0.2~several nm);
• phase identification- interface, transition layer;
• crystal structure-crystal quality, lattice parameter (several nm);
• crystal orientation-single: orientation relation of the substrate and film;
• poly: preferred orientation, pole figures; particle/pore size analysis 1~102 nm;



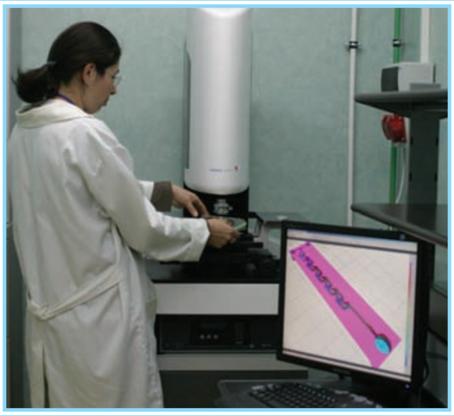

**RSM [parallel beam+Ge(220)4 bounce monochromator of 300nm(400)-InP/p+InGaAs(1mm)/n-InP(2mm)/n+-InP, symetric reflection**

**Applications:** • crystal structure (HR RSM, HR RC); • film thickness, density, roughness; • characterization of the ultra thin film (in plane XRD, grazing incidence); • particle/ pore size analysis (reflection SAXS, transmission SAXS); • phase identification, crystal structure (powder/thin film/poly/ mono/ crystal, trace, small area/quantity);

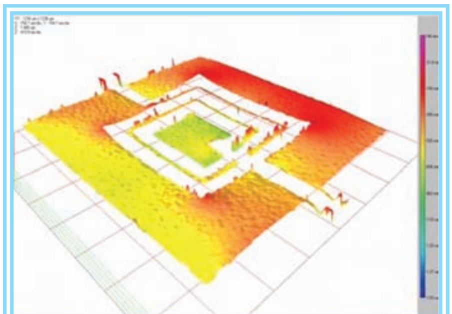
**Persoana de contact: Phys. Mihai Danila**, mihai.danila@imt.ro;

## ❖ Non-contact profiling surface measurements by interferometry using White Light Interferometer - Photomap 3D (Fogale Nanotech, France)

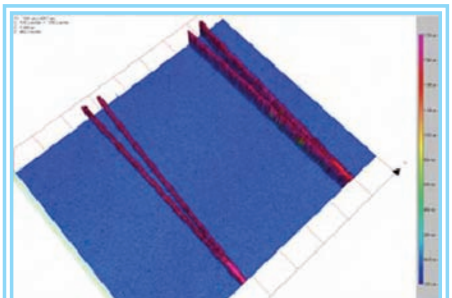
**The white light interferometer perform optical, non-contact profiling of rough surfaces, that uses interferometric techniques as well as digital signal processing algorithms to produce fast, accurate, repeatable two and three-dimensional surface profile measurements.** The method of determining surface height is based on white light as the source in an interferometer, and measurements of the fringe modulation degree, or coherence, instead of the phase of interference fringes. The white light interferometric profilometer uses the measurement of surface height through vertical scanning of the reference arm of the interferometer, and calculate the relative modulation of the intensity signal as a function of vertical position. The equipment present sub-nanometer vertical resolution (down to 0.1 nm), non-contact measurements allowing accurate and repeatable results, all axes motorization enabling automatic stitching of multiples fields of view, sub-nanometric roughness measurements, reflectivity 1% to 100%, ability to measure transparent films and require no sample preparation.



**Characteristics:** • manual translation stage 100x100 mm range, 20μm resolution; • optical head vertical range 150mm; nanometric objective translation unit; capacitive sensor closed loop control, 500μm range; • white light and Monochromatic light source; • automatic switching, software control; antivibration feet; • field of view 126x96 μm up to 2.5x1.9mm depending on objective (without zoom); • white light profilometry, 3nm rms z resolution; • monochromatic light profilometry, 0.1nm rms z resolution; • automatic step height and roughness measurement; • semi-automatic focus detection; • results exploitation (heights, roughness, dimensions, field stitching, filtering, 3D view, bump size, height, roughness measurements); • motorized x0.35 to 1.6 zoom; • out of plane measurements (by stroboscopic interferometry within range 100Hz-2MHz and by time averaged operation without frequency limitations); synthesized function generator: 2 channels controlled by software (one channel for stroboscopic illumination, the other one for MEMS AC voltage supply); • high voltage module (amplitude up to 200V; offset up to 200V; 1% resolution; sinusoidal and square signal; power 20W; current output max 100mA); • multi-reflectivity (5%,25%,50%,85%) objectives (x2.5, x5, x20); • motorised XY stage; • active vibration isolation stage.



**Analysis of the stress influence over the circuit topography**



**Optoelectronics: SU8 guide manufactured on silicon substrate**

**Applications:** • surface topography of diverse materials (metals, plastics, semiconductors, biological materials etc); • residual stress measurement for different thin film deposition layers; • conceived not only for statistical surface roughness measurements but also for high precision measurement of mechanical or chemical micromachining;
• transparent layers thickness measurements (plastics, glasses or varnish) with known refraction index; • MEMS dynamic measurements

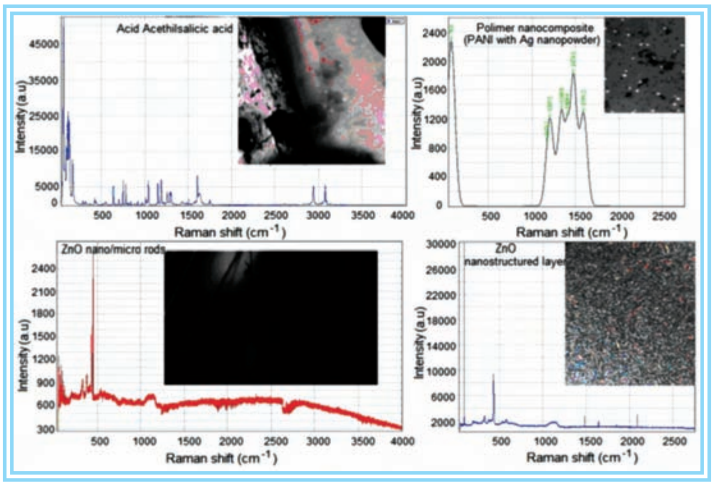
**Partnership:** • **MEMS-4-MMIC**- Enabling MEMS-MMIC technology for cost-effective multifunctional RF system integration; STREP, FP7-ICT-2007-2, Contract no. 204101, 2008-2011; Coordinator: IMST GmbH. web: http://www.mems4mmic.com/
• **MIMOMEMS**-European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors, FP7-Capacities, 2008-2010; http://www.imt.ro/mimomems
• **GIGASABAR-SAW and FBAR** type resonators dedicated to applications in communications for 2-6 GHz, based on micro and nanomachining of wide band semiconductors (GaN and AlN); PN II Partnership, 2008-2011; http://www.imt.ro/gigasabar
• **MIMFOMEMS** - Advanced circuits for microwave, millimeter wave and photonics based on MEMS technologies, PN II Partnership, 2007-2010, http://www.imt.ro/mimfomems

**Contact Person: Dr. Alina Cismaru**, alina.cismaru@imt.ro

## ❖ Spectroscopy services using High Resolution Raman Spectrometer - LabRAM HR 800 (HORIBA Jobin Yvon, Japan)

LabRAM HR 800 Raman Spectrometer is a powerful optical technique for materials study and characterization based on inelastic scattering of light due to light-matter interaction during which the wavelength of the incident laser will be shifted. This energy loss is characteristic for a particular bond in the molecule. The Raman spectrum provide qualitative and quantitative information: peak position is determined by chemical species; line intensity is proportional to concentration; shift in position of the peak indicate the stress and temperature effect and the line width the structural disorder.

**Characteristics:** • Flexible system with confocal microscope and mapping options; • He-Ne laser ($\lambda$ = 633 nm) and tunable air cooled Ar laser ($\lambda$ = 488 nm and 514 nm); • High spectral resolution (0.3 $cm^{-1}$/pixel at 633 nm);
• Large spectral range of Raman shift from 30 to 4000 $cm^{-1}$ ideal for organic and inorganic species; • LabSpec Software for control the instrument, data acquisition, data manipulation and mapping option;




**Applications:** LabRAM HR 800 Raman Spectrometer can be used for the analysis of solids, liquids and solutions for: • chemical identification, characterization of molecular structures; • to determine the composition and phase (crystalline/amorphous) of composites materials;
• environmental stress on a sample and crystal quality and composition of alloy semiconductors;
• polymers characterizations and polymer nanocomposites; • chemical and biological detection using SERS technique; • Micro/nano structures characterization (micro/nano rods, carbon annotates), self assembled molecule (SAM) on functionalized substrate and other.

**Partnership:** • **MIMOMEMS** - European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors (FP7-Capacities) 2008-2010; *Project Coordinator: IMT-Bucharetst*. web: http://www.imt.ro/mimomems/
• **FLEXPAET -** Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology (IP-FP7/NMP) 2008-2010; *Project Coordinator:Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. Fraunhofer Institut für Produktionstechnolgie (IPT).*
web: http://www.e-squizoide.com/flexpaet/project.php

**Contact persons: Dr. Phys. Munizer Purica**, munizer.purica@imt.ro.
**Eng. Florin Comanescu,** florin.comanescu@imt.ro;

## ❖ Spectroscopy services using UV-VIS-NIR Spectrophotometer - SPECORD M42 (Zeiss, Germany)

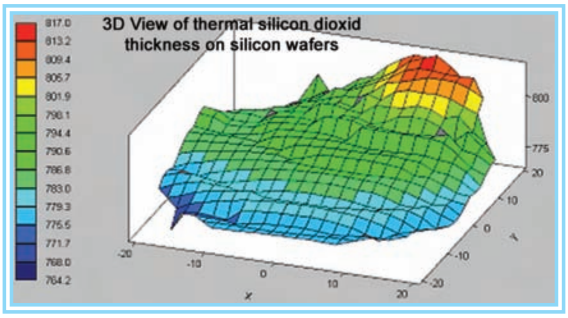
The spectrophotometer SPECORDM42 with double spot and 200-900nm spectral range contains modules for transmittance and reflectance measurements and enables data acquisition by a PC in order to processing of the measured data with specific softwares. It operates in any transparent ambient, including vacuum, gases and air.

**Applications:** • optical characterization by recording the transmission dand absorption spectra for transparent samples and for solutions with +/- 0.3 nm precision in wavelength; • thin films characterization by recording the transmittance, absorbance spectra [T($\lambda$) , A($\lambda$) ] and the reflectance, R($\lambda$) used for optical coatings;
• surface reflectivity characterization of the texturized and porosified surfaces; • material properties: the absorption coefficient and the bandgap for the semiconductor and dielectric films obtained by processing of T($\lambda$) and R($\lambda$).
**Contact Person: Dr. Munizer Purica**, munizer.purica@imt.ro; **Phys. Elena Budianu,** elena.budianu@imt.ro

## ❖ Spectroscopy services using Spectroscopic ellipsometer - SE 800 XUV (SENTECH Instruments, Germany)

The SE 800 XUV is a high performance spectroscopic ellipsometer in the UV/VIS range featuring both fast data acquisition and full spectral resolution. The high measurement precision is further improved by tracking the computer controlled motorized polarizer.
***Characteristics:*** • Spectral range: 240 -800 nm; • Micro-spot diameter: 200 mm; • X-Y maping option; • Software: SPECTRARAY II/WINDOW;

SE800XUV ellipsometer assures fast measurement of $\psi$ and $\Delta$ spectra makes and is an ideal tool for analysis and characterization for the nanometric thin films, interfaces, multilayer structures from different materials - dielectrics, conductive oxides, polymers, semiconductors. The software includes modelling, simulation, and fit programs in order to support the customer for successfully processing even complex tasks. It is also able to fit any multilayer structure (single, stack, periodical groups) for $\psi$, $\Delta$; tan $\psi$, cos $\Delta$ and Fourier coefficients, transmission, reflection, etc. This includes anisotropic layers, dispersion relations for layers-Cauchy, Sellmeier model, Schott glass, Drude-Lorentz model (oscillators), Lorentz, Urbach, Leng oscillator, Tauc-Lorentz oscillator, Forouhi-Bloomer, polynomial dispersion and index gradient (effective medium approx-Maxwell-Garnett, Bruggeman, Lorentz-Lorenz, Clausius-Mossotti).




**Applications:** • measuring optical constant, index of refraction (n) and the extinction coefficient (k) for a single layer permits to determine the material composition and modelling of optical performance; • thickness of thin films and multilayer structures. If the optical constants are approximately known, then ellipsometry can determine the thickness, interface roughness, inhomogeneity in multilayer structures; • thin-film deposition process optimisation.
Ellipsometry can be used to study the formation and properties of thin films on thick substrates, ZnO, CdS, ITO, polymer on semiconductor substrate (Si, $SiO_2$/Si, $A_3B_5$). Layers characterized regarding refraction and thickness index are transparent oxide layers ($TiO_2$, ZnO, $SiO_2$, SiON, $SnO_2$ e.a); porous semiconductor layers; nanocomposite materials (doped layers); polymers (PMMA, PVA, PANI), silicon, glasses.

**Partneship:** • **FLEXPAET-**Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology, IP, FP7/NMP, 2008-2010; *Project Coordinator: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. Fraunhofer Institut für Produktionstechnolgie (IPT).*
web: http://www.e-squizoide.com/flexpaet/project.php

**Contact Persons: Dr. phys. Munizer Purica,** munizer.purica@imt.ro;
**Eng. Florin Comanescu,** florin.comanescu@imt.ro;

## Other equipments that provide Spectroscopy services:

### ❖ Fourier-Transform Infrared Spectrometer-Tensor 27 (Bruker Optics, Germany)

**Characteristics:** Spectral Range: 4000-400 $cm^{-1}$, Resolution: 0,5 $cm^{-1}$; Wavenumber Accuracy: 0.01 $cm^{-1}$, Scan Speed: 3 velocities, 2.2-20 kHz (1.4-12.7mm/sec opd).
**Applications:** • polymers, coatings; • liquid, e.g. solvents, varnish; • powder; • waxes, gels, pastes;
**Contact Person: chem. Vasilica Schiopu,** vasilica.schiopu@imt.ro

### ❖ UV-Vis-NIR Thermo-Electric Cooled Fiber Optic Spectrometer-AvaSpec2048TEC (Avantes, The Netherlands)

**Characteristics:** • UV-, Vis-, NIR-region; • Spectral Range: 200-1100 nm; • Resolution: 0,5 nm; •
**Applications:** • absorbance, transmittance, reflection, fluorescence and irradiance.
**Contact Person: Chem. Vasilica Schiopu**, vasilica.schiopu@imt.ro

### ❖ NIR Spectrometer-AvaSpec NIR256-2.2 (Avantes, The Netherlands)

**Characteristics:** • Wavelength range: 1100-2100nm; • Resolution: 10.0-60 nm;
**Applications:** • Absorbance, transmittance/reflectance, luminescence; • layers with thickness 10 nm - 50 mm with resolution of 1nm; • optical transparent coatings on metals and glass substrates;
**Contact persons: Dr. Rodica Plugaru,** rodica.plugaru@imt.ro, **Dr. Cristian Kusko,** cristian.kusko@imt.ro

## ❖ Fluorescence and phosphorescence spectrometry services using Combined Time Resolved and Steady State Fluorescence Spectrometer - FLS920P (Edinburgh Instruments, UK)

Fluorescence lifetime and steady-state spectrometer (FLSP 920) is a suite of combined steady state and time resolved luminescence (fluorescence and phosphorescence spectrometers. All instruments of the FLSP 920 series are based on modular construction, enabling systems to be flexibly configured to meet individual research needs. The steady state mode uses single photon counting whilst lifetime measurements are based on Time Correlated Single Photon Counting: the technique widely accepted to be the method of choice for maximum sensitivity, dynamic range, accuracy and precision. The system sensitivity guarantees a signal/noise ratio of 6000:1 for water Raman spectrum measured with excitation at 350nm, emission at 397nm, in 1sec integration time and 5nm spectral bandwidth.

**Characteristics:** Lifetime ranges 10 ps - 10 s; UV - Vis - NIR spectral range; Single Photon Counting sensitivity; **Sensitivity:** Water Raman Spectrum Excitation wavelength= 350nm; Spectral bandwidth 5nm, integration time 1s; Peak Counts > 750,000cps @ 397nm; RMS Noise < 125cps @ 450nm; Signal to Noise Ratio > 6000:1

**Applications** in the broad areas of photophysics, photochemistry, biophysics and semiconductor study. Complex intermolecular interactions can be revealed by lifetime measurements made across an emission spectrum which has little structure. Time resolved polarisation measurements reveal the rotation rates of the emitting molecules and have many applications in structure determination, membrane fluidity, polymer dynamics and protein engineering. • **Biomedical field:** study of enzymes, dynamics and structure of nucleic acids, protein folding and DNA sequencing, use a-priori fluorescence lifetime knowledge of the fluorescent probe to characterise various systems. • **Materials physics:** study semiconductors and novel structures such as quantum wells and quantum dots or for the quality control monitoring in a wafer foundry, to characterise the doping or impurity level present.
• **Pharmaceutical sector:** for monitoring drug interactions.

