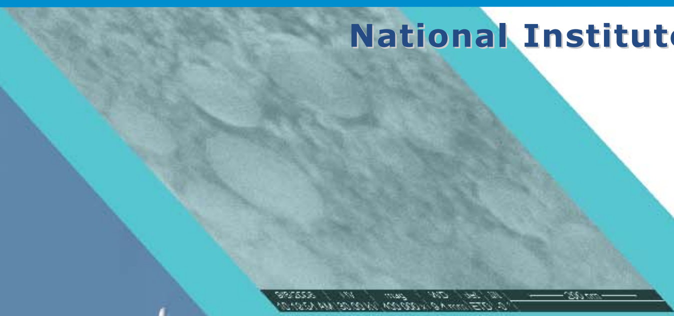
Ministry of Education, Research, Youth and Sport, Romania
National Authority for Scientific Research

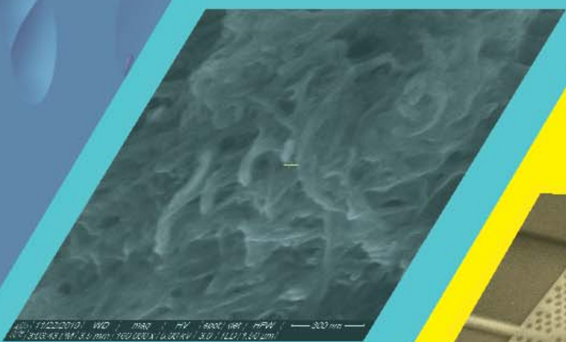
SCIENTIFIC REPORT 2010

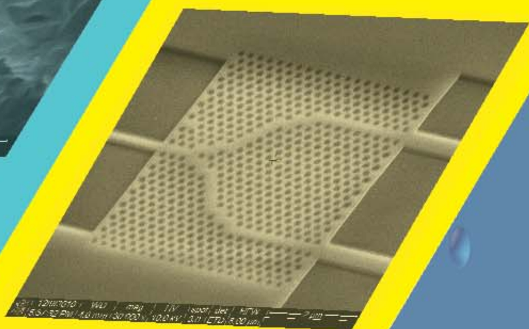
National Institute for R&D in Microtechnologies

IMT-Bucharest



From micro- to
nanotechnologies and
micro-bio-nanotechnologies





Ministry of Education, Research, Youth and Sport, Romania
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Experimental infrastructure

Research and technological development

Design: IMT - Bucharest

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About IMT

The present organization originates in the Centre of Microtechnology (founded in September 1991), then becoming the Institute for Microtechnologies (IMT) by a decision of the Romanian Government, in July 1993. The present National Institute for Research and Development in Microtechnologies (IMT - Bucharest) was set up at the end of 1996 from IMT merging with the former ICCE (Research Institute for Electronic Components).

The field of activity of IMT corresponds today to micro-nano-biotechnologies. IMT is coordinated by the Ministry of Education, Research, Youth an Sports, through the National Authority for Scientific Research. However, 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.

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), and then from CEEX (since 2005) and the 2nd National Plan (since 2007). Between 2003 and 2010 IMT was involved in more than 20 European projects in FP6 and FP7, as well as in other European projects from ENIAC, Eureka, Leonardo, ERA-NET etc..

IMT houses a European Centre of Excellence financed by the EC (2008-2011) through the project MIMOMEMS (RF and Opto MEMS). In December 2009, the European Associated Laboratory (LEA) was inaugurated, with IMT - Bucharest, LAAS/CNRS Toulouse and FORTH, Heraklion. This LEA is acting in the field of RF MEMS/NEMS.

About the present report

The Scientific Report 2010 starts with the basic figures about IMT in 2010 and continues with the organizational chart and the Board of Directors. This chart is valid only since 1st of December, 2010. The order of presentation of R&D laboratories follows this new chart (and not the arithmetic order).

The personnel figures are rather stable in the last years, with no significant brain drain. In financial terms, the volume of activity of IMT in 2010 experienced a slight recovery in comparison with 2009, an year of dramatic decrease, following the continuous rapid increase taking place during the previous four years (2005-2008). In 2010, three projects with financing from structural funds started, continuing the investments until 2013 (these are briefly presented in this section).

The second part of this report is devoted to basic infrastructures (clean room areas) and equipments. IMT displays a broad range of resources for micro- and nanotechnologies, from simulation and design computer techniques, to characterization tools, fabrication equipments (including a mask shop), and testing equipments (including a reliability laboratory). Most of these resources are now grouped in the IMT centre for Micro- and NAnoFABrication (IMT-MINAFAB), an open centre for research, education and innovation.

The third part is devoted to the presentations delivered by IMT laboratories for research and development (R&D). These research groups, rather stable during the relatively short history of IMT, are presenting their assets, as well as the results of the ongoing projects (including international ones) during 2010. The last part of the report contains the list of main scientific publications.

Other information about IMT

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. This last possibility opens the way for an exchange of services with IMT, including cooperation in a small-scale production. CTT-Baneasa is pursuing the technology transfer and innovation, by promoting the development of a "cluster" of organizations either providing or using the knowledge and the technologies in the domain. IMT-MINAFAB (mentioned above) is providing services to companies in the Science and Technology Park for micro- and nanotechnologies (MINATECH-RO), Including Honeywell Romania.

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 and in "Eurotraining". Since October 2009, IMT is covering fully a number of disciplines in the new M.Sc. Courses organized by the University "Politehnica" of Bucharest (PUB). Since 2010, IMT is coordinating a programme of postdoctoral studies in micro- and nano-technologies, financed from structural funds (2010-2013).

IMT is organizing the Annual Conference for Semiconductors (CAS), an IEEE event (CAS 2010 was the 33rd edition), now largely devoted to micro- and nanotechnologies. IMT is also organizing within the Romanian Academy the "National Seminar for Nanoscience and Nanotechnologies" (the 9th edition - in 2010). The institute is co-editing (in English) the series of volumes Micro- and Nanoengineering", in the Publishing House of the Romanian Academy (17 volumes until 2010).

Prof. Dan Dascalu
CEO and President of the Board

Prof. *Dan Dascalu* was the founder and the director of the Centre for Microtechnology (1991), then of the Institute of Microtechnology (July 1993), and finally (November 1996) of the National Institute for Research and Development in Microtechnologies (IMT-Bucharest).

Dan Dascalu is also Professor at the "Politehnica" University of Bucharest (PUB), Department of Electronics and Telecommunications and full member (academician) of the Romanian Academy (of Sciences). He is the author of *"Transit-time Effects in Unipolar Solid-State Devices"* and *"Electronic Processes in Unipolar Solid State Devices"* (both published by Abacus Press, Kent, U.K., 1974 and 1977, respectively) as well as of many technical papers published in scientific periodicals or conference proceedings.

Prof. Dan Dascalu is an expert representing Romania in the NMP FP6 and FP7 Programme Committee (since 2002), in the "mirror group" for the European Technological Platform for Nanomedicine and in the Governing Board ENIAC-JU (public-private partnership in nanoelectronics). He is a member of the Consultative Board for R&D and President of the Commission for "New Materials, Micro- and Nanotechnologies". He is also a member of the Advisory Board of the EUMINAfab.

Human resources, funding sources, investments

Fig.1 (a, b, c) provides information about the number and distribution of researchers active in IMT in 2010 (74 persons). One third of them are senior researchers (Fig. 1.a). 72% of them have the Ph.D. degree or are Ph.D. students (Fig. 1.b). The average age is slightly above 40 years (Fig. 1.c).

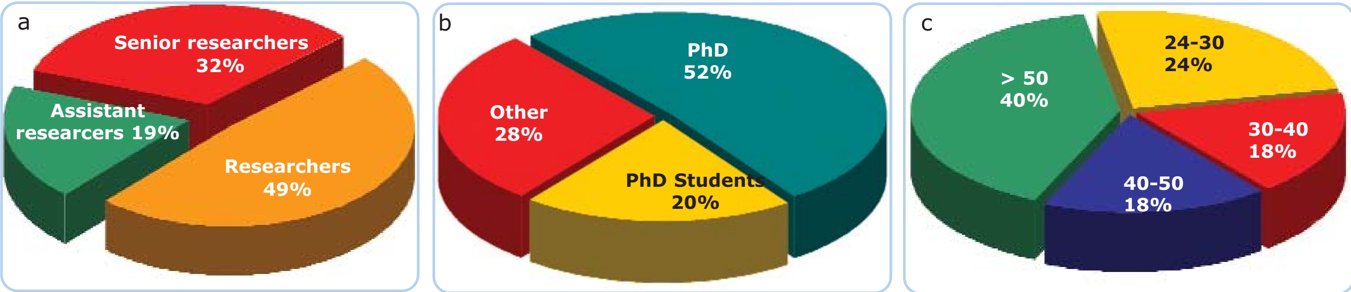


Fig 1 - Researchers active in IMT (74)

Fig.2 gives information about the total number of specialists active in IMT in 2010 (108 people): researchers and specialists providing technical services. Their background is shown in Fig.2. The male (58) - female (50) number is relatively balanced. The number (and age distribution) of specialized IMT personnel temporarily working abroad (22) is shown in Fig. 3 in comparison with the personnel active in the institute (108).

Fig 2 - Background of researchers and specialists providing technical services (108)

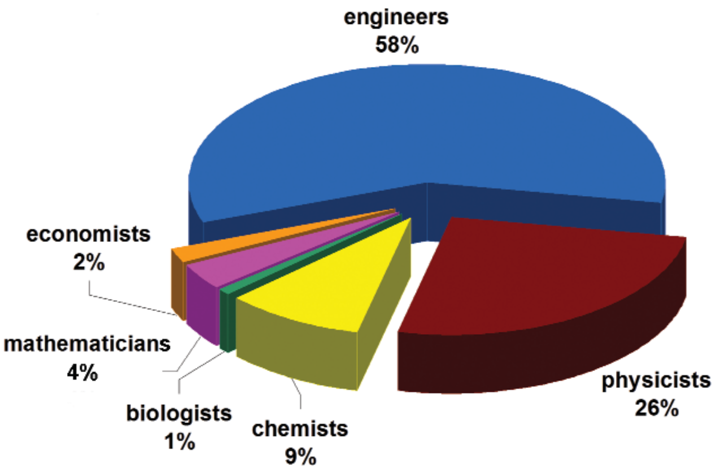
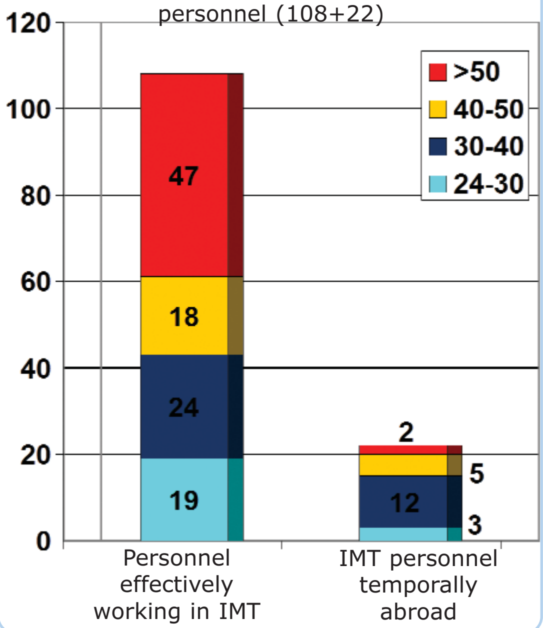


Fig 3 - Age distribution of specialised personnel (108+22)



Funding sources.

Fig. 4.a shows the funding sources in 2009, excluding investments from various contracts. In 2010, the majority of total funding (55%) comes from national R&D programmes (competitive funding, through open calls) and only 24% is provided by core funding (public money available to national institutes for R&D, since 2003).

Fig.4.b displays the evolution along the last six years (b). The decrease in 2009 in comparison with 2008 (approximately 6 millions in comparison with 8 millions of euro, due to dramatic cuts in public funding of research), is following a sustained and substantial annual increase from 2005 to 2008. The last year, 2010, brought, however, a slight recovery.

Fig 4a -Funding sources (EUR), 2010

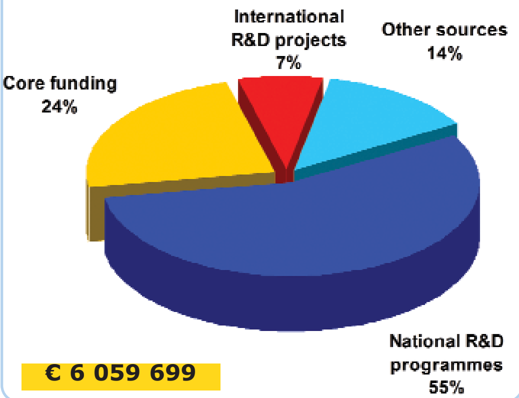
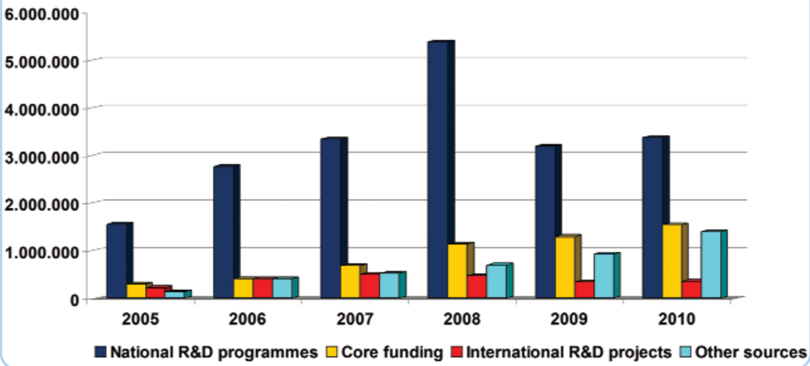


Fig 4b - Funding sources (EUR), 2005-2010



Human resources, funding sources, investments

The dynamics of investments during the last five years of existence of IMT as a national institute (2006-2010) is even more dramatic (Fig. 5). The investments in equipments in the previous four years (2006-2009) has been about 7 millions of euro, especially due to projects financed from the national programmes, including infrastructure projects. A European REGPOT project also brought a contribution.

Fig. 6 shows the structure of investments in the previous four years (a) and also in 2010 (b). The investments will continue in 2011-2013, due to financing from projects in structural funding programmes.

Fig 5 - Evolution of IMT investments (EUR), 2006-2010

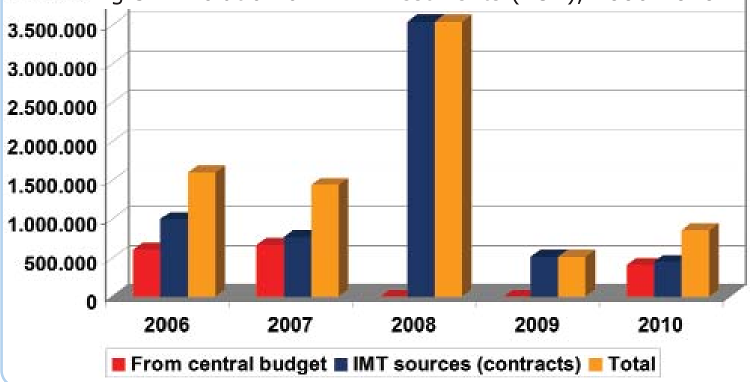


Fig 6a - IMT investments, per category 2006-2009

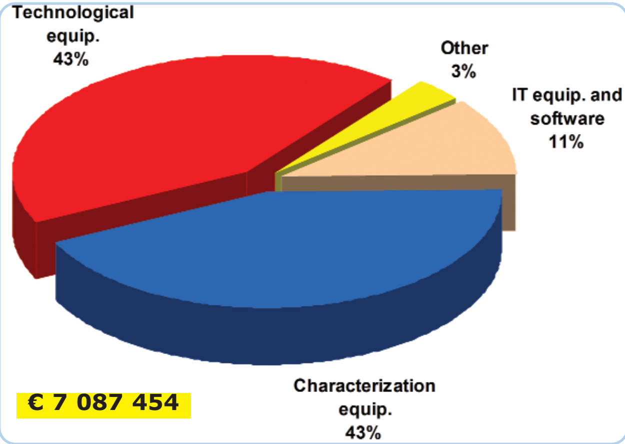
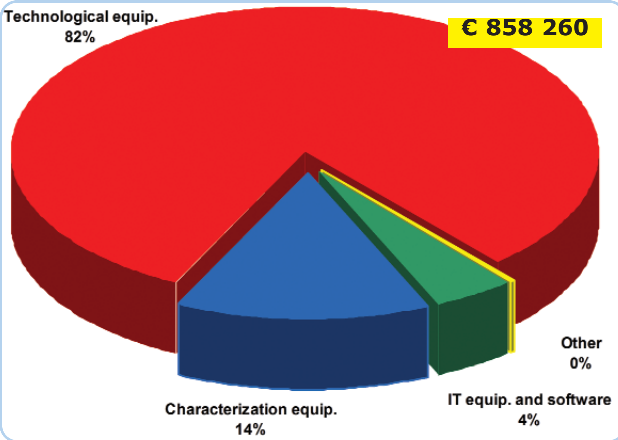


Fig 6b - IMT investments, per category 2010



A new source of financing: structural funding

Project Title: "Research center for integrated systems nanotechnologies and carbon based nanomaterials" - CENASIC
(ID 905/28.09.2010; SMIS COD 14040)
Priority Axis 2: "Competitiveness via research, technological development and innovation"
Intervention field: D.2.2 „Investments in CDI infrastructure and development of administrative capability"
Operation: O2.2.1. Developing the available C-D infrastructure and creating a new C-D infrastructure.
Financing unit: The increase of economic competitiveness (POS CCE)
Period of time: September 2010- September 2013 (36 months); **Grant:** 20.000.000 RON
Project manager: Dr. Lucian Galateanu (lucian.galateanu@imt.ro)

The objective is the creation of a new center within IMT. The center will have modern facilities and laboratories designed for the development of new research areas with high application potential, in concordance with EU models and strategies. The mission of the CENASIC Center is to become a national and European excellence centre in the area of applied research in integrated micro-nanotechnologies using carbon based materials.

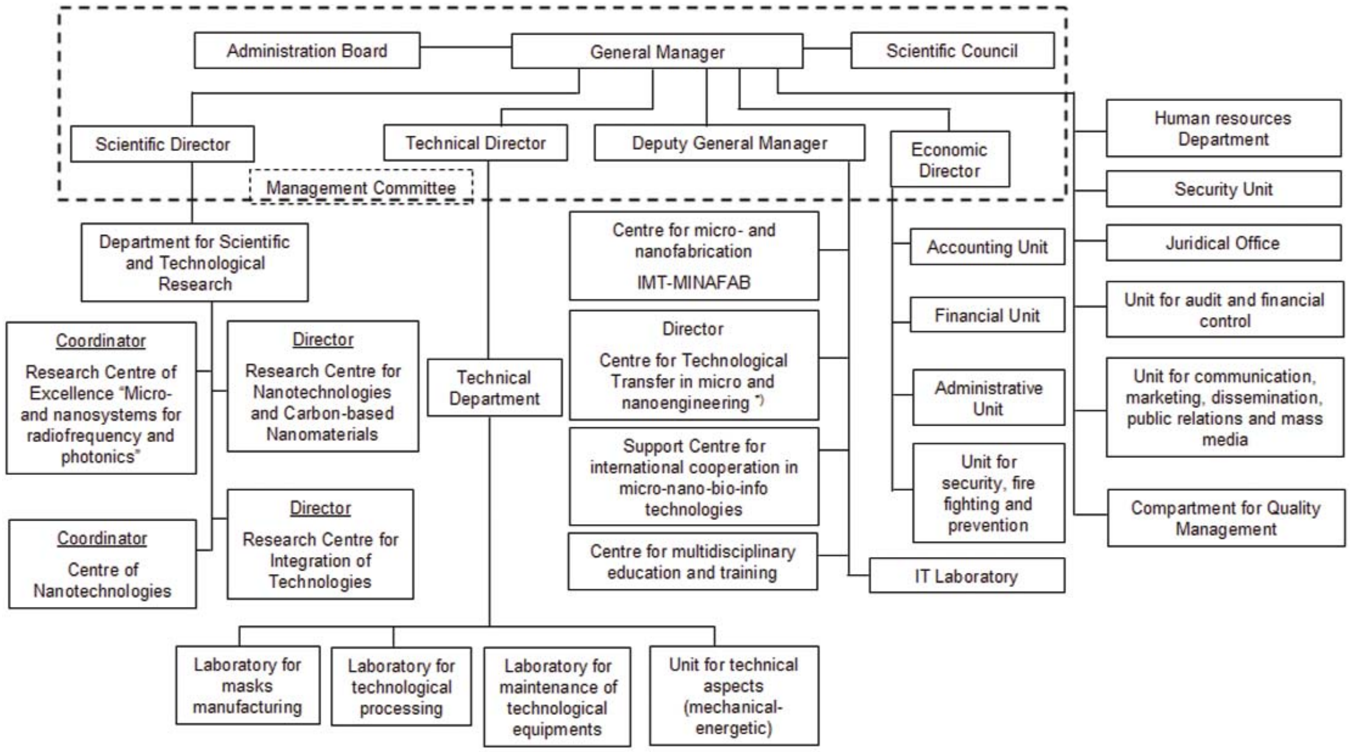
Project Title: "Microfluidic Factory for "Assisted Self-Assembly" of Nanosystems" - MICRONANOFAB
Project thematic area: Innovative materials, products and processes
Operational programme: POS CCE
Priority Axis 2 – Research, Technological Development and Innovation for Competitiveness
ID/COD SMIS/No.: 665/12609/209/20.07.2010
Duration of contract: 36 months (July 2010- July 2013)
Operation: O.2.1.2 "Complex research projects fostering the participation of high-level international experts"
Grant: 7.071.000/5.900.000 lei
Scientific manager: Dr. Ciprian ILIESCU (cipi_sil@yahoo.com)
Contact person: Acad. Dan DASCALU (dan.dascalu@imt.ro)

The fundamental objective of this project is the realization of a prototype of an integrated microfluidic system able to dose, encapsulate and deliver different chemicals for medical treatment. The idea is to develop some microfluidic technological platforms, under the form of flexible and modular technologies such that with the same modules to perform different tasks like transportation, manipulation, and structural analysis of biological samples.

Project Title: "Human resources development through postdoctoral research in micro and nanotechnologies domain".
(ID: POSDRU/89/1.5/S/63700)
Priority Axis 1: Education and training in support for growth and development of a knowledge based society
Intervention field: 1.5 Doctoral Post-doctoral Programme for research support.
Financing unit: Sectoral Operational Programme Human Resources Development 2007-2013 (SOP HRD)
Period of time: April 2010 – March 2013 (36 months); **Grant:** 10.072.499 RON
Contact data: Acad. Dan Dascalu (dan.dascalu@imt.ro) Coordinator; Corneliu Trisca-Rusu (corneliu.trisca@imt.ro) Deputy coordinator.

This project has the objective to provide financial support to 35 PhD researchers, through grants for scientific research in Romania, traineeships abroad, and attendance to scientific events, in a postdoctoral programme for the micro- and nanotechnologies domain.

Organizational chart (since 1st of December, 2010)



Raluca Müller received the M.Sc (1978) in Electronics and Telecommunications from "Politehnica" University of Bucharest, Romania and PhD in Electronics and Telecommunications, from the same university.

From 1978-1994 she was Research Scientist with ICCE-Research Institute for Electronic Components, Romania; since 1994 she is with IMT- Bucharest (National Institute for Research and Development in Microtechnologies). She is Scientific Director starting with 2009. Her main scientific interests include design, and technological processes (nanolitography) for microelectronic devices, integrated optics, microsensors and microsystems.

Mircea Dragoman was born in Bucharest in 1955. He graduated the "Politehnica" University of Bucharest, Electronic Faculty, in 1980. He received the doctoral degree in electronics in 1991.

Mircea Dragoman is a senior researcher I at the IMT-Bucharest, he is working in the laboratory "Microsystems and micromachined circuits for microwaves- (RF MEMS)" where he designed and characterized a series of circuits in the microwave and millimeter range. Currently he is Director of Centre for Research and Technologies Integration. He has published 159 scientific papers: 86 in journals (76 ISI papers) si 73 communications at various national and international conferences. The papers are dedicated to the following areas: nanoelectronics, microwaves, MEMS, optoelectronics. He is co-author of several books.

Radu Cristian Popa Radu Cristian Popa graduated in 1989 the "Politehnica" University of Bucharest, Department of Electronics and Telecommunications. In 1998 he received his PhD at the Department of Quantum Engineering and Systems Science, University of Tokyo. 1989-1992 he was with IIRUC-Bucharest, specializing in computer architectures.

Afterwards, he obtained the position of assistant professor in the Department of Electrical Engineering, Polytechnic University of Bucharest and participated in the scientific collaboration contracts with Electricité de France, Paris. 1998-2003, Radu Popa was Senior Researcher with Science Solutions International Laboratory, Inc., Tokyo, where he was in charge with, or participated in competitive research contracts for various Japanese corporations, companies and universities. 2003-2006, he was first scientific associate at the University of Tuebingen and became Director of Development at Neurostar, GmbH, Germany.

He is currently with IMT-Bucharest, leads the Molecular Nanotechnology Lab., which belongs to the Center for Nanotechnology and he is Director of the Research Centre for Nanotechnologies and Carbon-based Nanomaterials. He studies techniques and solutions for the identification of DNA nucleotide sequences.

Marin Nicolae received the M.Sc (1972) in Electronics and Telecommunications from "Politehnica" University of Bucharest, Romania and in 1998 PhD in Electronics and Telecommunications, from the same university.

He has extensive background in manufacturing/design semiconductor devices, characterization, electrical circuit simulation, debugging, evaluation and product monitoring.

He is Technical Director starting with September 2009.

Domnica Geambazi graduated in 1979 the Bucharest Academy of Economic Study. She was appointed Financial Director in 2009 (delegated as Financial Director since 2001).

Image from clean room

General. This part of the Scientific Report 2010 provides information about the clean room spaces available, as well as about the equipments available at the time of printing this report. The majority of the equipments listed below are new, purchased through the investments taking place recently (approximately 7 million euro in 2006-2009). The majority of experimental resources are accessible through an "open experimental centre", the so-called **IMT** centre for **MI**cro- and **NA**no **FAB**rication (**IMT-MINAFAB**). The main achievement is the set-up of to two new clean room areas (operational since September 2008), as follows:

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 µm resolution), RIE, vacuum deposition system (E-Beam and sputtering), double-face alignment, deep pen nanolithography, etc. A new clean room (to be operational soon) will contain LPCVD, PECVD, APCVD, RTP equipments, etc.).

Characterization area, class 100,000 (220 sqm): The characterization area (class 100,000) is equipped with SEM/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.

The facilities are presented in more detail on the next few pages. Basic experimental and CAD facilities are covering the whole chain from simulation and design to mask fabrication, technological processes, characterization, and testing (including reliability).

Therefore, *IMT has the opportunity to provide complex services to both companies and universities*. This was leading to the idea of the centre of services, IMT-MINAFAB. On the other side, the process of obtaining ISO certification of these services started in 2010.

IMT-MINAFAB
IMT Centre for MIcro and NAnoFABrication

A new infrastructure initiated in 2008 and launched in 2009, **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 (cleanroom 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 modeling 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".

IMT policy related to MINAFAB. A strategic target for IMT-MINAFAB is to initiate at the national level a network of complementary facilities in micro- and nano-technologies. Such a network was 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.

Details of the types of services provided by centre. *Internally,* IMT-MINAFAB achieves the grouping - in a *unique* experimental centre - of the resources acquired and exploited by the IMT RDT laboratories, and enables their optimal usage by all IMT researchers. The "centre" is optimizing the use of the support infrastructure and the maintenance; it also deals with cost evaluation, standardization of processes, know-how management and other supporting activities. Secondly, as an interface to the "external world" of partners and users, the MINAFAB centre ensures a *fast and flexible* interaction with partners and clients, fully exploiting the RD potential based on the existing knowledge, and the emerging opportunities.

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);*
- *Direct 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?
- The potential customers should consult first the extensive information about the equipments and technologies available at: www.imt.ro/MINAFAB. You may also e-mail a request for further details to the person in charge with an 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 40-21.269.07.72 or phone at +40-21.269.07.70 ext. 19 (Dr. Radu Popa).

Equipments and Experimental Laboratories

About Experimental laboratories

On the next pages one may find information about the main equipments available in IMT. In some cases an equipment, or a group of equipments are located in a special room and they are managed by a certain RTD laboratory, part of the organizational structure. In such a case we are speaking about an "experimental laboratory". The person in charge is usually a researcher, with his/her own research interest and motivation. However, apart from the usual cooperation between labs, the "experimental laboratories" should be accessible (directly or indirectly) to any researcher from IMT. Moreover, the "services" provided by these "experimental labs" should be also available outside IMT. A typical situation is that of experimental labs created by some research laboratories in the characterization area (class 100,000), which has a special support infrastructure for providing demanding operating conditions of delicate equipments. All looks like a "joint venture" of individual research laboratories in an special area provided by the institute.

Another important concept is that of an interdisciplinary group working as a "research centre", due to interactions of two or more research labs. The MIMOMES Centre of Excellence financed by EU provides such an example: it is the result of combined activities of RF MEMS and Photonics laboratories, respectively. The second case corresponds to the so-called "Centre for nanotechnologies", grouping other laboratories. This centre, also mentioned below, is functioning "under the aegis" of the Romanian Academy (this is a "purely scientific" interaction, without administrative or financial consequences).