**Contact Person: Chem. Adina Bragaru**, adina.bragaru@imt.ro; **Phys. Monica Simion,** monica.simion@imt.ro

## ❖ Impedance spectroscopy using Electrochemical Impedance Spectrometer - PARSTAT 2273 (Princeton Applied Research, USA)

The equipment consists of hardware capable of ±10V scan ranges, 2A current capability (1.2fA current resolution), 100V compliance, >1013Ω input impedance, <5pF of capacitance and 10μHz to 1MHz built in analyzer for impedance measurements, Electrochemistry PowerSuite software required for data analysis and ZSimpWin-EIS modelling software package. The system could be useful for: materials and fabrication processes characterization; electrochemical systems and physico-chemical phenomena characterization of the coresponding interfaces; bio-electrochemical systems characterization.

**Applications:** • *microelectronics* - development of new processes and materials with improved electrical properties; • *energy* - development of new fuel cell devices as clean energy sources; • *sensors area* - development of electrochemical immunosensor devices for food, pharmaceutical chemistry and clinical diagnostics industry; • *solar cells area* - development of new structures with improved parameters; • *biomedical applications* - implant biocompatibility studies; • *fundamental studies* of physico-chemical phenomena at bio-hybrid interfaces;

**Partnership:** • "Study of membrane - electro-catalyst nanocomposite assemblies on silicon for fuel cell application", PNII, 2007-2010); http://www.imt.ro/electrocatalizatori/index.htm
• "Miniaturised power source for portable electronics realised by 3D assembling of complex hybrid micro- and nanosystems-**MiNaSEP**", PNII, 2007-2010, http://www.imt.ro/minasep/

**Contact Person: Dr. Phys. Mihaela Miu**, mihaela.miu@imt.ro

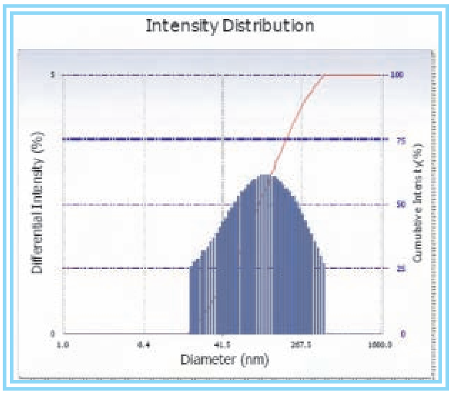
## ❖ Particle size and zeta potential measurements services using Zeta Potential and Submicron Particle Size Analyzer - DelsaNano (Beckman Coulter, USA)

Is a new generation of instruments that use photon correlation spectroscopy (PCS), which determines particle size by measuring the rate of fluctuations in laser light intensity scattered by particles as they diffuse through a fluid, for size analysis measurements and/or electrophoretic light scattering (ELS), which determines electrophoretic movement of charged particles under an applied electric field from the Doppler shift of scattered light, for zeta potential determination. The equipment has a broad range of capabilities, including conventional static and automatic titration measurements for both size and zeta potential distributions of suspended particles in a wide range of size and concentration. The DelsaNano also can measure zeta potential of a solid surface (as glass, metal, metal oxide, ceramics, etc.) or film. Due to the high sensitivity size and zeta potential, it can measure particles from 6 Angstrom to 7 micron in suspension with concentration ranging from 0.001% to 40%.

**Range**: -100mV - +100 mV; **Temperature Range**: 10° C - 90° C; **Environmental Operating Specifications**: temp 10°C-40°C; Humidity: 0-90% w/o condensation; **Light Source**: Laser diode, 658 nm, 30 mW; **Scattering Angle**: 15°, 30°, 160°;

**Applications:** • Preparation of colloidal dispersions: of nanoparticle Au, Pt, Ag, Fe, $Fe_2O_3$/$Fe_3/O_4$; $SiO_2$, $TiO_2$, $SnO_2$ or of core-shell systems, functionalized or non-functionalized;
• capillary phenomena which are important in the wetting of powders; • coating of surfaces;
• absorption of impurities;
• Biomedical and Pharmaceutical: Proteins, lipids, polysaccharides, bacteria, blood cells, viruses, colloids drug carrier systems, drugs in aqueous suspension, micelles for biomaterials.

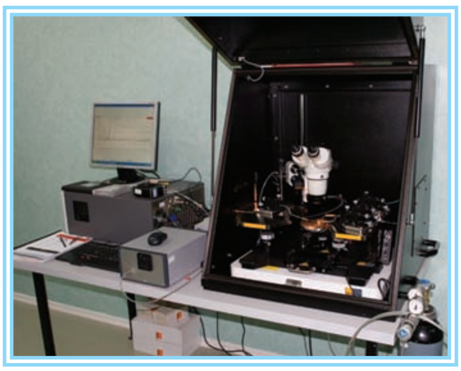
| | | |
|---|---|---|
| Diameter | (d) | : 63.0 |
| Polydispersity Index | (P.I.) | : 0.438 |
| Diffusion Const. | (D) | : 7.806e-008 |
| Molecular Weight | | : 1.641e+008 |
| Measurement Condition | | |
| Temperature | | : 25.0 |
| Diluent Name | | : WATER |
| Refractive Index | | : 1.3332 |
| Viscosity | | : 0.8878 |
| Scattering Intensity | | : 6904 |




**Contact Persons: Chem. Teodora Ignat,** teodora.ignat@imt.ro; **Chem. Adina Bragaru,** adina.bragaru@imt.ro

## ❖ Semiconductor Characterization System (DC) with Wafer Probing Station - 4200-SCS/C/Keithley Easyprobe EP6/ Suss MicroTec (Keithley Instruments, USA; Suss MicroTec, Germany)

It is fully programmable for on-wafer/structure sourcing and measurements of DC voltage and current simultaneously. 4200-SMU power: 2.2W (max.105mA, 210V). It has shielded manual probe station with 4 triaxial cable manipulators. Can measure on wafers and substrates up to 150 mm (6"). Positioning resolution: 3um. Current upgrade status: 2x 4200-SMU and 2x4200-PA. Semiconductor Characterization System 4200-SCS configured with the 4200-PA Remote Preamplifiers, offers exceptional low current measurement capability with a resolution of 0.1fA and 5mV. The software is Keithley Interactive Test Environment (KITE) for device characterization application.

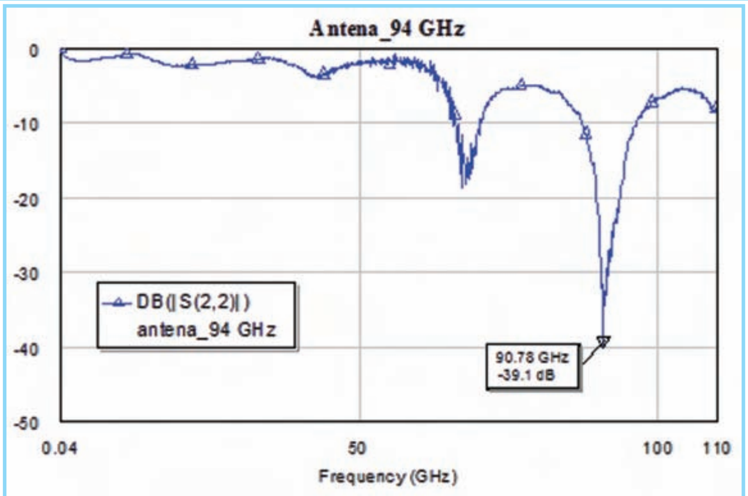


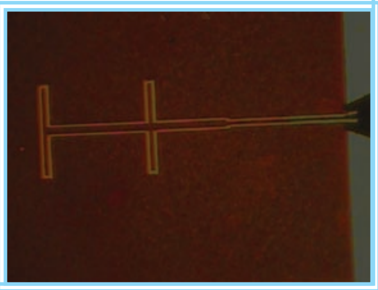
**Applications:** • Characterization of nanodevice structures: electronic nanodevices (diodes, transistors, field effect transistors, capacitors), sensors, special devices with unique properties.
• Research of nanoscale materials: characterization of resistance and conductivity over wide ranges for nanocrystals, nanotubes, nanowires, nanofibres, thin layers. • Resistance measurements and I-V curve generation on macro/microscale components and materials using a two-point electrical measurement technique. • Low resistance measurements for: molecular wires, semiconducting nanowires, and carbon nanotubes.

**Contact Persons: Dr. Phys. Rodica Plugaru**, rodica.plugaru@imt.ro; **Dr. Eng. Radu Popa**, radu.popa@imt.ro.

## ❖ Probes, on-wafer, electrical characterization using Microwave network analyzer (0.04-110GHz) with Manual Probing Station - Lightning 37397D VNA/Anritsu; PM5/Suss MicroTec (Anritsu, Japan; Suss MicroTec, Germany)

The VNA is the main equipment of MICROLAB. MICROLAB is a laboratory dedicated to on-wafer characterization of devices and circuits in the frequency range 0.5 GHz -110GHz. This frequency range encompasses the entire area of the devices and circuits used in the most advanced communications systems such as WLAN, GPS, mobile phones, radar. The MICROLAB consists of a vectorial network analyzer (VNA) and a probe station. The MICROLAB measures directly on- wafer all S parameters of any device and circuit up to up to 110 GHz. The laboratory is managed by a quality system according to ISO 17025 and will be accredited at the end of 2009.



S22 parameter for the 94 GHz antenna suspended on a micro-machined $SiO_2/Si_3N_4/SiO_2$ membrane (top)
Photo image of the antenna (right)

The frequency generator (Agilent) up to 110 GHz purchased in the frame of the European FP7 project MIMOMEMS together with the spectrum analyser (Anritsu)

**Applications:** S parameters of microwave circuits up to 110 GHz

**Contact Persons:**
**Dr. Mircea Dragoman**, mircea.dragoman@imt.ro. **Dr. Alexandru Muller**, alexandru.muller@imt.ro.
**Dr. Dan Neculoiu**, dan.neculoiu@imt.ro

## ❖ Probes, on-wafer, electrical characterization using Wafer Probing Station - Easyprobe EP4 (Suss MicroTec, Germany)

• Base machine (base plate with embedded hand rests; sliding stage, 100mm travel in x and y; working position secured by vacuum);
• Substrate chuck (standard chuck for wafers and substrates up to 100mm; material: stainless steel; working position secured by vacuum);
• Magnetic probe head semiring (2 semiring suitable for probeheads with magnetic adapter; max. 4x PH120 or 8xPH100);
Motic SMZ 140S stereozoom microscope complete with adapter + fixation (microscope body, tube, focus drive; two 15 eyepieces; adjustable integrated illumination; magnification 15x-60x, working distance 80mm).

**Contact persons: Dr. Mircea Dragoman**, mircea.dragoman@imt.ro; **Dr. Alina Cismaru**, alina.cismaru@imt.ro;

# 3. RELIABILITY AND TESTING

• **Electrical characterization** (electrical characterization of micro and nano technologies products according approved standards and special specifications);
• **Mechanical and climatic tests** (application specific tests developed for micro and nano technologies products);
• **Life tests** (storage and endurance tests in various environmental and electrical conditions);


**Chambers for: -Thermal cycling – TSE-11-A (Espec):** High temp. (-65...0°C) and Low temp.(+60…200°C); **-Highly accelerated stress test (HAST) - EHS 211M (Espec):** Temperature range: +105 ... +142°C, Humidity range: 75%…100% RH, Pressure range: 0.02…0.196 Mpa; **-Damp heat - CH 160 (Angelantoni)**

*Scientific services about Materials, Microelectronic devices and Microsystems*, containing:
• Environmental & reliability testing;
• Failure & reliability analyses;
• Assessment of reliability parameters;
• Reliability screening for selecting high reliability components;
• Consultance / technical assistance on: Reliability analysis for all families of semiconductor devices; Elaborating standards and other documents for various types of electronic components; Qualification of semiconductor devices;
• Testing at combined stresses: Damp heat, Thermal cycling, Pressure + Temperature, Thermal stress + Electrical stress, Electrical stress + Thermal stress + Humidity + Vibrations, Electrical stress + Thermal stress + Pressure, Mechanical (“Tilting”) + Thermal stress;


**Electrical characterization: 4200SCS system Keithley, UK.**

**Services:** • Qualification tests (electrical, mechanical, climatic and life tests); • Reliability tests (normal and accelerated tests); • Electrical characterization of micro and nano technologies products; • In house tests (On demand tests and test programs, with specified parameters); • Test certificate (for performed tests programs); • Consultancy (tests programs, product standards, documentation, etc.).

**Chamber for testing at temperature + low pressure - VO400 (MEMMERT)**

**Electrical characterization system and measurement equipments:**
• **Keithley 4200SCS**: modules C-V 3532-50, DMM 2700-7700 and 2002; low level measurement units 6211-2182; Stimulus: voltage DC < 100V, current DC < 1A; Pulse: analogic signal 30V, <40MHz; Measurements: voltage 0,5μV, current 1fA .
• **Temperature conditioning equipment for electrical measurement**
• **Temptronic TP04300A-8C3-11** - ThermoStream: Temperature range: -8° ..+225°C; Transition time: up 7 sec, down 20 sec; Temperature control +/- 0.1°C
• **Damp heat Climatic chamber,** Angelantoni, Italia: Temperature range -70 ...+180°C; speed 5°C/min; Relative humidity range: 20…95%, between +10°C…+80°C
• **Temperature chamber** with Forced air circulation, Memmert (Germany) / UFB 400: Capacity 53 l; Temperature range 20...220°C
• **Vacuum oven,** MEMMERT (Germany) - VO 400: Capacity: 49 l; Temperature range: 20 ... 200°C; Pressure range: 10 ... 1100 mbar;

**Contact person: Dr. Marius Bazu**, marius.bazu@imt.ro

# 4. MICROARRAYS, BIOMOLECULE RESEARCH

## ❖ Microarray spot plotting and scanning using: Micro-Nano Plotter - OmniGrid and Microarray Scanner - GeneTAC UC4 (Genomic Solutions Ltd., UK)

**Scanner microarray (GeneTAC UC4)** is used for reading the chips, for DNA detecting → it offers high resolution scanning across the entire surface of standard microarray substrates. The system has two-color lasers - green (532nm) and red (635nm) - coupled with high performance optics optimized to maximize collection of fluorescence signal while minimizing the damage caused by photobleaching. The scanner includes: → hardware; → powerful and easy-to-use microarray analysis software for fast and reliable imaging, collection and storage of very large data sets and consolidates these data with experimental information. The entire 1 in. x 3 in. array surface can be imaged at five micron resolution for accurate quantitation of high density arrays. Or a sub area can be scanned at up to single-micron pixel resolution.

**Characteristics:** • Resolution: from 1 μm/pixel; • Resolution for a standard microscope slide: 5 μm/pixel; • Microarray Scanner includes also a workstation with powerful software that automates the identification and quantification of microarray data;

**Ploter microarray (GeneMachines OmniGrid Micro)** is designed for production of DNA and protein microarrays slides. Omni Grid Micro Plotter used contact printing method for deposit on a solid surface (e.g. glass slide, silicon substrate) a small volume of sample solution. A Control Computer assures the utilization interface. A vacuum wash station ensures active washing in between sample transfers while humidity control minimizes evaporation of precious sample.

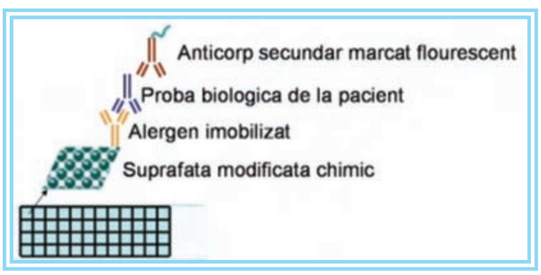
**Characteristics:** • x/y resolution: 1 1μm; • available pins: 50, 100, 200 μm ; • humidity control during processing; • flexibility in array configuration;

**Protein microarray** - Depending on the application field, protein microarrays can be classified in two categories: (1) Arrays for proteomics or focused protein profiling. (2) arrays for functional studies. Low and high density arrays of proteins, peptides and small molecules could be used to study the binding of DNA, RNA, small chemical ligands and proteins to their immobilised binding partners.

**Applications: *Protein Arrays:*** • study tens of thousands of proteins in a time as short as possible; • producing high density protein arrays on specialized slides; • automated hybridization and imaging of cDNA and oligonucleotides now allow the consistent high throughput study of antibody/antigen interactions; ***Protein Assays:*** • immuno-assays, protein-protein interaction assays, enzyme assays;

**Application procedure:** • For each application it is necessary to be specified the material that should be printed and spot configuration in order to elaborate the software program; • A preliminary accept is necessary to avoid the contamination risk;

**Results:** • In microarray area, results are related to functionalization of different surfaces (glass and silicon wafer) in order to immobilized DNA and Proteins used in medical diagnosis. We have optimised the process parameters in order to obtain a uniform hydrophilic/hydrophobic surface, high signal intensity and low background, spot with well defined morphology, and high efficiency with lower cost of slides and chemicals.




• Enzyme-based sensors designed for electrical measurements of several toxins. The sensors are made of interdigital electrodes built on silicon substrate. Biomaterials are deposited on the electrode surface and are characterized using this equipments.

**Partnership:** • Multi Allergen Biochip realised by MicroArray technology, MAMA, 2007-2010, http://www.imt.ro/mama

**Contact person: phys. Monica Simion**, monica.simion@imt.ro

# 5. SIMULATION, MODELLING AND COMPUTER AIDED DESIGN SERVICES

## We offer simulation, consulting and training services in micro and nano domains

**Application areas:** *microsensors and actuators, integrated microsystems, MEMS/NEMS, MOEMS, RF MEMS, microfluidics, lab-on-chip, micro and nano-systems for diagnosis and drug delivery*

→ **Computer Aided Design** using dedicated software tools: **COVENTOR WARE 2008 and ANSYS, COMSOL:**

- **Mask Design, Process Editor, 3D building and mesh**
- **Modeling for technological processes/optimizations**
- **Special features**: particularized use (macro or subroutine) creation; special geometrical modeling (AFM images reconstruction in CAD format, surfaces generated in accordance with mathematical expression, etc)
- **Modelling and simulation of MEMS, MOEMS**: switches, cantilevers, membranes, resistors etc). Analysis include simulation for mechanical, thermal, electrical, electrostatic, piezoelectric, optical, electromagnetic and coupled field.

→ **Computer Aided Engineering and Analysis (using FEM, FVM, BEM tools):**

- **Modelling and simulation** of microfluidic components and systems: micropumps and microvalves with various actuation principles (electrostatic, piezoelectric, pneumatic, electroosmotic), microreservoires, microchannels, micromixers, microfilters. Microfluidic analysis: fluid dynamics in microstructures (flow under pressure, thermal flow, fluid mixing), electrokinetics, diffusion, bubble-drop formation, fluid-structure interaction
- **Electro-thermo-mechanical and piezoelectric analysis** (steady state and transient).
- **Coupled field simulations**: thermo-mechanical simulations; electro-mechanical simulations; multiphysics, fluid-solid interaction
- **General (macro to micro scale) simulations that include**: Linear and nonlinear types of simulations in static, modal, harmonic and transient regime (including contact problems); Analysis with parameter variation, goal driven optimizations; Material data variation (various types of materials and material models); Fluidic simulations with various types of fluids (Newtonian and non-Newtonian), in laminar or turbulent flow, free surfaces, surface tension phenomena, etc.

→ **Consultancy regarding design and simulation optimization**

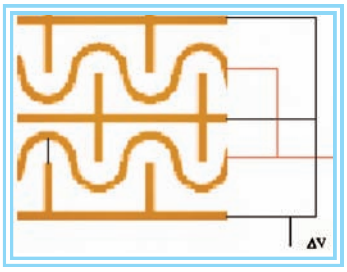
→ **Training in COVENTOR and ANSYS**: hands-on courses, access to computer network and software.

→ **Software facilities:**

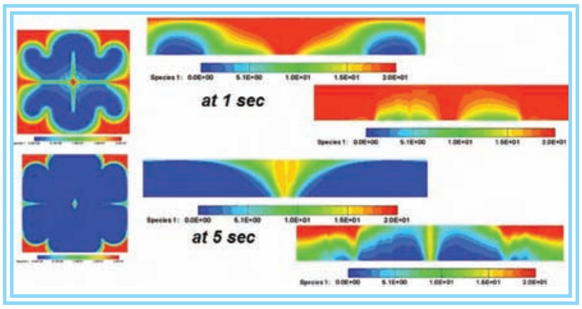
- **COVENTORWARE 2008.010:** Computer aided design and simulation of MEMS and microfluidic components used in microsystems for bio-medical applications: Design modules: 2D layouts, editing technological processes, 3D models of ready-to-manufacture devices; static and transient analysis, coupled phenomena approach;
- **ANSYS Multiphysics 11.0**: provides high-fidelity engineering analysis tools that enable the accurate simulation of complex coupled-physics behavior. Combine industry-leading solver technology for all physics disciplines - structural mechanics, heat transfer, fluid flow and electromagnetics - with flexible coupled-physics simulation methods, and parallel scalability. Include also FEM simulations, Structural, thermal, acoustic, electromagnetic and coupled field analyses, CFD, Pre and Postprocessor;
- **COMSOL Multiphysics 3.4** (enabling parallel computation)- a powerful interactive environment for modeling and solving all kinds of scientific and engineering problems based on partial differential equations (PDEs);
- **MATLAB 7.8-7.9 and Simulink**: a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Using the MATLAB product, you can solve technical computing problems faster than with traditional programming languages, such as C, C++, and FORTRAN. **Modules: Optimization Toolbox; Extended Symbolic Math Toolbox; Partial Differential Equation Toolbox; Genetic Algorithm and Direct Search Toolbox; Statistics Toolbox; Neural Network Toolbox; Curve Fitting Toolbox; Spline Toolbox; Signal Processing Toolbox; Image Processing Toolbox; Simulink;**
- **Visual Studio 2008 Pro**: for in–house development of specific applications;
- **Solidworks Office Premium 2008**: 2D and 3D design for complex geometries;
- **Mathematica 7**: software environment for technical and scientific computing, mathematical computings;
- **Origin PRO 8**: Data analysis and graphing software for scientists and engineers;

## Examples of applications

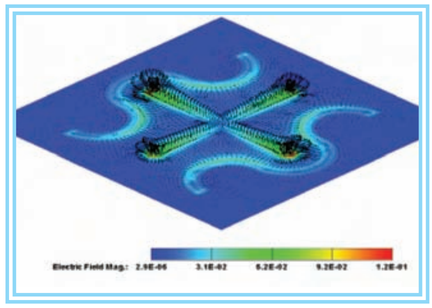
***Lab-on-chips for control of chemical processes to obtain molecular imaging products used in medical diagnosis*** (FP6 Project "Lab-on-a-chip implementation of production processes for new molecular imaging agents")




a) Electrodes Layout

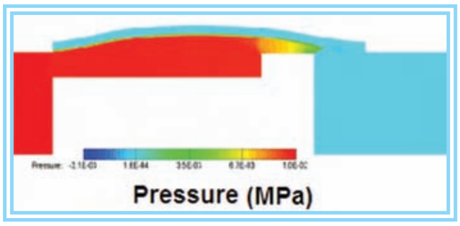


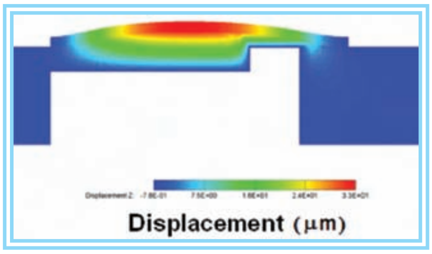

b)Distribution of ions (µMoles)

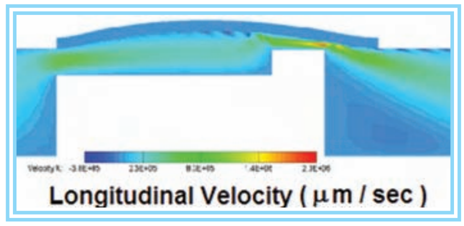


c)Electric field distribution

*Electrokinetic analysis of ions separation from a aqueous solution*

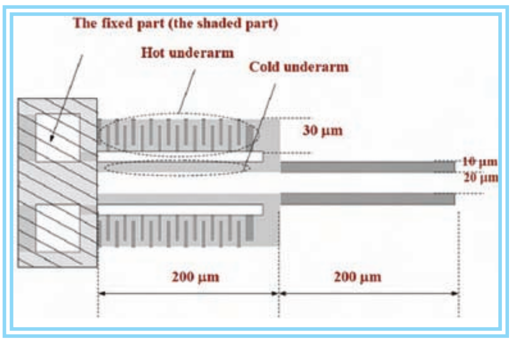


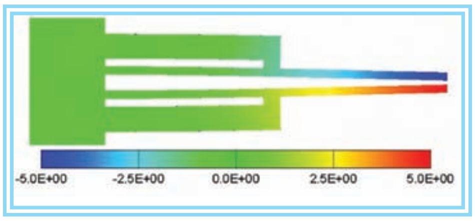



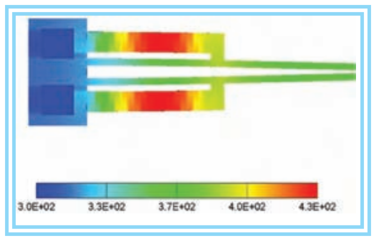




**Coupled Fluid-Structure analysis of a pneumatically actuated micropump used in fluid flow control, integrated in lab-on-chip for molecular imaging**

Application: *Microprobes manipulation / handling and microrobotics (CEEX National Project - MEMSAS)*

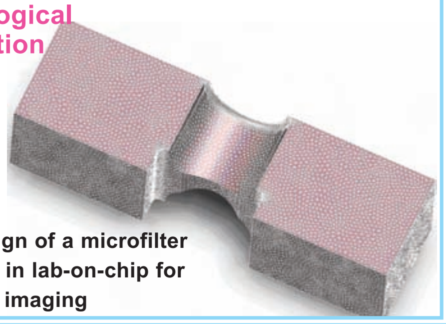



**Coupled electro-thermal simulation with Coventorware: analysis of a microgripper for micromanipulation**

### Application: Filters for biological cells separation



**SolidWorks 3D Design of a microfilter (fluid volume) used in lab-on-chip for molecular imaging**

### Application: Laser heated system used in lab-on-chip for molecular imaging

**Electro-thermal simulation with Coventorware 2008: Simulation of electromagnetic field propagation through the designed optical system**

▸ **Hardware facilities:**

- **Dual IBM 3750 Server** with 8 quad-core Intel Xeon MP 2.93 GHz processors, 196 GByte RAM and 1 TByte HDD + 876 GByte external storage;
- **Computer network used for training;**

**Contact: Simulation, Modelling and Computer Aided Design Laboratory, http://www.imt.ro/**
**Raluca Muller** (raluca.muller@imt.ro); **Oana Nedelcu** (oana.nedelcu@imt.ro);
**Irina Stanciu** (irina.stanciu@imt.ro), **Rodica Voicu** (rodica.voicu@imt.ro);
**Victor Moagar-Poladian** (victor.moagar@imt.ro), **Catalin Tibeica** (catalin.tibeica@imt.ro).

# 6. RAPID PROTOTYPING

We may build any 3D body imagined by the customer by using selective laser sintering with the **Formiga P100, EOS (GmbH, Germany)**.
This object may be used for illustrative models, functional parts/end products and spare parts!

**We offer two services for that purpose:**

- **CAD (Computer Aided Design) 3D modeling of the objects imagined by customer**
- **Physical realization of the respective objects**


**Description**

• minimum size of the obtainable structures: 500 microns; • maximum building volume: 200 mm x 250 mm x 330 mm; • minimum layer thickness: 100 microns;

**Applications:**

• Models realization (for engineering, architecture, education);
• Realization of molds for implants;
• Realization of molds for automotive industry, rubber industry (envelopes for tyres), plastics industry, optical industry (special lenses and special mirrors), medicine (prosthetics), museums (copies of sculptures that are very important), components for construction of industrial machines, glass industry, porcelain industry;
• Realization of fix, mobile or semi-mobile mechanical components for specific applications, including robotics;
• Realization of microfluidics structures and circuits (channels of several hundreds of microns diameter, connected in complex 3D geometries) containing pipes, valves, micropumps (at milimetric and centimetric scale);
• Realization of joining elements (screws, etc.) at milimetric scale;
• Realization of customized encapsulations for different type of MEMS structures;
• Realization of MEMS models for testing their concept and working principle;
3D Printer by using Selective Laser Sintering;

**Materials used by 3D printer:**

• PrimePart: Fine polyamid - biocompatible, excellent economics, withstands high mechanical and thermal load;
• PA 2200: Fine polyamid - biocompatible, withstands high mechanical and thermal load;
• PA 3200 GF: Glass-filled fine polyamide - hard-wearing, withstands high mechanical and thermal load;
• PrimeCast 101: Polystyrene - for lost patterns, minimal remaining ash content;
• PA 2210 FR: Flame-retardant polyamide - contains chemical flame retardant, high mechanical properties;
• PA 2201: Fine polyamid - withstands high mechanical and thermal load;
• Alumide: Aluminium-filled polyamid – stiff structures, thermally conductive;
• PS 2500: Polystyrene - for lost patterns;

**Contact person: Dr. Phys. Gabriel Moagar-Poladian,** gabriel.moagar@imt.ro
**Phys. Eng. Victor Moagar-Poladian,** victor.moagar@imt.ro

# Competences in scientific research

## Microsystem technologies

**IMT-Bucharest** mission is devoted to research and development in **micro-and nano-technologies**, reflected by a rich experience in coordinating national networks, research and education projects, international cooperation (participation in 15 FP6 EU Projects, 7 FP 7). **IMT-Bucharest** is integrating research, education and technology transfer (innovation)-playing a national and regional role. **The research laboratories of IMT-Bucharest** are involved in **joint research** with international and national partners, **including SMEs**, based on a **multidisciplinary** approach, promoting the **convergence** of **micro-nano-bio- info technologies. IMT-Bucharest** is involved in the development of several different types of microsensors and smart systems based **on microsystem technologies**, which have become a key of innovation for traditional industrial sectors as well as for new emerging technologies.

## Main topics of research

- **MEMS** based microsensors and actuators for bio-medical, environmental applications and robotics: pressure sensors, accelerometers, microgrippers;
- **RF-MEMS** devices and circuits: design, modelling and manufacturing of dielectric membrane supported inductors, capacitors, filters and antennae based on silicon and GaAs micromachining; micromachined millimetre and sub millimetre wave receiver modules, SAW interdigitated traducers;
- **Photonic** devices and **MOEMS** (waveguides, optical couplers, microring filters and resonators; grating-based microstructures, tunable interferometers based on movable micromirrors, optical sensors), photonic circuits for optical interconnections;
- **CNT** based micro-nanostructures for sensing and interconnections;
- **Microfluidic** devices;
- **Biochips** for biological materials investigation and detection (proteins, DNA, enzymes) on various substrates (silicon, glass, polymers), **microarrays, biosensors**;
- **Silicon nanoelectrode arrays**, porous silicon layers (El, PL and bio-active properties); field emission nanostructures;
- **Magnetic nanostructures**;

Apart from its formal executive structure in research laboratories, in IMT-Bucharest are active two centers:

- **MIMOMEMS: European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems; Project No 202897 financed (2008-2010) through the “Regional potential” part (REGPOT call 2007-1).** It has very strong links (including exchange of researchers) by twinning with two important research centers in Europe: CNRS LAAS Toulouse and IESL FORTH Heraklion.

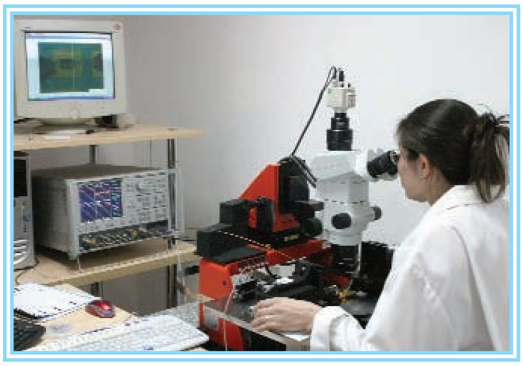
- **CNT-IMT: Centre of NanoTechnologies**, under the aegis of the **Romanian Academy of Sciences**, which is an interdisciplinary group, coupling activities in nanostructuring and nano-characterization of some research labs from IMT. Starting January 2009, the Centre of NanoTechnologies CNT-IMT is extending his activities becoming an interdisciplinary centre offering a variety of scientific and technological services in the nanotechnology field

We present first the two centers and several examples of **IMT competences** in ***design/fabrication and characterization of microsensors and microsystems***.

***Scientific competences*** presented in this brochure are demonstrated also by the **ISI publications,** see details on **http://www.imt.ro/news**

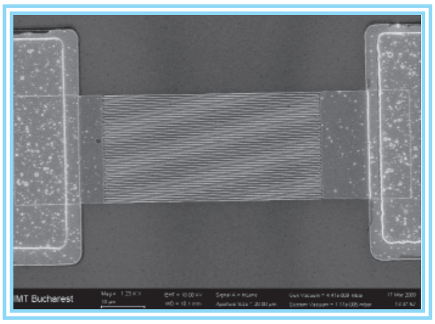
## European Centre of Excellence MIMOMEMS

**The overall aim** of the **MIMOMEMS** project is **to bring the research activity in RF and Optical-MEMS at the IMT Bucharest to the highest European level**. Two laboratories from IMT Bucharest (the **Microwave and Millimeter Wave Laboratory and the Microphotonics Laboratory**) have joint their efforts to create this European Center of Excellence.

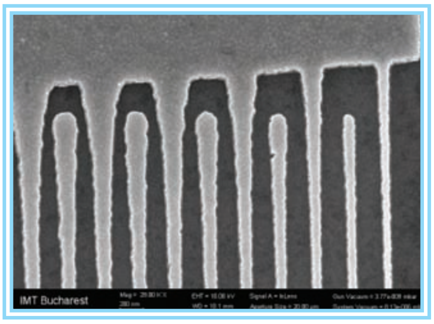


After the first year of the MIMOMEMS project, the **Scanning Near field Optical Microscope (SNOM)** the **up-grade to 110GHz of the existing 65 GHz set-up for "on wafer" millimetre wave characterization and the frequency generator up to 110 GHz** (presented in page 16) are already working. An ongoing project in the National Capacities program ("SIMCA", http://www.imt.ro/simca) has financed the **spectrum analyzer up to 110 GHz and a white light optical profilometer** working in the Microwave laboratory.