A. Experimental laboratories in the characterization area (class 10,000 to 100,000).

Centre of Nanotechnologies an interdisciplinary group, involving a few RTD laboratories, was developed as follows:

Laboratory of nanotechnology (L1) with the following experimental laboratories:

Monica Simion (monica.simion@imt.ro) working on the Micro Plotter to prepare a protein C reactive microarray slide

Experimental laboratory for "Microarrays", or NanoBioLab

- Microarray Scanner, GeneTAC UC4 (GenomicSolutionsLtd., UK) used for reading the chips, DNA detecting and deposition.

Technical specifications: 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. Resolution: from 1μm/pixel; Resolution for a standard microscope slide: 5μm/pixel. Includes also a workstation with powerful software that automates the identification and quantification of microarray data.

- Micro Plotter - GeneMachines OmniGrid Micro (Genomic Solutions Ltd., UK): designed for producing DNA or protein microarrays on slides.

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

Applications *Protein Arrays:* - study tens of thousands of proteins in as short a time 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;

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

Experimental laboratory for surface spectroscopy, with:

- **Electrochemical Impedance Spectrometer PARSTAT 2273** (Princeton Applied Research, USA)

Technical specifications: The PARSTAT 2273 consists of (i) hardware capable of ± 10 V scan ranges, 2 A current capability (1.2 fA current resolution), 100 V compliance, >1013 Ω input impedance, <5 pF of capacitance and 10μHz to 1 MHz built in analyzer for impedance measurements; (ii) Electrochemistry PowerSuite software required for data analysis and ZSimpWin - EIS modeling software package.

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*;

Mihaela Miu (mihaela.miu@imt.ro) investigating the electrocalalytic activity of the gold nanoparticle electrode array with SECM

- **Scanning electrochemical microscope** (SECM) (HEKA, Germany): HEKA ElProScan is an Electrochemical Probe Scanner for various investigations of electrochemical active surfaces.

Technical specifications: - The HEKA ElProScan is the only system which can perform measurements in an extremely wide current range up to 2 A. It also operates as a standard (Bi-) potentiostat/Galvanostat, thus, making it usable for many other electrochemical applications also.

- Low current preamplifiers allow high-resolution low-noise recordings in the low pA range.

- High precision real time controlled positioning system mounted on a stable holder made of granite, 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.

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

Experimental laboratory for surface spectroscopy:

- **Autolab TWINGLE** - Dual Channel E-SPR (Metrohm Autolab, The Netherlands): Designed for high quality and high accuracy measurements, both electrochemical and surface plasmon resonance (SPR), the Autolab TWINGLE is a compact double channel instrument, having a reference channel option that can be used to correct for experimental errors and/or matrix effects.

Technical specifications: no. of channels: 2; fixed wavelength: 670 nm; sample volume: 20 - 150 µl; manual offset of SPR angle: 62° -78°; dynamic range: 4000 m°; angle resolution: ‹ 0.05 m°; baseline noise: 0.1 m°; minimum molecular weight: 180 Da; refractive index range: 1.26 - 1.38 (BK7 slider).

Applications: Biosensors (in combination with amperometry/impedance spectroscopy); conducting polymers; enzymes; membrane proteins; DNA - DNA interactions; protein - virus interactions; peptide - antibody interactions.

Contact person: Dr. Antonio Radoi, antonio.radoi@imt.ro

Autolab TWINGLE - Dual Channel E-SPR

Experimental laboratory for X-Rays diffraction, with:

- **X-ray Thin film Diffraction System** (triple axis rotating anode) - SmartLab -9kW rotating anode, in-plane arm (Rigaku Corporation, Japan).

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 alignement computer aided, small measurement time), modern techniques for producing X-ray sources, real time ultraspeed detectors and difraction data processing (especialized software, databases, etc).

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

Contact person: Phys. Mihai Danila, mihai.danila@imt.ro

Mihai Danila (Mihai.danila@imt.ro) introducing in the sample in the XRD for investigation the Pt nanocystallite orientation and size

Experimental laboratory for nanoparticles, with:

- **DelsaNano Zeta Potential and Submicron Particle Size Analyzer** - Allegra X-22 (The 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.

Technical specifications: High sensitivity size and zeta potential measurement for particles from 6 Angstrom to 7 micron in suspension with concentration ranging from 0.001% to 40%. Zeta potential measurement of solid surface or film Range: -100mV - +100 mV. Fully automatic pH or additive titration for both size and zeta potential.

Measurement Temperature Range: 10° C - 90° C, Environmental Operating Specifications: Temperature: 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/Pharmaceutical: Proteins, lipids, polysaccharides, bacteria, blood cells, viruses, colloids drug carrier systems, drugs in aqueous suspension, micelles for biomaterials

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

- **Fluorescence spectrometer** - FLS920P (Edinburgh Instruments, UK)

Technical specifications: 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 sensitivity of the system guarantees a signal to noise ratio of 6000:1 for water Raman spectrum measured with excitation at 350 nm, emission at 397 nm, with 1 second integration time and 5nm spectral bandwidth.

Characteristics: Lifetime ranges 10ps-10 s; UV-Vis-NIR spectral range; Single Photon Counting sensitivity

Applications: - 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 by studying the energy transfer mechanisms using fluorescence lifetimes as the indicator.


Adina Bragaru (Adina.bragaru@imt.ro) working for nanoparticle centrifugation and characterization

Contact persons: Chem. Adina Bragaru, adina.bragaru@imt.ro; Dr. Monica Simion, monica.simion@imt.ro

- **Centrifuge - Allegra X-22** (Beckman Coulter);

Contact persons: Chem. Adina Bragaru, adina.bragaru@imt.ro;

Laboratory for nanoscale structuring and characterization (L6), created the following experimental labs:

Experimental laboratory for Electron Beam Lithography (EBL)/Scanning Electron Microscopy Laboratory (SEM)/Energy Dispersive X-ray Spectroscopy (EDX) - NANOSCALE-LAB;

- Scanning Electron Microscope SEM - Vega II LMU and Pattern Generator - PG Elphy Plus (TESCAN s.r.o, Czech Republic and RAITH GmbH, Germany); - A Nanolithography Equipment composed of a SEM/EDX and EBL pattern generator which can investigate different samples at nm range (SEM resolution 3 nm, smallest geometry line in the range of 30-50 nm) is used for different sample investigations, EDX analysis, direct writing in PMMA of nanometric configurations and for students training in microscopy and nanolitography.

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

Experimental laboratory for E-line Nano Engineering Work Station;

- Electron beam lithography and nanoengineering workstation - E_Line (RAITH GmbH, Germany). EBL - Direct writing Electron Beam nanoLithography is an ideal tool for nanotechnology research and a versatile equipment with specific requirements for interdisciplinary research: options for nanomanipulations; EBID-Electron Beam Induced Deposition;

Applications: • Nanolithography with less than 20 nm resolution; • 3D nanostructures; • CNT based interconnections for next-generation integrated circuits; • CNT based nanodevices; • SAW devices with nanometer interdigitated electrodes; • Optical devices, holograms, micro lenses, gratings; • Development of Nanodevices using E-beam induced deposition and etching; • Development of circuits for communications based on photonic crystals;

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

FEG-SEM - Nova NanoSEM 630

Experimental laboratory for SEM/FEG (Field Emission Gun);

- **Field Emission Gun Scanning Electron Microscope/FEG-SEM-Nova NanoSEM 630 (FEI)**; The FEI Nova NanoSEM 630 is a high-quality nanoscale research tool for a variety of applications that include sample characterization, analysis, prototyping, and STEM sample preparation. 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).

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

Experimental laboratory for Scanning Probe Microscopy and Nanomechanical Testing;

- **Scanning Probe Microscope** (NT-MDT Co., Russia)

It is a versatile research SPM enabling to perform a broad range of techniques (AFM, LFM, C-AFM, EFM, SKPM, STM etc.) in various environments (including low vacuum and controlled atmosphere) for investigating the properties of samples at or near the surface. Depending of the sample and technique, different properties could be characterized together with topography (relative variations of conductivity, stiffness, electric field gradient and distribution, surface potential etc.). The modular design, high resolution, large scan range (100x100x10 μm) and accuracy provided by closed loop sensors allow addressing a wide range of applications:

Examples: • High resolution surface morphology inspection; •3D metrology of surface features at nm scale (texture, roughness, grain and particle size analysis etc) • Evaluation and optimization of thin films • Advanced characterization of polymer materials • Investigations of failure mechanisms in semiconductor and data storage devices • Studies of biological and biocompatible materials etc.

Contact person: Phys. Raluca Gavrila, raluca,gavrila@imt.ro

- **Nano Indenter G200, Agilent Instruments (former MTS Nano-Instruments)**: G200 is a nanomechanical characterization equipment operating by instrumented indentation and scratch testing. It provides access to various mechanical properties of small-volume samples, such as thin films, but could be equally applied to investigate bulk samples. It is equipped with CSM (Continuous Stiffness Mesurement) module for performing measurements in dynamic regime. Accuracy and repeatability of the measurements are guaranteed by implemented methods according to ISO 14577.

• maximum load : 500 mN; • load noise floor : 100 nN; • maximum indentation depth : 500 μm; • displacement noise floor: 1 nm; • position accuracy: 1 μm

Applications: Studies of mechanical properties of materials on small scales or near surfaces with high spatial resolution (hardness, elastic modulus, nano-scratch critical loads, stress-strain data). The provided information could be used for developing and/or optimizing application specific materials and processes or as input data for running simulations of the material behavior by finite-element analysis.

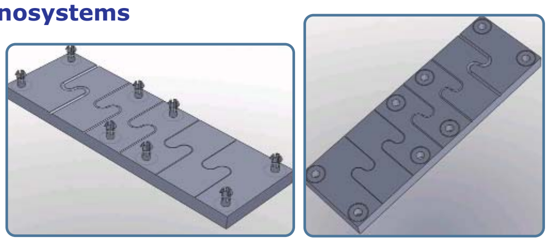
Contact person: Phys. Raluca Gavrila, raluca,gavrila@imt.ro

Nano Indenter G200

Laboratory for computer simulation and design (L5) has an experimental lab belonging to the "Centre for nanotechnologies" placed in the class 1,000 clean room.

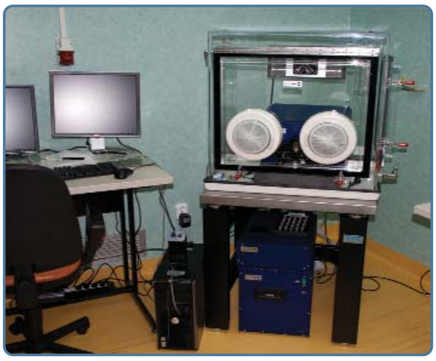
Integrated laboratory of advanced technologies for micro and nanosystems

The experimental laboratory "Integrated laboratory of advanced technologies for micro and nanosystems" aims at putting together different techniques from the field of rapid prototyping so as to allow covering the dimension scale from tens of nanometers up to macro, centimeter sized, structures. Harmonizing these techniques in a synergic way is the main aim of the laboratory.



Micro channel test with different dimension by using Selective Laser Sintering.
G. Moagar-Poladian, G Boldeiu

Mission: research in the field of rapid prototyping for micro- and nanostructures: improving or conceiving new technologies for rapid prototyping at these scales, developing new materials made by using such technologies;
- rapid prototyping services from nanoscale (dip pen nanolithography) to several tens of microns and to sub-milimeter and normal scale (3D Printing);
- education in the field: short courses, hands-on training, seminar;



Dip pen nanolithography system

• **Dip Pen Nanolithography Writer - NSCRIPTOR** (NanoInk, Inc.);
System allows patterning in nanometric range and is direct writing method that can use molecular and biomolecular "inks" on a variety of substrates. It can selectively place molecules at specific places.
Applications: surface functionalization (with direct liaison to proteomics, DNA recognition, virus identification); deposition materials onto semiconductor substrates for electronic industry; photolithographic masks correction; molecular electronics; realization of master stamps for NIL; novel nano- devices;

• **3D Printer Selective Laser Sintering EOS Formiga P100**
(EOS GmbH, Germany)
Performance: - minimum feature width: 500 microns;
- laser beam positioning accuracy: 50 microns;
- maximum build volume: 200mm x250 mmx330 mm;
- minimum layer thickness: 100 microns;
- laser beam scanning beam: maximum 5 m/s;
- vertical build speed: minimum 10 mm / hour.
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 hat 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 based on single photon photopolymerization

• **3D Printer based on Single Photon Photopolymerization MiniMultiLens system** (EnvisionTEC, Germany).
Performance: - Voxel size (Enhanced Resolution Mode): XY – 16 microns;
- Dynamic Voxel Thickness Z: from 15 microns to 50 microns;
- Build speed: is constant through the build up to 10 mm per hour at 50 μm Z-Voxel thickness;
- Build volume size (X x Y x Z): 44 x 33 x 230 mm at 16 micron voxel size 84 x 63 x 230 mm at 30 micron voxel size (voxel size in Enhanced Resolution Mode);
- Models are suitable for direct manufacturing through Rapid Casting;
Applications: R11 is ideal for creating master patterns in Rubber Molding applications, suitable for Electrical Housing, Medical, Snap-Fit Parts, Jewelry, Consumer Products and Automobile applications.
- e-shell 200 and e-shell 300 has been developed especially for parts of Hearing Aid Industries.
- PIC 100 is for producing high quality parts in the Jewelry market for production capacity direct investment castin, optimally suitable for producing precious metal castings.
- RC25 NanoCore is ideal for applications requiring superior stiffness and high heat deflection temperature, such as automotive components, pump housings and impellers, wind tunnel test parts, light reflectors, injections molds, hard chrome plating, et al.

Laser microengraving system

• **Laser microengraving system:** An in-house made laser microprocessing facility, starting from a high-power ps laser at 29 ps pulse duration, 266 nm wavelength, 10 Hz repetititon frequency, 600 MW peak-power per pulse. At the present, the system accepts computer control and may micro-engrave manually or in an automated manner (using AutoCAD software for pattern design) the patterns desired by the beneficiary.
The system will be completed with optics for a better control of the beam shape.

Contact person: Gabriel Moagar-Poladian, gabriel.moagar@imt.ro

Equipments and Experimental Laboratories

MIMOMEMS - EU Excellence Centre (grouping the RF MEMS lab and the Photonics lab) created from the following experimental laboratories:

- **Scanning Near-field Optical Microscope** (SNOM) - Witec alpha 300S (WITEC GmbH, Germany);
- **High Resolution Raman Spectrometery** - LabRAM HR 800 (HORRIBA Jobin Yvon);
- **White Light Interferometer (WLI)** - Photomap 3D Standard 2006 (FOGALE NANOTECH, FRANCE);

Scanning Near-field Optical Microscope (SNOM) - **Witec alpha 300S (WITEC GmbH, Germany)**; It allows the optical characterization 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 infrared spectral range.

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; fluorescence characterizations.

Contact person: Dr. Cristian Kusko, E-mail: **cristian.kusko@imt.ro;**

High Resolution Raman Spectrometery - **LabRAM HR 800 (HORRIBA Jobin Yvon)**: 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. 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 (λ=633nm) and tunable air cooled Ar laser (λ=488nm and 514nm);
• Large spectral range of Raman shift from 50 to 4000 cm^{-1} ideal for organic and inorganic species;
• LabSpec Software for control the instrument, data acquisition 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 and polymer nanocomposites characterizations;
• chemical and biological detection and self assembled molecule (SAM) on functionalized substrate using SERS technique;
• micro/nano structured oxidic thin films – micro roads, nanowires and other;
• carbonic materials and nanostructures – carbon nanotubes and graphene sheets;

Contact person: Dr. Munizer Purica, E-mail: **munizer.purica@imt.ro;**

"On wafer" microwave characterization up to 110 GHz
• Recently in the microwave laboratory the existing 65 GHz set-up for on wafer S parameter measurements (the Anritsu VNA and the Karl Suss probe station) has been upgraded to 110 GHz.
• A frequency generator up to 110 GHz (from Agilent Technologies)
• A spectrum analyzer up to 110 GHz (from Anritsu).

The Fig.1 presents the recently upgraded to 110GHz set-up for "on wafer" S parameters measurements; in Fig. 2 there are presented the frequency generator up to 110 GHz and the Spectrum Analyzer up to 110 GHz

Upgraded to 110GHz set-up for "on wafer" S parameters measurements (left), Generator up to 110GHz and the Spectrum Analyzer up to 110GHz (top).

Applications:
• Characterization of microwave and milimeter wave circuits in the 0.5 – 110 GHz frequency range
• "On wafer" S parameters measurements for microwave and millimeter wave devices and circuits
• Characterization of microwave devices based on carbon nanotubes (CNT) and graphene

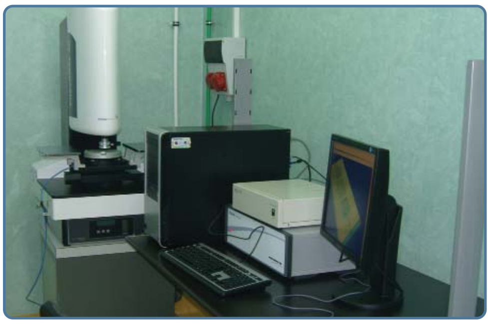
Contact person: Dr. Alexandru Muller, E-mail: **alexandru.muller@imt.ro;**
Dr. Mircea Dragoman, mircea.dragoman@imt.ro

- White Light Interferometer (WLI) Optical profiler – Photomap 3D Standard 2006 (FOGALE NANOTECH, France);

Technical characteristics:
The optical profiler perform optical, non-contact profiling of rough surfaces, that uses white light interferometry techniques as well as digital signal processing algorithms to produce fast, accurate, repeatable two and three-dimensional surface profile measurements. The photo below presents the WLI equipment (Photomap 3D, microscope, electronic module).

Applications:
• Optical profilometer allow to measure the surface topography of very diverse materials (such as metals, plastics, semiconductors, biological materials etc);
• Can be used for 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;
• Useful for thickness measurements of transparent layers (pastics, glasses or varnish) with known refraction indices;
• Can be used for MEMS dinamic measurements;

Results:
The 3D topography of the FBAR structure working at 8.3 GHz is presented in Fig. 1, where the "A" area indicates the pressure of the electrodes metallization of thin GaN membrane. The characterization of the membrane deflection is very important in order to improve the performances of FBAR structure for higher frequencies.


Optical profiler using white light interferometry technique (WLI)

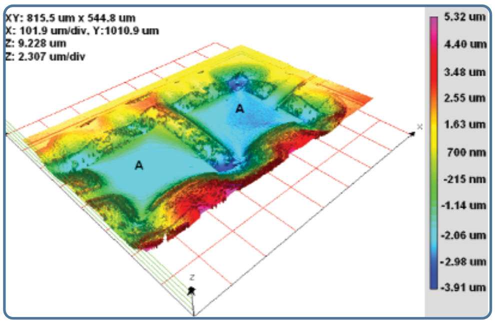


Fig. 2. 3D topography of the FBAR structure in the membrane area (0.4 mm GaN plus buffer thin membrane)

Contact person: Dr. Alina Cismaru, E-mail: alina.cismaru@imt.ro;

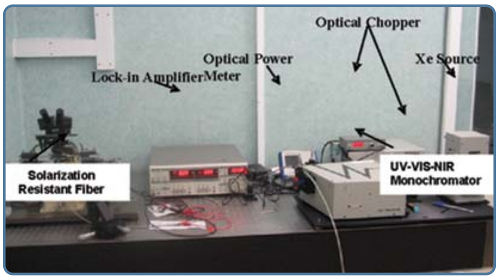
- Optical Theta Tensiometer (KSW Instruments, Finland): Instrument designed for measurement of surface and interfacial tension, static and dynamic contact angles, surface free energy of solids with assisted software for curve fitting to Young-Laplace equation, circle and polynomial or Bashforth/Adams models.
Technical specifications: FireWire camera 60 fps with telecentric optics and 55 mm focus length with 640x480 pixels resolution; Monochromatic LED based background lightning with integrating sphere; Contact angle measuring range 0-180 degrees; Accuracy ± 0.1°, ± 0.01 mN/m.
Applications: Contact angle, pendant drop and surface energy experiments. The provided information is useful for developing applications including process/functionalized surface treated films and nanostructured materials.


Photodetectors characterization set-up

Contact person: Eng. Cosmin Obreja, cosmin.obreja@imt.ro

- Photodetector Characterization System: This experimental set-up is a versatile system which enables the measurement of spectral response of various photodetectors covering the UV-VIS-NIR (200-1100 nm) spectral range. At the heart of this system is the Cornerstone™ 260 ¼ Monochromator connected by a mounting kit with a NEWPORT 300 W Xe Research Source, providing the broadband light source from which a certain wavelength is selected at the two exit slits of the monochromator. An Optical Power/Energy Meter (NEWPORT 1918-C) together with a calibrated UV Enhanced Silicon Photodetector (NEWPORT 918D-UV-OD3) is used for measuring the output light of the monochromator. A solarization resistent fiber cable is connected at one of the monochromator exit slit for measuring micrometer-scale photodetectors. The measurements are based on lock-in technique using the Stanford Research SR830 Lock-In Amplifier and SR540 Optical Chopper. The monochromator and lock-in amplifier are controlled through a GPIB interface using an in-house developed software package.

Technical specifications: • UV-VIS-NIR Oriel Cornerstone 260 1/4 m Monochromator: F/3.9; three gratings (200-1400 nm: 350 nm blaze, 450-1400 nm:750 nm blaze), 600-2500 nm:1000 nm blaze); 0.10 nm resolution (dual grating instruments with a 1200 l/mm grating and 10 μm x 2 mm slit);
• Xe Research Source: 300 W, UV Fused Silica, 1.3 in Collimated, F/1, 1.5";
• SR830 LOCK-IN AMPLIFIER: mHz to 102.4 kHz frequency range (nV or nA), >100 dB dynamic reserve, 5 ppm/°C stability, 0.01 degree phase resolution, Time constants from 10 μs to 30 ks (up to 24 dB/oct rolloff), Auto-gain, -phase, -reserve and –offset, Synthesized reference source, GPIB and RS-232 interfaces;



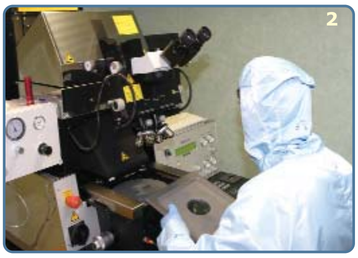
Photodetectors characterization set-up

• SR540-Optical chopper system: 4 Hz to 3.7 kHz chopping frequencies, Low phase jitter, Single and dual beam experiments, Sum & difference reference outputs;
• Optical Power Meter/Energy Meter: High-Performance, Hand-Held, peak-to-peak measurements of pulses with repetition-rates of up to 4 kHz at a sampling rate of 250 kHz. Pulse, peak-to-peak and DC source measurements can be displayed in units of W, dBm, dB, J, A, V and Sun depending on the detector types used;
• Solarization Resistant Fiber Cable: 600μm Core, 2m Length, 180-1100nm, SMA;

Applications: Measurements of photodetector characteristics (responsivity, quantum efficiency, etc.).

Contact person: Dr. Emil Pavelescu, emil.pavelescu@imt.ro

B. Main technological equipments in the clean room class 1,000



Dry etching: - Reactive Ion Etching (RIE) Etchlab 220 (SENTECH Instruments GmbH, Germany) (img 1);

Lithography: - Double Side Mask Aligner MA6/BA 6 (Suss MicroTec, Germany); for alignment/exposure nanolithography and nanoimprint: double face exposure alignment, UV, nanoprint 4”-6” (img 2).
- Spinner; Spinner SUS MICROTEK;

Masks: - **Pattern generator DWL 66fs Laser Lithography System** (Heidelberg Instruments Mikrotechnik GmbH, Germany); Writing facility on mask (with dimensions ranging between 2,5” and 6”) and on plates (with the diameter up to 3”). Resolution: minimum feature size 1ìm for lines, not complex geometry (img 3).

Thin film deposition: **- Electron Beam Evaporation an DC sputtering system AUTO 500** (BOC Edwards);

Note: Several CVD / thermal equipments will be installed in the new clean room (class 10,000) in the second semester of 2010. These include: ***LPCVD - LC100*** *(AnnealSys-France);* ***PECVD - LPX-CVD*** *(STS, UK);*

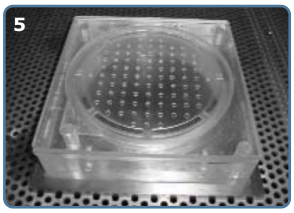
RTP- Rapid Thermal Processing ***system for Silicon, Compound Semiconductors, Photonics and MEMS processes AS-One 100*** *(ANNEALSYS,France)* -available soon.
Applications: Applications: •Implant annealing; •Contact Alloying; •Rapid Thermal Oxidation (RTO); •Rapid Thermal Nitridation (RTN); •Diffusion from spin-on dopants; •Densification and crystallization; •Glass reflow; •Silicidation(etc);
Substrate types: •Silicon wafers; •Compound semiconductor wafers; •Poly silicon wafers for solar cells; •Glass substrates; •Graphite and silicon carbide susceptors (etc).

PlasmaLab System 100 (Oxford Instruments, UK) (img 4)**:** ICP RIE system for deep reactive ion etching of silicon. It can perform silicon etching using both Bosch and Cryogenic. The anisotropic etching is independent of the crystallographic orientation of the wafer. Both 3” and 4” wafers can be processed, by easily changing the clamping system.

4

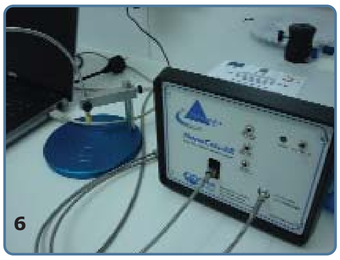
Etching profiles can be controlled via process temperature and process parameters. Two ultra-fast mass flow controllers ensure fast gas chopping for perfectly vertical walls.
Technical specifications: • Single wafer processing; • Etch profile: 90o±1o vertical side-walls; • selectivity: 50:1 for PR mask or 200:1 for SiO_2 mask; • aspect ratio: 20:1;
Applications: Silicon deep etching using the Bosch Process or the Cryogenic Process.
Contact person: Drd. Andrei Avram, andrei.avram@imt.ro

XeF2 etching system (IMT-Bucharest, Romania): The XeF_2 etching system (img 5) was fabricated within IMT-Bucharest as part of the MICRONANOFAB research project. The system ensures the isotropic bulk etching of silicon using sacrificial layer techniques for MEMS and NEMS. The system performs dry etching, having major advantages over wet chemical etching and plasma etching. The operator can obtain the isotropic etching usually obtained in wet etching, but without surface tension and sticking effects. Currently the system is under testing, it isn’t commissioned yet.



Technical specifications: • Single wafer processing; • Isotropic etching; • Selectivity to SiO_2, PR and many metal masks: 1000:1;
Applications: Isotropic etching for fabricating microchannels. Can be used for fabricating cantilevers and suspended structures.
Contact person: Drd. Andrei Avram, andrei.avram@imt.ro

C. Other equipments available in IMT-Bucharest

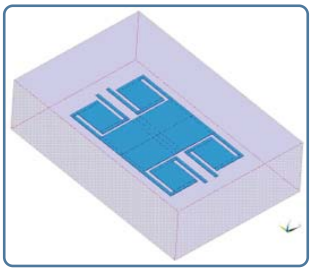


Characterization equipments: - **Spectroscopic ellipsometer - SE 800 XUV**
- UV-VIS-NIR Spectrophotometer, SPECORD M42;
- FTIR Spectrometer, Tensor 27 from Bruker Opticks;
- UV-Vis Spectrometer AvaSpec-2048TEC (Thermo-electric Cooled Fiber Optic Spectrometer);
- Semiconductor Characterization System with Manual Probe Station-4200 SCS/C/Keithley, EP6/ Suss; MicroTec (Keithley; Suss MicroTec)**;**
Performs electrical measurements for a wide range of applications from materials research and nanostructures development to I-V characterization of nanoelectronic devices. System 4200-SCS configured with the 4200-PA Remote Preamplifiers, offers exceptional low current measurement capability with a resolution of 0.1 fA, 5 mV.

- Ocean Optics NanoCalc-XR (Mikropack, Germany, img 6): Instrument for measuring the thickness of different layers. Can perform thin film thickness measurements of Silicon Oxide, Silicon Nitride, different types of photoresists and thin metal films. It can perform reflective measurements in a wide range of wavelengths, from 250 nm up to 1050 nm. It can measure stacks of layers, up to 10 layers simultaneously. Measurements are not disturbed by surface non-uniformity, roughness or dust.
Technical specifications: • Resolution: 0.1 nm; • Thickness range measurements: 10 nm to 100ìm; • Fast measurements: 100 ms to 1s; • Broad materials database;
Applications: Studies of various materials thickness on small scales. Accurate measurements of grown or deposited thin films. The provided information is useful for optimising silicon oxide growth or deposition of oxides and nitrides in LPCVD and PECVD equipments. Provides useful information regarding spin coated polymers and photoresists.
Contact person: Drd. Andrei Avram, andrei.avram@imt.ro

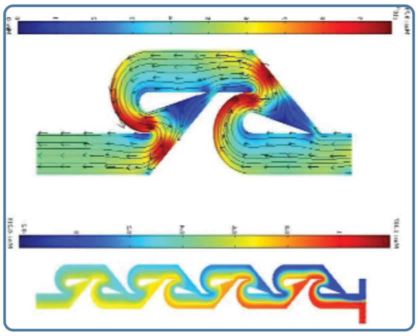
Computer technique for simulation and design:

- ***CoventorWare 2010:*** suite of software tools dedicated to microsystems design and simulation. It is comprised of three major modules (Architect, Designer and Analyzer) that can be used individually, or jointly to provide a complete MEMS design flow. The following single field and coupled field simulations can be performed: mechanical, electrical, thermal, piezoelectric, electro-thermo-mechanical, but also microfluidic simulations (general flows, electrokinetics, chemical reactions, two-phase flow, coupled fluid–structure interaction).
- **MATLAB & Simulink R2011:** High-level language and interactive environment specialized for technical calculations, data acquisition, data analysis and visualization. The following toolboxes are included: Extended Symbolic Math Toolbox; Curve Fitting Toolbox; Global Optimization Toolbox; Image Processing Toolbox; Neural Network Toolbox; Optimization Toolbox; Partial Differential Equation Toolbox; Signal Processing Toolbox; Spline Toolbox; Statitics Toolbox; Symbolic Math Toolbox.
- **ANSYS Multiphysics 11.0**- ANSYS Multiphysics is based on the finite element method and is capable of performing static (stress) analysis, thermal analysis, modal analysis, frequency response analysis, transient simulation and also coupled field analysis. The Ansys multiphysics can couple various physical domains such as structural, thermal, fluidics and electromagnetics. Ansys offers APDL (Ansys Parametric Design Language). The APDL allows users to execute all the commands required to pre process, solve and post process the problem, from a separate text file known as macro.