Other new facilities have been obtained recently in the frame of national programs by the technological department of IMT (a new MA6 /BA6 mask aligner, a laser pattern generator, a thin film deposition system a RIE machine) and by the characterization department (the E-line Nano-engineering workstation from Raith), a high performance SEM an XRD equipment, a SPM equipment. All this equipments are included in the new facility MINAFAB recently inaugurated by IMT, as a center of research and services in micro and nanosystem fabrication and characterization in a new clean room environment.

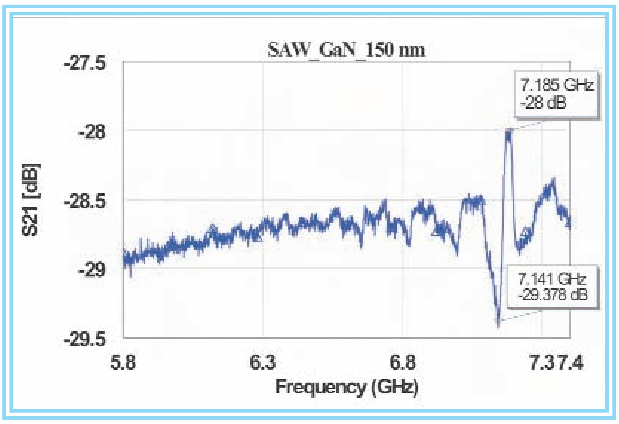



**The technical and scientific objectives** supported by the **MIMOMEMS** project are: • millimeter wave receiving modules based on silicon and GaAs micromachining;
• millimeter wave reconfigurable filters;
• acoustic devices for GHz applications based on GaN/Si and AlN/Si micromachining and nanoprocessing;
• Polymer-based micro-photonic devices;
• Sub-wavelength photonic structures;




**SAW structure manufactured on GaN/Si having the resonance at 7 GHz**

**A new SAW structure** manufactured on GaN/Si having the resonance at 7GHz. *The structure was manufactured in cooperation by IMT and FORTH with the support of the MIMOMES project*. Nanolithography was performed at IMT-Bucharest.




**First acoustic devices operating at frequencies higher then 7GHz, based on GaN/Si processing developed for the first time in the world by IMT- Bucharest in cooperation with FORTH Heraklion**

**The first workshop** devoted to the **MIMOMEMS** project took place in October 2008. The second one (a strategic workshop in MEMS for applications in microwave and optical devices took place in October 2009 during the Annual Semiconductor Conference of IMT (**CAS 2009**) (http://www.imt.ro/cas)

**Research equipments:**

• **Microwave network analyzer** (0.04-65 GHz) with Manual Probing Station-Lightning 37397D VNA/Anritsu; PM5/Suss MicroTec (Anritsu, Japan; Suss MicroTec, Germany);
• **Wafer Probing Station** - Easyprobe EP4 (Suss MicroTec, Germany);
• **White Light Interferometer** - Photomap 3D (FOGALE nanotech, France);
• **Scanning Near-field Optical Microscope** - Witec alpha 300S (Witec, Germany);

**Contact person: Dr Alexandru Muller**, alexandru.muller@imt.ro.

## Centre for Nanotechnologies CNT-IMT

The **Centre for Nanotechnologies** was represented before 2009 by a single laboratory **"Laboratory for Nanotechnology"** functioning as a centre of excellence under the aegis of the Romanian Academy. Now the centre joined the activity of the following laboratories:

- ***Laboratory of Nanotechnology;***
- ***Laboratory for Nanoscale structuring and characterization;***
- ***Laboratory for Molecular nanotechnology;***
- ***Dip pen nanolithography Laboratory;***
- ***Laboratory for scientific services (will contribute to some extent);***

The main **specific activities** of the centre consist in: • correlation of R&D activities and services of the laboratories involved, also offering technical and financial support; • dissemination of the common offer towards potential partners and beneficiaries outside IMT-Bucharest;

These laboratories **offer state of the art facilities/equipments** concentrated in the **technological area** in the form of experimental laboratories:

### Grey Area

#### Laboratory of Nanotechnology:

- ***Experimental laboratory for "Microarrays"*** – NanoBioLab
- ***Experimental laboratory for surface spectroscopy***
- ***Experimental laboratory for X-Rays diffraction***
- ***Experimental laboratory for nanoparticles***

#### Laboratory for nanoscale structuring and characterization

- ***Experimental laboratory for Electron Beam Lithography (EBL)/Scanning electron Microscopy Laboratory (SEM)*** – NanoScaleLab

- ***Experimental laboratory for e-line work station***
- ***Experimental laboratory for SEM/FEG***
- ***Experimental laboratory for SPM***

#### Laboratory for molecular nanotechnology

- ***Experimental laboratory for nanofluidics***

### Clean room area

- ***Dip pen nanolithography Laboratory***

# IMT-Bucharest competences in design/fabrication and characterization of microsensors and microsystems

## ▶ Optoelectronic and micro/nano-photonics expertise

Research and development activities are focused on the development of micro/nano structures based on new materials and processes and photonic integrated circuits based on heterogeneous integration technology; development of materials, technologies and components for optical MEMS.

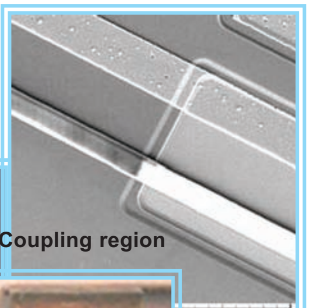
### Main areas of expertise:

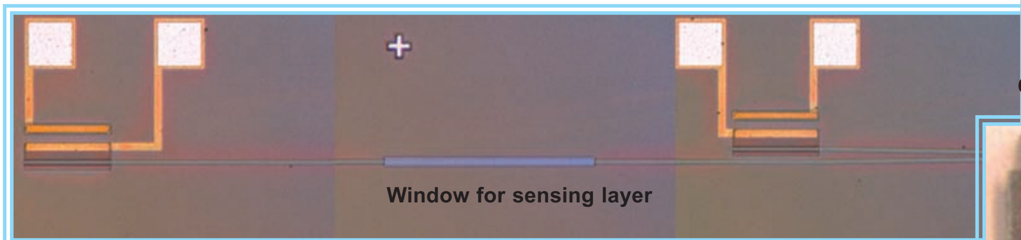
• **modeling and simulation** of micro and nano photonic structures; development of simulation tools;
• **new materials for micro/nano opto-electromechanical systems integration** (e.g. compound semiconductors, functional polymer, hybrid organicinorganic nano-composites and glasses), and related fabrication processes (including mixed technologies);
• **passive and active micro- nano- photonic structures**;
• **hybrid or monolithic integrated photonic circuits and MOEMS** (including heterogeneous platforms) for optical communications, interconnects and optical signal processing;
• **micro-optics design and fabrication** based on replication techniques;
• **optical and electrical characterization** of materials and devices;

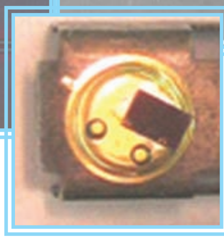
## RESULTS

### ▶ Integrated Polymer Chip for biophotonics.

The optical coupling waveguide- photodiode is obtained with a grating realized in the bottom cladding of the waveguide (pitch 4 μm). The coupling efficiency depends on the refractive index of the surrounding media.
**Applications:** ***chemo and biosensors***.





**SU-8 waveguide coupled with a silicon photodiode by leaky waves**

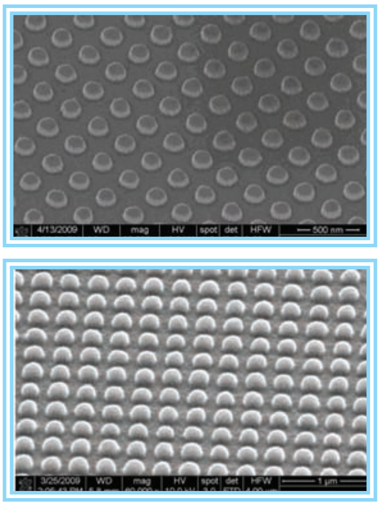
***Partnership in European project***: Multi-Material Micro Manufacture Technologies and Applications (**4M http://www.4m.net**), FP6 NoE, Co-operation with Institute for Microstructure, 2005-2008.

**Contact Person: Dr. Dana Cristea,** dana.cristea@imt.ro;

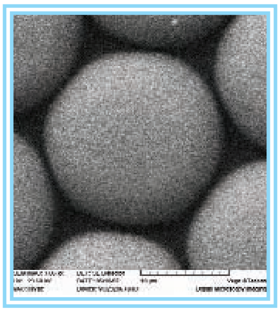
### ▶ Replication techniques for micro and nano-optical components

(Development of replica molding techniques for replication of optical elements and microfluidic structures with feature size in the micron and submicron range). New non-photolithographic techniques known as soft lithography have been improved and developed. These techniques including replica molding (REM), micro-transfer molding (TM), micro-molding in capillaries (MIMIC), solvent-assisted micro-contact molding (SAMIM), micro-contact printing (CP) in combination with micromachining of silicon and embossing of thermoplastic were used in microfabrication of the components for MEMS/MOEMS.

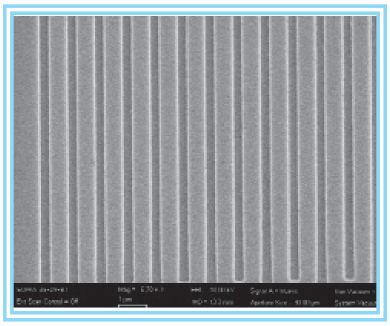
**Various masters (silicon, silicon oxide, AZ, SU-8 or PMMA) were replicated in polymers** and the molding and demolding parameters required for the fabrication of micro/nano photonic structures were established. The molds were fabricated in PDMD and the replicas were obtained in epoxy resin and acrylic polymers in different coating and curing conditions. **Diffraction gratings and microchannels with potential applications in microfluidics were obtained**



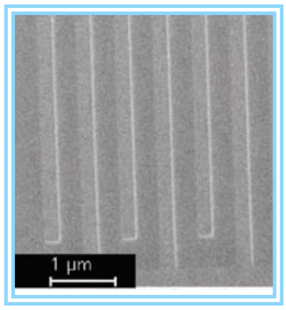
**Lenses in epoxy resin obtained by replica molding with a master obtained by EBL in a thin layer of PMMA 950K layer (top); double PMMA layer (ϕ~150nm, h~200-300nm).**



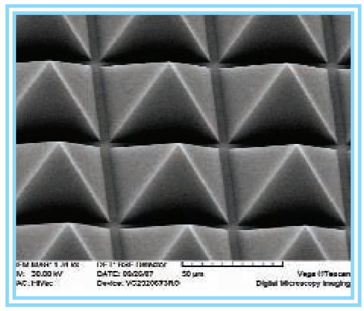
Microlens (epoxi)
ϕ = 20 μm



Diffraction grating line 8 μm




Microfluidic channels in PDMS width~250 nm



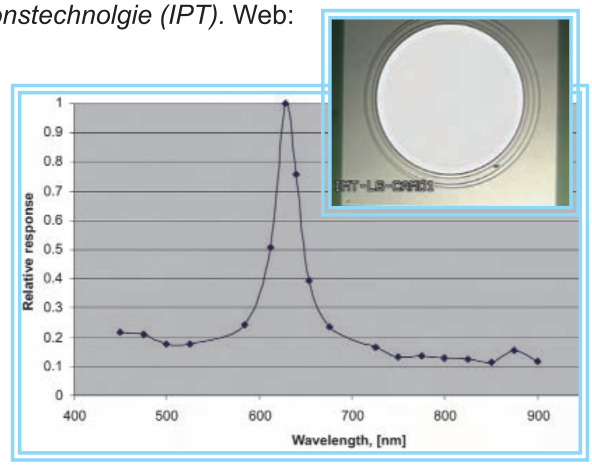
SEM image of the replicated DOEin: PMMA.

**in PDMS and epoxy resin** with feature size in the range 5-200μm. PMMA master obtained by electron beam lithography (**EBL**) was used to obtain the gratings or the channels **with sub-micron feature size in PDMS and epoxy resin**. Also, PMMA master was used to obtain the dots (150 nm feature size). Antireflective layers (micro-pyramids) with feature size in the range 40-150μm) were obtained by using silicon dioxide/silicon based master prepared by optical lithography followed by silicon anisotropic etching.

***Partnership in European project***: **FLEXPAET -** Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology (IP- FP7/NMP) 2008-2010; *Coordinator: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. Fraunhofer Institut für Produktionstechnolgie (IPT).* Web: http://www.e-squizoide.com/flexpaet/project.php

**Contact Person: Chem. Paula Obreja,** paula.obreja@imt.ro;

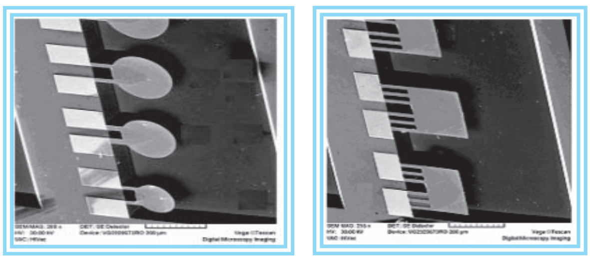
▶ **Multilayer structures with controlled optical properties:** Photodetector with selective spectral response was fabricated by integration of a multilayer structure with controlled optical properties with a silicon PIN photodiode with an active area of 0.6mm$^2$ fabricated by silicon planar technology. Multilayer structure onsists in semitransparent metallic films and dielectric layer with controlled thickness.




Optical microscope image of the structure.
Relative spectral response of the structure.

**Contact Person: Dr. Dana Cristea**, dana.cristea@imt.ro.

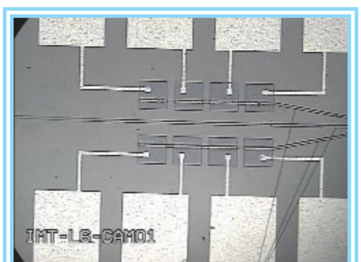
▶ **Micromirrors** with different geometry were obtained on silicon or SOI substrates by wet etching, RIE, thermal oxidation, lithography and metal deposition by vacumm evaporation technique.



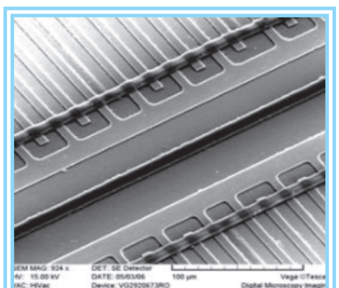
SEM image of micromirrors with circular and rectangular geometry obtained on Si substrates

**Contact person: Dr. Munizer Purica**, munizer.purica@imt.ro.

▶ **Optical microsensors** which can function as positioning sensor detecting the position of an object placed on his axis in 0-300μm domain and as proximity sensor. In the second case it can find out the presence of very small objects, in a predefined area, without measuring the distance between the sensor and the object. These configurations were composed of 2 different types of photodetectors: PIN and Schottky Metal-Semi-conductor-Metal (MSM) photodiodes both integrated with SU-8 optical waveguides. The breakdown voltage was greater than 90V at 100μA and a dark current less than 0.02 nA at 5V reverse bias, was measured. The device has a very good rectifying characteristic with low absolute leakage current. A responsivity of 0.39A/W for 630 nm wavelength and 20V bias was obtained.




Optical microscope image of the linear photodetector arrays integrated with SU8 optical waveguides

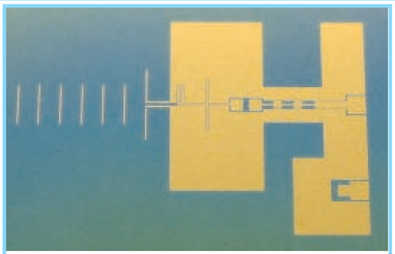


Detail of the MSM photodiode (interdigitated structure integrated with the SU-8 optical guide)

**Contact persons: Dr. Raluca Muller**, raluca.muller@imt.ro.
**Phys. Elena Budianu**, elena.budianu@imt.ro

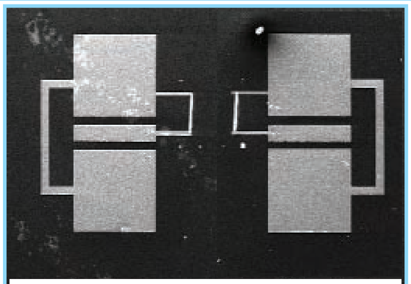
## ▶ RF MEMS

**Main area expertise:** • **Development of a new generation of circuits** devoted to the millimeter wave communications based on the semiconductor (Si, GaAs, GaN) micromachining and nanoprocessing materials; • **Design and manufacturing of passive circuits elements**, monolithically and hybrid integrated receiver front-ends based on silicon and GaAs micromachining; • **Acoustic devices (FBARs and SAWs)** based on micromachining and nanoprocessing of wide band gap semiconductors (AlN, GaN); • **Microwave devices based on carbon nanotubes**; • **Microwave devices using CRLH materials** (metamaterials); • **MEMS and NEMS technologies developement**;



Optical photo of the 77 GHz receiver structure micromachined on a $SiO_2/Si_3N_4$ membrane

▶ **77 GHz millimeter wave receiver module** based on the hybrid integration of a $SiO_2/Si_3N_4$ membrane supported Yagi-Uda antenna with GaAs Schottky detector diode. Design, modeling and manufacturing of 77GHz silicon micromachined receiver structures. The design procedure, the technological processing and characterization techniques open a window of opportunity for the development of innovative architectures for circuits and systems operating at higher frequency, up to the sub-millimetre wave frequency range. The membrane supported millimeter wave receiver operating in the 60GHz frequency range was and characterized. The receiver structure is based on the hybrid integration of a Yagi-Uda antenna with a Schottky diode, the antenna having as support a 1.5 $\mu$m thin $SiO_2/Si_3N_4$ dielectric membrane. Results obtained in the frame of "**ACOMEMS** Integrated RF-MEMS circuits based on silicon, gallium arsenide and wide band gap semiconductors for advanced communication systems", CEEX Project (2005-2008). Web: http://www.imt.ro/acomems

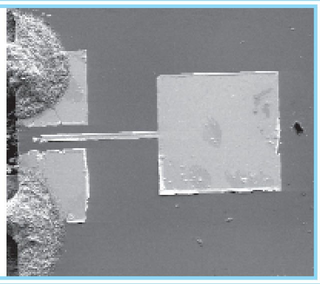


Two experimental SAW structures with the two IDTs placed “face to face”

▶ **Wide band gap semiconductor SAW type devices for GHz applications**, manufactured using nanolithographic techniques. A SAW structure for an operating frequency of about 2.8GHz was successfully developed on a thin AlN layer sputtered on high resistivity silicon. The structures were obtained with the support of the *Nanoscale-Conv* Project (Nr 6111/2005-CALIST). Experiments to develop SAW structures with operating frequencies in the GHz range were performed on AlN and GaN thin films with nano-metric lines for an interdigitated transducer (IDT). After the nanolithography there were obtained some very good quality inerdigitated Ti/Au structures (with 30 digits and 29 interdigits 300nm wide, 220nm high and 200$\mu$m long). Lift-off techniques to remove the undesired metal were used. On wafer microwave measurements of the SAW structure have demonstrated its functionality. It was evidenced a pronounced resonance at about 2.8GHz. Results obtained in the frame of "**ACOMEMS”** Project.

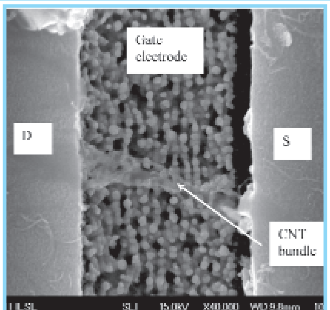
▶ **GaN based resonator on high resistivity** <111> silicon substrate for operation around 1.2 GHz has been fabricated using micromachining techniques. **Resonator structures** of this type can be used as building blocks for the fabrication of high Q and wide bandwidth filters, for use in reconfigurable front-ends of various **mobile and wireless applications**. Results obtained in the frame of "**ACOMEMS”** Project.

**SEM photo (top side) of the GaN membrane supported F-BAR structure.** The silver epoxy on the left side is used in order to provide a connection of the ground electrode to the bottom metallization of the FBAR membrane and allow measurements with GSG probes



**Contact person: Dr. Alexandru Muller**, alexandru.muller@imt.ro;

▶ **Nanoelectronics based carbon nanotubes.** The design of test structures for CNT characterization, experiments regarding CNT manipulation of CNT and dc characterization technological implementation of the microwave test structures were succesfully performed. ***Achievements:*** the interconnection of a CNT bundle over a dielectric trench. Results obtained in the frame of the PN II Project "Nanoelectronic devices for high frequencies based on carbon nanostructures for communications and environment monitoring" (2007-2010). Web http//:www.imt.ro/nano-hf

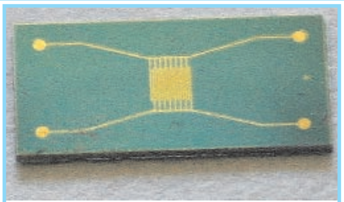



A FET-like configuration based CNT

**Contact person: Dr. Mircea Dragoman**, mircea.dragoman@imt.ro;

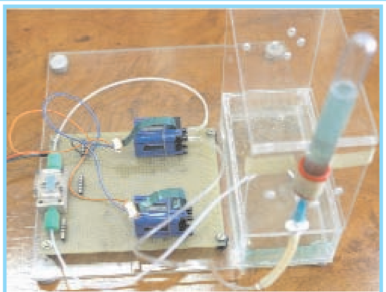
# MICROSENSORS

**Main area expertise:** • **Sensors:** chemoresistive, resonant gas sensors, accelerometers, microarrays, ISFET (Ion Sensitive Field Effect Transistors) sensors, electrodes for biological sensors, microprobes for recording of electrical activity of cells and tissues; • **Materials development for sensors and packaging;**


Silicon chip based on interdigitated electrodes

## Microfluidic Pesticide Biosensor:

• based on silicon chip and acetylcholinesterase biomaterial.
• sensitivity is in the range of $10^{-9}$M-$10^{-6}$M.
• is reacting at organophosporus compounds that can be found in food, water, drugs, soil, vegetables, fruits.
• is fast and the overall preparation and measuring operation can be done in less of ˝ hour.


Silicon biochip into the microfluidic module, pumps and reservoirs

The biosensor is placed into the microfluidic module which allows the preparation of the sensor by injection of the electrolyte, the introduction of the sample and the electrical signal recording by using 4 spring probes connecting the biosensor pads with the measuring instruments. ***IMT is offering** the silicon chip, the electrolytes and the specifications for sensor preparation and measuring.* The sensor is a consumable one and needs to be removed after every detection step. According to customers requests the pH and temperature can be monitored inside the microchannels. A pH and a temperature sensor will be placed close to biosensor side. EPIGEM is offering the microfluidic module hosting the silicon biochip. According to customer requirements, a heating module can be developed, for keeping the sensor at 370C during its life time. ***IMT is offering** the pesticide sensor, the Labview interface, the heating module and the microelectronics module for signal conditioning. The measurements will be computer controlled and data acquisition can be achieved.* The silicon chip is based on interdigitated electrodes 6x12mm which are deposited with *acetylcholinesterase* enzyme.

• Partnership in **"INTEGRAMplus"** - Multi-domain platforms for integrated micro-nano technology systems, IP, Priority 2 -IST, Contract no.: 027540 (2006-2008), Coordinator: QinetiQ Ltd, UK. IMT position: partner; Project web: http://www.integramplus.com/
• Results obtained also in the frame of the project: "Miniaturized immunosensor arrays technology, for herbicide detection" **IMUNOSENSE**, PNII national project. Web: http://www.imt.ro/imunosense/

**Contact Person: Dr. Carmen Moldovan**, carmen.moldovan@imt.ro

## Integrated microfluidic system for advanced in vitro biochemical analysis for diagnostic and treatment in medical applications

The microfluidic device incorporates a sampling, dispensing and delivering system for magnetic marked biomolecules or with intrinsic magnetic properties, and it consists of two main modules. ***The first module contains***: a rotary viscosimeter, for viscosity measurements; microchannels with input and output reservoirs for fluid transport and a microfluidic platform that can trap, measure, manipulate and sort magnetic marked biomolecules in an array of magnetophoretic spin valves. ***The second module** is the detection and measurement magnetoelectronic system* consisting of a double Wheatstone bridge with four sensing GMR resistors and four reference shielded GMR resistors. This magnetic microsystem could detect the presence of bioparticles or microbeads. These microdevices enjoy the advantage of being compatible with silicon IC fabrication technology. It is possible to build an array of GMR sensing elements that can simultaneously tests multiple biological molecules. The originality consists of extracting information regarding molecular interactions and rheological properties of the biological non - Newtonian fluids from a single microsystem.

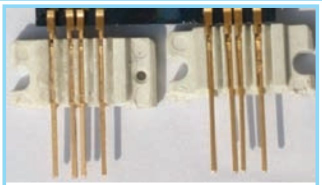
• Results obtained also in the frame of the project: **MICRO-DIAG** - Integrated Microfluidic Systems for Advanced in vitro Biochemical Analysis for Diagnostic and Treatment in Medical Applications/ Sistem microfluidic integrat pentru analiza in vitro a fluidelor biologice cu aplicatii in diagnoza si tratament medical, 2005-2008, Web http://www.imt.ro/Microdiag/

**Contact Person: Dr. Marioara Avram**, marioara.avram@imt.ro

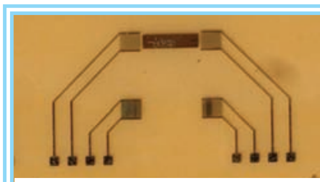
**Microsensor: New technology for microbiosensors** for real time detecting and monitoring tuberculosis.

• Differential SAW piezoelectric microsensor development with lay-out designed to increase sensitivity and selectivity;
• Processing of the tantalate and langasite substrates;
• Microsensors assembly using reusable support;

Results obtained in the frame of the project **MICROBALERT**-"New technologies for achieving microbiosensors for real time detecting and monitoring tuberculosis in groups with increased risk potential", CEEX 2006-2008. Web: http://www.imt.ro/microbalert



**Type of connectors proposed for sensors**

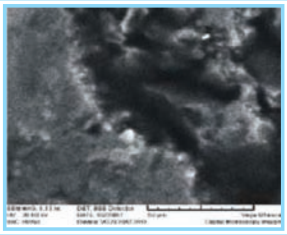


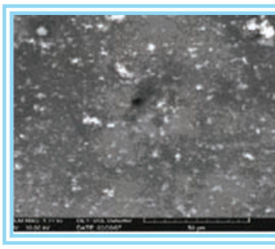
**Sensor for detection of TB on langasite substrate**

**Materials and Packaging: New materials and micro/nanosensors technologies development**

⇨ **Advanced nanocomposites materials** used in civil construction with antibacterial properties for ambiental improvement. It has been developed a new construction material, a "smart wall", from composites cement-wood. Thin polymeric composites films with oxide nanopowders content (having antibacterial, antistatic tailored proprieties) and solar concentrators were applied.

Results obtained in the frame of the project **NANOAMBIENT** Advanced Nanocomposites materials used in civil constructions with antibacterial, selfcleaning properties and solar energy concentrators integrated structures for ambiental improvement (http:www.imt.ro/nanoambient).



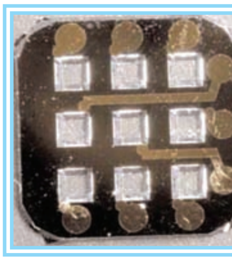


**1 Cement-wood composite substrate**
**2 Polymeric films with doped nanopowder**

**Contact Person: Ileana Cernica**, ileana.cernica@imt.ro.

⇨ **New MCM packaging technique for PIN microdetectors matrix** with improved technological processes for optimized performances in transmission and direct coupling to the optical cable.

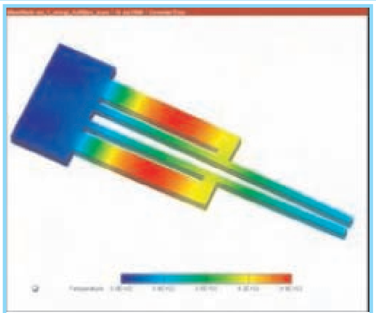
***Characteristics:*** • a silicon wafer used for PIN detectors assembly;
• optimized 2 masks technology;
• two steps anisotropic silicon etching for lowering the roughtness;
• 50µm thick bronze-beryllium support used as ground palne for the micromatrix and also for configure the external pin connection of the micromatrix.



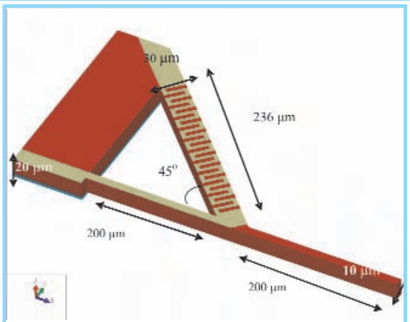
**Contact Person: Ileana Cernica**, ileana.cernica@imt.ro.

## Simulation/modelling competences

**Design:** A new design was developed for a polymeric microgripper, which can realize a movement of the gripping arms with possibility for positioning and manipulating of the gripped object. Two models of the microgripper, electro-thermo-mechanical actuated, using low actuation voltages, designed for SU-8 polymer fabrication were investigated and compared. Finite-element analyses (FEM), using COVENTOR-WARE 2008 tool, were performed in order to evaluate the relation between the displacement, temperatures and the electrical current passing through the metallic layers.



Maximal values of the temperatures in the microgripper when a voltage of 0.25 V is applied-simulation with CoventorWare tool

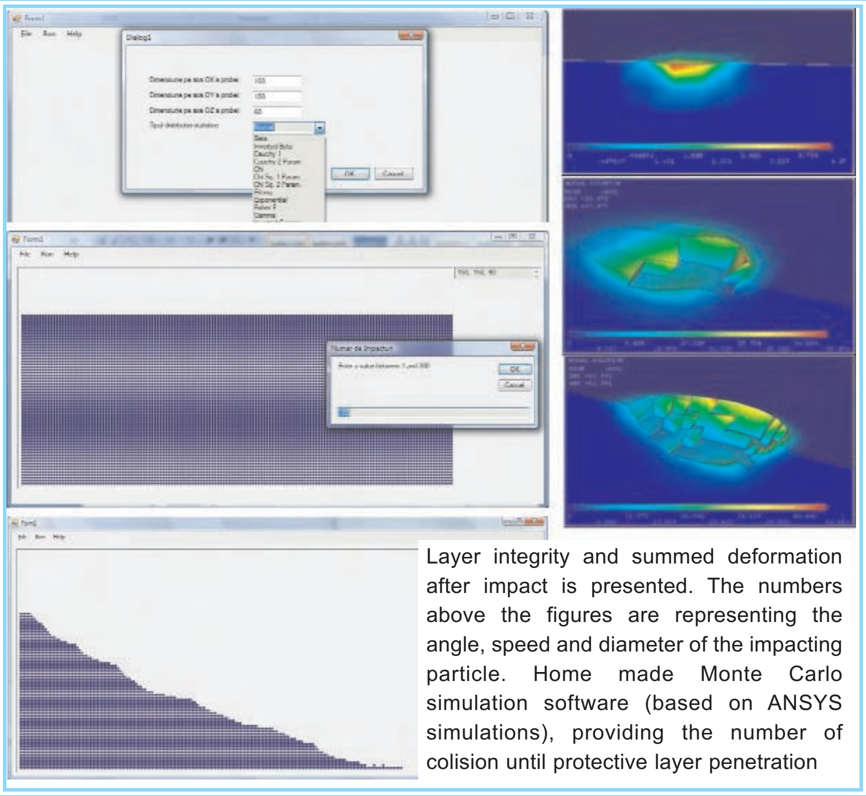



Design of the half of microgripper model without the SU-8 layer on the 0.25V is applied- simulation with CoventorWare tool

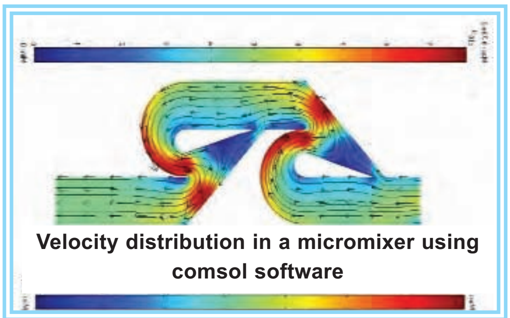
**Contact person: Mat. Rodica Voicu**, rodica.voicu@imt.ro

**Simulation:** New materials need to be used in industrial fields by providing protection against harsh environments (high temperature, aggressive chemical agents, abrasion, thermal and mechanical shocks, etc.). Simulations regarding the protective layer behaviour in contact with different types of aggressive agents were performed. Due to the complexity of the problem, the software used was ANSYS Multiphysics 11.0.

**Contact person Victor Moagar-Poldian**, victor.moagar@imt.ro



Layer integrity and summed deformation after impact is presented. The numbers above the figures are representing the angle, speed and diameter of the impacting particle. Home made Monte Carlo simulation software (based on ANSYS simulations), providing the number of colision until protective layer penetration



Velocity distribution in a micromixer using comsol software

**Computer aided design for microfluidic components**

The project scope was to develop new design of microfluidic components, particularly micromixers.

**Results:** Micromixers have been designed simulated and fabricated microfabricated in polymer (SU-8)

**Contact persons: Mat. Irina Stanciu**, irina.stanciu@imt.ro;
**Mat. Oana Tatiana Nedelcu**, oana.nedelcu@imt.ro.

# IMT-Bucharest competences in Nanotechnology

**Nanotechnologies** are the most advanced technologies with huge applications in biology, electronics or medicine. Nanonstructured materials such as silicon, nanoparticles, nanowires or nanotubes are used for biomedical sensors, harvesting, or fuel cells. Self assembly techniques and other molecular technologies are used in DNA recognition and detection or other medical diagnosis. The nanotechnologies which are developing such advanced applications are backed by very advanced equipments for processing and characterization such as AFM, STM, or electron beam microscopy and processing. The design, chemistry for nanomaterials, characterization and processing tools are gathered together in the **CNT-IMT Center for Nanotechnologies** which is affiliated at Romanian Academy.