Model of the surrounding air and of the structure for electro-structural coupled simulation. (V. Moagar-Poladian)

ANSYS Multiphysics allows engineers and scientists to simulate the interaction between structural mechanics, heat transfer, fluid flow, acoustics and electromagnetics all within a single unified simulation environment. Samples of ANSYS simulations performed at IMT Bucharest Electrical field sensor simulation using ANSYS.
- **COMSOL Multiphysics 4.2** is a multiphysics modeling and simulation software containing the following modules: CAD Import Module; Microfluidics Module; Chemical Reaction Engineering Module; CFD Module; Structural Mechanics Module; RF Module; Optimization Module; MEMS Module; Material Library; Heat Transfer Module; Acoustics Module; AC/DC Module;
- **Solidworks Office Premium 2008** is a software package for 2D and 3D. It provides tools for creating geometries and allows the assembly and export of files in formats compatible with simulation software and 3D printers.
- **Mathematica 7:** Mathematical software for technical and scientific data processing: numeric and symbolic calculus; suitable for solving linear and nonlinear differential equations, computational geometry, statistics.



COMSOL Simulation of a Tesla micromixer
National Project Computer aided design for microfluidic components

Graphics: - **Origin PRO 8**: data analysis and graphing workspace, analysis tools for statistics, 3D fitting, image processing and signal processing.
- **Microsoft Visual Studio** is an integrated development environment (IDE) from Microsoft. It is used to develop console and graphical user interface applications along with Windows Forms applications, web sites, web applications, and web services in both native code together with managed code for all platforms supported by Microsoft Windows, Windows Mobile, Windows CE, .NET Framework, .NET Compact Framework and Microsoft Silverlight. The integrated debugger works both as a source-level debugger and a machine-level debugger. Other built-in tools include a forms designer for building GUI applications, web designer, class designer, and database schema designer. It accepts plug-ins that enhance the functionality at almost every level—including adding support for source-control systems (like Subversion and Visual SourceSafe) and adding new toolsets like editors and visual designers for domain-specific languages or toolsets for other aspects of the software development lifecycle (like the Team Foundation Server client: Team Explorer). *Source: Wikipedia*
- **Dual IBM system** composed of an X3950M2 chassis linked to a X3850M2 chassis with a combined capacity of 192GB of RAM, 32 cores (8 quad core Intel Xeon X7350 at 2.93GHz) and 1.4TB redundant high speed storage. Researchers from various laboratories and with different computing needs use this system which runs various operating systems in parallel through virtualization, enabling the use of modelling and simulation software in multiple configurations at the same time. The base operating system is SuSE Linux on top of which there is the Xen virtualization solution with Windows and Linux virtual machines used for modelling-simulation and the administration of the computing power.;

Services: - Optimized solutions for increasing performances of MEMS and microfluidic components;
- Microsystems design: Layout 2D, Process Editor, build 3D models based on silicon technology;
- Modeling and simulation of Micro-Opto-Electro-Mechanical Systems (MOEMS Analysis include simulation for mechanical, thermal, electrical, electrostatic, piezoelectric, optical, electromagnetic and coupled field);
- Modeling and simulation of microfluidic components and systems: micropumps and microvalves with various actuation principles (electrostatic, piezoelectric, pneumatic, electroosmotic), micromixers, microfilters. Microfluidic analysis include: fluid dynamics in microstructures (flow under pressure, thermal flow, fluid mixing), electrokinetics, bubble-drop, fluid-structure interaction;
- Consultancy in computer-aided-design and microsystem simulation; Assistance and training by research: hands-on courses, access to computers and software;

Applications: MEMS (sensors, actuators, accelerometers), Optical MEMS, RF-MEMS, microfluidic microsystems as micropumps, micromixers, microfilters, reaction chambers used in lab-on-chips for pharmaceutical research, medical field (diagnosis, drug delivery), ink-jet devices.

Teaching activities: - Labs for the "Microsensors" Courses for 4th year students of the Faculty of Electronics, Telecommunications and Information Technology, "Politehnica" University of Bucharest;
- "Intelligent sensors and microsystems" Courses and labs for Masters students from the Faculty of Electronics, Telecommunications and Information Technology, "Politehnica" University of Bucharest
- Short simulation courses for companies through the Leonardo da Vinci Project: ComEd (2008-2010); Coordinator BWAW Thüringen GmbH, Germany, Contract Number: DE/08/LLP-LdV/TO/147174.

L3: Laboratory of micro/nano photonics

- Mission
- Main areas of expertise
- European Projects
- Research Team
- Specific facilities

Mission: Research and development activities in the field of micro/nano-photonics and optical MEMS 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 af simulation tools
- **new materials** for micro/nano opto-electro-mechanical systems integration (e.g. compound semiconductors, functional polymer, hybrid organic-inorganic nano-compozites 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
- **plasmonics**
- optical and electrical **characterization** of materials and devices

European Projects

FP7: •Flexible Patterning of Complex Micro Structures using Adaptive Embossing Technology, **FlexPaet**, IP, NMP; •European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, **MIMOMEMS**, CSA-programme capacities;
MNT-ERANET: •Multifunctional Zinc-Oxide based nanostructures: from materials to a new generation of devices (MULTINANOWIRES)

National Projects:
- Development of soft lithography techniques for micro and nano-photonics- National Program "Partnership"
- Development of processes and devices based on oxidic and polymeric thin layers for transparent Electronics and Optoelectronics- National Program "Partnership"
- Multifunctional molecular architectures for organic electronics and nanotechnology- theoretical and experimental studies- National Program "Ideas"

The **Research team** has *multidisciplinary* expertise and is composed of 6 senior researchers (5 with PhD in optoelectronics, materials for optoelectronics, microsytems, physics, chemistry), 2 PhD students (with physics and electronics background), 1MSc student.

Cristian Kusko, Roxana Tomeascu, Munizer Purica, Mihai Kusko, Paula Obreja, Roxana Rebigan, Florin Comanescu, Elena Budianu, Dana Cristea.

Specific facilities:

Modeling and simulation: • **Opti FDTD 9.0** - design and simulation of advanced passive and nonlinear photonic devices
• **OptiBPM 10.0**- design of complex optical waveguides, which perform guiding, coupling, switching, splitting, multiplexing and demultiplexing of optical signals in photonic devices
• **OptiGrating**- design software for modelling integrated and fiber optical devices that incorporate optical gratings
• **Opti-HS** - components and of active devices based on semiconductor heterostructures
• **LaserMod** - analysis of optoelectronic devices by performing electrical and optical analysis of III-V and other semiconductor materials.
• **3Lith** – 3D micro-optical elements
• **Zemax**

Characterization: • *spectrophotometers for UV-VIS-NIR and IR spectral range*;
• *spectroscopic ellipsometer;*
• *High Resolution Raman Spectrometers* LabRAM HR
• *Alpha300 S System* – combines the characterization methods of Scanning Near-field Optical Microscope (SNOM), Confocal Microscopy (CM) and Atomic Force Microscopy (AFM)
• *experimental set-up for optoelectric characterization in UV-VIS-IR* spectral range of optoelectronic and photonic components, circuits

Technology: glove box for preparation and deposition of nanocomposites and organic layers

Laboratory Head — Dr. Dana Cristea (dana.cristea@imt.ro)

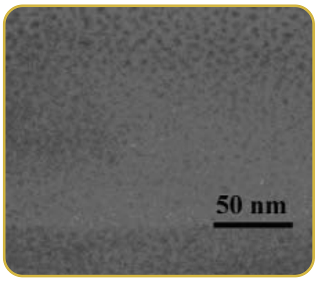
Dr. Dana Cristea received a MSc in Electronics (1982) and PhD in Optoelectronics and Materials for Electronics from "Politehnica" University, Bucharest, Romania. Between 1982-1994 she was a research scientist in the Department of Optoelectronics and Sensors at Research & Development Institute for Electronic Components, Bucharest, Romania.

Since 1994 she has been a senior researcher in the National Institute for R&D in Microtechnologies (IMT-Bucharest), Romania, head of Laboratory for Micro/Nanophotonics since 1997 and head of Department for Multidisciplinary Research between 2002 and 2008; since 1990 she has also been an Associate Professor at "Politehnica" University, Bucharest, Faculty of Electronics.

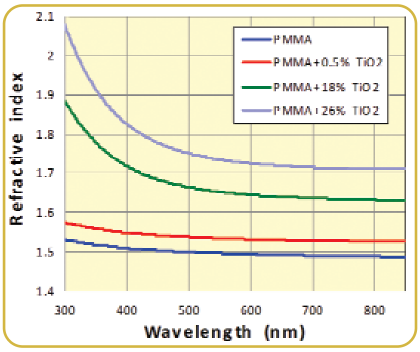
Her main research activities are in the fields of optoelectronics and photonic integrated circuits, optical MEMS, new nanostructured materials for photonics, chemo and bio-sensors, micro-optics. She wrote for more than 80 publications in international scientific journals and conference proceedings, and is also a reviewer for Romanian and International scientific journals. Dr. Dana Cristea has coordinated more than 20 national projects, has participated in several FP6 projects (WAPITI, 4M, ASSEMIC), and is currently involved in two FP7 projects (FlexPAET, MIMOMEMS).

Nanocomposite materials with controlled optical properties for micro-optics

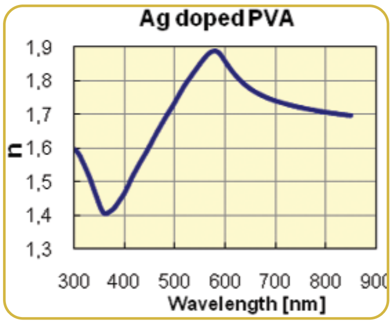
The nanocomposites have been obtained from commercial polymers (PMMA, PVA) and dopants: metal (Ag), metal oxide nanoparticles (TiO_2, ZrO_2) or organic materials (Rhodamine, Alq_3) by chemical routes and sol-gel processes. The optical properties of these materials depend on the composition, metal/oxide concentration, particle size and dispersion homogeneity. Micro/nano pattering techniques based on combination of electron beam lithography and replication techniques have been developed to obtain structures with applications in micro-optics.

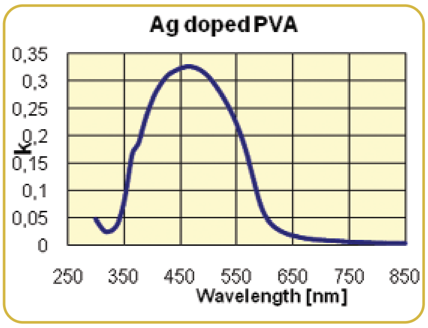


XTEM image of PMMA-TiO_2 film ($dTiO_2$ = 5-10 nm). TiO_2 nanoparticles are uniform dispersed in the film.

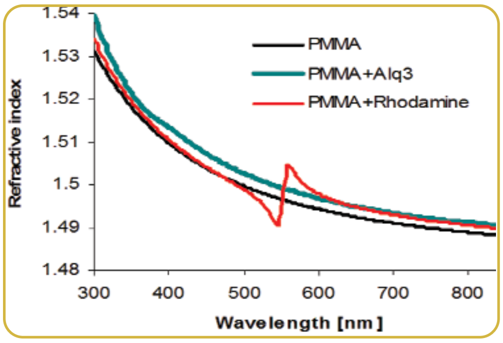


Dispersion of the refractive index of PMMA-TiO_2 film.

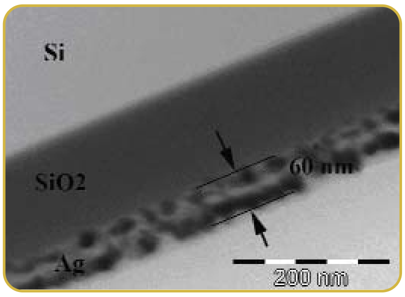


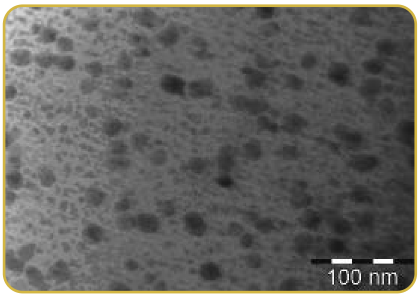


Real and imaginary refractive index of Ag – PVA film

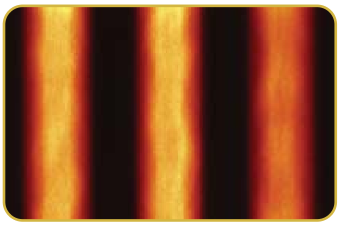


Dispersion of the refractive index of dye doped PMMA films





XTEM images of Ag-PVA film (d Ag = 5 - 30 nm)

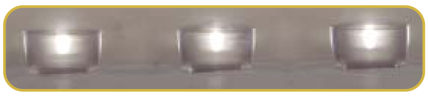


Surface plasmon enhanced emission from RhB doped PMMA/Au strips at λ=600 nm (excitation with λ=530 nm) - application in biosensing and OLEDs

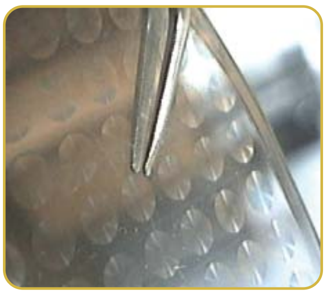
PN II Project (2007-2010), "Development of soft lithography techniques for micro and nano-photonics" – **LISOFT**
PN II project (2009-2011) Program Ideas „Multifunctional molecular architectures for organic electronics and nanotechnology-theoretical and experimental studies". Contract No. 617/2009; **Contact person**: Dr. Paula Obreja (paula.obreja@imt.ro)

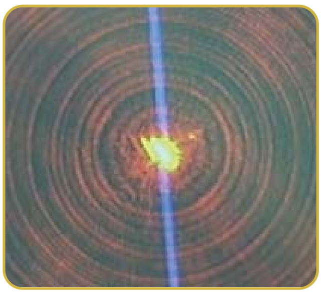
Micro optical components in polymers

Replica molding technique was used to replicate micro-optical components (lens, array lenses), components for micro-fluidic applications and to generate nano-components in polymers with different feature size.

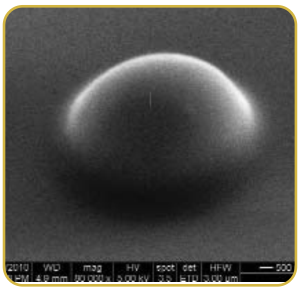


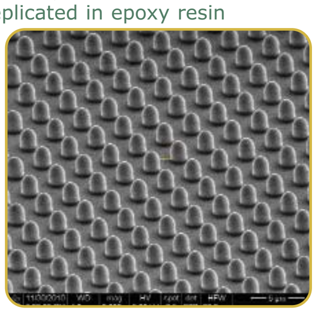
Optical images of an array lenses replicated in epoxy resin





Optical images of Fresnel lens replicated in epoxy resin





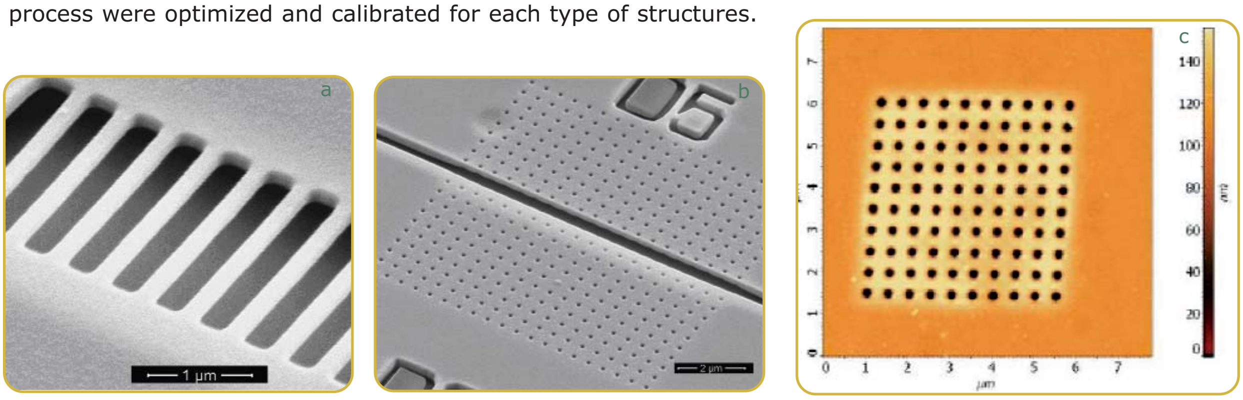
SEM images of a lens and an array lenses replicated in PDMS

PN II Project (2007-2010), "Development of soft lithography techniques for micro and nano-photonics"
Coordinator: IMT Bucharest, **Project manager:** Paula Obreja (paula.obreja@imt.ro)

Results

3D Electron beam lithography in for μ- and n-optics

3D-profile structures with feature size in the submicron range, for applications in photonics (photonic crystals, optical waveguides, and holograms) were obtained by EBL in multi-layer resist systems. If the polymers that compose the multi-layers have different charge sensitivity and/or different dissolution rate, the remaining structure after exposure and development will have a 3D profile. T-shape and suspended structures can be obtained in by-layer systems PMMA950K /PMMA495K PMMA 950K/LOR and /PMMA950K/ PMMA35K. The exposure parameters and the development process were optimized and calibrated for each type of structures.

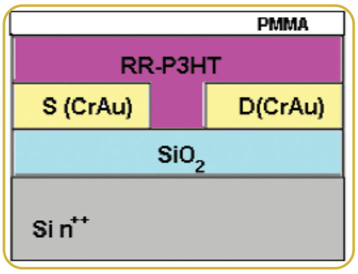


Structures obtained by EBL in bi-layer system PMMA 950K/LOR: a) SEM image of suspended PMMA waveguides; b) SEM images and c) AFM – 2D image of PMMA photonic crystal (suspended PMMA membrane for with holes of 200 nm diameter and pitch of 500 nm)

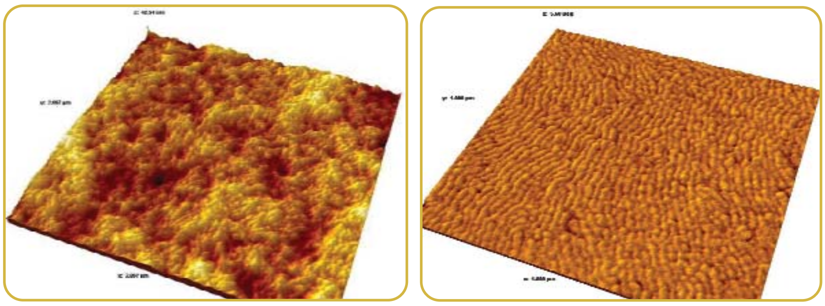
IMT core program Convert- project PN 09 29 02 05; Cooperation with Microphysical characterization laboratory (EBL, SEM).

Techniques for regioregular poly 3-hexyl tiophene (rr-P3HT) deposition for OFETs

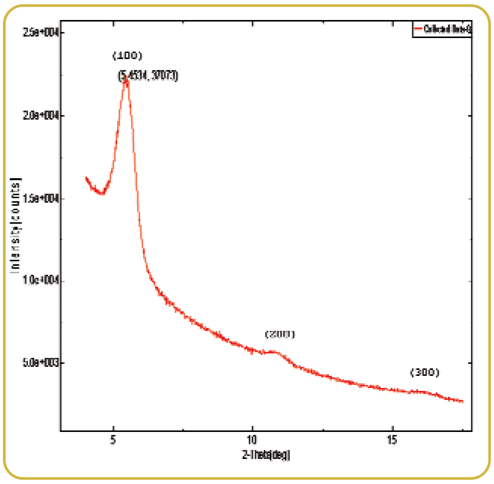
Thin layers of rr-P_3HT were deposited by spin-coating or drop casting in N_2 atmosphere, on SiO_2 or SiO_2 functionalized with trimethylchlorosilane. The best results (enhanced crystalinity and higher conductivity) were obtained for the layers deposited by drop-casting on functionalised SiO2.



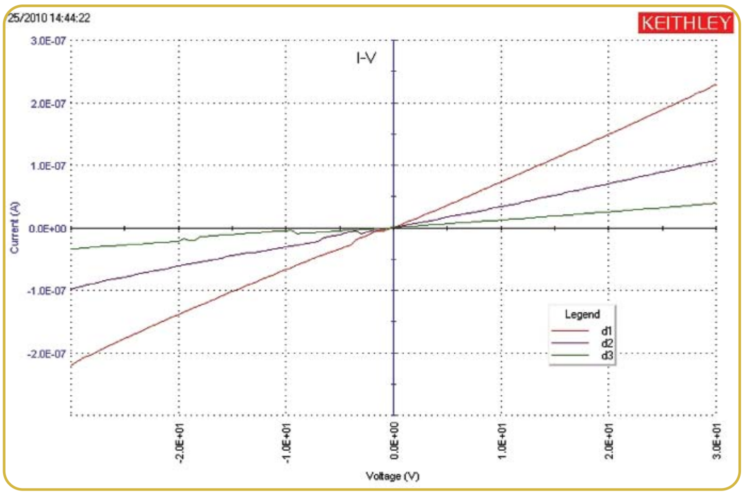
Schematic structure of the test device



AFM images of rr-P3HT thin films prepared by drop-casting on functionalised SiO2: a) topography; b) phase image



XRD profile of the rr-P_3HT thin films prepared by drop-casting on functionalised SiO_2



I-V characteristics of the rr-P3HT resistor (S-D) with width 2000 nm, length d_1 =30 nm, d_2 = 50 nm, d_3 = 80 nm, 100 nm

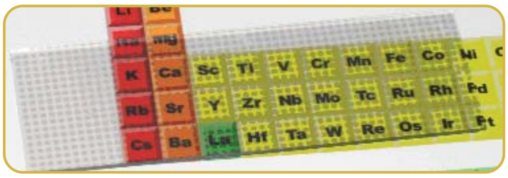
PN II project (2009-2011)-Program Ideas „Multifunctional molecular architectures for organic electronics and nanotechnology theoretical and experimental studies". Contract No. 617/2009

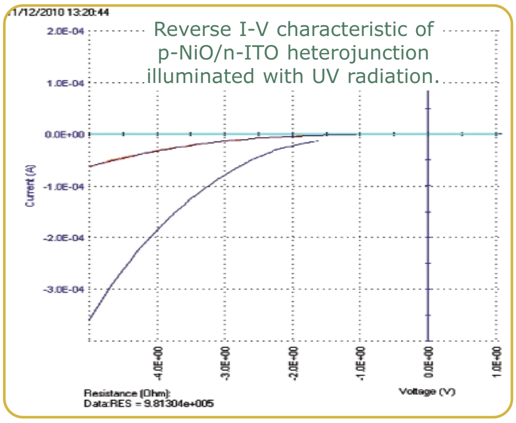
Results

Heterojunctions with semiconductor transparent thin films of p-type

- **p-NiO/n-ITO transparent heterojunction.**

Glass substrate with p-NiO/n-ITO transparent heterojunctions with circular geometry of 0.6 mm^2 area.

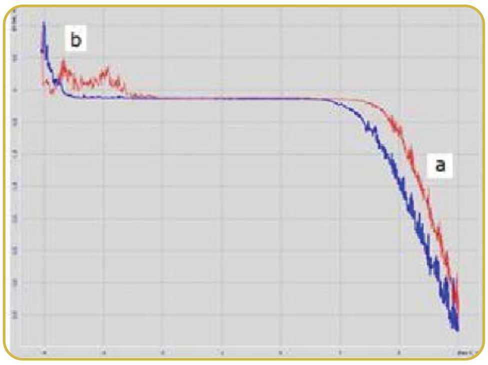




Reverse I-V characteristic of p-NiO/n-ITO heterojunction illuminated with UV radiation.

- **p-NiO/Ti Schottky barrier.**

The I-V characteristic of NiO/Ti obtained with electrical AFM method (AFM tip covered with Ti) at very low currents (~10 nA) showed forward bias of 2V and breakdown voltage>4V.

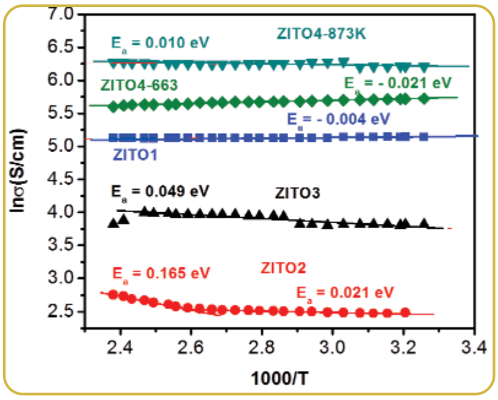


The I-V characteristic of NiO/Ti by conductive – AFM method: a) direct bias; b) reverse bias

Transparent films

- **p and n type - $In_{1.64}Sn_{0.16}Zn_{0.2}O_{3-5}$. (ZITO) transparent oxides layers.**

- high transparency: > 88%;
- polycrystalline structure with <222> preferential orientation;
- thickness: 120-200 nm.



Electrical conductivity vs reverse temperature.

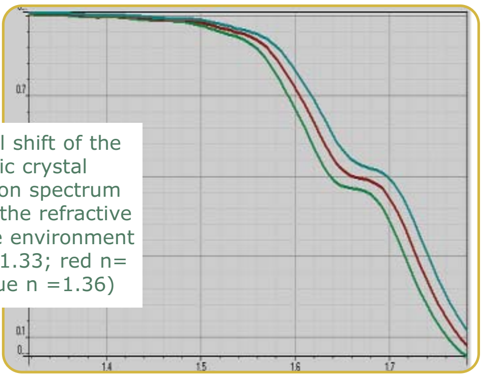
- **Transparent polymeric nanocomposites layers of PDMS-SiO_2-TiO_2 by sol-gel method.**

Optical image of transparent polymeric nanocomposites films.

PN II, Contract no: 12128/2008, "Development of processes and devices based on oxidic and polymeric thin layers for transparent Electronics and Optoelectronics - **ELOTRANSP; Co-operation** with ICMPP, Iasi.
Co-ordinator: IMT-Bucharest;
Project manager: Dr. Munizer Purica (munizer.purica@imt.ro)

Microphotonic sensors with biomedical or environmental applications

This project aims to design and fabricate microphotonic sensors based on photonic integrated circuits. The sensing principle is surface plasmon resonance (SPR) and the interaction between environment and the guided evanescent wave.

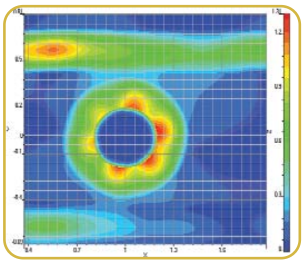


Theoretical shift of the photonic crystal transmission spectrum function of the refractive index of the environment (green n =1.33; red n= 1.345; blue n =1.36)

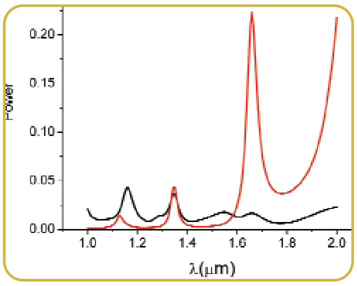
Contact person: Dr. Mihai Kusko, mihai.kusko@imt.ro

Theoretical and experimental investigation of plasmonic systems

This project aims to investigate theoretically and experimentally the optical radiation confinement in metallic waveguides with applications in optical signal processing and sensors. The propagation of field in subwavelength metallic structures has been investigated using the finite difference time domain and beam propagation method. Geometrical parameters and functional characteristic have been identified.



Field distribution in a subwavelength plasmonic nanoring resonator



Spectral characteristic of a subwavelength plasmonic nanoring resonator (red line).

Contact person: Dr. Cristian Kusko, cristian.kusko@imt.ro

Postdoctoral grants Sectorial Operational Programme Human Resources Development (SOP HRD) financed by the European Social Fund and by Romanian Government: POSDRU/89/1.5/S/63700.