## ▶ Functional NANOMATERIALS

The functional nanomaterals are mainly represented by ***nanostructured silicon*** based or composite materials, from preparation to surface functionalisation and integration in complex systems. As example the nano-, mezo- and macro- ***porous silicon*** (PS) layers or membranes, nanostructured microparticles and nanowires were extensively investigated for their interesting optical, electrical and bioactive properties and different applications in biosensing, nanomedicine (drug delivery carriers), or ***fuel cell membranes***. **Nanoparticles** - *metallic (Au, Ag, Pt, Ru, Pd, Fe) and dielectric ($SiO_2$, $TiO_2$)* nanoparticles prepared by (electro) chemical processes for applications in field sensors, photonics and electrocathalysis.

### ▶ Protein Biosensor based on Electrochemical Impedance Spectroscopy as Detection Method

The design of biosensor has to include: (i) the transducer for conversion and amplification of the biochemical reaction product into a recognizable, (ii) the matrix for the immobilization of a biomolecule and (iii) the bio-recognition element for analyte recognition. Recently, it has becoming increasingly important to control the organization of self-assembled monolayers (SAMs) of functionalized thiols and to bind various proteins on gold/silicon substrates for their potential integration in nanoscale sensors/biosensors and optical devices. In this context, utilization of the self-assembled monolayers (SAMs) a s matrices provides a simple route to functionalize metallic surfaces by organic molecules (thiols with free anchor groups) and allows oriented immobilization of signal biomolecules on a transducer surface.

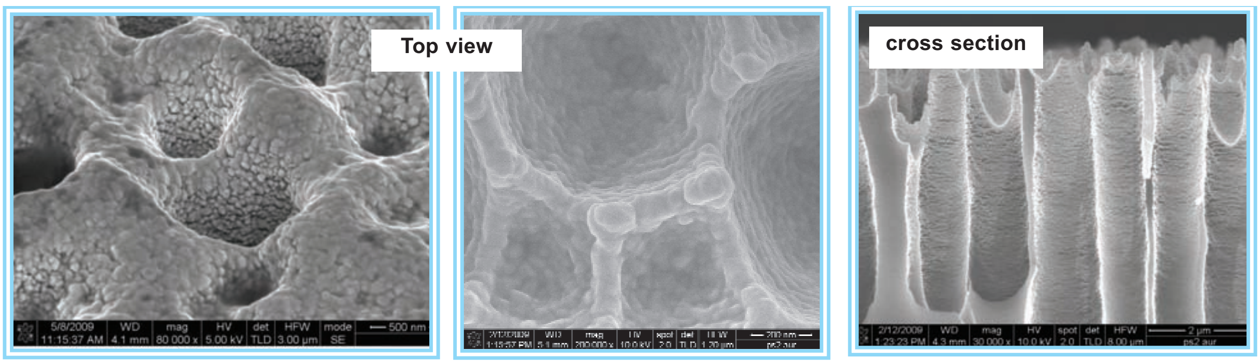
***Principle of detection:*** when a target biomolecule interacts with a probe-functionalised surface, changes in the electrical properties of the surface, as dielectric constant or resistance, take place leading to modification of the electrode – solution interface impedance.

Based on the promising results obtained using PS as a transducer converting of specific molecular recognition events into either an optical or electrical signal, we have developed different metal-silicon nanoanssamblies and we have studied the nature of changes induced in detection. Both optical and electrochemical analyses have demonstrated that fabrication of hybrid nanoassemblies leads to the properties merging from both semiconductor and noble metal nanostructures and therefore to new transducers with enhanced sensitivity by means of signal amplification.

• the effect of Surface Enhanced Raman Scattering (SERS) has been revealed being an useful technique resulting in strongly increased Raman signals from molecules, which have been attached to nanometer scale metallic structure and allows to probe individual molecules.

• as impedimetric sensor, the detection is based on the capacity of metallic nanoparticles (MeNPs) to act as nanoelectrode array enhancing the surface available for interaction with analyte molecules; on the other hand, compared with non-metallic sensing surfaces, the metal acts also as electrocatalyst and determines the reaction electrocatalysis to enhance the impedimetric detection.

**PVD - Au on macroPS/p -Si (100) substrate electrochemical macroporous p-type silicon substrate covered with gold layer.**
**SEM images of 100nm Au covered macro PS substrate**



***Equipments***: Electrochemical Impedance Spectrometer PARSTAT 2273 – Princeton Applied Research; Scanning Electrochemical Microscope (SECM), VOLTALAB10 and Trace Master 5; Rigaku SmartLab X-ray thin film diffraction system; DelsaNano Zeta Potential and Submicron Particle Size Analyzer and Fluorescence Spectrometer; AMMT wet etching system; High Resolution Raman Spectrometer (LABRAM HR800).

**Results** obtained in the frame of the projects: • Study of silicon-protein type biohybride nanostructured surfaces with applications in bio(nano)sensing, Financed by the National University Research Council (2007- 2010);
• Silicon based multifunctional nanoparticles for cancer therapy (NANOSIC), PNCDI Program (2007- 2010); Web http://www.imt.ro/nanosic

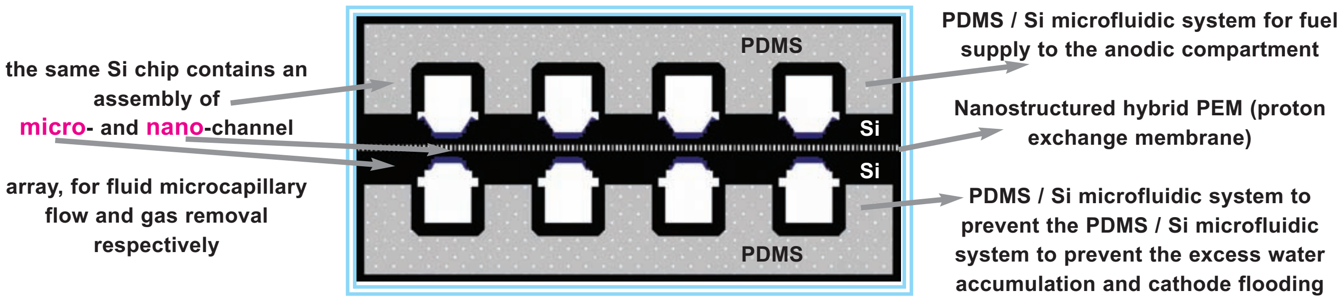
**Contact persons: Dr. Irina Kleps** (irina.kleps@imt.ro), **Chem. Teodora Ignat** (teodora.ignat@imt.ro)

### ▶ (N)MEMS technology for miniaturized direct methanol fuel cell (DMFC) hybrid device

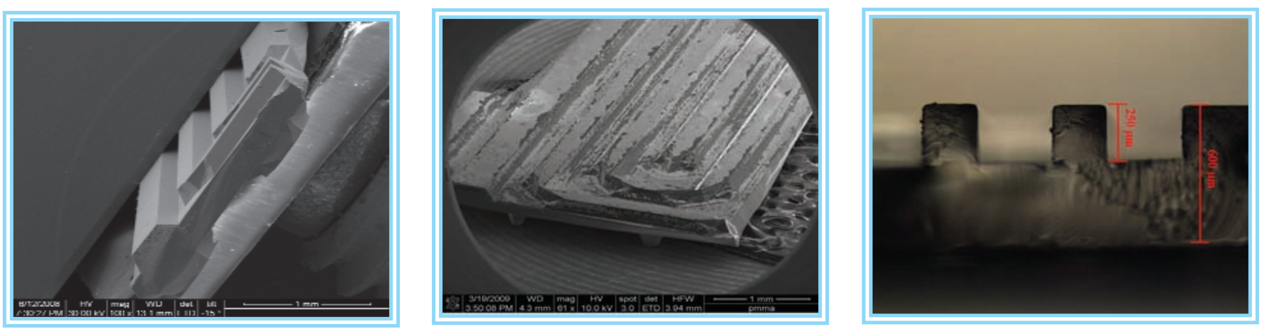
Since the 1990s, the direct methanol fuel cell (DMFC) has gained importance mainly because of its potential for direct utilization of methanol,which is a low-cost, renewable liquid fuel, without the need for reforming; in addition, the operation takes place at ambient temperatures, with high energy density and lower ecologically harmless $CO_2$ emissions. The standard design of fuel cell comprises an anode part, a cathode part and a proton exchange nanomembrane sandwiched in between the anode and the cathode, usually built on 2D geometries and assembled into 3D shapes. It is proposed the development of fabrication technology to achieve 3D device architectures at the micrometer-scale, to increase the total area of reactive surfaces per unit volume without increasing the footprint area.

*Integrated fuel cell hybrid system, as a 3D assembly, using specific processes from MEMS technology-miniaturised direct methanol fuel cell (micro-DMFC)*

- the channels width is 300µm;
- the distance between them (the rib structure) is 250µm;
- the 2x 2mm square inlet /outlet and corresponding through-holes for feed at ends.




The Si component device contains, besides the microfluidic system replica, the porous multilayer for microcapillary passively guiding of fuel/water and the nanostructurated layer for gas removal obtained by Si selective electrochemical etching (porosification)



**The Si component device contains, besides the microfluidic system replica, the porous multilayer for microcapillary passively guiding of fuel / water and the nanostructurated layer for gas removal obtained by Si selective electrochemical etching (porosification)**

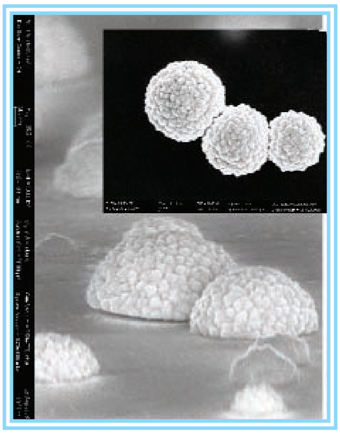
**Equipments:** Electrochemical Impedance Spectrometer PARSTAT 2273 – Princeton Applied Research; Scanning Electrochemical Microscope (SECM), VOLTALAB10 and Trace Master 5; Rigaku SmartLab X-ray thin film diffraction system; DelsaNano Zeta Potential and Submicron Particle Size Analyzer and Fluorescence Spectrometer; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system; computers for simulation; instruments and software for electrical characterisation of nanostructures. AMMT wet etching system.

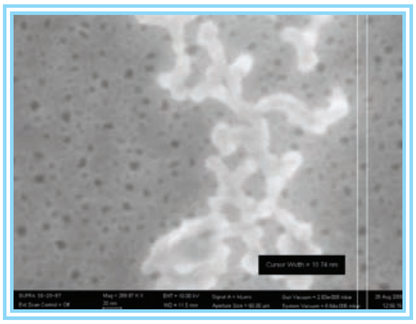
**Results** obtained in the frame of the projects: • Study of membrane - electro-catalyst nanocomposite assemblies on silicon for fuel cell application; Financed by the National University Research Council (2007- 2010);
• Miniaturised power source for portable electronics realised by 3d assembling of complex hybrid micro- and nanosystems (MINASEP); PNCDI Program (2007- 2010); Web: http://www.imt.ro/minasep

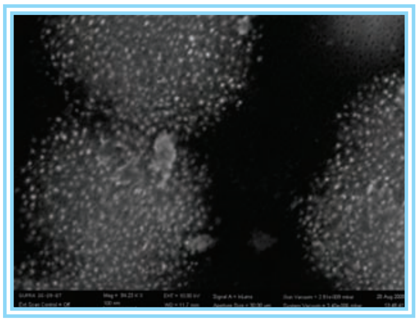
**Contact Person: Dr. Mihaela Miu**, mihaela.miu@imt.ro

## ▶ Electrocatalytic activity of Pt and Pt-alloy nanoparticles

***The general context:*** The proton exchange membrane (PEM)/electro-catalyst assembly represents the central compartment of the miniaturized fuel cell, where the electrochemical reactions take place, and also the produced ionic charges are conducted between the electrodes and thereby complete the cell electric circuit. A new metallic-semiconductor nanosystem on Si has been studied for potential integration in a micro fuel cell as membrane electrode assembly (MEA) using specific processes to nano- micro-electromechanical system (N/MEMS) technology. Silicon membrane has been subjected to an electrochemical process which determines the porosification/nanostructuring and consequently the increase of the geometry surface area and the density of chemically active sites. Si membrane morphology depends on process parameters, and the pores diameter can be tuned from nm to µm.







Pt nanoparticles/Porous silicon (PS). A Pt precursor solution (3.5mM $H_2PtCl_6$) was used for chemical impregnation. Also mixture of Pt and Au, Pt and Fe solutions have been used.

**Equipments:** Electrochemical Impedance Spectrometer PARSTAT 2273 – Princeton Applied Research; Scanning Electrochemical Microscope (SECM), VOLTALAB10 and Trace Master 5; Rigaku SmartLab X-ray thin film diffraction system; DelsaNano Zeta Potential and Submicron Particle Size Analyzer and Fluorescence Spectrometer; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system; computers for simulation; instruments and software for electrical characterisation of nanostructures.

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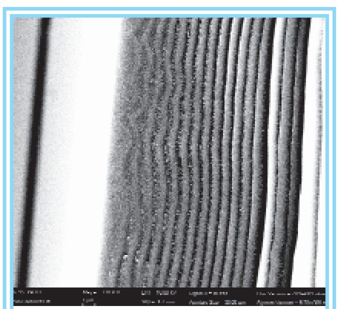
• Silicon based multifunctional nanoparticles for cancer therapy (NANOSIC), PNCDI Program (2007- 2010); Web:http:www.imt.ro/nanosic

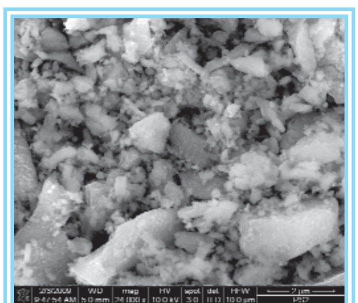
**Contact Person: Dr. Mihaela Miu** (mihaela.miu@imt.ro)

## ▶ Nanostructured microcarriers based on silicon for drug delivery

**The aim of this work** is to optimise the experimental conditions for nanostructured Si particles fabrication and to find the best methods for attaching on its surface cytotoxic molecules of therapeutic interest. In order to survey the biocompatibility of silicon, local and general tolerance on animals has been investigated. General tolerance was monitored by physiological aspects, weight gain, oxidative stress and biological markers. Macroscopic and histological examination of muscles and derma inoculation areas tissues were used as indexes of local tolerance.



PS multilayers obtained on p+ Si (top view and cross section)



Si microparticles with nano-porous structure obtained after wet ball mill treatment (1h)

*CONCLUSIONS:* Nanosilicon particles investigated as carriers for drug delivery are well tolerated by animal body. At molecular level, there were observed both amplifications of detoxification and of oxidative stress systems that represent normal responses to xenobiotics.

**Results** obtained in the frame of the project: • Silicon based multifunctional nanoparticles for cancer therapy (NANOSIC), PNCDI Program (2007- 2010); Web: http:www.imt.ro/nanosic

**Contact Person: Dr. Irina Kleps**, irina.kleps@imt.ro

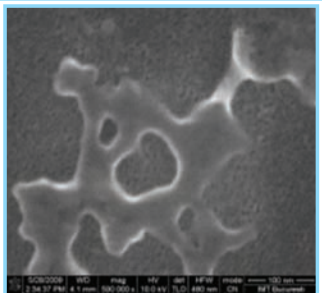
## Molecular-scale technologies

**Molecular-scale technologies:** functional interfaces between biological materials (from individual biomolecules to cells) and inorganic surfaces: molecular nanofabrication by *self-assembly* (thiols/Au) and *supramolecular systems* through self-organization concepts (polyelectrolyte multilayer membranes assembled by layer-by-layer technique); biosensing *core-shells NPs* (biotine/avidine/APTS/Au), *grafting of (bio)molecules* on various surfaces (protein or DNA/glass, Si, PS for biomolecular recognition) with applications in microarrays and immunologic sensors for medical diagnosis. Technologies/devices such as microarrays, biosensors for biological material investigation and detection (proteins, DNA, enzymes) are developed on various substrates (silicon, glass, polymers).

### CRP immobilization on nanostructured silicon

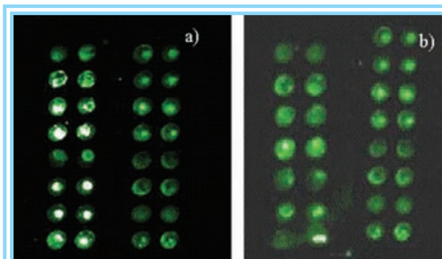
Protein microarrays have remarkably evolved in the last decade and became one of the main tools for proteomic studies. The porous surfaces have proven to be a very attractive substrate for protein microarrays, because they offer a three dimensional structure, thus enlarging proprieties and spot confinement.

Porous silicon substrate manufacture: Porous silicon (PS) layer was obtained by electrochemical etching of silicon p type substrate (100) crystallographic orientation with 5-10Ωcm resistively using HF electrolyte solution (1:1 in ethanol or water: ethanol) for 300s. SEM image presented as result two PS samples with pore size 10-20nm.



SEM image of PS onto which aCRP was immobilized

**Results:** The PS surfaces were used for the immobilization of two $Cy_3$ labelled CRP human antibodies: monoclonal rabbit (anti-mCRP) and polyclonal goat (anti-pCRP). Four different antibodies concentrations (between 0.75 mg/mL and 0.21875mg/mL, serial dilutions) were printed in various buffers (phosphate buffered saline (PBS), 0.25 M citrate in PBS, commercial printing buffer), using the same conditions of temperature and humidity. The slides were incubated overnight and thoroughly washed with PBS and deionized water.



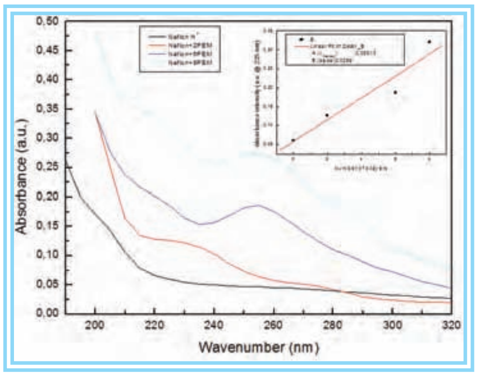

a) Solid pin size: 200 microns
Spot sizes: 200-200 microns, distance between spots 100 microns
d) Scanned image with immobilized fluorescent antibodies on the two PS surfaces

**Equipments:** Plotter microarray (GeneMachines OmniGrid Micro) and Scanner microarray (GeneTAC UC4); Electrochemical Impedance Spectrometer PARSTAT 2273-Princeton Applied Research; Scanning Electrochemical Microscope (SECM), VOLTALAB10 and Trace Master 5; Rigaku SmartLab X-ray thin film diffraction system; Fluorescence Spectrometer; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system; computers for simulation; instruments and software for electrical characterisation of nanostructures.

**Results** obtained in the frame of the project: • DNASIP - A "system-in-a-microfluidic package" approach for focused diagnostic DNA microchips. ERA – NET project; • Multi alergen biochip realised by microarray technology (MAMA), PNCDI Program (2007- 2010). Web: http://www.imt.ro/mama

**Contact Person: Phys. Monica Simion**, monica.simion@imt.ro

### ▶ Layer-by-layer deposition technique for hybrid nanostructures



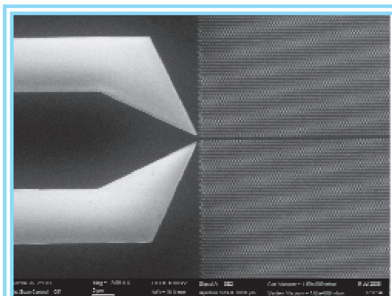

A new technique has been developed at IMT, layer-by-layer technology (LbL) based on deposition of electrically charged thin films. It consists in sequential absorption of positive and negative electrically charged species, called cationic and anionic polyelectrolytes, by alternative immersions into solutions of these polyelectrolytes. This technique relies on the electrostatic force of attraction assuring also a strong adhesion between the anionic and cationic layers. We prepared a multilayer polyelectrolyte film using Nafion 117 membrane as substrate and poly (sodium styrene sulfonate)-PSS, as polyanion and poly(diallyl dimethylammonium chloride)-PDDA, as polycation. The figure shows UV-vis spectra of the LbL self-assembled Nafion 117 membrane as a function of the number of PDDA-PSS bilayers. For PDDA-PSS multilayers although the absorbance peak at 225 nm was not shown clearly, the absorbance increased with an increased number of bilayers. Layer-by-layer technique can be used for surface modification and also, for fabrication of thin film devices-permitting multimaterial assemblies including proteins and colloids, with applications in anticorrosion, biocompatibility, fuel cell, biosensors, implants, optical waveguides, electroluminescent devices, microreactors.

**Equipments:** Electrochemical Impedance Spectrometer PARSTAT 2273-Princeton Applied Research; Scanning Electrochemical Microscope (SECM), VOLTALAB10 and Trace Master 5; Fluorescence Spectrometer; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system; computers for simulation; instruments and software for electrical characterisation of nanostructures.

**Results** obtained in the frame of the projects: • Silicon based multifunctional nanoparticles for cancer therapy (NANOSIC), PNCDI Program (2007- 2010); Web: http:www.imt.ro/nanosic;
• Study of membrane - electro-catalyst nanocomposite assemblies on silicon for fuel cell application. Financed by the National University Research Council (2007- 2010)

**Contact Person: Chem. Adina Bragaru**, adina.bragaru@imt.ro.

## ▶ Structuring at nanoscale



SEM photos of the experimental PC structures

▶ Using e-line EBL **nanoengineering workstation from RAITH**, which is a versatil equipment for nanolitography with specific requirements for interdisciplinary research (**EBID and EBIE**: electron beam induced deposition and etching) we can develop nanosale devices.

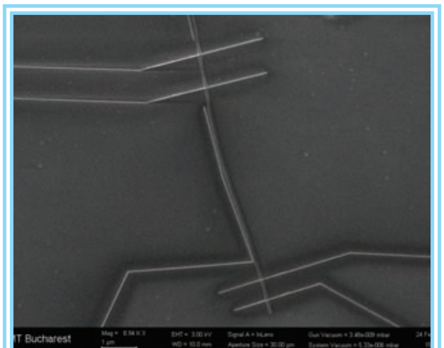
We have fabricated two-dimensional photonic crystals (PCs) obtained by direct patterning of positive PMMA electronoresist, using the **Electron-Beam Lithography** technique (EBL). The fabrication of the device was a challenge because we integrated the PC waveguide configuration with a taper optical waveguide on the same substrate.

**NANOSCALE-CONV** (2005-2008); Project type: PN II CEEX; No. 6111/2005
**Contact: Dr.Raluca Müller**, raluca.muller@imt.ro; **Phys. Adrian Dinescu**, adrian.dinescu@imt.ro.

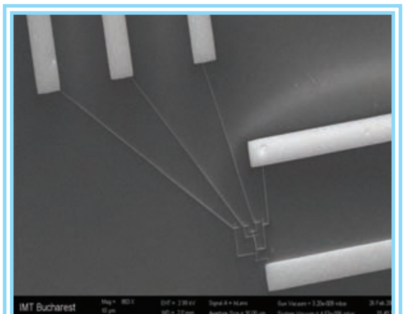
### ▶ Polymer nanowire electrically contacted using EBID

**Results** obtained in cooperation: IMT-Bucharest with Katholieke Universiteit Leuven.

**Contact person:**
**Phys. Adrian Dinescu**,
adrian.dinescu@imt.ro.




Polymer nanowire electrically contacted using EBID




Structure obtained using conventional litogrtaphy and EBID for 4 probes measurements of electrical properties of a polymer nanowire

# Education

▶ **New Master** (M. Sc. Courses) at the Faculty for Electronics, Communications and Information Technology, University "Politehnica" of Bucharest starting October 2009 and held in IMT (with access to experimental facilities).

- **Microsystems:**
  - **Intelligent sensors and microsystems;**
  - **Microphysical characterization of structures;**
- **Micro- and Nanoelectronics:**
  - **Advanced Technological Processes**
- **Electronic Technology for Medical Applications:**
  - **Micro- and Nanotechnologies for Medical Applications**

▶ **Postdoc program:** **A Postdoc program in the areas of RF MEMS and MOEMS** financed by FP7 MIMOMEMS project was launched in 2009 in IMT. Three postdocs were employed in IMT up to now.

## ▶ Other educational actions within different projects:

- **FP 6: ASSEMIC - Marie Curie Training Network** (2004-2007), Contract No. MRTN-CT-2003-504826, supervising the activity of PhD students and post doc.
- **2 Leonardo da Vinci -Life Long Learning projects, where IMT was partner:**

-"*Microteaching Project*" (2004-2007), coordinated by RWTH Aachen University

-"*Development of competences of educational staff by integrating operational tasks into measures of vocational training and further education*" ComEd, (2008-2010) coordinated by BWAW Thüringen gGmbH, Germany

- Short courses regarding microtechnologies were developed and presented to SMEs.
- Intership (3 months in 2007) for a student from INSA-Toulouse, France

## ▶ Simulation, consulting and training services in micro and nano domains;

➪ **Computer Aided Design** using dedicated software tools: COVENTOR 2008 and ANSYS

- **Mask Design, Process Editor, 3D building and mesh**;
- **Modeling for technological processes/optimizations**;
- **Special features:** particularized use (macro or subroutine) creation; special geometrical modeling (AFM images reconstruction in CAD format, surfaces generated in accordance with mathematical expression, etc);

➪ **Computer Aided Engineering and Analysis** (using FEM, FVM, BEM tools);

- **Microfluidics analysis** (thermo)dynamics, electro-kinetics, diffusion, fluid mixing and separation in micro-components;
- **Electro-thermo-mechanical and piezoelectric analysis** (steady state and transient).

**Training room for courses and services in MEMS design, modelling and simulation**

- **Coupled field simulations**: thermo-mechanical simulations; electro-mechanical simulations; multiphysics, fluid-solid interaction;

➪ **Consultancy regarding design and simulation optimization**;

➪ Training in COVENTOR COMSOL and ANSYS using training dedicated infrastructure;

# CENTRE FOR TECHNOLOGY TRANSFER IN MICROENGINEERING (CTT-Baneasa)

CTT-Baneasa was established by IMT-Bucharest in 2003 and was accredited as an autonomous entity in March 2006. The major mission of the Center is to develop the micro- nanotechnologies domain, by stimulating the technological transfer and innovation at national level, and by interacting with European entities.
CTT Baneasa must assure a critical amount regarding knowledge and technological transfer in the field of micro- and nanoengineering, taking into consideration only the offers from Romanian research entities regarding this field.

The Centre has adopted 4 driving strategies for continuously effective technology transfer and commercialization:
• identification of market needs by: market research, selection of target industries, and evaluation of technology trends;
• potential evaluation and effort driving in collaboration with the R&D groups to optimally address the real industrial needs and requirements, by: active contact, focused information feeding and informed advice;
• actively promoting the R&D outcome, by: identifying and participating in most relevant technology transfer and promotion events (exhibitions, innovation salons, conferences, seminars, brokerages, workshops), or encouraging the authors to attend; publishing newsletters through networking channels; creating and distributing promotion materials;
• participation to emerging opportunities, by: partnerships with technology transfer intermediaries worldwide; identifying/establishing/maintaining contact with decision factors from relevant enterprises and keeping them informed via focused electronic information materials; CTT- Baneasa has a key role as intermediator regarding valorisation of the research projects obtained results.



**Participation to fairs and exhibitions:**
• Hannover International Industrial Fair HANNOVER MESSE, 21-25 April 2008, Hanover, Germany;
• European Research and Innovation Exhibition in Paris (the fourth edition), 5- 7 June 2008, France;
• International Inventors Exhibition from Croatia- ARCA, 16-21 September 2008, Zagreb, Croatia;
• INNOVA Exhibition- Bruxelles International Contest- EUREKA, dedicated to inventics, 13- 15 November 2008, Bruxelles (2 Gold Medals);
• INVENTIKA Exhibition 2008, 7- 11 October 2008, Bucharest (1 Gold Medal, 1 Silver Medal and 2 Bronze Medals);
• Research Exhibition 2008, 7- 11 October 2008, Bucharest, Romania;
• Research Exhibition 2008, 20- 23 November 2008, Bacau, Romania;




For these actions, CTT-Baneasa elaborated advertising materials, identified and promoted services and technologies corresponding with the domains proposed for IMT, companies from MINATECH-RO park, and also, for the members of the suppliers and users of MNT knowledge network. The presentation materials revealed essential elements as the scientific, technological and applicative potential, the offered services, structures for technological transfer and activities of those structures, application domains and national and international projects reviews, human resources, patents portfolio, technological services offer and recent scientific and technological achievements with accent on the transfer, patenting and patentability potential. These materials were accompanied by exhibits from the domains and their technical sheets. More details on: www.imt.ro/ctt.

**The SMEs access to micro and nanotechnologies (IMT offer):** CTT-Baneasa provides part of the services from the IMT offer for SME's. CTT-Baneasa is involved in the following activities: • Information seminars (general or oriented to specific competitions) (home or abroad); • The execution and dissemination of promoting informational materials (posters, flyers, calendars, notebooks); • Electronic communication (webpage, database, e-newsletter) and media activities (journalism, radio, TV); • The consolidation of the knowledge and technology transfer network in micro and nanotechnology domain, including information dissemination and events;
• Possibility of accessing European funds, gaining the IMT and his experienced partners support;

**Promoting, advertising media:** Some events provided by CTT-Baneasa with logistic support (dissemination, promote, consultancy): • Day of the open gates IMT Bucharest, an annual event organized at IMT headquarters. • “The opening of the IMT-MINAFAB micro- and nanofabrication facility”, 9th April 2009, IMT headquarters. Public presentation of the IMT-MINAFAB facility (Center for MIcro and NAnoFABrication) where IMT (INCD-Microtehnologie) offers his services to the partners from research, education and industry. IMT-MINAFAB provides scientific and technological services for the suppliers and knowledge users’ network developed by CTT-Baneasa. IMT-MINAFAB facilitates R&D common research projects and the direct access of the innovative companies to technology.

CTT-Baneasa ensures the dissemination of the information about MINAFAB services and contributes to the growth of the number of potential Romanian user’s through the MNT network support. Details available at: www.imt.ro/MINAFAB. The facility has as model, the most advanced international centres. On 8th of May 2009, this facility was presented in “New Materials, Micro- and Nanotechnologies: discover a good partner in Romania” at Bruxelles, a promotion event organized by ROST – Romanian Office for Science and Technology from EU.

• “Informing the SME’s about the possibilities of accessing high technology seminar” CCIB headquarters.

• “ROMNET-MINAFAB launch” , Press conference 26 May 2009

The ROMNET-MINAFAB Network includes: INCD – Microtehnology Bucharest, INCD – Mecatronics and Measuring Technique Bucharest and INCD – Electrical Engineering CA.

The network, conceived as an occidental model, put forward a complex of facilities for micro- and nanofabrication offered to the industry (like in France, Sweden, USA).

**PATENTS**. CTT-Baneasa has a major portfolio in products and technology patents, brands in MNT domain. The database maintenance is provided, together with assistance for patent request statement, the collaboration with OSIM and support for innovative achievements and opportunities promotion among partnering SME’s. (Details: www.imt.ro/news/)


**PATENTS**: CTT-Baneasa has a major portfolio in product and technology patents, brands in MNT.
**Details: www.imt.ro/news/**.
Example: PROCESS FOR MAKING A SPIN VALVE TRANSISTOR (EN); No: 122168
PROCEDEU DE REALIZARE A UNUI TRANZISTOR CU VALVA DE SPIN (RO)

The invention relates to a process for making a spin valve transistor, with emitter and semiconductor collector and a base. According to the invention, the process consists in that the transistor base is metallic, consisting of a structured nano multilayer, with gigantic magnetoresistance, consisting of 12 very thin layers of magnetic and non-magnetic metals deposited onto a porosified monocrystalline silicon substrate, the emitter being structured in the drain of a constant current source (MOSFET), in saturation conditions, for stabilizing and uniformizing the emission current, the architecture and composition of the nanostructured multilayer with gigantic magnetoresistance, which represents the base, being the following: $NiFe/Co/Cu_{80}Ag_{15}Au_5/NiFe$, and the metals constituting the base are deposited onto a porous silicon, in 99% argon atmosphere at a pressure of 30m Torr and power RF of 250 W, in non/magnetic intermediary Cu layer there being added low amounts of surfactants: 15% Ag and 5% Au, the silver segregating to the thin layer surface, enriching the surface quality while the gold embedded into the crystalline Cu network eliminates the occurrence of magnetic bridges and intensifies the magnetoresistance.

CTT-Baneasa is developing activities complementary to the IMT-MINAFAB Micro- and Nanofabrication Centre for services, which recently became part of the IMT structure. This centre is in charge with internal organization, considering the increase of diversity and complexity of services, the necessity to ensure a complex support infrastructure (climatic and cleaning conditions, pure fluids etc.). The IMT-MINAFAB system ensures, among other things, the operation of some individual instrumentation from laboratories, the run of a service order system, the activity cost decrease, the intensive use and training of personnel. CTT-Baneasa drives a “transfer of knowledge and technology network” with over 60 groups of research or companies. The exchange of information between these entities is essential for exploiting all possibilities for cooperation and access to various financing sources.

**CTT-Baneasa** is member of ReNITT, National Network for Innovation and Technological Transfer.

CTT-Baneasa is also the founding member of ARoTT, Romanian Association of Technology Transfer (AROTT).

**Contact data**: CTT-Baneasa (www.imt.ro/ctt); Tel/Fax: 021-269.07.71; E-mail: info-ctt@imt.ro;
**Address**: 126A Erou Iancu Street, Bucharest, 077190. Conventional delivery: C.P. 38-160, Bucharest 023573.

# THE SCIENCE AND TECHNOLOGY PARK FOR MICRO AND NANOTECHNOLOGIES (MINATECH-RO)

The main objective of MINATECH-RO is to facilitate the access of the small companies to advanced technologies (including start up companies/ incubation).
The Park was created in April 2004 and received institutional funding during 2004-2005 through the national INFRATECH Program.