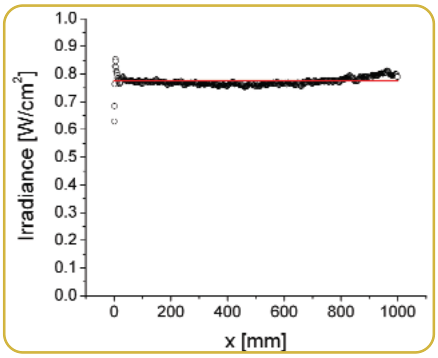
Flexible Patterning of Complex Micro Structures using Adaptive Embossing Technology

Grant agreement no.: 214018 (IP, FP7, NMP-2007-3.5-2)
Coordinator: Fraunhofer Institut für Produktionstechnolgie (Germany). **Partners:** Oy Modines Ltd. (Finland), Zumtobel Lighting GmbH (Austria), CEA LITEN (France), Gaggione (France), Eitzenberger Luftlagertechnik GmbH (Germany), Johann Fischer Aschaffenburg Präzisionswerk GmbH & Co (Germany), Datapixel S.L.(Spain), Innovalia (Spain), Temicon GmbH (Germany), IPU (Denmark), IMT-Bucharest (Romania), Fundacion Privada Ascamm (Spain)
Contact person for IMT: Dr Dana Cristea dana.cristea@imt.ro

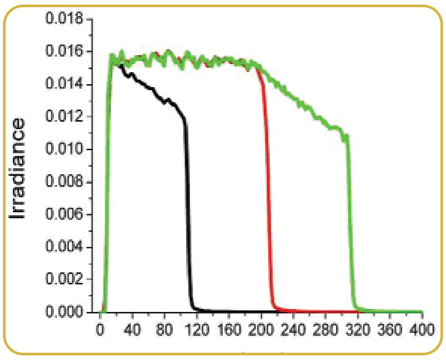
■ Optimization of the embossing process for large area diffractive optical elements

A theoretical framework for finding the optimal distribution of scattering elements in an edge-lit light guide plate (LGP) presenting intrinsic absorption losses for rendering a uniform distribution of the outcoupled light has been elaborated. Based on a simple mathematical model describing the light propagation in an LGP with a distribution of scattering elements located on its lower surface, a relation giving the distribution of scattering elements leading to a uniform irradiance along the LGP has been found. The validity of the theory has been verified by performing ray tracing simulations. The simulations show a quantitative agreement between the analytical results and the simulated ones, confirming the mathematical model [M.Kusko, C. Kusko, and D. Cristea, J. of Optical Soc. Of America 27]

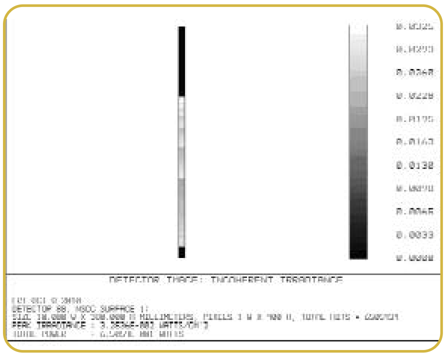
A step by step adaptive algorithm for designing and optimizing a LGP with uniform radiance having no prior knowledge regarding the outcoupling coefficients of the scattering elements their embossed configuration and the intrinsic losses of the LGP has been elaborated. This algorithm relies on online luminance measurements. The validity of this algorithm has been verified by performing ray tracing simulations and a logical diagram describing the logical flow of the measurement and embossing operations has been proposed.



The irradiance for a waveguide embossed with a distribution of scatterers generated for a k=0.0017 obtained from simulation (circles) and theory (solid line).



The ray tracing simulations illustrating the step by step adaptive embossing algorithm

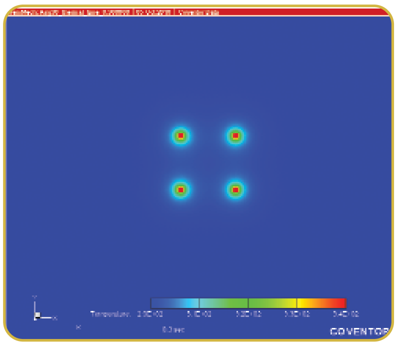


The simulated irradiance for a structure realized with multipixel stamps

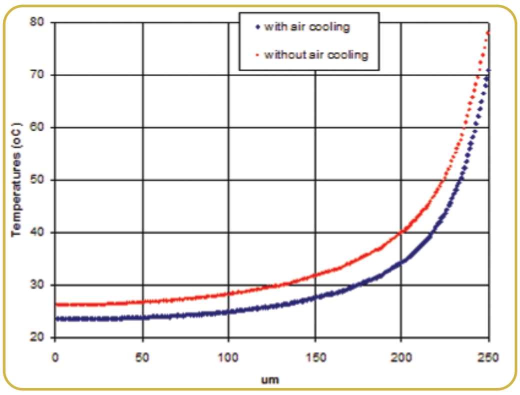
Contact persons: Dr. Cristian Kusko (cristian.kusko@imt.ro)**, Dr. Mihai Kusko** (mihai.kusko@imt.ro)

■ Thermal transient analysis of the embossing step

We performed design/simulations with CoventorWare software for thermal transfer of the embossing steps for two types of tools (Ni-Shim tool with 25 pixels and 4 pixels 40x40um tool) and considered a polymeric substrate with high thermal conductivity or a commercial one with less high thermal conductivity. In order to decrease the temperature of the PMMA surface between the embossed pixels (thus the already embossed pixels are not melted/damaged) we considered for cooling an air flow on surfaces between substrate and tool.



Simulations results of temperatures at 0.3 s with air cooling



The different temperatures (with air cooling and without air cooling) in the PMMA substrate between two pixels for the tool with 4 pixels at 0.3s, Step 1, Initial temperature of Ni at 150 ºC, air gap 30 um

Cooperation with Simulation, Modeling and Computer Aided Design Laboratory.
Contact person: Rodica Voicu (rodica.voicu@imt.ro)

L4: Laboratory of micromachined structures, microwave circuits and devices

The laboratory is one of the promoters of the RF – MEMS topics in Europe. It has coordinated the FP4 MEMSWAVE project (one of the first EU project in RF MEMS) nominated in 2002 for the Descartes prize. It has participated in the FP6 network of excellence "**AMICOM**" (2004 -2007) with new and original results obtained in cooperation with key players in the European research in this topic (LAAS–CNRS Toulouse, VTT Helsinki, FORTH Heraklion). Since 2009 the laboratory is member of LEA "Smart MEMS/NEMS Associated Lab" together with LAAS-CNRS Toulouse and FORTH Heraklion.

Mission: scientific research and technological development of micromachined microwave and millimetre wave devices and circuits, contributions to the developing strategy of the domain. The new RF MEMS technologies including the "membrane supported circuits" represents a solution to manufacture high performance microwave and millimeter wave devices and circuits devoted to the emerging communication systems and sensors. Lately, the laboratory has also started the research to develop acoustic devices using micromachining and nano-processing of wide band gap semiconductors (GaN/Si, AlN/Si) and experimental devices based on carbon nanotubes and graphene.

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 micromachined, 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 (meta-materials); ⬩ MEMS and NEMS technologies developement.

International projects **MIMOMEMS**-FP 7, REGPOT call 2007-1 "European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors" (2008-2011).
MEMS-4-MMIC-FP7-ICT-2007-2, No.204101-"Enabling MEMS-MMIC technology for cost-effective multifunctional RF-system integration", (2008-2010).
ENIAC JU projects: **SE2A**-"Nanoelectronics for Safe, Fuel Efficient and Environment Friendly Automotive Solutions" and **Mercure** "Micro and Nano Technologies Based on Wide Band Gap Materials for Future Transmitting Receiving and Sensing Systems" beginning in Sept 2010.
MNT-ERANET "MEMS Based Millimeterwave Imaging System" MEMIS (2010-2012).

International bilateral cooperations: The laboratory has bilateral governmental cooperations with University of Pretoria, South Africa and with Korea Electrotechnology Research Institute, Korea.

National projects: In the PN II programme, the laboratory has 6 projects (3 Partnerships and 3 Capacities) as coordinator and one as partner. The laboratory had finished three CEEX projects as coordinator, two CEEX projects as partners and four projects in the MINASIST+.

Research team: has multidisciplinary expertise in physics and electronics of microsystems and is composed of 11 senior researchers (9 of them with PhD in physics, electronics, microwave and chemistry), 1 PhD student in electronics and 2 Masters Students.

Mariana Dionian, Marius Voicu, Ioana Petrini, Valentin Buiculescu, Cristina Buiculescu, Alexandra Stefanescu, Emil Pavelescu, Cornel Anton, Alexandru Muller, Dan Neculoiu, Alina Cismaru, Mircea Dragoman, Andrei Muller, Alina Bunea, Gheorghe Sajin

Awards: **Finalist of the Descartes Prize 2002** of the EC for the coordination of the MEMSWAVE Project.
Romanian Academy Prize "Tudor Tanasescu" for "Micromachined circuits for microwave and millimeter wave applications – MEMSWAVE" (2001); second prize for the MATNANTECH project, SIRMEMS (CONRO 2003)

Laboratory Head — Dr. Alexandru Muller (alexandru.muller@imt.ro)

M.Sc. in Physics at Bucharest University (1972) and PhD in Physics at Bucharest University in 1990;

Competences: Silicon, GaAs and GaN micromachining and nanoprocessing: manufacturing of RF MEMS components and circuits, technological process in GaAs MMICs, design, modeling and manufacuring of microwave passive membrane supported circuits (1997-European priority), micromachined inductors, filters and antennae, monolithically as well as hybrid integrated receiver front end modules, acoustic devices (FBARs and SAWs) based on micromachining and nanoprocessing of wide band gap semiconductors (AlN , GaN).

Dr. Müller is the coordinator of the European project FP7 REGPOT (2008 – 2011) "European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors" - Project No 202897

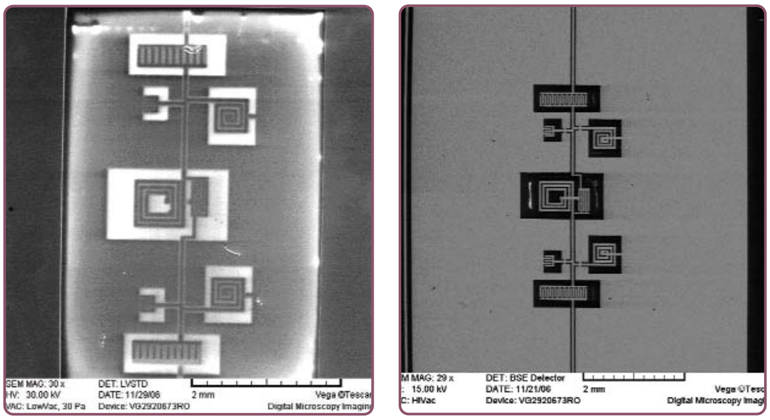
Dr. Müller has coordinated the European Project FP 4 MEMSWAVE (1998-2001), and was the leader of the Romanian team in the FP6 NoE AMICOM and member of the Board of Directors of this project He is member of Micromechanics Europe Workshop and MEMSWAVE workshop steering committees. He is member of IEEE and EuMA. Dr Muller is member of PhD Jury in Politechnica Univ. Bucharest and Univ. Paul Sabatier/LAAS Toulouse. Co-editor of the Micro and Nanoengineering Series (Romanian Academy). He had invited papers at important European conferences. He has more than 150 contributions in books and international journals/conferences.

Dr. Müller is finalist of the Descartes Prize competition 2002 of the European Community with the MEMSWAVE Project, Romanian Academy Prize "Tudor Tanasescu".

Specific facilities: **Computers and software for microwave electromagnetic simulations** (IE3D, Fidelity and CST software packages); *"On wafer" measurement system in the 0.1 -110 GHz range* (microwave network analyzer Anristu in Karl SUSS Microtec Probe Station), *Frequency Syntesizer Agilent up to 110 GHz*; *Spectrum Analyzer Anritsu up to 110 GHz*; *Tektronix digital serial analyzer DSA8200 with TDR module*; *Keithley Semiconductor characterization system, Optical profiler WLI – Photomap 3D; Millimeter wave power-meter in 0.1 – 40 GHz range*, Measurement accessories.

Results

New reconfigurable micromachined filters dedicated to reconfigurable frontends for mobile communication systems 3G and „beyond 3G" which endure the DCS 1800MHz and WLAN 5.2 GHz standards – design and manufacturing

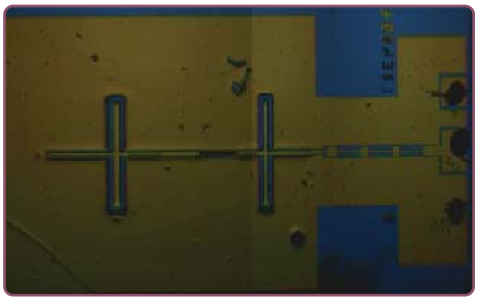

Top view (left) and bottom view (right) of reconfigurable filter structure

The filters are realized with two levels of micromachining (air bridges of the membrane supported spiral inductors). The structure is suspended on a dielectric membrane of 1.5 μm thick $SiO_2/Si_3N_4/SiO_2$. S parameters measurements between 1-8 GHz have been performed. A good agreement between measurements and simulations has been obtained. Measured losses are 1.8 dB above the simulated ones.

Achievements: design, electromagnetic simulation and optimization of band pass filter model, technological fabrication of reconfigurable filters with resistive switches in "on-DOWN" and "off-UP" states, S parameters measurements.

PN II Partnership Project "Advanced circuits for microwave, millimeter wave and photonics based on MEMS technologies „MIMFOMEMS" (2007-2010) **Co-ordinator,** IMT-Bucharest, **Project Manager**: Dr. A Müller (alexandru.muller@imt.ro)
Partners: National R&D Institute for Material Physics, "Politehnica" Univ. Bucharest, Institute of the Macromolecular Chemistry "Petru Poni" Iasi, SITEX 45 Bucharest

Design and fabrication of monolithic integrated micromachined 60 GHz receiver with double folded slot antennas on thin GaAs membrane to be used as MMID TAG


The optical photo of the fabricated receiver structure.

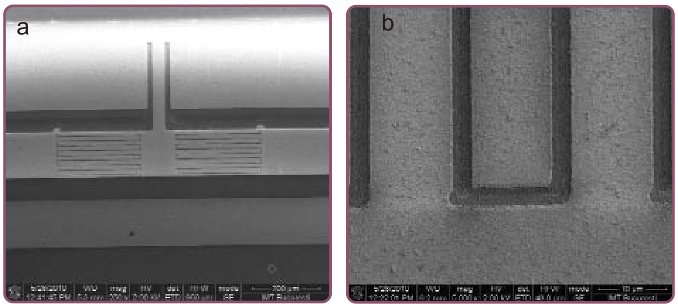

The micromachined receiver structure mounted on a printed circuit board for microwave characterisation.

The structure was simulated with IE3D Zeland software. The antenna integrated with the Schottky diode are supported on a 2.2 μm thick semi-insulating membrane fabricated using GaAs micromachining. The experimental results demonstrate an isotropic voltage sensitivity of 20.000 mV/mW at 61 GHz operating frequency.

Achivements: design and fabrication of monolithic integrated micromachined receiver test structures on GaAs membrane.

PN II Partnership Project "Advanced circuits for microwave, millimeter wave and photonics based on MEMS technologies „MIMFOMEMS" (2007-2010) **Co-ordinator,** IMT-Bucharest, **Project Manager**: Dr. A Müller (alexandru.muller@imt.ro)
Partners: National R&D Institute for Material Physics, "Politehnica" Univ. Bucharest, Institute of the Macromolecular Chemistry "Petru Poni" Iasi, SITEX 45 Bucharest

CRLH structures in millimeter wave frequency range fabricated by laser ablation



SEM image of CRLH cells processed by laser ablation (a) and a detail of an interdigital capacitor (b)

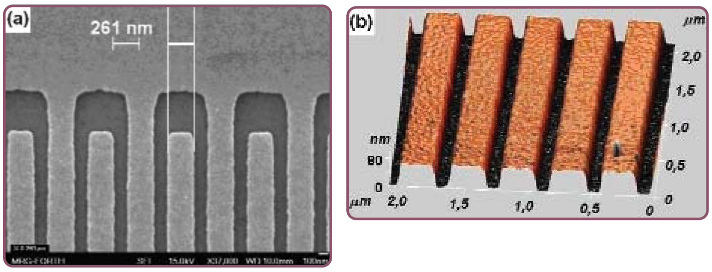
In the mm-wave frequency domain, the dimensions of the devices' metallic lines and the spaces are close to the limits of the standard photolithographic technology. The laser ablation process developed in collaboration with the NILPRP is a valuable alternative to process CRLH mm-wave structures. Using this technique, the fabrication of mm-wave filters, couplers and antennas were demonstrated.

PN II Project 11-030: Advanced femtosecond laser system for metamaterials and photonic crystals nanostructuring – **FEMAT**. . Partnership with NILPRP Bucharest. Scientific manager for IMT: dr.ing Gheorghe Ioan Sajin

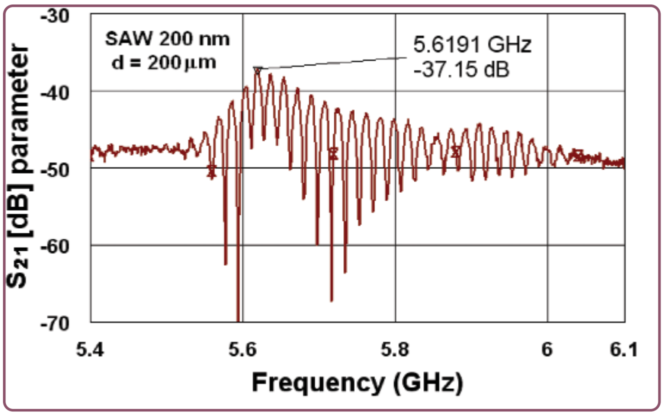
SAW structures manufactured on GaN and AlN for frequencies beyond 5 GHz

GaN and AlN piezoelectric layers can be a solution for manufacturing FBAR resonators with very high resonance frequencies. The SAW structures consist in two face to face interdigitated transducers (IDTs), placed at different distances. Using advanced nanolithographic techniques, different SAW structures with fingers and interdigit spacing 200 nm wide have been manufactured, measured and analyzed.

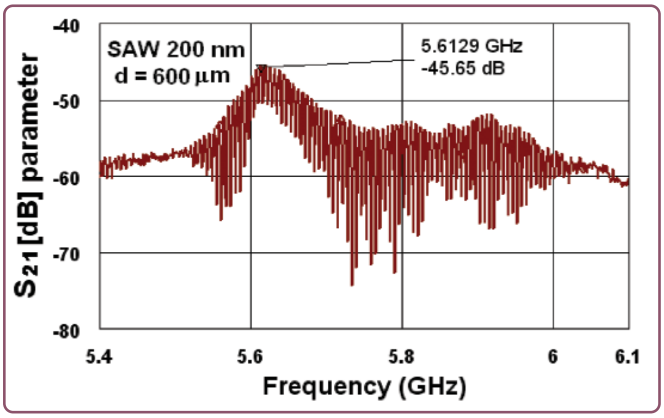
Achievements: SAW structures obtained on GaN and AlN based on nanolithographic techniques



Detail of the nanolithographic process with fingers and intedigits nominally 200 nm wide developed on the GaN surface: a) (left) SEM photo and b) (right) AFM image



The transmission measurements for the SAW test structure having a 200 µm distance between the IDTs

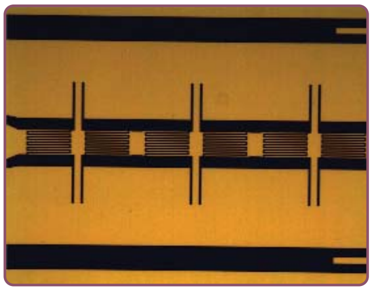


The transmission measurements for the SAW test structure having a 600 µm distance between the IDTs

PN II Partnership Project "SAW and FBAR type resonators dedicated to applications in communications for 2-6 GHz, based on micro&nanomachining of wide band semiconductors (GaN and AlN) – GIGASABAR" (2008-2011). **Co-ordinator**, IMT-Bucharest, **Project Manager:** Dr. A Müller (alexandru.muller@imt.ro). **Partners:** National R&D Institute for Material Physics, "Politehnica" Univ. Bucharest, "Ovidius"University Constanta, SITEX 45 Bucharest

Millimeter wave metamaterial devices

Metamaterials are propagation media exhibiting simultaneously negative permittivities ($\varepsilon<0$) and negative permeabilities ($\mu<0$). These kinds of media are named Left Handed Materials (LHM). The combination between left handed and right handed variants of a transmission line is a special kind of line named Composite Right/Left Handed Transmission Line (CRLH-TL). Using the CRLH-TL approach allows substantial space reduction compared to the standard devices. Moreover, if combined with other metamaterial devices and circuits, it offers the possibility to develop a new and different kind of microwave and mm-wave circuitry.

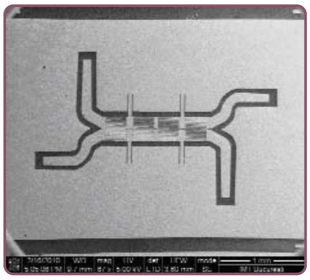


Optical microscopy photo showing the active part of the CRLH antenna

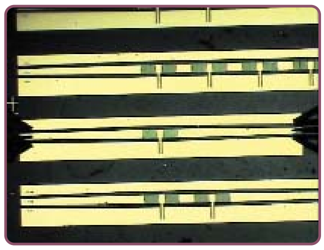
Achievements: a) Leaky Wave CRLH Antenna on Silicon Substrate A CPW CRLH leaky wave antenna structure working at a frequency of 28.7 GHz consists of three resonant CRLH cells processed on a high resistivity silicon wafer. The area occupied by the antenna is 2.15x0.6 mm^2, having a size reduction of approx. 30% compared with a standard $\lambda/2$ patch antenna.

b) Millimeter Wave CRLH Band-Pass Filter on silicon substrate is made by cascading a number of identical CRLH cells. A silicon wafer was used as substrate. It was plated with a metallic layer of 2000 Å Au/500 Å Cr. The measured S parameter values show a return loss S_{11}<-15 dB in a frequency range of approx. 45GHz–56GHz. The losses in the same frequency range are around 6 – 7 dB.

c) CRLH mm-Wave Directional Coupler on Silicon Substrate. The device consists of two coupled artificial lines, each composed of two identical cascaded CRLH structures. Experimental data show a return loss RL<-20 dB for a frequency domain between 24.01 GHz ... 38.11GHz. The isolation S_{41} is greater than 30 dB in a large frequency range, exceeding the domain 20GHz–40GHz.



Structure of a CRLH CPW directional coupler

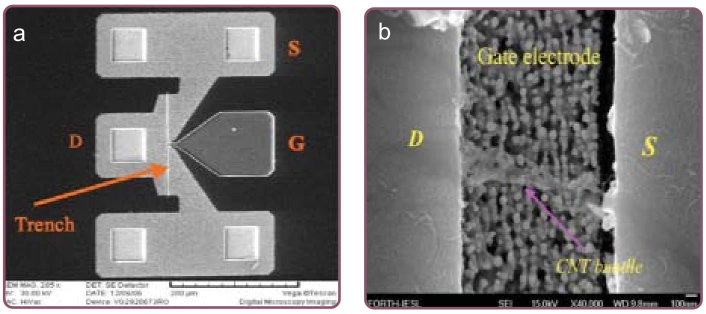


BPF structures with one, two and four CRLH cells; a BPF structure supports the probe-tips of the on-wafer measuring system

PN II Partnership Project PN II Partnership Project 11-010: Millimeter wave devices on metamaterials microprocessed by laser ablation – METALASER. Project manager: dr.ing Gheorghe Ioan Sajin

Results

Nanoelectronics based on carbon nanotubes and graphene

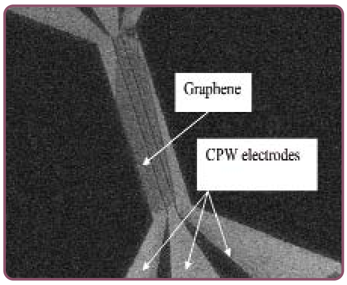


Picture of the FET-like device: (a) top view showing drain source gate layout; (b) SEM close-up on the suspended DWCNT bundle and 1μm gate electrode.

The aim of the research is the utilisation of nanomaterials like CNT or graphene with high mobility for microwave devices.

Achievements: The realization and characterization of FET based on CNT transistor and a CPW graphene test structure in the microwave range

The microwave measurements CNT FET device were performed using a VNA and a probe station. The maximum stable gain MSG = $|S_{21}|/|S_{12}|$ of the CNT-FET structure for V_D = 1.6 V, V_G = 8 V and I_D = 2.25 mA is 1,5. The results show an active behavior of the CNT-FET structure up to 3.25 GHz.



CPW lines on graphene

Achievements: A coplanar line on graphene with variable transmission response up to 60 GHz and 50 ohm impedance

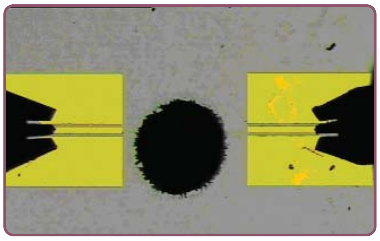
The S_{21} parameter display low losses in the frequency range 5-60 GHz when the bias was varied in the range 0-6 V. The almost 50 ohm impedance of graphene is a result of its physical properties so it can be used for devices in microwave applications range.

PN II Partnership Project "Nanoelectronic devices for high frequencies based on carbon nanostructures for communications and environment monitoring" (2007-2010)
Co-ordinator: IMT-Bucharest,
Project Manager: Dr. M. Dragoman(mircea.dragoman@imt.ro)
Partners: National R&D Institute for Material Physics, "Politehnica" Univ. Bucharest, SITEX 45 Bucharest

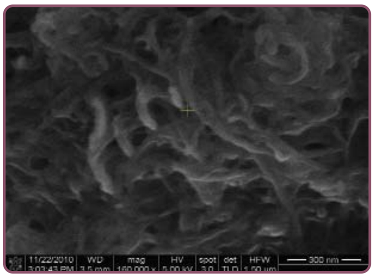
Sensing DNA using carbon nanotubes

The aim of this research was to sense DNA decorated CNTs

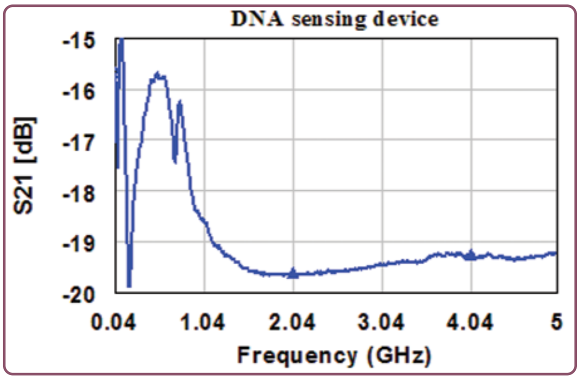
Achievements: The realisation and characterisation of DNA sensing device



Optical photo through microwave characterization of the DNA sensing device



SEM image of DNA and CNT composite deposited on the coupled lines structure



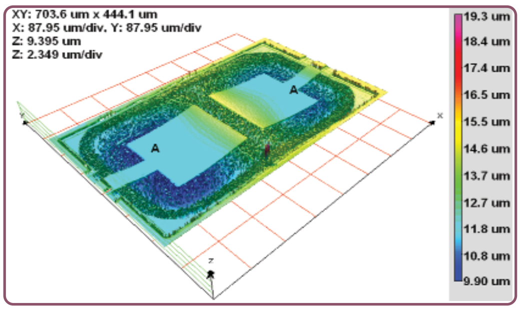
S_{21} parameter for the DNA sensing

PN II Partnership Project (2008-2011) „Biosensors based on carbon nanotubes for the real-time detection of nucleic acids with oncogenic potential". **Co-ordinator:** IMT-Bucharest, **Project Manager:** Dr. M. Dragoman (mircea.dragoman@imt.ro)
Partners: Institute of Oncology, National R&D Institute for Material Physics, "Politehnica" Univ. Bucharest

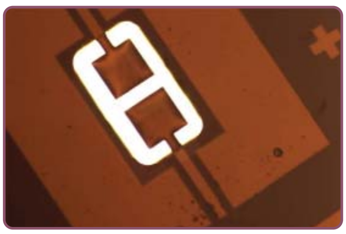
L4 - FP7 projects

MIMOMEMS - "European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors", project No 202897 financed (2008-2011) through the "Regional potential" part (REGPOT call 2007-1) of the European Framework Pogramme (FP7), starting date May 2008 (**www.imt.ro/mimomems**)

Co-ordinator: Dr. Alexandru Muller, alexandru@muller@imt.ro



3D topography of the FBAR structure in the membrane area (0.54μm GaN plus buffer thin membrane) MME 2010

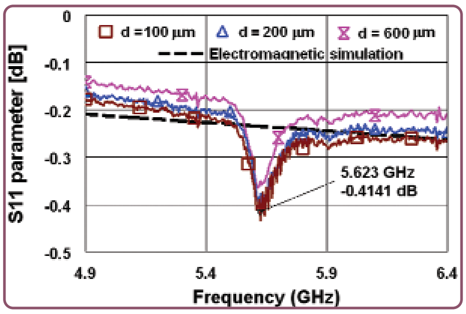


Optical photo of the series connection FBAR structure on GaN/Si membrane, (MEMSWAVE 2010 Conference)

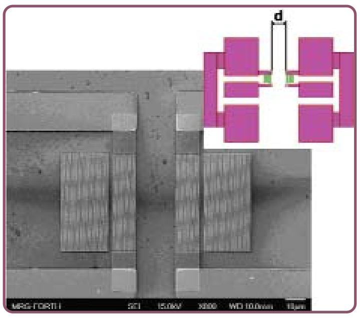
Results obtained for the objectives of the MIMOMES project

- **"Exchange of know-how and experience".** This activity is performed **by twinning with two research centres: LAAS-CNRS** in Toulouse and **FORTH-IESL-MRG** in Heraklion.

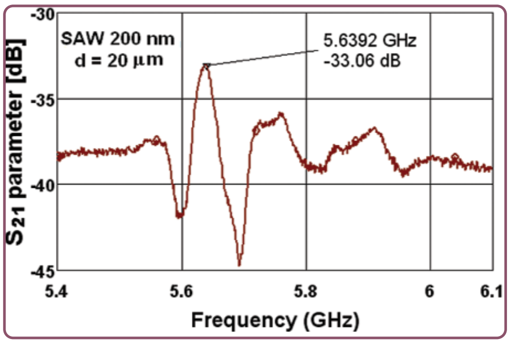
Results obtained for the objectives of the MIMOMES project



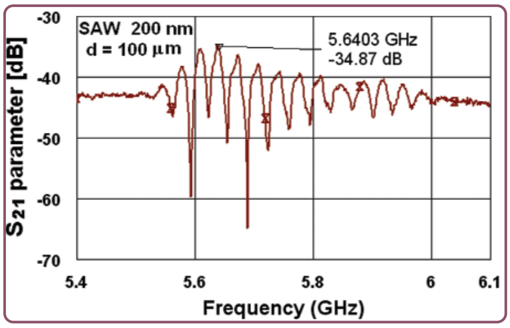
The measured reflection losses (S_{11}) versus frequency for 3 structures with different distances between the IDTs compared with electromagnetic simulated results (without the inclusion of the piezoelectric effect).



SEM photograph of the SAW test structure with 200 nm wide fingers/interdigit on the IDT structures test structure. The distance between the IDTs was d = 20 µm; for the other test structures, it was d = 100, 200, and 600 µm. The inset presents a schematic of an entire structure, including the connection Pads (Electron Devices Lett. 2010, vol 31, no. 12, pp1398-1400)



The transmission measurements for the SAW test structure having 20 µm distance between the IDTs



The transmission measurements for the SAW test structure having 100µm distance between the IDTs

"Recruitment of incoming experienced researchers" 3 PhD experienced researchers were hired for 18 month in the frame of the project. One of them has already a permanent position in IMT (since November 2010).

"Acquisition, development or upgrading of research equipment" 50% of the total funding of the project is dedicated to this objective. A gold plating facility for semiconductor wafers was purchased in 2010.

"Organizing workshops and conferences"- Knowledge transfer at national and international levels is supported by organizing international scientific sessions and seminars: The MIMOMEMS project has organized the second International Scientific Session at the CAS Conference 2010 (11-13 October 2010) having 4 oral sessions and 1 poster session. Invited lecturers were T. Vähä Heikkilä and P. Pursula (VTT Helsinki), R Baggen (IMST GmbH), G. Deligeorgis and A Montmayrant (LAAS Toulouse).

"Dissemination and publications": *1 ISI paper* in IEEE Electron Device Letters; *9 papers* in international conferences proceedings: EMRS, Memswave, CAS International Semiconductor Conference, HETECH 2010, Micromechanics Europe 2010; *A chapter* in „Advanced materials and technologies for micro/nano-devices, sensors and actuators", Springer 2010, Editors E. Gusev, E. Garfunkel, A Dideikin

"Proposals in FP7": Connected to the MIMOMEMS project one ENIAC JTU-call 2010 proposal and three proposals for the FP7 were submitted: 2 IP, and 1 STREP in Objective ICT-2011.3.2: Smart Components and Smart Systems Integration (deadline 18 January 2011) The ENIAC JTU proposal (NANOCOM) has been approved and will start in 2011.

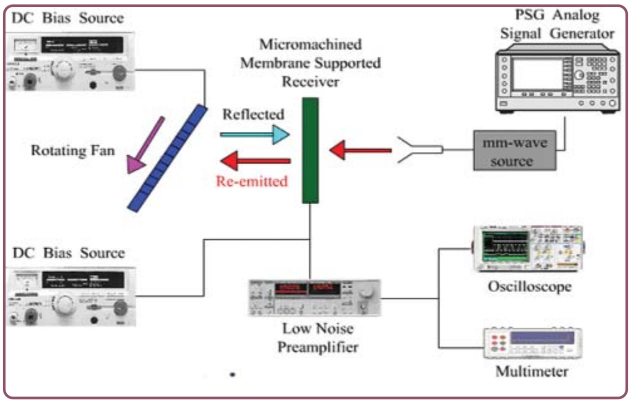
ENIAC Project SE2A

"Nanoelectronics for Safe, Fuel Efficient and Environment Friendly Automotive Solutions - SE2A" Coordinator: NXP Semiconductors Netherlands BV

20 partners from 7 countries; **4 SMEs, 2 Universities, 11 Institutes, 3 LSEs**;
Budget 21 MEuro

IMT Bucharest and FORTH Heraklion together are involved in designing, manufacturing and characterization of a 77 GHz radar sensor for automotive ground speed detection. Classical methods for car speed measurements have a low precision if on a road conditions are not normal (mud, snow, dirt, dust) especially at low speed (v<60 km/h). The ground speed sensor proposed by us is based on System in a Package (SiP) transceiver using GaAs MMIC technologies and GaAs micromachining. This type of sensor will have as end- user Volvo from Sweden.

The proof of concept was done with a membrane supported monolithic integrated direct (video-type) receiver module based on GaAs micromachining for 77 GHz



The experimental setup and a detail with the receiver mounted on PCB

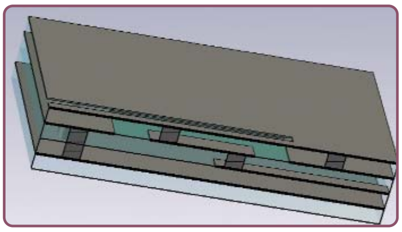
Contact person for IMT: Dr Alexandru Müller alexandru.muller@imt.ro

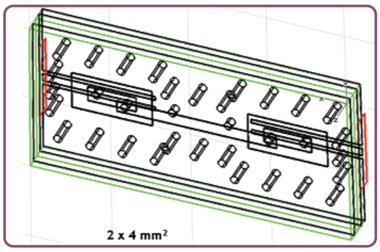
L4 - FP7 projects

MEMS-4-MMIC "Enabling MEMS-MMIC technology for cost-effective multifunctional RF-system integration" MEMS-4-MMIC, FP7-ICT-2007-2, No.204101.

STREP project financed (2008-2010) through the ICT Challenge 3: Components, Systems and Engineering, Micro/Nanosystems of the FP7.
Coordinator: **R. Baggen, IMST GmBH**. ***Partners:*** *IMST GmbH, Germany, Swedish Defence Research Agency- FOI, Sweden, Technical Research Centre of Finland-VTT, Finland, OMMIC, France, National Institute for research and Development in Microtechnologies-IMT Bucharest, Romania, Institut d'Electronique de Microélectonique et de Nanotechnologie, IEMN, France*.
Responsable person for IMT: **Dr Dan Neculoiu, dan.neculoiu@imt.ro**

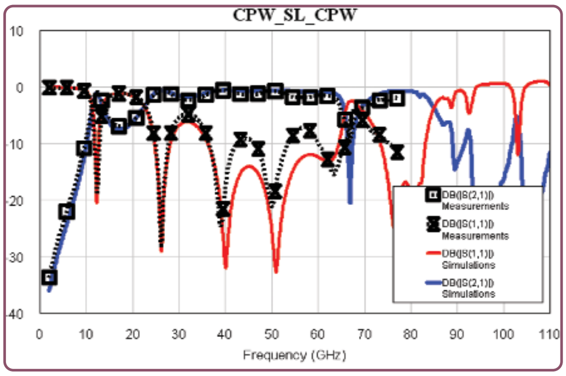
The MEMS-4-MMIC project aims at the integration of RF-MEMS switches onto Monolithic Microwave Integrated Circuits (MMIC) creating highly integrated multifunctional building blocks for high-value niche applications. RF-MEMS is an essential building block of next-generation smart systems that are characterised by cost-effective designs, compact build-up, high performance, flexibility and configurability.


Cross section of the CPW to SL vertical transition

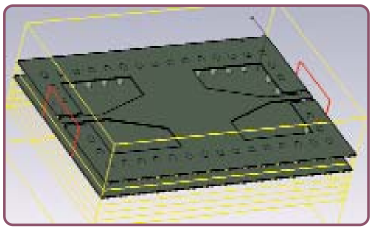


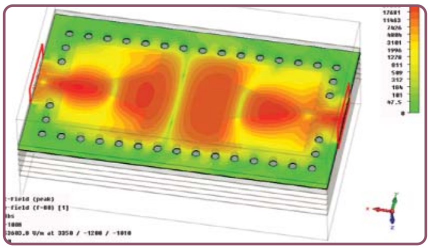
3D view of the two vertical transitions of CPW stripline on test structure

IMT results in 2009 – Based on LTCC technology, embedded transmission lines and their transition to grounded CPW were designed.



Experimental results: Simulated and measured S parameters for the two vertical transitions connected by an embedded stripline (long line)


3D view of the two CPW to SIW transitions

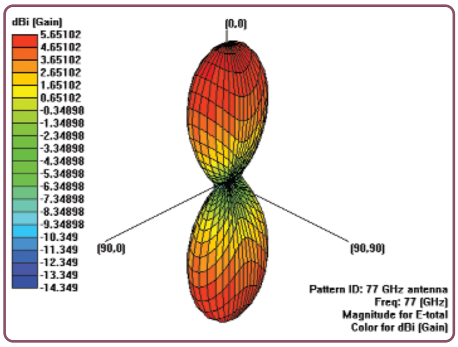

Simulated electric field distribution

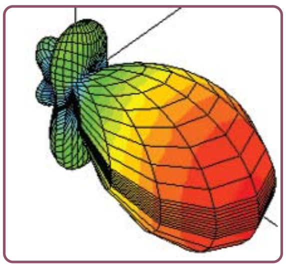
MNT-ERANET
" MEMS Based Millimeterwave Imaging System" acronym MEMIS

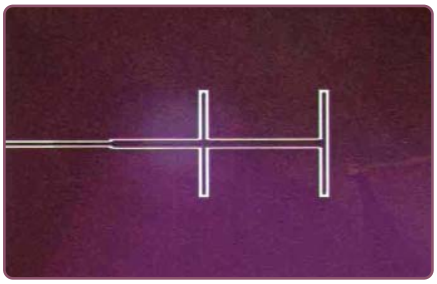
Coordinator: LAAS Toulouse; partners IMT-Bucharest, FORTH Heraklion

Millimetre wave and Terahertz imaging technology refers to passive (or active) imaging in the millimetre and sub-millimetre range by using very sensitive radiometers (or radars). Millimeter wave imaging is useful for a wide variety of commercial applications such as aeronautic (near-all-weather vision landing), security (weapon detection), automotive (collision avoidance radars), and biomedical (tumor recognition, disease diagnosis, thermal burn imaging, recognition of protein structural states, detection/imaging of tooth decay). The project targets the enhancement of present solution by developing a low-loss high gain antenna array using a true planar topology, using high resistivity silicon bulk and surface micromachining. IMT will play a key role in the design, simulation and optimisation of passive circuits elements (antennas, antennas array, RF-switch) and monolithically and hybrid integrated receiver front-ends based on silicon micromachining

The project started with the design of the Yagi-Uda and folded slot antennae for the W band millimeter wave frequency.




3D radiation pattern for the Yagi-Uda and folded slot antennae for 77 GHz


Optical top view of the experimental structure: folded slot antenna for 77 GHz

Contact person for IMT: Dr Alexandru Müller alexandru.muller@imt.ro

L5: Simulation, Modelling and Computer Aided Design Laboratory

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

Simulation, Modeling and Computer Aided Design Laboratory is involved in simulation and modeling of micro-nanosystems. An **experimental laboratory for Advanced technologies for micro and nanosystems** settled-up in the frame of a *CAPACITIES* Romanian Project.

Mission: research, design, simulation and modeling activities oriented to collaborative research projects, education, services (providing access to hardware and software tools) and consulting (design/optimization) in the field of micro-nano-bio/info technologies. **The lab plays a key role in supporting the research activities of other laboratories from IMT- Bucharest.**
Mission of the experimental Lab of Advanced technologies for micro and nanosystems: to provide services from nanoscale (dip pen nanolithography) to sub-milimeter and normal scale (3D Printing); rapid prototyping.

Expertise: • **Design, development and optimization of MEMS/MOEMS components and devices** (switches, cantilevers, bridges, membranes, microgrippers); mechanical, thermal, electrical and electrostatic, piezoelectric, fluidic, as well as coupled field (static and transient) analysis; (embossing steps- thermal transfer with transient analysis) modeling and simulation for multi-physics problems; **design, modeling and simulations of microfluidic components and systems**; the microfluidic analyzes include: fluid dynamics in microstructures (general flow, fluid mixing, thermal analysis); electrokinetic flow (electrophoresis, electro-osmosis); electrokinetic with field switching analysis; fluid diffusion; bubble and droplet simulation (transport, merging, splitting); interaction between fluids and mechanical parts; mechanical, electrostatic, piezoelectric analysis for microfluidic actuators; modeling of opto-electronic devices, neural networks; computational modeling of electronic structure of materials with applications in advanced nanodevices (effect of dopant impurities and defects on the band structure, electrical conductivity and magnetic properties of semiconductor oxides);

• **Rapid prototyping:** design for and operation of 3D Printer based on selective laser sintering, 3D Printer based on single photon photopolymerization, dip pen nano-lithography, laser microengraving.

• **Characterization of physical phenomena** in wide band gap semiconductors (light emission, optical transitions, radiative-nonradiative centers, shallow and deep donors/acceptors, band gap tailoring).

Research Team: The team has a multidisciplinary expertise in: mathematics, physics, electronics; 4 PhD, 1 Post-doc, 2 physicists, 1 engineer, 2 PhD students.
Postdoctoral position: Oana Nedelcu in the frame of POSDRU project "Human Resource Development by Postdoctoral Research on Micro and Nanotechnologies", POSDRU/89/1.5/S/63700, 2010-2013; Research activity "Theoretical models for coupled phenomena in microfluidics", domain: Micro-nanosystems for bio-medical applications BIO-MEMS.

Team from left to right: Rodica Voicu; Rodica Plugaru; Catalin Tibeica; Victor Moagar-Poladian; Raluca Muller; Gabriel Moagar-Poladian; Oana Nedelcu; George Boldeiu;

Specific software/hardwere tools:
• COVENTOR 2010; MATLAB 7; ANSYS Multiphysics 11.0; COMSOL Multiphysics 4.2; Solidworks Office Premium 2008 ; Mathematica 7; Origin PRO 8; Visual Studio 2008 Pro; • Dual IBM 3750 Server; • Computer network for training

International networks and projects:
• **ComEd:** Leonardo da Vinci - **Life Long Learning Development of competences of educational staff by integrating operational tasks into measures of vocational training and further education**" – ComEd (2008-2010); *Coordinator BWAW Thüringen GmbH*, Germany, No.: DE/08/LLP-LdV/TO/147174 (2008-2010) Partners: PROREC GmbH, Germany, Technical Univ of Kosice, Slovakia, TUK, IMT Bucharest, Instituto de Soldaura e Qualidade-ISQ Portugal (www.comed-project.eu)
Mutual exchange of best practices; contribution to the **Final product–common Brochure** which is a summary of the partner's activities on implementation and institutionalization of the Exploration Task concept and on implementing in each country the vocational education process; new courses on micro-nanotechnologies using the new teaching concept of exploration tasks, an innovative and interactive learning technique. This method has helped the pilot companies to be part of a continuous education system, to be in contact with new emerging fields of science, making possible to diversify their products.
• **Bilateral Cooperation with Institute of Applied Physics, Academy of Science of Moldova** (2010-2012): "Biochemical sensors based on nanoporous InP and metal nanoparticles, obtained by MEMS/MOEMS techniques for electrical and optical measurements"

Laboratory Head — Dr.Raluca Muller (raluca.muller@imt.ro)

Raluca Müller received the M.Sc and PhD in Electronics and Telecommunications from "Polytehnica" University of Bucharest. From 1978-1994 she was researcher scientist with ICCE Bucharest; since 1994 she is with IMT-Bucharest. Currently R. Müller is Scientific Director of IMT-Bucharest and Head of the Simulation, Modelling and Computer Aided Design Laboratory. Her main scientific interests include design and technological processes for sensors and actuators based on MEMS/MOEMS techniques, integrated optics, nanolithography. She was involved in teaching activities as associated professor at Univ. "Valahia Targoviste" and Master of Science courses at Univ. Politehnica Bucharest.

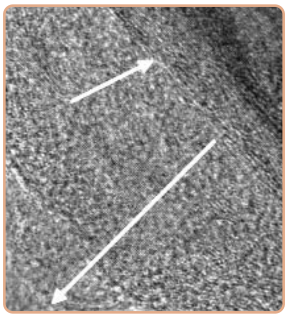
Raluca Muller was coordinator of an important number of national research projects and scientist in charge from IMT-Bucharest in international projects as: FP6 ASSEMIC- Marie Curie Training Network (2004-2007), FP6-PATENT (Modelling and Simulation cluster), Leonardo da Vinci- Microteaching (2005-2007),IPMMAN- CA (2006-2009).

She is author and co-author of more than 80 scientific papers presented at conferences and published in journals (Sensor & Actuators, J. of Micromechanics and Microengineering, Appl.Optics., Journal of Luminescence, Thin Slod Films, etc)

Results

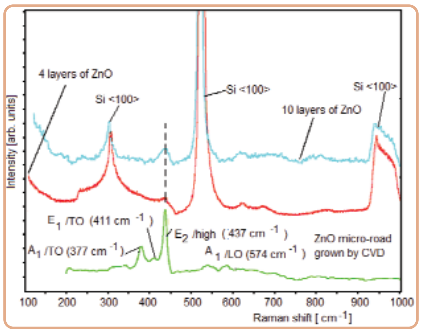
ELECTRONIC NANODEVICES BASED ON OXIDIC MATERIALS

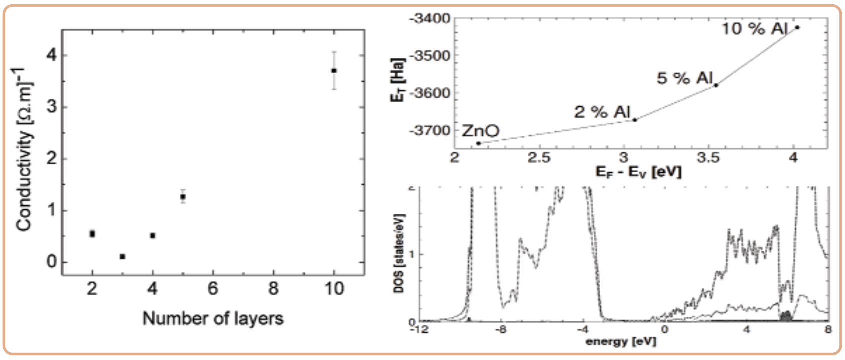
NANOXI Project Type: PNII Cooperation, Nr. 11-048 (2007-2010), Coordinator IMT- Bucharest; **Project manager:** Dr. Rodica Plugaru (rodica.plugaru@imt.ro); **Partners:** UPB-Bucharest, Institute of Physical Chemistry "I.G. Murgulescu", ICPE-CA, S.C. METAV-Research & Development S.A.



Results: • Experimental and computational investigation of electrical conductivity in doped wide band gap semiconductor oxides with applications in nanodevices. Doped Al, Mn thin films, synthesis and characterization. Spectroscopy studies of optical transitions in nanostructured ZnO. First principles investigation on the electronic structure in wurtzite-type ZnO modified by Al and Mn doping, aimed to clarify the impurity effects on conductivity and magnetism in disordered matrices.

Advanced studies on ZnO:0.5%Al doped films: • Structural and compositional investigation by HRTEM and EDX. Crystallinity and doping analysis by Raman spectroscopy. • Electrical conductivity of Al:ZnO thin films.
• DFT study of the electronic structure of $Al_xZn_{1-x}O$ and $M_xZn_{1-x}O$ systems (x=0.02, 0.05, 0.10).





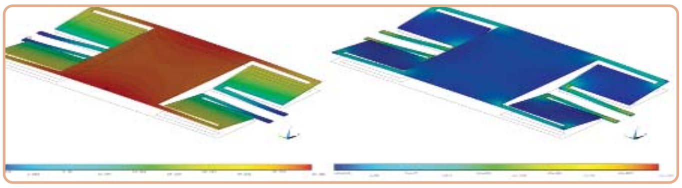
APPLICATIONS OF HIGH TECHNOLOGIES BASED ON MICROSYSTEMS AND NONLINEAR OPTICS FOR MEASUREMENT OF THE ELECTRIC CURRENT PARAMETERS ON THE HIGH VOLTAGE LINES

Project Type: PNII - Cooperation 31-021/2007-2010; **Coordinator**: IMT-Bucharest, **Project Manager**: Dr.Gabriel Moagãr-Poladian (gabriel.moagar@imt.ro); Partners: Bucharest University, S.C. SITEX 45 S.R.L.

Image with the two types of sensors structure (the maximum size of the left Central membrane is 1,5 cm)

Image showing the high deflection of the optimized membrane

Results: • 3 Romanian patent requests (2 in the field of nanomaterials and nanotechnology) and a request for topography of semiconductor structures ("Topografie optimizatã de electrod mobil" by V. Moagãr-Poladian, OSIM 1012360 /10.05.2010).
• We have realized some test structures of the high voltage sensor in order to test its mechanical behaviour, especially that of the optimized structure. These structures were made by polymer, using a 3D Printer based on selective laser sintering, and they were mechanically tested for comparison. Deflection of the left structure exceeds several times that of the right structure, demonstrating the feasibility and correctness of the concept and simulation. The high deflection can be seen also in the right image (finger pushing of the structure). Both structures were augmented in order to overcome the problem of the minimum achievable size (400 microns) of the 3D Printer.
• We have conceived the structure of the measurement ensemble that is to be used on the high voltage lines.
• We have developed a way of optical interferometric reading that reduces significantly the effect of vibrations for accelerations for up to 0,3g (g the acceleration of the gravitational field); this feature allows the high voltage sensors to operate even when earthquakes of 7 Richter degrees hit the measurement ensemble.



Simulation results of the optimized structure: left - displacement of the membrane; right - the von Mises stress. These were calculated with direct coupling method for the device produced by SLS technology under mechanical load. Courtesy of Phys. Eng. Victor Moagãr-Poladian.

PNII Project: Micro-Joining Systems For Electronic Circuits And Encapsulating Elements Of Micro-Sensors And Actuators**, MICROWELD; IMT Bucharest Partner** (Eng. Victor Moagãr-Poladian), **Coordinator: ISIM Timisoara**

Results: Measurements of the electrical contact resistance for Cu-Cu, Cu-Al contacts realized by different technologies. The value of the electrical contact resistance of the samples was in the range from 5,6μΩ to 665μΩ, the margin of error for the measurement being of the order of 41 % at 5,6μΩ and less than 4 % for the other values in the range. We put into evidence the asymmetry of the Cu-Al contact when biased / polarized in opposite directions, with a margin of error of 1,5 % for the performed measurement.

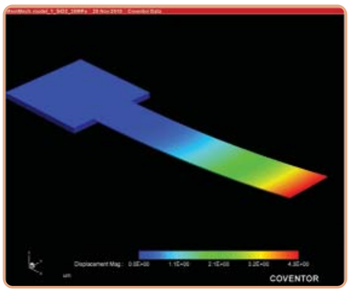
PNII Project: Durable protection solutions for the aluminum – copper contacts part of installations for the transmission of electrical energy to insure the energy safety and efficiency**-ELCUAL**, **IMT- Bucharest Partner** (Eng. Victor Moagãr-Poladian), **Coordinator: ICEMENERG S.A.**

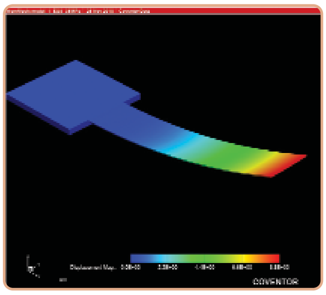
Results: Investigation (using optical reflective microscopy) in order to underline the difference in surface roughness produced by different type of treatments applied to the surfaces.

MEMS sensors and actuators based on micro-cantilevers structures

Project Type: PNII - Cooperation– Contract No. 72-212/2008- INFOSOC (2008-2011); **Project coordinator:** IMT Bucharest, **Project manager**: Dr. Raluca Müller (raluca.muller@imt.ro); **Partners:** INCD-SB, INCD-FLPR, National Research and Development Institute for Electrical Engineering- ICPE-CA, Technical Univesity- Cluj-Napoca- UTC.

The purpose of the project is the development of new applications (environment control, bio-medical) for sensors and actuators fabricated in microsystems technologies, MEMS (micro-electro-mechanical systems), based on microcantilever or area of cantilevers.



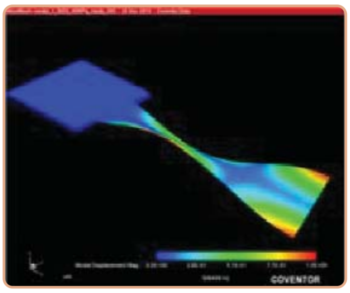


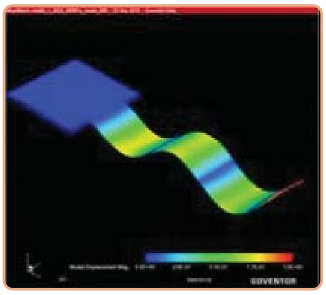
SiO2 Cantilever covered with Au   SU8 Cantilever covered with Au
Deformation due to the residual stress in the Au top layer of the cantilever-- COVENTOR

Results:

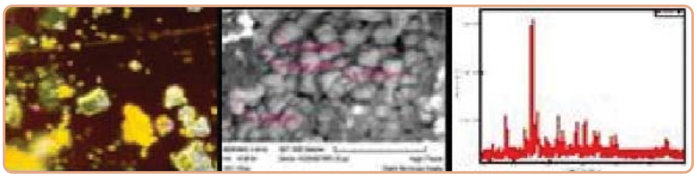
- analyses of the influence of the top gold metalic layer on static and mechanic behaviour of the cantilever
- Experimental processes for manufacturing a cantilever MEMS switch - two stage driving, based on a SiO_2 or LOR sacrificial layer
- we prepared and deposed different aqua solutions on the top of the cantilevers: chromic anhydride with gold particles and serum albumin, serum albumin, serum albumin with gold particles, for mass sensor applications: microphysical investigation of the experimental structures.

Array of cantilevers functionalized on the top face





Torsion mode   Bending Mode
Simulation of the natural oscilation mode of the cantilever- COVENTOR (Fiz.Catalin Tibeica)



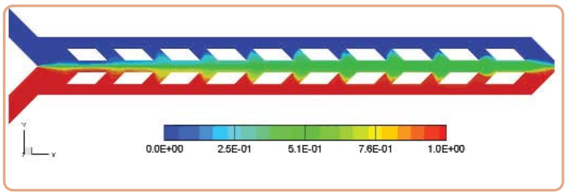
Results of investigation of chromic anhydride with gold patricles and albumin solution placed on the Au top layer of the cantilever: a) optical microscopy b) SEM, c) XRD

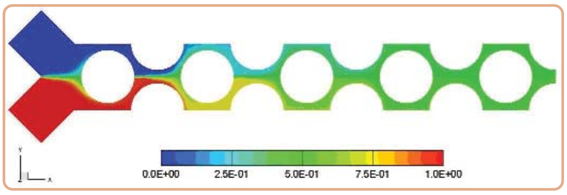
National basic funding projects

Lab-on-Chip type microfluidic platforms integrated with microelectronics and optoelectronics components (2009-2011);

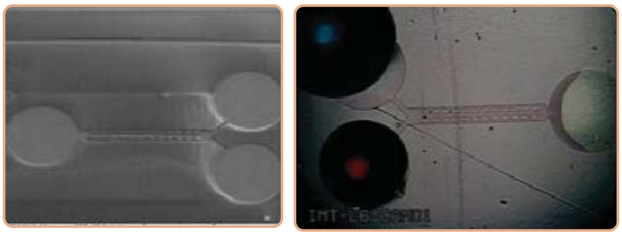
Coordinator Dr. Oana Nedelcu/PhD Student Irina Codreanu

Results: Design, simulation, technological processes and functional characterization of four different micromixer configurations, using COVENTORWARE software. The purpose was to obtain passive micromixers with specific geometries that maximize the transversal velocity in order to increase the diffusion and mixing effect, leading to decreasing time / length of liquid mixing phenomena.