**The specific objectives of MINATECH-RO**:
• Technological transfer; • Designing of prototypes, demonstrators or experimental models;
• Small scale/pilot production after realizing (fabrication) the prototype; • Incubation;
• Technological services, micro-physical characterization, simulation and computer aided design;
• Learning/training by preparation of courses and stages (with practical training) in the Microsystems, micro- and nanotechnologies and microengineering domains;
• Assistance and consultancy activities for SMEs and small innovative enterprises:
- Information in micro-engineering, Microsystems, micro- and nanotechnologies, access to databases, documentation, etc; - Technological consultancy; - Brokerage (for the domain services); - Feasibility studies;
- Facilitating the access of Romanian innovative SMEs to European networks and partnerships;
• Dissemination of information (organizing conferences, workshops, editing publications, etc.);
• Research & Development;

**Companies that activate in MINATECH-RO Park:**
• S.C. ROM-QUARTZ S.A. (www.minatech.ro/romquartz) performs studies and scientific researches regarding some BAW devices fabrication (bulk acoustic wave) and SAW (surface acoustic wave) based alternative piezoelectric materials (lithium niobate, lithium tantalite langasite and gallium orthophosphate );
• S.C. SITEX 45 SRL (www.microsisteme.ro) manufactures 50 Pa – 100 kPa pressure sensors (rapid prototyping) and ceramic capacitive transducers for low pressure, ceramic diaphragm and dedicated ASIC integrated circuits; R&D activity: sensors, optoelectronic devices, transducers, pressure sensors, materials, MEMS; is offering solutions regarding RFID identification: tags, cards;
• EUROPEAN BUSINESS INNOVATION & RESEARCH CENTER SA. R&D activity: micro/nanotechnology for aeronautics and space applications, clean energy applications, precision agriculture applications, active screening systems, protection against space residues and electromagnetic turbulences;
• S.C. ROMES S.A.
• OPTOTECH SRL–active electronic devices experience (photodiodes, photothyristors, (photo)transistors;
• TELEMEDICA SA–R&D activity for bio applications;
• DDS DIAGNOSTIC SRL– produces other chemical reagents, R&D in physics and natural science; Expertise: application research for in-vitro diagnostic medical devices, design kits for in-vitro diagnostic, market studies for in-vitro diagnostic kits.

**Lavinia Ruta, pharmacist, DDS DIAGNOSTIC**

**Research and industry interaction:**
• Access to the MINATECH-RO incubator, scientific and technological park (IMT in collaboration with UPB), park resident companies.
- Companies that collaborates with the consortium and/or offer services in park have priority;
- Consultancy services are included;
• Access to scientific and technology services (local and abroad SMEs);
• Complex technologic assistance through CTT-Baneasa www.imt.ro/ctt;

**Development of bio-Microsystems for genomic analysis (for health and life quality development)**– *IMT collaboration with one of the park resident companies (DDS DIAGNOSTIC):* This experiment was possible due to the new equipments: **Omni Grid Micro Plotter and UC4 Scanner** that are inside **NanoBioLab** from IMT Bucharest. These equipments allow **obtaining diagnostic chips**, on glass or silicon, and also, the results interpretation. This microarray chips obtained involve multidisciplinary research in microtechnology, chemistry, biology, physics and pharmacology.

**Monica Simion, and Teodora Ignat, in NanoBioLab room, IMT-Bucharest**

**Research institutes cooperation**:
• Access to new equipment, especially trough technologic networks that have laboratories inside IMT, so in contact with the park. • Working point in technology area.
• Common scientific and technological services offer (park benefit in the first place)
• Possible strategic partnership with various domains institutes, in association with MINATECH-RO consortium.

**Universities cooperation**:
• Access in institute for masters and PhD students
• Common offer for education and training: Various partnership with Romanian universities
• Contact points in universities: Partnership with Polytechnic University of Bucharest
• Systematic cooperation (organize of a framework and a "interaction space" in park): Possible "spin-off" from universities.

**In park are located:**
• **Common laboratories** for **RO-NANOMED, NANOSCALE-CONV and RTN-NANOEL** networks. The laboratories are financed through complex projects from CEEX program.
• National contact points for ENIAC, NANOMEDICINE, PHOTONICS 21 European technological platforms.
• Contact points for German networks (IVAM, NANOBIONET and MST Network Rhein Main) and for **Romanian-German Micro- and Nanotechnologies Centre.**

The Science and Technology Park for Micro and Nanotechnologies MINATECH-RO (www.minatech.ro) was established using the resources offered by the IMT-Bucharest (www.imt.ro ) and the "Politehnica" University of Bucharest (PUB) in a national consortium that created the park (opened in June 2006). The Park is administrated by SC MINATECH ADMINISTRATOR SRL.

MINATECH-RO is participating to technological transfer dedicated actions (informing, exhibitions, innovation road show, debate-seminars in this domain). At the Research Salon 2008, the resident companies, their competence and offer were promoted. The opportunity to meet the interest people and establish partnerships was offered for the company representatives. The first edition of the Research Excellency Top has brought the first place and a gold medal for MINATECH-RO - Scientific and Technologic Park for Micro and Nanotechnologies, which IMT-Bucharest and UPB ("Politechnica" University of Bucharest) are part of. A first place at the section "Innovative SME" from the Research Excellency Top was offered to SC SITEX 45 SRL, a resident company in MINATECH-RO Park.

**Interactions in infrastructures developed by IMT-Bucharest:**
Access to technological and characterization services for the partners from research, education and industry are available through **IMT-MINAFAB**, Micro- and Nanofabrication Centre (IMT-Centre for Micro- and NAnoFABrication), where IMT (National Institute for R&D in Microtechnologies) offers services for partners from research, education and industry domain. Details: www.imt.ro/MINAFAB.
A part of the MINATECH-RO specific objectives, linked to the technology transfer and services providing (including training and consultancy), is implemented through CTT-Baneasa, a TTI entity that autonomous acts inside IMT. CTT-Baneasa provides services (consultancy, dissemination etc.) for Park companies, and facilitates access to the services offered by IMT. These companies can contribute to the diversification of the IMT technical services offer.

**Estimated benefits for the potential beneficiary:** The companies, that have direct benefits from the facilities offered by the Park and the coordinator consortium also, have access to the state-of-the-art technology for micro- and nanofabrication, characterization techniques, simulation, modelling and computer aided design. The companies can install equipments in technology area and can develop microproduction activities. The access to high-tech offers to innovative SMEs the advantage to create competitive products and also, the possibility to successfully access the public funds designated for RDI. By cooperating with the Park, the companies will have easy access to set up national and international partnerships.

**Contact data**: MINATECH-RO (www.minatech.ro); Tel: 021-269.07.67; E-mail: team@minatech.ro;
**Address**: 126 A Erou Iancu Street, Bucharest, 077190. Conventional delivery: C.P. 38-160, Bucharest 023573.

# Electronic dissemination and networking

▸ **Inventory and Networking** of researchers and research centers (research institutes, organization, SME) for active participation in FP 6, FP7 and European technological platforms. The networking focused on interaction between researchers active in micro-nano-bio technologies field at European level based on previous experience gained in MINOS-EURONET (http://www.minos-euro.net), MINAEAST (http://www.minaeast.net).

IMT-Bucharest is active in: • European Technology Platform for Micro- and NanoManufacturing (MINAM);
• European technology platforms ENIAC; • PHOTONICS21;
• Future Manufacturing Technologies MANUFUTURE;

▸ **Dissemination** of information about the researchers, centres, institutes expertise, research interest, involvement in international projects trough e-newsletter, electronic and printed MNT Bulletin, flyers, and posters.
Communication with partners; dissemination of information about institute and institute partners, research activities, national and international projects; develop and maintain the internet “interface” regarding all activities carried on by the institute; administration and maintenance of specially designed communication platform for networking.

▸ **IT services:** • IT services: interactive databases, web pages on Internet, Intranet, Extranet, specially designed e-room communication platform for networking.
• INTERNET & INTRANET applications design, web sites design and maintenance;
• Interactive database design and application, creation and maintenance;
• Soft and hard integration of designed system;
• IT maintenance, system development; Consulting in IT problems and development;
• Equipment up-grade, maintenance and PC network internal organization;
• Administration of communication platform for networking (web-based application that allows gradual access to a virtual space, reducing costs for project management and enhancing transparency of communication. General functionalities: offers a user rights system and a file management policy and capabilities to describe projects by publishing web media content.)

**IT and communication infrastructure**: 100Mb/s computer network (IBM servers, CISCO routers), radio and optical fibre connection to Internet, 2 computer networks for courses, training and conferences (one connected to the graphic station Dual IBM 3750 Server with 8 quad-core Intel Xeon MP 2.93 GHz processors, 196 GByte RAM and 1 TByte HDD+876 GByte external storage)

## ▸ Editing and publishing:

• **Series of books in Micro and Nanoengineering** (since 2001) published by the Romanian Academy.(Last volume No. 15) ”New Developments in Micro Electro Mechanical Systems for Radio Frequency and Millimeter Wave Applications”, Editors: George Konstantinidis, Alexandru Muller, Dan Dascalu, Robert Plana. Web: http://www.nano-link.net/mne
• **Romanian Journal for Information Science and Technology** (of the Romanian Academy), quoted in the Thomson ISI database; Web: http://www.imt.ro/romjist
• International publications in English (editing): **Micro and Nanotechnologies (MNT) Bulletin** (since 2000, MNT activities in Romania; since 2004 MNT activities in Eastern Europe), also on http://www.imt.ro/MNT;

## ▸ Organizing scientific conferences and other events:

• **International conferences: CAS Conference**, IEEE annual event (in 2009 at its 32nd edition); Web: http://www.imt.ro/cas
• **International events such as Micromechanics Europe** (in 2002), MEMSWAVE (first two editions), the first Nanoforum Workshop (2003).
• **National Seminar of Nanoscience and Nanotechnology** (annually edition since 2004). Web: http://www.romnet.net

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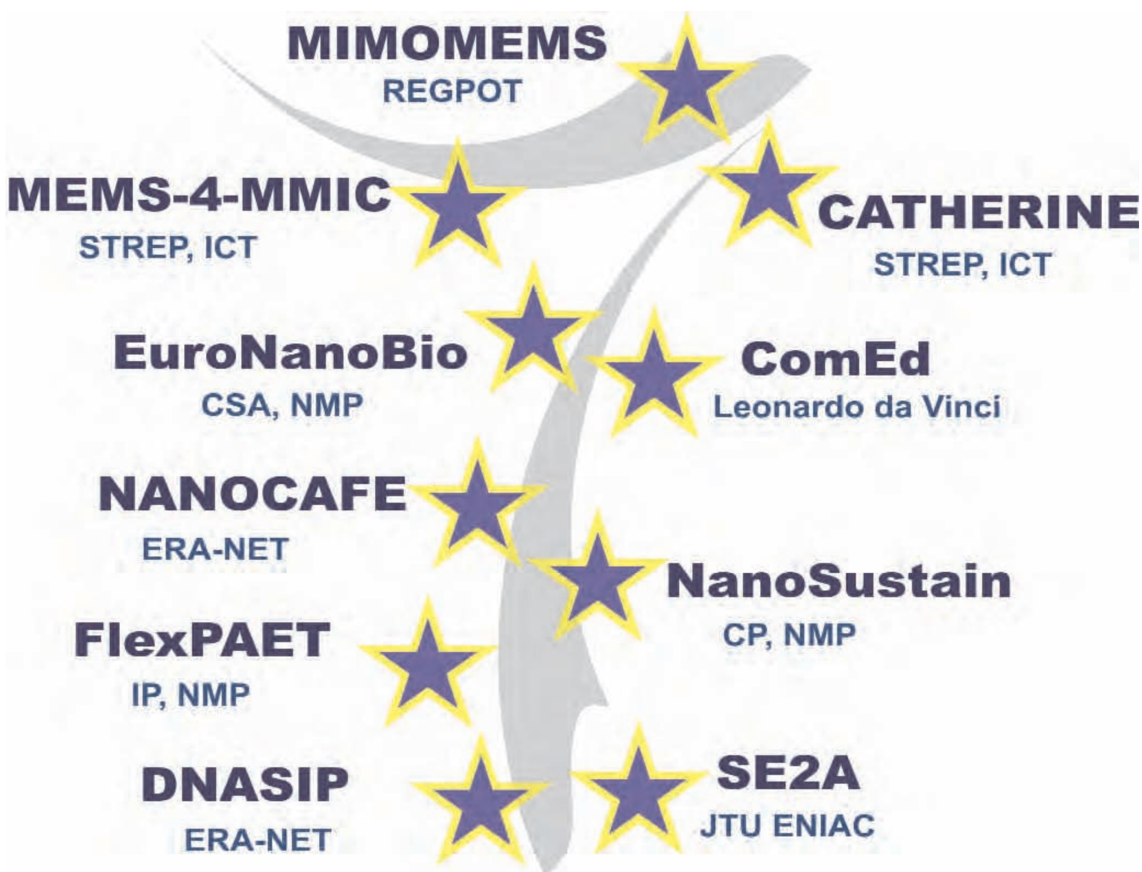
President of the Scientific Council: **Dr. Alexandru Muller** (alexandru.muller@imt.ro)

**IMT-Bucharest participation to FP7 projects**



## *European Commission officials visiting IMT-Bucharest*

With the occasion of the Info- and brokerage event in new technologies and materials (FP7/2007: NMP/ICT) **"Cooperation in industry-oriented research in an enlarged Europe",** Bucharest, Romania, on 22-23 March 2007, **Dirk Beernaert**, *Head of unit "Nanoelectronics", DG Information Society and Media, EC* and **Nicholas Hartley,** *Acting Director "Industrial technologies", DG Research, EC visited IMT-Bucharest* and wrote down the following remarks in the institute *Guest Book*:

*"I very much enjoyed the visit of the Institute and the Conference. IMT is doing interesting work. The work is also important for future long term applications and for innovation in the nanotechnology, bio-nanotechnology field and for nanophotonics. I hope they get fast the right equipment to play on important role on the European scene.*

*In the Conference, I have very much appreciated that they form a good focal point for the local and for the participants from the NMS. This is very much appreciated…*

**Dirk Beernaert,** *DG-IST, Head of Unit Nanoelectronics*"

*"A very impressive centre with a good team during interesting and important with. I have very much enjoyed this visit. Thank you for your excellent hospitality – good luck for the future and keep up the good work.*

**Nicholas Hartley**"

With the occasion of the Info and brokerage event: **"Micro- and nanosystems in the FP7/2007 call",** Bucharest, Romania, 24 May 2007, **Augusto de Albuquerque**, Head of Unit, INFSO G.2 Microsystems, EC, visited IMT-Bucharest.

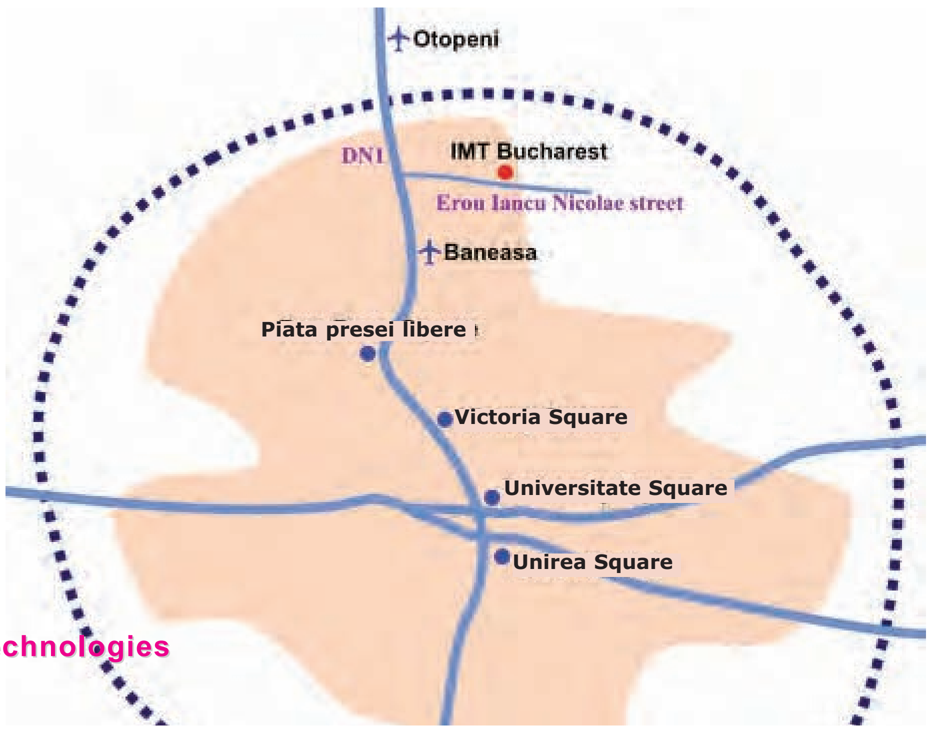
The main point of the visit was IMT-Bucharest technology area, which allows structures manufacturing at the micrometer or nanometer scale. The new equipments acquired during the last years were presented. Some of the laboratories such as *Micro and Nano-Photonics*, *Simulation Modelling and Computer Aided Design* lab and *Micromachined structures, microwave circuits and devices lab* have been visited also.

After the visit, **Augusto de Albuquerque** wrote down the following remarks in the institute Guest Book:

*"I enjoyed very much to see the very good infrastructure and the organization to build the full chain: simulation, design, testing and manufacturing. Congratulations for the very systematic building of competence in MEMS, Photonics and Nano-Bio convergence. Best wishes for the future.*

**Augusto de Albuquerque**, *Head of Unit Microsystems, EC-DG Information Society and Media*"


IMT-Bucharest is publishing scientific report annually since 2005.
The annual reports are available at http://www.imt.ro

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