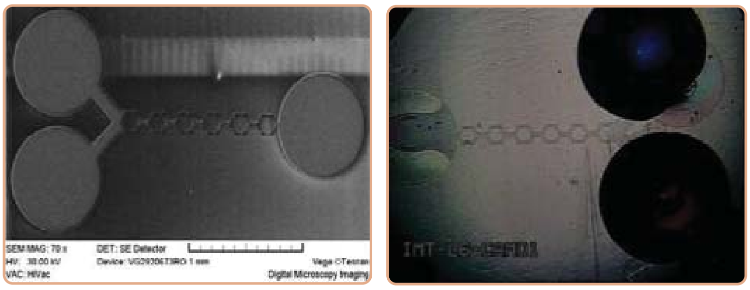




COVENTORWARE simulation: fluid fraction distribution in micromixers



Optical microscope view of mixing experiments (top)
Experimnetal set-up (below)

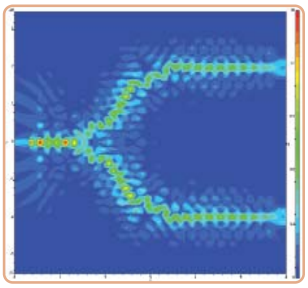


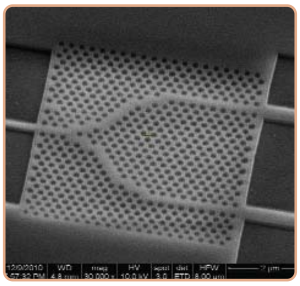
Optical microscope view of micromixers made in SU-8 on a Si substrate

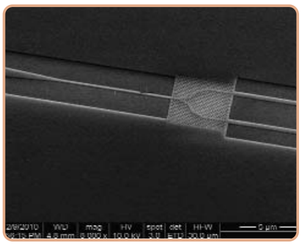
Results

Photonic crystal (PCs) based photonic structures, using EBL technique; (National basic funding projects)

Coordinator Dr. Raluca Muller (raluca.muller@imt.ro)







Simulation of the electromagnetic radiation propagation in an optical waveguide spliter, obtained in photonic crystals (Dr. Mihai Kusko) and experimental configuration using EBL nanolithography (Phys. Adrian Dinescu).

The purpose of the project is to develop passive optical devices based on PCs for communication applications.

We have investigated different materials, with different refractive index: PMMA, SU8, Si_3N_4 Electron Beam. Lithography was used to obtain different configurations based on photonic crystals.

Results: Using FDTD was simulated the electromagnetic radiation propagation (λ= 635 nm) in an optical splitter with one input and two outputs, based on Y junction. An angle of 60 degrees was considered between the optical waveguide and the Y junction. The lattice constant was 255 nm, and the hole radius = 87.5 nm. The line defects were simulated for a Si_3N_4 300 nm layer.

Development of the monocrystalline Silicon microprocessing technology in a rapid prototyping regime by using single photon and two photon absorption. (National basic funding projects)

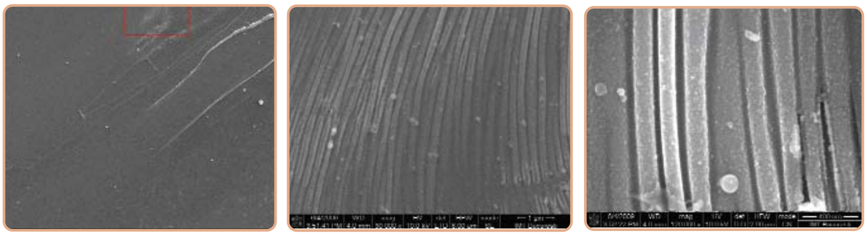
Coordinator: Dr. Phys. Gabriel Moagar

Results: Experiments with the photodecomposition of the hexafluoric acid were done and gas emanation obtained. Further investigation will be done in order to determine precisely the gas composition. The experiments performed on deionized water have also shown photodecomposition effects, the gas emanation being directly dependant of the increasing laser power. The laser source used have 29 ps pulse duration, 266 nm wavelength, 10 Hz repetition frequency, 800 MW peak-power per pulse.

INTEGRATED LABORATORY OF ADVANCED TECHNOLOGIES FOR MICRO AND NANOSYSTEMS - MICRONANOLAB

Experimental laboratory Coordinator: Dr. Gabriel Moagãr-Poladian (gabriel.moagar@imt.ro)

This new experimental laboratory is running in the frame of the Simulation Lab. It was completed with an in-house made laser microprocessing facility, starting from a high-power ps laser at 29 ps pulse duration, 266 nm wavelength, 10 Hz repetition frequency, 800 MW peak-power per pulse. For the present, the system accepts computer control and may micro-engrave manually/automated manner (using AutoCAD software for pattern) the patterns desired by the beneficiary. The system will be completed with optics for a better control of the beam quality.



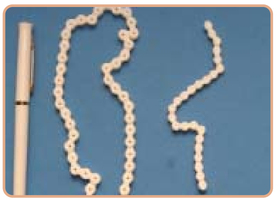
SEM image of the Si surface irradiated with high-power UV pulses (Phys. Adrian Dinescu). The red rectangle is the region augmented in the central and left figures, respectively. The Si wires have less than 130 nm diameter, are curved and form bundles. Their lengths are between 10 microns and several tens of microns. The bar scale in the right image is of 400 nm.

Results obtained with the system:

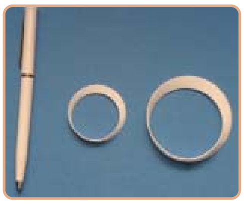
- The system was used for engraving Si, Ge, thermally-grown SiO_2, Cr/SiO_2, glass, SiC. In some cases, structures at the nanoscale have been obtained.
- Micro-engraving of Si wafers followed by wafer breaking at un-natural angles (others than those of natural cleavage) was also demonstrated.

A new 3D Printer, based on photopolymerization, has been acquired from EnvisionTec, Germany.

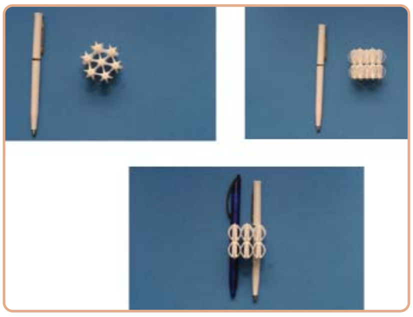
As regards the 3D Printer based on selective laser sintering, this was placed in a specially designed room and was used for production of different structures, at normal and at mili-scale. Some examples of structures realized at the 3D Printer based on selective laser sintering:



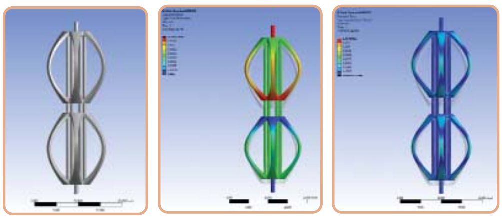
Bike mini-chains, Eng. Dragos Varsescu



Moebius ring, Phys. Victor Moagãr–Poladian



Structure exhibiting negative Poisson coefficient. (Phys. Victor Moagãr–Poladian)



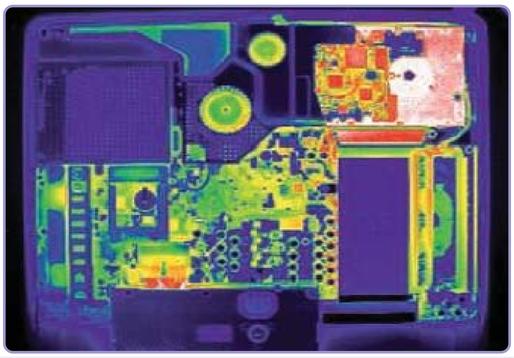
Study of an auxetic structure involving simulation techniques and rapid prototyping fabrication of a sample. CAD model (left), total deformation (center) and stress map (right); Simulation were performed in ANSYS 11.0 software (Phys. Eng. Victor Moagãr–Poladian). The structure behaviour was in total agreement with the simulations results.

L7: Reliability Laboratory

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

Mission: Providing tools and expertise to improve the design & technology of sensors, actuators, microsystems, nanostructures and microelectronic components by assessing and building the quality & reliability in a Concurrent Engineering approach.

Main areas of expertise:
Reliability building: Reliability building: Designing for reliability and testability - Design for manufacture, Reliability monitoring & screening of micro and nanostructures, Burn-in and selection, Reliability of components used in harsh environment (nuclear, geology, automotive, aeronautics, etc.);
Reliability assessing: Accelerated testing of micro and nanostructures; Failure analysis & physics, Data processing & reliability prediction, Behaviour of electronic components in harsh environment, Virtual prototyping;
Standardization: Certification, Qualification and periodic tests, Standards and other specifications.

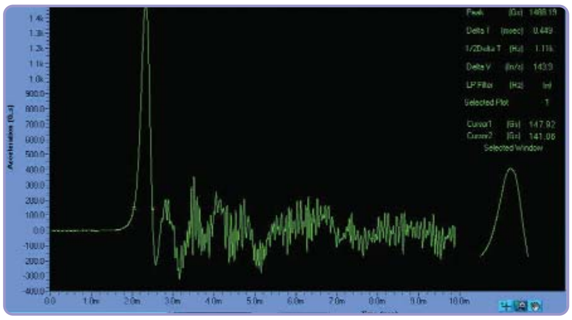


Thermal map of an electronic system, obtained with IR microscope. The colour scale corresponds to the temperature: from blue (the lowest temperature), to red (the highest one).

Partner in International Networks: The Reliability Laboratory is part of the Board of EUMIREL (European Microsystem Reliability) Cluster Service, aiming to deliver services in the reliability of micro and nanosystems, established in December 2007 by the NoE "Patent-DfMM" (other members: IMEC Leuven, Politecnico di Milano, Fraunhofer Institute Duisburg, 4M2C, CSL Liege, BME Budapest, Warsaw Technical University, QinetiQ, Lancaster University, Herriot Watt University, NovaMems, Baolab).

National networks: As contractor of "Micro-biosensors for pesticide detection in environment and food samples" Project (2007-2010), the Reliability Laboratory is also involved in the National Research "PARTNERSHIP" Programme.

Specific instruments and equipment: The Reliability Laboratory contains a laboratory for evaluating the quality of microtechnology products according to EU requirements (LIMIT), provided with modern equipment for:
Environmental testing: Constant mechanical acceleration, Vibration, Storage at temperature, Hermeticity, Mechanical shock;
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 characterising at various temperatures: Keithley 4200SCS, Temptronic TP04300A-8C3-11 / Thermo Stream.
Thermal analyses: IR microscope SC 5600 + G3 L0605 / FLIR Systems.



Results obtained with the equipment for shock with free fall (MRAD): Maximum acceleration 4500 g; Maximum height: 60 in; Maximum speed at impact: 200 in/sec; Minimum time duration: 0,3 ms

Research Team: The research team is formed of three senior researchers and a research assistant, all with microelectronics background.

From left to right: Marius Bazu, Lucian Galateanu, Dragos Varsescu, Virgil Emil Ilian.

Laboratory Head — Dr. Marius Bazu (marius.bazu@imt.ro)

He received the B.E. and PhD. degrees from the University "Politehnica" Bucharest, Romania. He was involved in device design and semiconductor physics. Recent research interests: methods for building, assessing & predicting the reliability of MEMS. In Romania, he developed the accelerated reliability tests, building-in reliability and concurrent engineering approaches. He was also leading one of the European projects (Phare/TTQM) on a building-in reliability technology (1997-1999).

He is a member of the Management Board and the NoE "Patent-DfMM", FP6/IST (2004-2008), and a work package leader. He is referent for the following journals: Sensors, IEEE Transactions on Reliability, IEEE Transactions on Components and Packaging, IEEE Electron Device Letters and Microelectronics Reliability. In 2000, he received the AGIR Award (General Association of Romanian Engineers). Dr. Marius Bazu is also a Chairman/lecturer at international conferences: CIMCA 1999 and 2005 (Vienna, Austria), CAS 1991-2009 (Sinaia, Romania), MIEL 2004 (Nis, Serbia), author of more than 100 scientific papers (IEEE Trans. on Reliability, J. of Electrochem. Soc), Sensors and contributions to international conferences (Annual Reliability and Maintainability Symp., Probabilistic Safety Assessment and Management Conf., European Safety and Reliability Conf., etc.) and Co-author of two books about the reliability of electronic components, published by Artech House, in 2010 and Springer Verlag, in 1999.

Results

Above: Samples introduced in the Chamber for Highly Accelerated Stress Test (HAST) - EHS 211M (Espec). Below: Working parameters of the equipment.

RELIABILITY TESTS AND ANALYSES

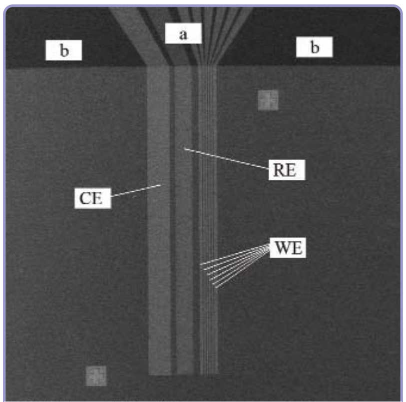
A large range of reliability tests were performed by our laboratory, such as: environmental tests, reliability selections and electrical characterisation at continuous increasing temperatures. The photos below show the test performed for Arcelik, a Turkish company.

Contact person: Virgil Emil Ilian (virgil.ilian@imt.ro)

BIOSENSOR FOR ENVIRONMENTAL MONITORING

Our laboratory developed biosensors for the detection of the environmental pollutant concentrations.

Achievements: The micro biosensors obtained ensure efficient, rapid and cheap bio detection, allowing the monitoring for the concentration of the organophosphate insecticides in the environment and food samples, at the levels required by the international legislation in the field. The developed method allows determining by single analysis the presence of any organophosphate insecticide; it is simple to be used and could be applied in laboratories with medium level infrastructure. This allows monitoring the environment, to locate the pollution sources and to take the necessary protection methods.



Microelectrodes achieved by vacuum deposition and photolithography: WE – Working electrodes; CE – Counter-electrode; RE – Reference electrode; a – zone of extension for the metallizations stripes; b- zone of isolation with photoresist

"PARTNERSHIP" Project Micro-biosensors for pesticide detection in environment and food sample (2007-2010).
Contact person: Lucian Galateanu (lucian.galateanu@imt.ro).

SPECIFIC INSTRUMENTS AND EQUIPMENT

Equipments from CAPACITATI project

- ***Thermal cycling*** *TSE-11-A (Espec Europe), Compact type (air-to-air);*
- ***Combined tests at temperature, humidity, pressure and electrical bias*** *EFS 211M (Espec Europe): Highly Accelerated Stress Test (HAST)*

- Combined tests at temperature and electrical bias
Three climatic chambers UFB 400 (Memmert), Rack N6711A (Agilent), with modules N6741B, N6743B, N6746B and N6773A, two sources E3648A and E3649.

Chambers for: -Thermal cycling – TSE-11-A (Espec): Low temp. (-65...0^{o}C) and High temp.(+60…200^{o}C); - Highly accelerated stress test (HAST) - EHS 211M (Espec): Temperature range: +105 ... +142^{o}C, Humidity range: 75%…100% RH, Pressure range: 0.02…0.196 Mpa; - Damp heat - CH 160 (Angelantoni): Temperature range: -70...+180^{o}C; Speed: 5^{o}C / min, Humidity range: 20…95%RH, between +10^{o} C…+80^{o} C

Chamber for testing at temperature + low pressure - VO400 (MEMMERT): 49 l; +20 .. +200°C; 10 .. 1100 mbar

Electrical characterization: 4200SCS system (Keithley, UK): Voltage CC<100V, Current CC<1A; Impulses: analogical signal 30V, <40MHz; Measurements: Voltage 0,5 μV, Current 1 fA.

L1: Laboratory for Nanobiotechnologies

Affiliated to the Romanian Academy (of Sciences)

- Mission
- Main areas of expertise
- International participation
- Research Team

Mission: Nanomaterials and nanostructures: design, modelling/simulation and technological experiments.

Main areas of expertise: The research activities carried on in the Laboratory of Nanotechnology can be divided into four areas: Functional nanomaterials, Nanobiosystems, Nanophotonics and Micro electromechanical Systems.

- The main research direction in Functional nanomaterials area goes toward the study of nanostructured silicon based or composite materials, from preparation to surface functionalisation and integration in complex systems.

- The Nanobiosystems area focuses on utilizing the various technologies developed in nanofabrication and MEMS with the purpose of studying and solving biological issues. Bio molecular patterns in micro arrays, integration of sensing elements onto biochips for study of bio reactions, and implantation of active device elements in cells to study cellular biochemistry are only a few examples of the research activities being carried out by our laboratory.

- The Nanophotonics area is represented by two directions, porous silicon with emission in the visible spectrum for microparticles visualisation in vitro and for optical biosensors and metallic nanoparticles (Au, Ag) on silicon substrates for SERS/ SEIRS applications.

- The Bio-Micro- Electromechanical Systems (Bio-MEMS) area focuses on design and fabrication of new complex devices on silicon, for applications in many interdisciplinary areas. Recently, new results were obtained in biochips and micro fluidic systems (such as laboratory-on-a-chip) with applications in biomedicine and environmental monitoring as well as in the development of new fuel cell devices (such as clean energy sources).

International participation

• *Development of sustainable solutions for nanotechnology-based products based on hazard characterization and LCA–NanoSustain*, **FP7 Collaborative** Project, 2009-2012;

• *A "system-in-a-microfluidic package" approach for focused diagnostic DNA microchips - DNASIP*, **MNT-ERA Project**, 2008-2010.

• *Nanostructural carbonaceous films for cold emitters – NANOCAFE*, **MNT-ERA Project**, 2009-2011;

• *Development of plasmonic biosensors based on metals – silicon nanoassemblies*, **Brancusi Bilateral** Project (Institute for NanoSciences Paris), 2009-2010.

Research team has a multidisciplinary expertise and is formed of 4 senior researchers (with a background in physics and chemistry), 4 PhD students, and 1 MSc student (with a background in physics, chemistry, engineering and bio-chemistry and nano-electronics specializations).

Old team (from left to right):
Irina Kleps, Florea Craciunoiu, Mihaela Miu, Mihai Danila, Monica Simion , Adina Bragaru, Andrei Avram, Marioara Avram, Teodora Ignat, Lucia Cortojan

AND
New entries:

Andra Iordanescu

Razvan Pascu

Acting Laboratory Head Dr. Mihaela Miu (mihaela.miu@imt.ro).

Dr. Irina Kleps (former Laboratory Head, founder of the Laboratory)

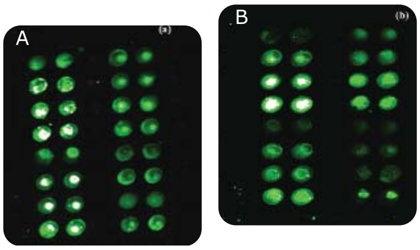
She obtained her MSc. in Chemistry Engineering, in 1973, and the PhD in chemistry in 1998 at Politehnica University of Bucharest. Her competence domains are: nanomaterials, nanostructures, nanotechnology, new materials and technological development for MEMS/NEMS, bio-medical devices, protein microarray.

Dr. Kleps participated in several European projects: INCO-COPERNICUS SBLED (1998-2001), EMERGE (guest experiments at IMM, Germany) Metallics (2000-2003), PHANTOMS (Network of Excellence on Nanoelectronics) (2001-2004), NANOFUN-POLY (2004-2008). She was involved as expert for project evaluation in the EC-FP5 (IST; Growth, Improving programmes), FP6, FP7 (NMP and Marie Curie) and MATNANTECH, CEEX and PN2 national programs. Other activities: Golden medal (2001, 2007, 2008) Salon International des Inventions-Geneve; Chapter Electrochemical Nanoelectrodes, in Encyclopedia of Nanoscience and Nanotechnology; Co-editor of the Nanoscience and Nanoengineering (2002), Advances in Micro and NanoEngineering (2004), Convergence of Micro-nano-Biotehnologies (2006), Progress in nanoscience and nanotechnologies (2007), Series in Micro and Nanoengineering, (Romanian Academy). More than 150 papers published in international journals/conferences, 90 technical reports, and 6 Romanian patents. Dr. Kleps retired from 1st of March, 2010, but is still cooperating with IMT on certain projects.

Results

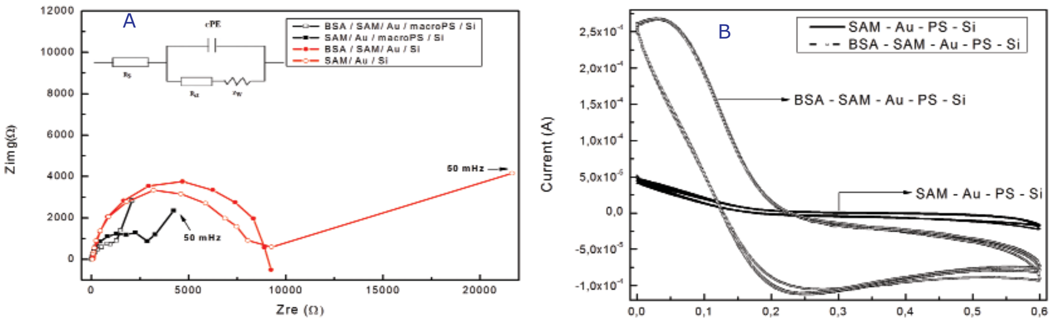
STUDY OF SILICON-PROTEIN TYPE BIOHYBRIDE NANOSTRUCTURED SURFACES WITH APPLICATIONS IN BIO(NANO)SENZING

The aim of this project is to realize a sensing surface for application in biomolecule detection and to characterize the biohybrid interfaces. The Si-biomolecule hybrid interfaces have been optimised in the view of specific applications and complementary characterizations of the structures before and after interaction with biological media have been performed.
Besides SE(I)RS detection, the molecules of interest labelled with commercial fluorescence marker have been analysed with Genomics scanner for fluorescence detection.



The scanned images of micro-arrays spotted with proteins and antibodies on the surfaces of porous silicon support functionalized with APTES (a), and respectively poly-l-lysine (b)

The optical detection of biointeraction has been supported by the electrochemical analyses, known for their sensitivity in detection of new bonds creation or changes in original bonds with direct applications in a broad range of analyte recognition via formation of covalent bonds to the sensing layer:



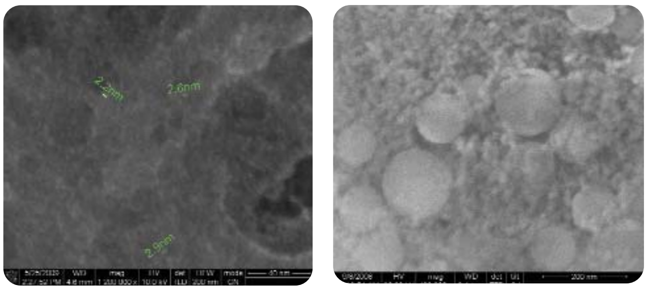
The SAM (11-MUA) and BSA immobilization on the electrode realized by gold deposition on porous silicon substrate were tested using:
- (A) the cyclic voltammetry (CV) and
- (B) impedance spectroscopy (EIS)

Deposition of alkanethiols and proteins was monitored by Raman spectroscopy, optimized by microarray technology and further confirmed by electrochemical techniques.

Financed by the **National University Research Council (2007- 2010). Coordinator: Dr. Irina Kleps, irina.kleps@imt.ro**

STUDY OF MEMBRANE - ELECTRO-CATALYST NANOCOMPOSITE ASSEMBLIES ON SILICON FOR FUEL CELL APPLICATION

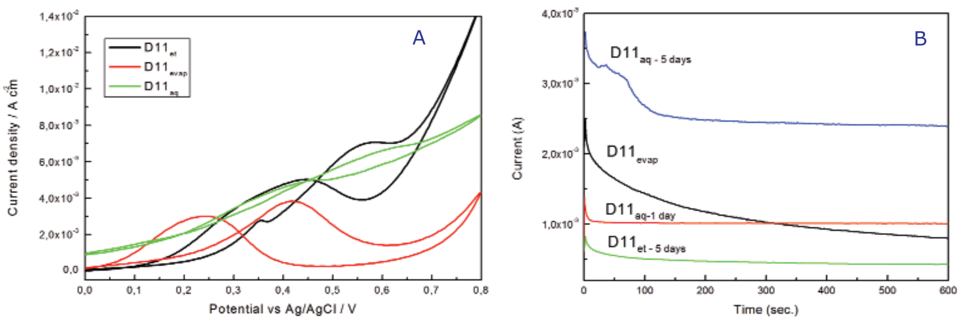
The purpose of this project is the fabrication of a nanocomposite electrocatalytic proton exchange membrane based on silicon.
The silicon substrate has been subjected to a porosification process for nanostructuration and subsequently impregnation with platinum nanoparticles (a), and on the other hand SiO_2 nanoparticles have been covered with PtNPs (b):



The structural analyses, in plane diffraction spectra and EDAX, confirmed the hypothesis that PtNPs deposited on nanostructurated surfaces based on Si have an (111) predominant texture, representing an advantage for envisaged applications in fuel cell complex devices.

The electrochemical tests reveal that improving of Pt nanostructuration down to discrete nanoparticles with 2-3 nm in size, PtNPs significantly reduce the barrier to methanol oxidation and also a larger amount of methanol is oxidized at the electrode:

The long term stability of Pt nanoparticles dispersed in nanoSi matrix implies that most CO adsorbed species could be oxidized and removed from nanoPt catalyst, due to the vicinity of Si fibrils and their active surface sites.



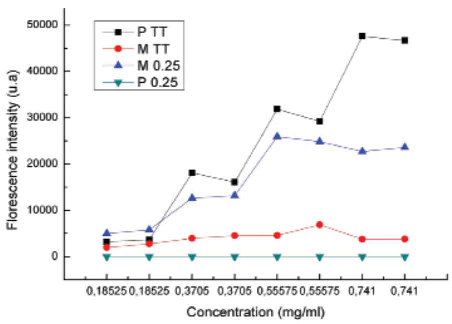
(A) Electrocatalytic activities of Pt / PS nanocomposite structures in 1 M CH_3OH + 1 M H_2SO_4 electrolyte. (B) Chronoamperograms.

Financed by the **National University Research Council (PNII-ID 2007- 2010). Coordinator: Dr. Mihaela Miu, mihaela.miu@imt.ro**

Results

MULTI ALERGEN BIOCHIP REALISED BY MICROARRAY TECHNOLOGY (MAMA)

Because in the developing of any biochip in TMA (Microarray technology), an essential role is played by the interface of biomolecules with the solid support, we prepared a porous nanostructured silicon surface which has been used as support for immobilization of proteins. Its surface has been chemically modified with APTES and respectively poly-L-lysine, and physically, by depositing gold with thiol functionalized. As a reference, in all experiments we have used glass functionalized with aldehyde groups.

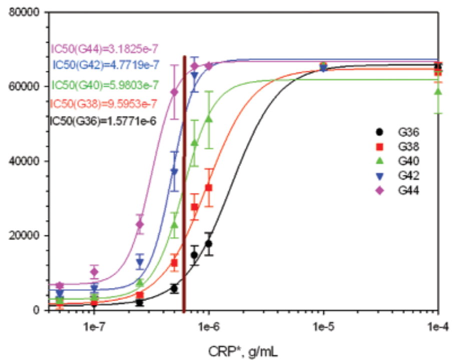


Influence of buffer solution on the immobilization of the mono and polyclonal antibodies anti-CRP on the aldehyde surface

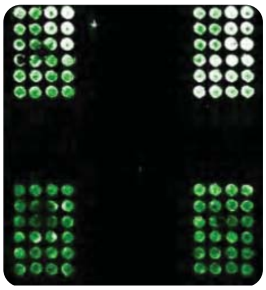
To study the effects of buffer solution used for immobilization of biomolecules on surfaces made in the laboratory, we analyzed a set of mono and polyclonal antibodies in two different buffer solutions: commercial printing buffer (pH 7.4) and, then, citrate buffer (pH = 8,8).

Reaction between printed antibodies with labeled antigens was done on surfaces functionalized with aldehyde groups.

Also in the optimization stages of biochip's structures were determined optimum density of target molecules and optimum density of molecules in the sample, the influence of composition and pH of the solutions used for the biological material immobilization, the influence of the structure of the biochip and the way in which the interface is functionalized, the range of concentrations of protein solutions can be immobilized on the biochip, so as to be detectable and can make interactions with other proteins.



Binding curves


The scanned image of 4 printed subarrays after reaction with fluorescent labeled CRP

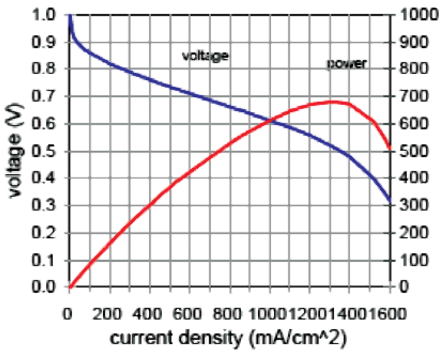
PNCDI Program (2007- 2010) Coordinator: IMT Bucharest, Dr. Irina Kleps/Monica Simion
monica.simion@imt.ro
Partners: "Carol Davila" University of Medicine and Pharmacy- Bucharest; Bucharest University, Faculty of Chemistry; Telemedica SA and DDS Diagnostic SRL;

MINIATURISED POWER SOURCE FOR PORTABLE ELECTRONICS REALISED BY 3D ASSEMBLING OF COMPLEX HYBRID MICRO- AND NANOSYSTEMS (MINASEP)


The micro-DMFC assembly subjected to standard tests

A 3D hybrid system has been proposed and realized using new solutions provided by micro and nano-technologies to work as an integrated fuel cell - miniaturised direct methanol fuel cell (micro-DMFC). The device architecture at the micrometer-scale has been designed in order to increase the total area of reactive surfaces per unit volume without increasing the footprint area.

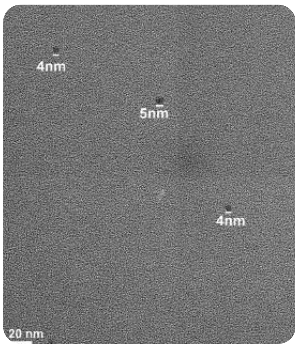
In order to improve the performances of the classical device, besides the common polymeric membrane, new types of proton exchange membrane based on nanostructured materials have been used. Also, Pt nanoparticles have been chemically deposited inside of hydrated Nafion membrane, confirmed by TEM analyses:

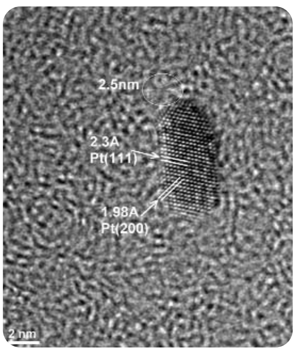


UV-Vis spectra

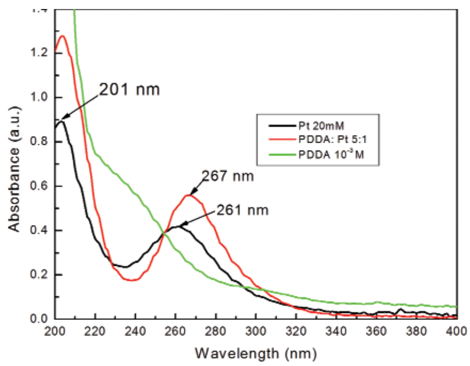
The Pt catalyst efficiency has been further improved by fabrication of binary nanosystems as PtNP-PDDA:

The Tafel graphs reveal the performances of the test structures:





The TEM images of PtNP embedded in polymeric matrix



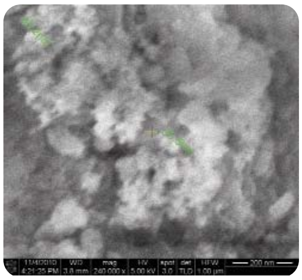
I–V and power density characteristics of the miniaturised fuel cell

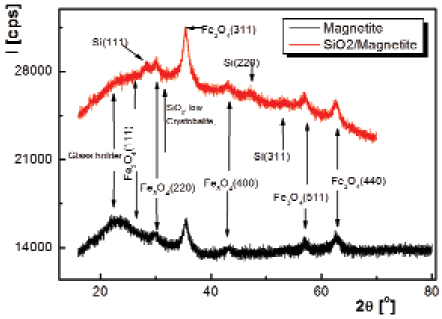
PNCDI Program (2007- 2010), Coordinator: IMT Bucharest, Dr. Mihaela Miu,
mihaela.miu@imt.ro
Partners: University of Bucharest, Faculty of Physics and Petroleum - Gas University of Ploiesti;

Results

SILICON BASED MULTIFUNCTIONAL NANOPARTICLES FOR CANCER THERAPY (NANOSIC)

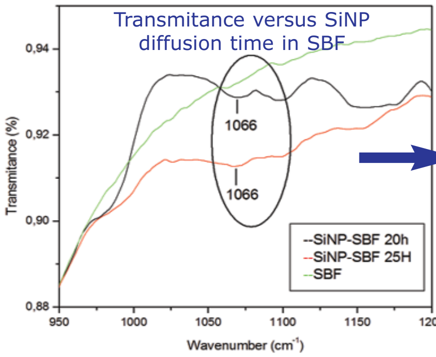
The aim of this project is to optimise the experimental conditions for nanostructured Si (porous silicon – PS) particles fabrication, and to find the best methods for attaching on its surface cytotoxic molecules of therapeutic interest.
Moreover, the drug targeting based on ferrous ferric oxide-magnetite, known as SPION (superpara-magnetic iron oxide nanoparticles), has been obtained by attaching to PS microparticles. Complementary analyses confirm the attachement of both SPIONs and drugs on PS microparticles:

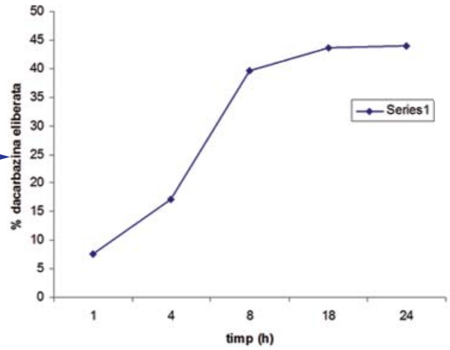




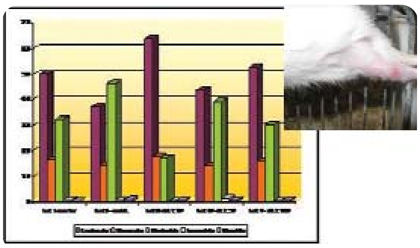
SEM image of the nanostructurated silicon microparticles impregnated with magnetic nanoparticles- dacarbazine-dextran- SPION system

Therapeutic agent diffusion rate from SPION system obtained from in vitro tests in SBF:





Experimental rat lots were analyzed at 24h, 48h, 2 weeks and 1 month since the last drug administration, taking in consideration the following organs: liver, epidermic and muscular tissue and blood, in order to make some determinations, like, biological markers, hystopathological and biochemical examination, oxidative stress:

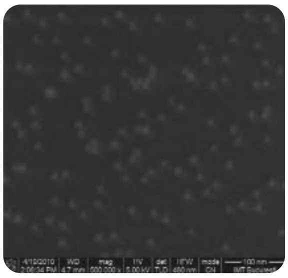


Financed by the **PNCDI Program (2007- 2010).**
Coordinator: IMT Bucharest: Dr. Irina Kleps/Adina Bragaru
adina.bragaru@imt.ro
Partners: INSB Bucharest and IOB Bucharest;

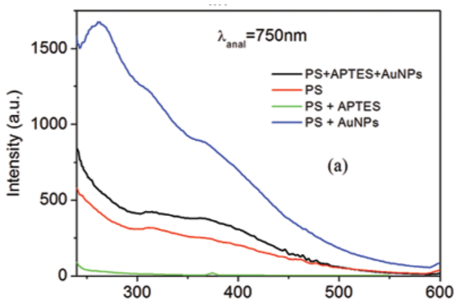
DEVELOPMENT OF PLASMONIC BIOSENSOR BASED ON METALS- SILICON NANOASSEMBLIES- BIOSENS

The goal of this project was to design a "plasmonic biosensor" base on porous silicon surface. This biosensor is based on nanostructurated porous silicon that exhibits well characterized photoluminescence properties. A uniform deposition of gold nanoparticles (AuNP) on PS surfaces has been achieved by first grafting a layer of silane on the PS surface.

As far as the influence on the luminous emission is concerned, the photoluminescence spectra obtained at INSP Paris, using a Jobin-Yvon Fluorolog 3 spectrometer with a double monochromator and 450W Xenon lamp:

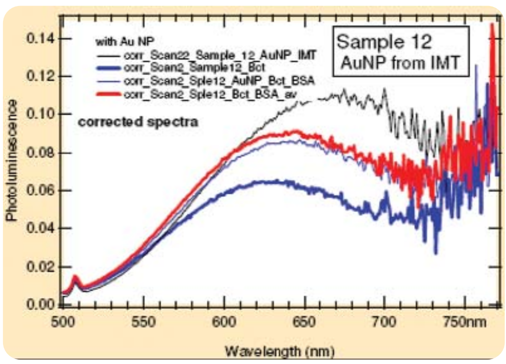


SEM image of the AuNPs deposited on PS surface



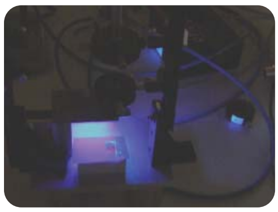
The excitation spectra for λemission=750 nm

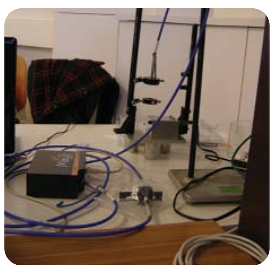
In order to test this biosensor the reaction based on avidin-biotin interaction was employed and the light emission was checked by recording photo-luminescence spectra after each step.



PL spectra recorded after the samples biointeractie steps

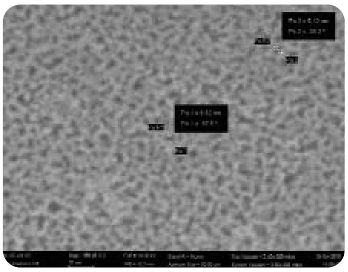
Moreover, an experimental set-up for the in-situ monitorization of the biorecognition reactions has been realized:

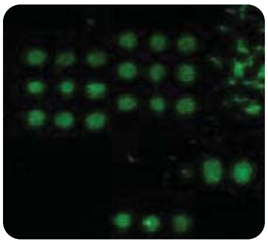




Brancusi Bilateral Project - **Coordinator: IMT Bucharest, Dr. Irina Kleps/**
Dr. Mihaela Miu, mihaela.miu@imt.ro
Partners: Institute for Nanoscience in Paris, France

A "SYSTEM-IN-A-MICROFLUIDIC PACKAGE" APPROACH FOR FOCUSED DIAGNOSTIC DNA MICROCHIPS - DNASIP


SEM image of nano PS layer


Scanned image after hybridization of HPV chip

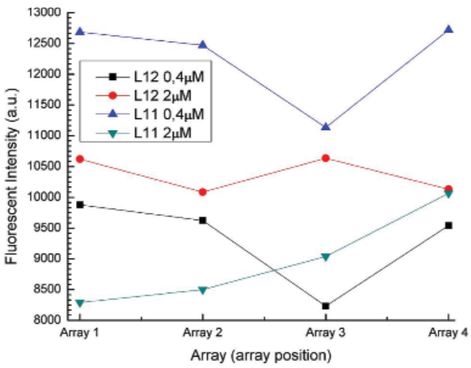
New nanostructured surfaces on porous silicon having 5-7nm pore size was used as support for HPV DNA detection based on microarray technique. An improved of immobilization was obtained using an electron excitation step during pre-hybridization process.

Was performed an anodization process on silicon wafer p type (100) with 5-10 Ωcm resistivity in 25% HF concentration of the electrolyte solution, at 30mA•cm^{-2} current densities in order to obtain an PS layer with thickness about 5-10 μm.

The HPV-DNA sequences were deposited on the PS surface in two concentrations: 2 μM, 0.4 μM. The genomic DNA was extracted using Wizard Genomic DNA Purification kit or DNA IQ kit (Promega Biosciences, Madison, USA).

The samples printed with HPV-DNA were incubated at 4^{0}C for 24 h. In order to activate the surface and to promote binding between surface and unmodified HPV-DNA sequences samples from each type were exposed to an electron fascicules emitted from an electron shutting gun mounted on VEGA II LMU under vacuum for 1h.

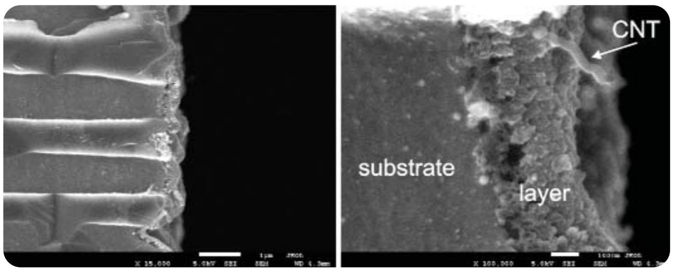
The final step was the hybridization which was performed at optimum temperature and time: 2h 30 min at 42^{0}C.



Fluorescent hybridiignal of L11-12 sequence

MNT-ERA Program (2008 – 2010)
Coordinator: IMT Bucharest, **Monica Simion** monica.simion@imt.ro
Partners: Genetic Lab SRL, Université catholique de Louvain, University of Liège, Coris BioConcept

NANOSTRUCTURAL CARBONACEOUS FILMS FOR COLD EMITTERS – NANOCAFE



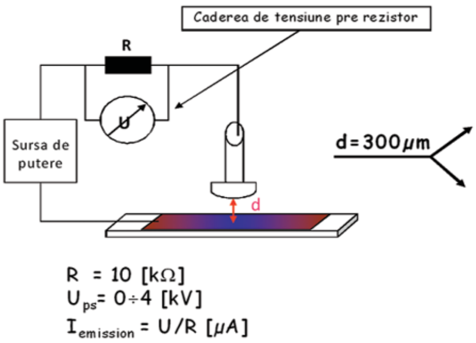
Cross section by a porous silicon substrate with CVD deposition

Following the goal of the project – the preparation of a new type of cold cathode based on nanocomposite carbonaceous material and design of prototype device based on this cathode, new series of experiments was developed.
Films consisting of nanocomposite materials, as assembled carbon nanotubes, carbonaceous and metal (Ni) nanocrystals, deposited on the porous silicon substrates; the films were deposited both by PVD and CVD methods.

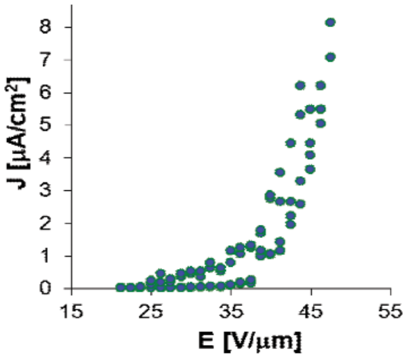
The porous silicon assures the active surface and a good adherence of the carbonaceous material. Complementary analyses were used to investigate the structure and composition related to the type of porosification.

Field emission efficiency was studied for each of these deposited films.

The good field emission efficiency observed, at a low value of the electric field encourages the research to realize a new electron sources based on carbonaceous films deposed on the porous silicon as a new type of cold electron emitters.



Schematic presentation of experimental stand for field emission measurements



I-V field emission curves for CVD deposited sample

MNT-ERA Program (2008 – 2010)
Coordinator: IMT Bucharest, Florea Craciunoiu, florea.craciunoiu@imt.ro
Partners: Industrial Institute of Electronics Warsaw, Kielce University of Technology and Institute of Microelectronics and Optoelectronics Warsaw

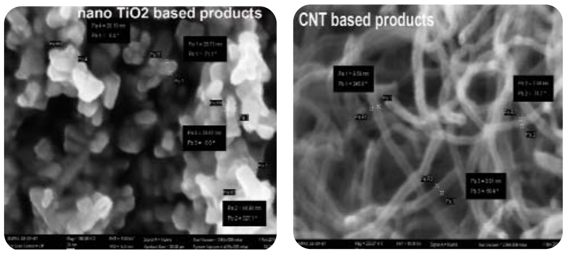
Results

DEVELOPMENT OF SUSTAINABLE SOLUTIONS FOR NANOTECHNOLOGY-BASED PRODUCTS BASED ON HAZARD CHARACTERIZATION AND LCA – NANOSUSTAIN

The objective of the NanoSustain project is to develop innovative solutions for the sustainable design, use, recycling and final treatment of nanotechnology-based products.

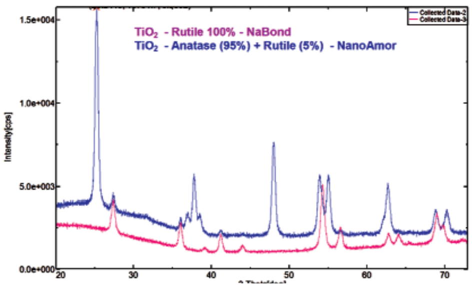
This will be achieved by a comprehensive data gathering and generation of relevant missing data, as well as their evaluation and validation, for specific nano-products or product groups in relation to their human health and environmental hazards and possible impacts that may occur during after-production stages.

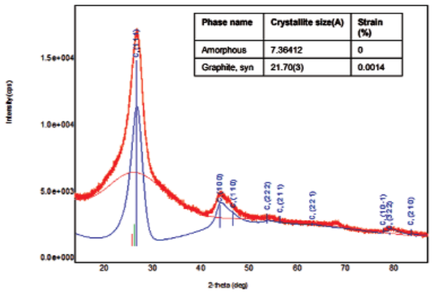
IMT, due to the characterisation facilities, will contribute to obtain a complete characterisation of proposed specific organic and inorganic nanomaterials / associated products:



Morphological analyses (ex. TiO_2 and CNT)

Phase structure (ex. nanoTiO_2 and CNT):
The interplanar distance values are slightly higher (e.g. d002=3.348Å) than that of the perfect graphite (e.g. d002=3.354Å) indicating the presence of a tensile strain (impurity presence)





FP7 Collaborative Project (2009-2012)
Partner: IMT Bucharest,
Acad. Dan Dascalu, dan.dascalu@imt.ro

SERVICES OFFER AND CONSULTANCE ACTIVITIES:

(i) X-RAY DIFFRACTION CHARACTERISATION

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

Contact: Phys. Mihai Danila, mihai.danila@imt.ro

(ii) MICROARRAY BIOCHIPS

• Development of technologies (controlled deposition of biologic material) and devices (microarray biosensors) for biological material investigation and detection (proteins, DNA, enzymes) on various substrates (silicon, glass, polymers) with applications in medical diagnosis;
• Fundamental research for study of biomolecular recognition reaction;

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

(iii) ELECTRICAL/ELECTROCHEMICAL CHARACTERISATION

Material characterization; Fundamental studies of physico-chemical phenomena at bio-hybrid interfaces with applications in areas:
• *Microelectronics:* development of new processes and materials with improved electrical properties;
• *Energy:* development of new fuel cell devices as clean energy sources; development of solar cells with improved parameters;
• *Biomedicine:* development of electrochemical immunosensor devices for clinical diagnostics; implant biocompatibility studies;
• *Environmental* quality control: Detection of compounds/toxins/pathogens for water, food;

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

(iv) NANOPARTICLE CHARACTERISATION

• Determination of the submicron 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);
• Zeta Potential analysis of the functional surfaces;

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

(v) MICRO- AND NANOSTRUCTURED SILICON FABRICATION

• Fabrication of morphological controlled porous silicon (PS) (multi)layers / membranes (2-500 mm thickness) on Si wafers with different characteristics;
• Fabrication of Si nanowire arrays;
• Fabrication of Si nanostructured microparticles (2-10 μm with pore/fibrils diameters of 10-50 nm).

Contact: Florea Craciunoiu, florea.craciunoiu@imt.ro

INSTRUMENTS AND EQUIPMENTS

Laboratory of Nanotechnology has contributed to the development of new experimental and characterisation laboratories in the IMT-MINAFAB:

(i) **NanoBioLab** equipped with Plotter microarray (GeneMachines OmniGrid Micro) and Scanner microarray (GeneTAC UC4);
(ii) **Laboratory for Spectroscopic/Microscopic analyses** of interface electroactivities equipped with Electrochemical Impedance Spectrometer PARSTAT 2273 – Princeton Applied Research; Scanning Electrochemical Microscop (SECM);
(iii) **Laboratory for X-ray Diffraction** equipped with Rigaku SmartLab X-ray thin film difraction system;
(iv) **Laboratory for Nanoparticles** equipped with DelsaNano Zeta Potential and Submicron Particle Size Analyzer, Fluorescence / Time resolve Fluorescence Spectrometer.

Other available facilities are: AMMT wet etching system with software for 4' silicon wafers, potentiostat MC and etching power supply; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system; computers for simulation; instruments and software for electrical characterisation of nanostructures.

L6: Laboratory for nano-scale structuring and characterization

- •Mission
- •Main areas of expertise
- •Research Team
- •Specific facilities
- •International Projects

Mission: Research and development in the field of characterization and structuring methods for materials and processes at micro and nanometric scale. Application of high resolution surface investigation techniques to solve engineering problems at these scales, especially investigation of correlations between technological process parameters-structure and structure-properties order to obtain materials for specific applications etc. The laboratory is the first one in Romania developing research and providing services for nanolithography, using the Electron Beam Lithography technique.

Main areas of expertise: Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Electron Beam Lithography (EBL), Optical Microscopy, Electrical characterization of materials and devices.

Research Team: is composed of 3 senior researchers with background in Physics and Electronic Engineering, an early stage researcher with background in Chemistry and 2 MS students in Electronics.

Specific facilities: • **Multifunctional Scanning Probe Microscope** (SPM) Ntegra Aura –NT-MDT.
Features: built-in capacitive sensors, active antivibrational table, could be operated under different environments: air, liquid, controlled gaseous atmosphere, low vacuum (10-2 torr). Scan range: 100x100x10 ìm, noise level, XY: 0,3 nm, Z: 0,06 nm, non-linearity in X, Y with closed-loop sensors < 0.15 %.

• **FEI Nova NanoSEM 630**- Ultra High resolution Field Emission Gun Scanning Electron Microscope - This SEM delivers very high resolution surface information at low accelerating voltages and can be widely used in many applications: nanotechnology, materials analysis, semiconductor technology, quality assurance, life sciences. It features SE and BSE detectors both E-T and in lens, also LV BSE detector and high resolution SE detector for low vacuum working mode, true eucentric sample stage with encoder, charge compensation technique (water vapors).

• **SEM - TESCAN VEGA II LMU** - General Purpose Scanning Electron Microscope with thermionic electron gun (tungsten) which is able to achieve 3 nm resolution at 30 kV accelerating voltage. For electrostatic charge compensation it is able to work in low vacuum (nitrogen) up to 150 Pa.

• **EBL - Raith Elphy Plus** - pattern generator for Electron Beam Lithography, attached to Tescan SEM. Features: 6 MHz high-speed pattern generation hardware, 16 bit DAC vector scan beam deflection, 2 ns writing speed resolution.

• **Raith e_Line** - Electron beam lithography and nanoengineering workstation. It is a versatile electron beam lithography system having complied with the specific requirements of interdisciplinary research at nanoscale. The main features are: thermally assisted field emission gun, laser interferometer stage with 100 mm by 100 mm travel range and 2 nm resolution achieved by closed-loop piezo-positioning, modules for nanomanipulation, EBID and EBIE. Minimum achievable line width is better than 20 nm, stitching accuracy 40 nm and overlay accuracy 40 nm.

• **(Nano Indenter) G200** - Agilent Technologies
Nanomechanical characterization equipment operating by instrumented indentation and scratch testing - It provides access to various mechanical properties of small-volume samples, such as thin films, but could be equally applied to investigate bulk samples.
Maximum load: 500 mN, load noise floor: 100 nN, max indentation depth: 500 mm, displacement noise floor: 1 nm, position accuracy: 1 mm

Team from left to right: Adrian Dinescu, Cecilia Codreanu, Loredana Draghiciu, Marian Popescu, Mihaela Marinescu, Raluca Gavrila, Alexandru Herghelegiu

International projects: **FP7** ***CATHERINE*** "Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts"- STREP- FET proactive (2008-2010), ***Coordinator*** **Consorzio Sapienza Innovazione, Italy.** ***Partners:*** CNIS-Italy, TUD-Netherlands, CIRIMAT-France, USL-Italy, ULV- Lativia, IMT- Bucharest- Romania, FOI-Sweden, INFN-Italy, PHILIPS- Netherlands, Smoltech-Sweden.
IMT-Bucharest: contact person Phys. Adrian Dinescu-(adrian.dinescu@imt.ro)

CATHERINE project aims to provide a new unconventional concept for local and chip-level interconnects that will bridge ICT beyond the limits of CMOS technology.

The main goals are: - To develop an innovative cost-effective and reliable technological solution for high-performance next-generation nanointerconnects.
- To develop proof-of-concept nanointerconnects to assess and verify the new proposed solution.

Laboratory Head — Phys. Adrian Dinescu (adrian.dinescu@imt.ro)

He received the M. Sc. (1993) degree in Physics and PhD title in 2010 from Faculty of Physics, University of Bucharest. From 1993 -1997 he was Research Scientist at Research Institute for Electronic Components, ICCE Bucharest in the Optoelectronics Laboratory; From 1997 he is **Senior Researcher** at the National Institute for R&D in Microtechnologies (IMT Bucharest) in the ***Microphysical Characterization Laboratory***.

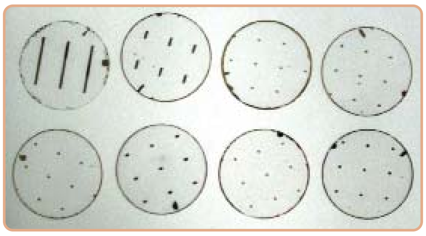
His main scientific interests are focused on patterningat the nanoscale using Electron Beam Lithography and on characterization using Field Emission Scanning Electron Microscopy.

Adrian Dinescu was the leader of several national research projects (Matnantech, Ceres, CEEX) and partner in international projects (CATHERINE FP7, ASSEMIC- Marie Curie Training Network, FP6) and the author more than 15 scientific papers presented at conferences and published in journals.

Results

FP7 PROJECT

CATHERINE - Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts



The calibration kit and the patterned substrate for the test vehicle

CATHERINE project aims to provide a new unconventional concept for local and chip-level interconnects that will bridge ICT beyond the limits of CMOS technology.

The main goals of CATHERINE are:
- To develop an innovative cost-effective and reliable technological solution for high-performance next-generation nanointerconnects.
- To develop proof-of-concept nanointerconnects to assess and verify the new proposed solution.

Results: - A technological process to integrate alumina membrane (filled with CNTs) in a device has been developed. The process is based on laser ablation to cut the membrane due to the thickness in the range of 60-80μm

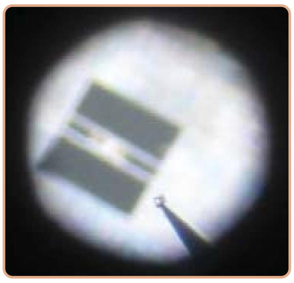
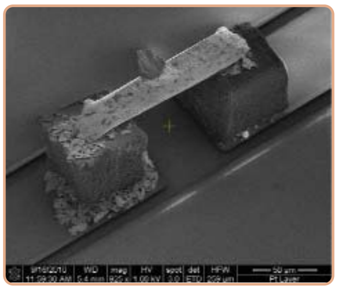


Image of alumina tower attached to the mounting tip. The CPW structure can be seen in the out of focus region, under the tip.



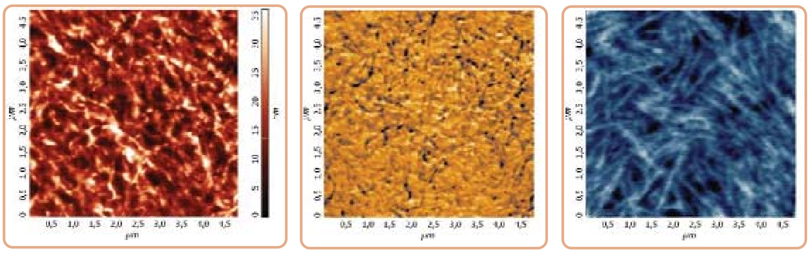
SEM image of the test vehicle for the vertical CNTs based interconnects

- A calibration kit for the EM measurements of the test vehicles was fabricated;
The test vehicles and the calibration kit packaged are sent to Sapienza CNIS and FOI for testing and measurements.

STREP- FET proactive (2008-2010), coordinator Consorzio Sapienza Innovazione, Italy
Partners: CNIS-Italy, TUD-Netherlands, CIRIMAT-France, USL-Italy, ULV- Latvia, IMT- Bucharest- Romania, FOI- Sweden, INFN-Italy, PHILIPS- Netherlands, Smoltech- Sweden.
IMT-Bucharest contact person: Phys. Adrian Dinescu (adrian.dinescu@imt.ro)

NATIONAL PROJECTS

Complementary characterization of surfaces by advanced SPM techniques



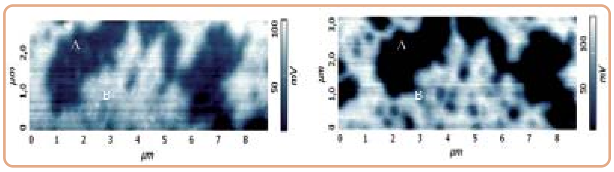
Morphology (a), phase image (b) and surface potential (c) for a P3HT blend for photovoltaic applications. KPFM image (c) revealed the nanoscale subsurface structure of the blend, masked by a oxidized and/or amorphous layer at the surface

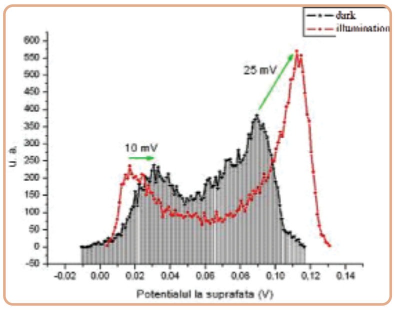
Main goals: Investigating the conceptual and practical implementation issues associated with the application of scanning probe microscopy-based techniques for complementary characterization of materials for micro and nanoelectronics.

Results: • We have used Electrostatic Force Microscopy (EFM) modes in several applicative studies to simultaneously gain insight into morphological and electronic properties of various thin film materials.

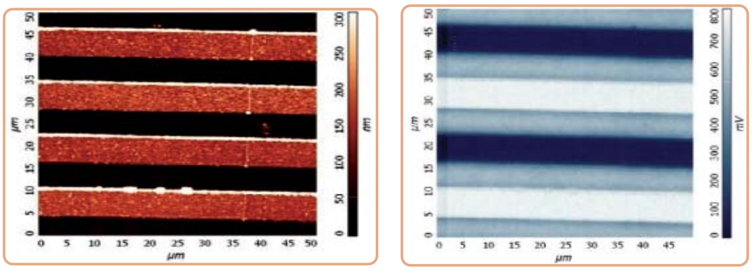
• In particular, KPFM technique has been applied to directly visualize the photovoltaic activity of an organic photovoltaic material (poly 3-hexylthiophene) - P3HT, thus allowing to acquire quantitative information regarding the correlation between nanoscale architecture and function.

• For assessing the functionality of EFM modes a special EFM testing structure with different pitch sizes was designed and fabricated using EBL and lift-off procedures





KPFM images of a sample area (9 μm x 2.5 μm) of a P(3HT- co-3ATH) thin film recorded (a) in dark and (b) under white light illumination. Fig (c) illustrates the photovoltaic activity occurring in this polymer by the histogram distributions of the surface potential in the dark and under illumination.



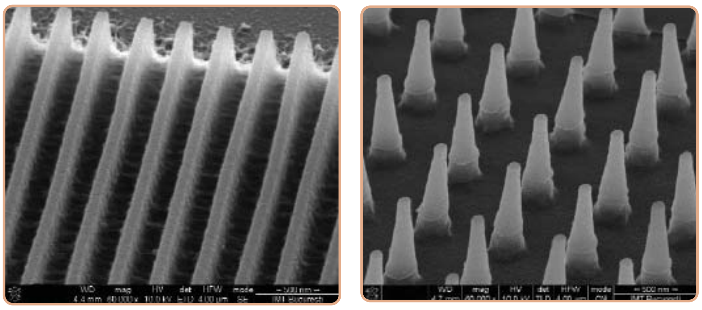
EFM test structure with interdigitated finger electrodes - simultaneously acquired topography (a) and KPFM images (b). For electrode pairs put to different bias, adjacent electrodes have the same height (a) but differ in the surface potential (b).

Project Type: National basic funding **Project CONVERT +, PN II (2009-2011);**
Project manager: Raluca Gavrila, raluca.gavrila@imt.ro

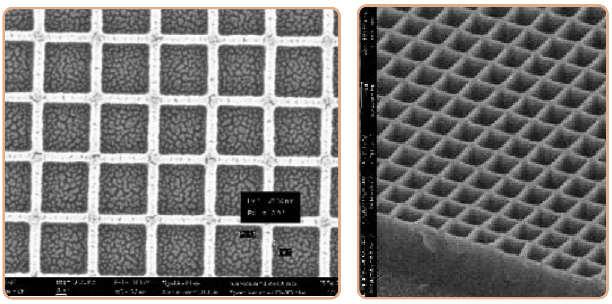
NATIONAL PROJECTS

Development of structuring technologies at the nano scale

Main goals: To develop and refine nano-structuring technologies based on Electron Beam Lithography patterning.
Results: We have used the EBL technique to obtain nanostructures with high aspect ratio both in PMMA and SU8 electronresists.



SEM micrographs of high aspect ratio (6:1) SU8 structures. a) lines with 1/3 fill factor b) pillars



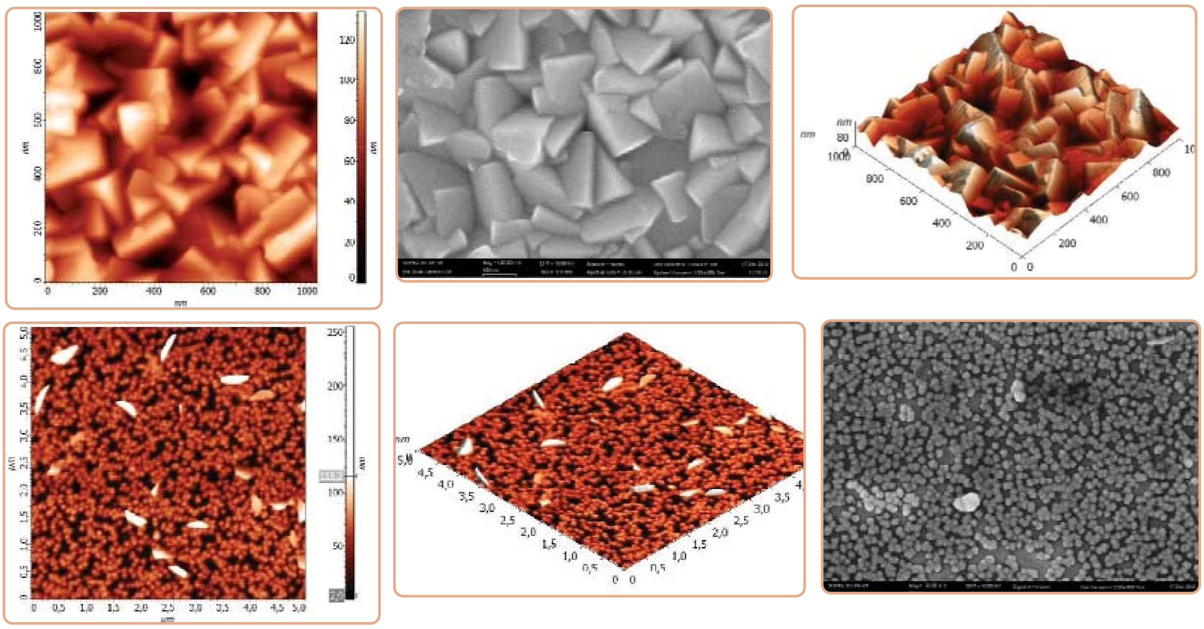
SEM micrographs of a high aspect ratio (12:1) PMMA structures. a) sample 45 degree tilted b) top view

Project Type: National basic funding **Project CONVERT +, PN II - (2009-2011);**
Project manager: Adrian Dinescu – adrian.dinescu@imt.ro

Services offered by the Lab: AFM, SEM, EBL,

▶ **High resolution surface morphology** investigations by AFM and SEM: 3D surface topography recording and measurement (waviness, roughness, step heights, grains, particles etc); 3D surface topography recording and measurement (waviness, roughness, step heights, grains, particles etc); Nanoscale morphology of PbS surface examined by SEM and AFM

▶ **Mechanical characterization of thin films (Young's Modulus, Hardness)**



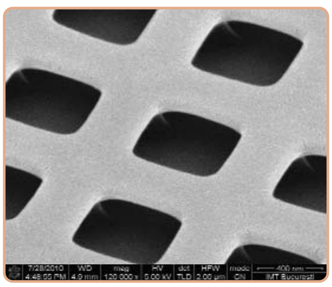
Contact Person: Phys. Raluca Gavrila, raluca.gavrila@imt.ro

▶ **High resolution – low voltage FEG- SEM imaging**

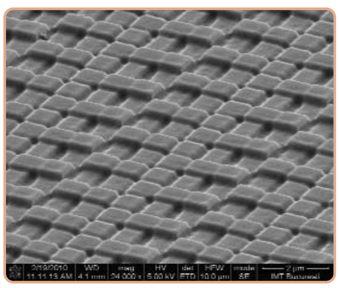
Iron oxide nanoparticles
HV=1kV, Mag= 300.000 X

Carbon nanotubes
HV=1kV, Mag= 150.000 X

▶ **Electron Beam Lithography patterning**



Suspended PMMA structures
for photonic applications



3D patterning of PMMA 35K

Contact person: Dr. Adrian Dinescu – adrian.dinescu@imt.ro

L9: Laboratory for Molecular Nanotechnology

Mission: Interdisciplinary laboratory established in 2009, relying on state of the art equipments (belonging to various labs). We work on functional integration of biological components, such as peptides, proteins, antibodies, nucleotides, DNA fragments, etc., with micro-nano processed and patterned inorganic structures, targeting various micro-nano-bio-info applications. We combine substrate preparation and processing, micro-nano scale lithography and controlled molecular deposition, adsorption and manipulation of biomolecules, nanoscale microscopy techniques, and equilibrium/non-equilibrium quantum mechanical numerical analysis, aiming at developing unified experimental and theoretical frameworks for the study of functional properties obtained from the interaction of biomolecules with nano/micro objects. Controlling and investigating the chemical and physical properties of new nanomaterials is another key research orientation. We address health and environmental applications focused on developing advanced solutions for (bio)sensors and (bio)sensor arrays using chemical and physical principles.

Main areas of expertise:

• Electrochemistry: investigation of redox mechanisms; design and development of electro-chemical sensors, electrochemical biosensors, immunosensors, DNA sensors, etc.;

• Materials chemistry and surface functionalization: - chemical modification of carbon allotropes (carbon nanotubes, graphene and carbon nanoparticles) and metallic nanoparticles;

- development of advanced carbon nanocomposites for thermal, electrical and biomedical applications;

• Analytical investigations and characterizations (UV-Vis, fluorescence, HPLC, FT-IR, etc.):

- nanoscale microscopy and patterning (SPM, dip-pen nanolithography).

• Substrate preparation and processing for molecular nanotechnology applications (micro-nanolithography, metal deposition, plasma etching, annealing).

• ELISA based techniques for the detection of food toxins (domoic acid, ochratoxins, mycotoxins, etc.).

• Modeling and simulation: ab-initio calculations of electronic structure optical response and electronic transport in materials; ab-initio molecular dynamics with Car-Parrinello method; quantum dynamics of electronic states strongly interacting with electromagnetic fields or vibrations; dielectric response of heterogeneous materials like suspensions of biological cells; light interaction with metallic nanoparticles; coupled field analysis.

• **Research Team:** 6 senior researchers, 1 research assistant; multidisciplinary expertise (physics, chemistry, engineering, HPC).

• ***Main tools:*** • Modeling and simulation:

- SIESTA/TRANSIESTA: packages for ab-initio molecular dynamics and electronic structure calculations (molecules and solids)

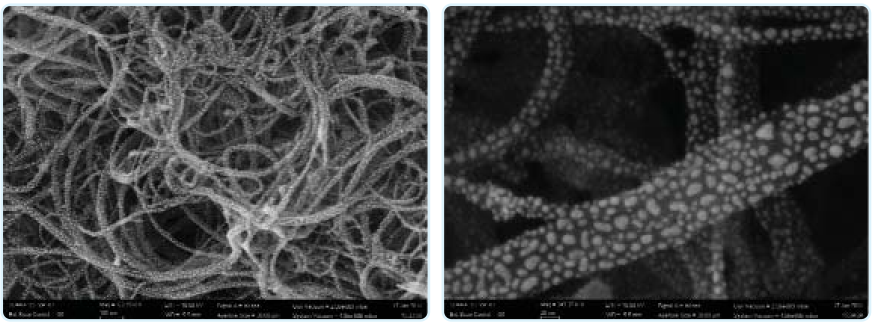
• Processing and characterization available in various IMT-Bucharest laboratories.

Laboratory Head — Dr. Radu Popa (radu.popa@imt.ro)

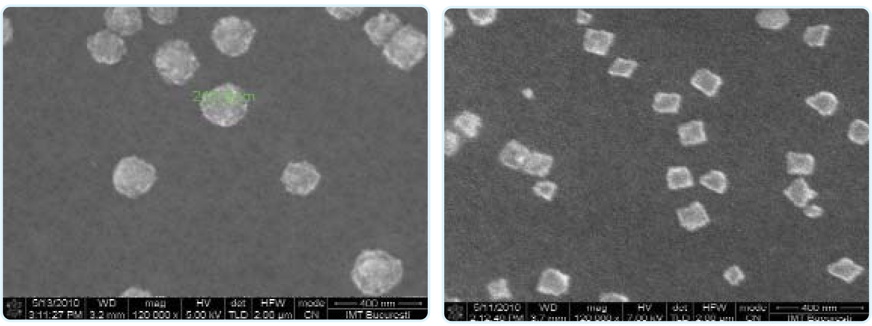
Main projects - Results

Efficient electrochemical catalysis and regeneration of nicotinamide adenine dinucleotide at layer-by-layer self-assembled doped membranes

Nanostructured materials exhibit interesting properties which enhance the electrochemical detection of NADH. Relevant issues in the effective use of nicotinamide adenine dinucleotide are the need of high overpotentials for direct oxidation or reduction of the cofactor, electrode fouling, dimerization of the cofactor, etc. Nevertheless, to promote economically efficient processes, the regeneration of the pyridine cofactor remains a key problem to solve. A platform for various dehydrogenase based bioassays should be obtained by developing an electrochemical probe based on layer-by-layer self-assembled doped metallic nanoparticles membranes. When using nanoparticles for catalysis two main aspects are relevant: the stabilization of particles while retaining sufficient catalytic activity and the problematic separation of the catalytic particles from the reaction product. One solution may be the immobilization of the nanoparticles in thin membranes, minimizing the mass transfer limitations. A generic platform offering a fast regeneration and an efficient catalysis of coenzyme is the goal of this project.



Gold nanosized particles on carbon nanotubes.



Synthesis of spherical (left) and square (right) Pt nanoparticles.

Project director: Dr. Antonio Radoi, antonio.radoi@imt.ro.
Coordinator: IMT-Bucuresti

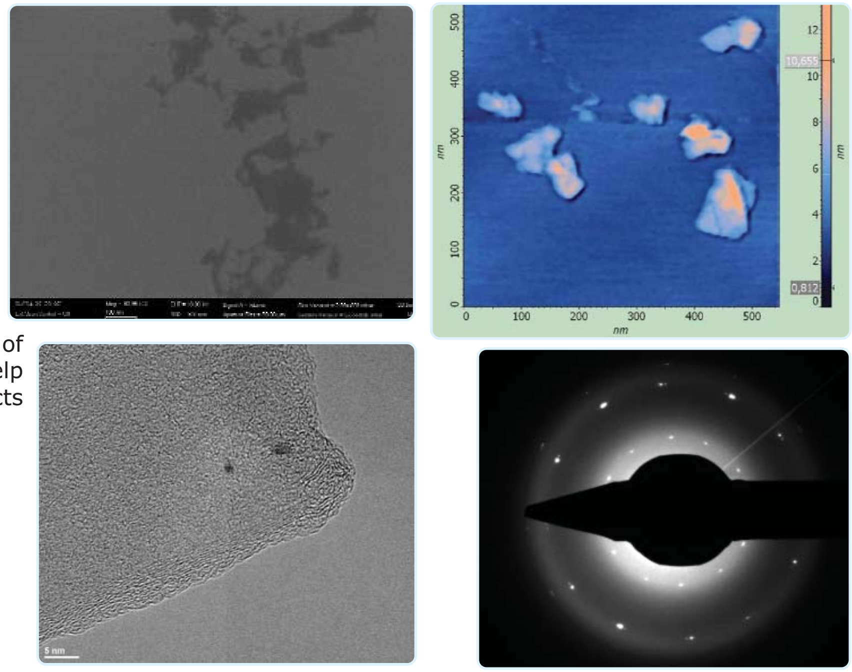
Financed by the National University Research Council (PNII-TE 2010- 2013)

Results

Synthesis and Molecular Assembly of Functional Nanomaterials

The novel properties and associated functionalities arising from graphene, a single layer of sp2 hybridized carbon atoms, has generated considerable attention and paved the way towards applications ranging from graphene-based composits, sensors, and biomedicines to nanodevices. However, as was the case in the early days of carbon nanotubes research, graphene suffers from a problem that is common to many novel materials, there is no method for the mass-production of this material. Thus, the focus of this project is to produce colloidal suspensions of monodisperse graphene sheets without the help of stabilizers or surfactants, with fewer defects which are amenable to surface chemistry.

Financed by the European Social Fund Human Resource Development by Postdoctoral Research on Micro and Nanotechnologies (POSDRU/89/1.5/S/63700, 2010-2013)
Project Director: Dr. Lucia Monica Veca, monica.veca@imt.ro

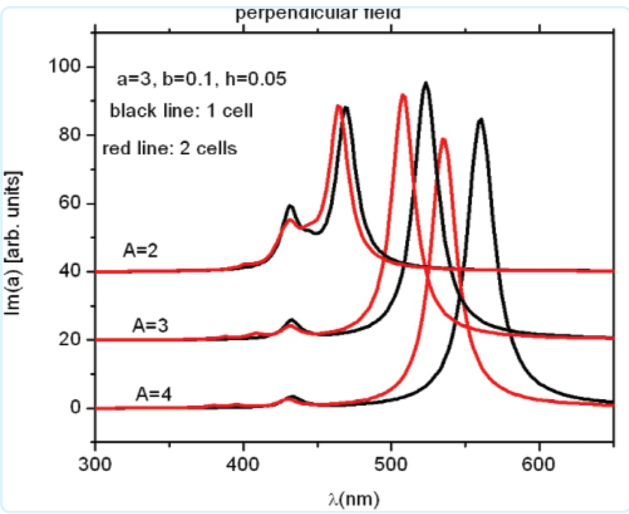


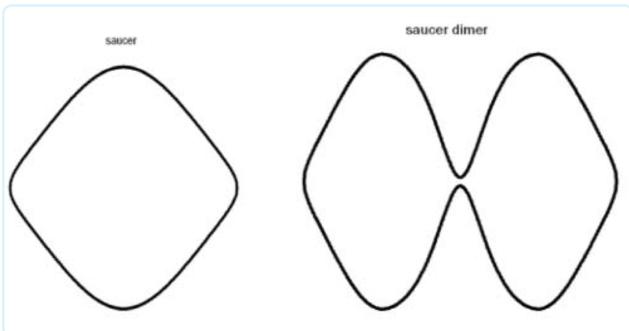
Graphene obtained by liquid phase exfoliation of graphite in organic solvents whose surface energies match that of graphene.

Interaction of low-dimension systems with electromagnetic/phonon fields via plasmon resonances

The interaction of electromagnetic/ phonon fields with heterogeneous systems is a central topic in physics with a large variety of applications in: photonic and phononic crystals, plasmonics or sensing like surface-enhanced Raman scattering and surface-enhanced infrared scattering.

Metallic nanoparticles interact with electromagnetic fields via particle polarizability. The response of metallic nanoparticles depends on their resonant behaviour with respect to the incident radiation field. The resonances of metallic nanoparticles are localized plasmon resonances which are placed in the ultraviolet-visible and near- or mid-infrared range of the electromagnetic spectrum. The response to electromagnetic fields can be calculated analytically only for high-symmetry structures like spheres, spheroids, ellipsoids, etc. For more general shapes the response to electromagnetic fields can be calculated only numerically with complex computational schemes like the discrete-dipole approximation or finite-difference time domain method, which offer little inside into the physics of plasmon resonances. It has been developed a method that calculates the electrostatic resonances of metallic nanoparticles. The main advantage of the method is the eigenmode decomposition of particle polarizability. The eigenmode decomposition permits the extraction of dielectric and geometric information about the nanoparticle and the surrounding medium which, in turn, can be used in designing plasmonic structures. The following figure shows the imaginary part of dielectric polarizability for various nanoparticle shapes. There are either individual nanoparticles or dimers. The imaginary part of polarizability is proportional with light extinction of metallic nanoparticles.





(a) Extinction spectra of metallic nanoparticles and metallic dimers as a function of shape. The shape of metallic nanoparticles and dimers is determined by the aspect ratio a/A, where 2A is the cross-section diameter and 2a is the axial length of the nanoparticle. The metallic tight junction in the dimer is characterized by h, its cross-section radius.-

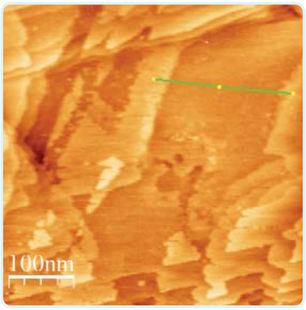
Financed by the European Social Fund Human Resource Development by Postdoctoral Research on Micro and Nanotechnologies (POSDRU/89/1.5/S/63700, 2010-2013)
Project director: Dr. Titus Sandu, titus.sandu@imt.ro

Main projects - Results

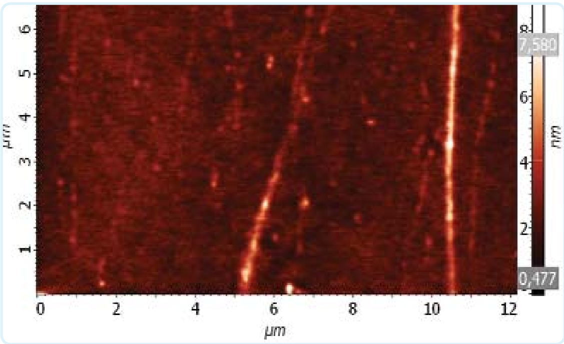
Theoretical and Experimental Study of Polynucleotides: Controlled Immobilization and Scanning Tunneling Microscopy Investigation

Developing alternative methods for fast and low-cost DNA sequencing is an increasingly active area of research. In this context we are focusing both on experimental and theoretical investigations on the feasibility of STM-based reading of the nucleobase sequence. Experimentally, we have obtained very high quality (atomically flat: 3Å roughness/200nm terraces, at single-crystal grade) Au layers on mica substrate based on TSG - template stripped gold - technique, as well as uniform depositions of alkanethiol layers for strand immobilization. YOYO-1 marked, λ-phage DNA strands were also linearized and immobilized on APTES/glass substrates using a controlled mechanical stretching (molecular combing) approach. We also realized the immobilization of Cy3-marked 25-base-long single-strand DNA sequences with end thiol modifications on Au substrate and preliminary experiments of controlled depositions of MHA thiols on Au substrate using dip pen nanolithography process.

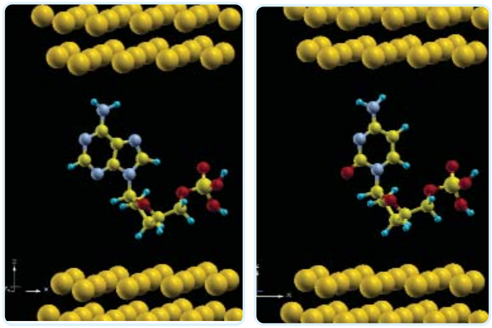
The theoretical experiments are based on ab-initio calculations under the DFT paradigm, as implemented in the SIESTA/Transiesta/Inelastica packages. We concentrate on assessing the molecule identification potential offered by tunneling spectroscopic signatures, with the latest accent on the inelastic electron tunneling spectroscopy (IETS) extension implemented in the Inelastica package. We place single A/G/C/T-based nucleotides in various orientations between metallic electrodes at fixed inter-electrode clearance and calculate the IETS spectra, aiming at identifying selectivity features in these spectral signatures in low-coupling, off-resonance regime. As a major computational bottleneck of these studies is determined by the initial relaxation of these "large" molecules (33-36 atoms), we inserted in the original SIESTA code an acceleration procedure consisting in successive temporary "freezing" sequences of quasi-relaxed portions of the molecule - this solution proved to significantly stabilize and speed-up the relaxation phase.



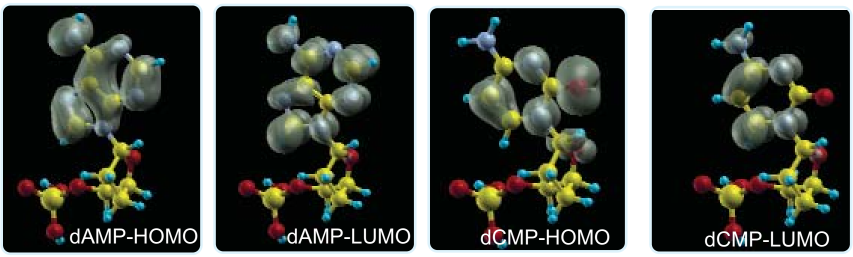
STM confirmation of Au terraces: RMS roughness=3Å.



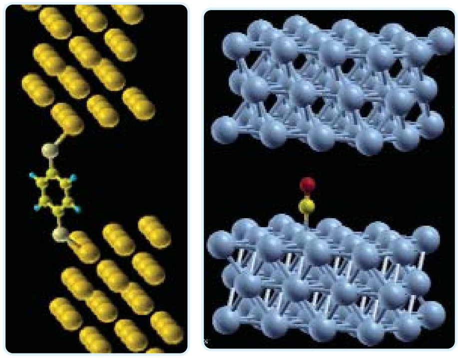
AFM image of λ-phage sequences combing-stretched and immobilized on APTES/glass substrate, at 10 μg/ml concentration.



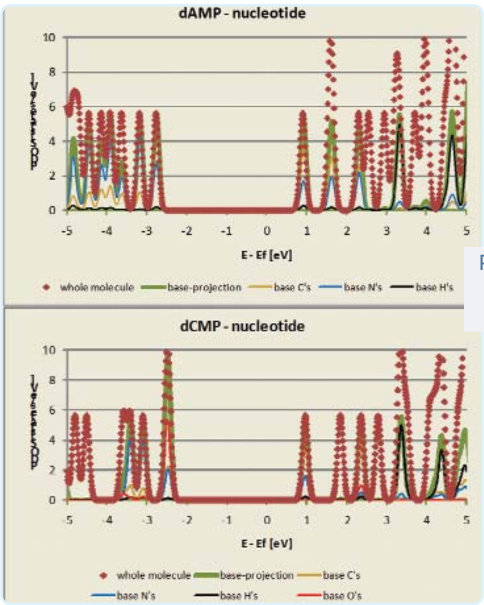
Tunneling model for dAMP, dCMP nucleotides between 15Å-spaced Au 111 electrodes.



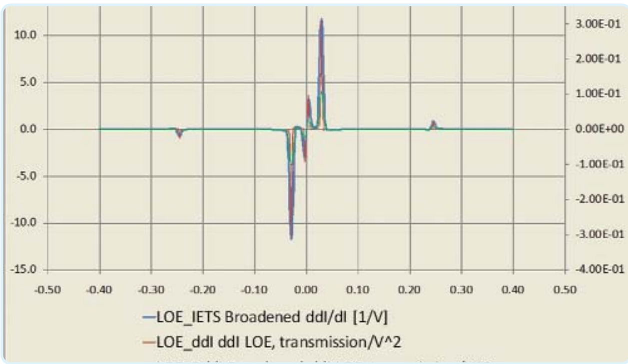
Localized DOS integrated around molecular HOMO, LUMO levels for dAMP, dCMP nucleotides: localization on atoms of nucleobases and major contributions of π-orbitals.



Other IETS simulations: CO molecule adsorbed on Cu-111, and BDT molecule adsorbed between Au-111 electrodes.



Projected DOS spectra confirm dominant π-orbital localization.



Simulated IETS spectra for CO adsorbed on Cu-111, and BDT molecule adsorbed between Au-111 electrodes.

Financed by the National Authority for Scientific Research (2009- 2011) – core funding

Project director: Dr. Radu Popa, radu.popa@imt.ro, Coordinator: IMT-Bucuresti

L2: Laboratory for Microsystems in biomedical and environmental applications

The **Mission** of the laboratory for microsystems in biomedical and environmental applications is **research**, focused on the development of microsensors (chemo resistive and resonant gas sensors), electrodes for biological sensors, microprobes for recording of electrical activity of cells and tissues, microfluidics and integrated technologies (silicon, polymers, biomaterials), **education** in the field of micro chemo and biosensors (in cooperation with University "Politehnica" of Bucharest), and **services** in design, simulation and technology for bio- and chemo-applications

Main expertise: development of a large area of microsensors (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), in terms of software simulations / modelling, using MEMS–specific CAD software (CoventorWare, CADENCE), technological development and electrical characterisation. Microfluidic platforms simulation and realization including tubes, microfluidic connectors and reservoirs, pumping system and microsensors integration are part of the laboratory expertise. The team was working in 20 national projects and seven FP6 projects during the last 5 years, both research projects and support actions.

National projects:
- **IMUNOSENSE** ("Miniaturized immunosensor arrays technology, for herbicide detection");
- **BIOMICROTECH** ("Miniaturized biosensor micro-technology for fast detection of contaminations from food")

Research team:
The Laboratory team includes 12 people, seniors and young researchers with multidisciplinary expertise (microelectronics, physics, chemistry, biology).

Team from left to right: Rodica Iosub; Carmen Moldovan; Ioana Ghinea; Claudia Roman; *second row*: Daniel Necula; Bogdan Firtat; Costin Brasoveanu; Marian Ion;

Laboratory Head - Dr. Carmen Moldovan (carmen.moldovan@imt.ro)

Dr. Carmen MOLDOVAN is the head of the laboratory. She graduated on Electronics and Telecommunications and she owns a PhD in Microsensors. She was responsible from IMT side in the **TOXICHIP project**, FP6 STREP (IST), for the development of temperature, pH sensors and O_2 sensor integrated into a microfluidic platform for toxicity detection.

She was involved in the **4M** NoE (NMP), working on demonstrators, in Ceramic cluster, having the goal to integrate a non-standard micromachining process into a ceramic substrate and in the Sensors and Actuators cluster and IMT in **INTEGRAMplus** FP6 IP (IST), dealing with technology convergence and integration and virtual design and manufacturing. She's currently coordinator of the PESTIPLAT MNT-ERANET project and BIOMICROTECH, a National Project The scientific activity is published in more than 70 papers in journals, books and communications in Proceedings.

MAIN ACTIVITIES AND RESULTS IN PROJECTS:

Miniaturized biosensor microtechnology for fast detection of contaminations from food

The goal of **BIOMICROTECH** (PN II contract no. 52-173/2008) project was the development of miniaturized biosensors technology integrated in microfluidic chips, for the detection in the ng/L domain of organophosphorus insecticides from food (milk, juices from fruits and vegetables) and water by involving the microtechnology techniques on silicon and microbiology techniques, accessible to project consortium. A sensitive acetylcholinesterase (AChE) amperometric biosensor proposed in the project is single use, reproducible, mass production, low cost and has commercial value. For obtaining the microelectrodes used like transducers for depositing biological material the optimization of MEMS (Micro Electro Mechanical Systems) technologies is required, such as: realization of 2D configuration and respective masks for microelectrodes structures, depositing dielectric on silicon substrate, metal (Ti/Au) deposition and patterning, PSG or Si3N4 deposition as passivation layers for protection of the metal. There are two techniques studied, for surface functionalisation: the organofunctionalisation method (organic compounds with: thiol (-SH) group, amino ($-NH_2$) group, medium modifier is organic group) and inorganofunctionalisation method (a metal (gold), Au<111>, for the adherence of the bovine serum albumin (BSA) to the substrate.

Fig.1. Agilent LCR Meter measurament system

Miniaturized biosensor microtechnology for fast detection of contaminations from food

The substrate's hydrolysis produces measurable changes in the PEG polymer layer impedance, seen as a capacitance variance as shown in figure 3, or as a conductivity variance as shown in figure 4.

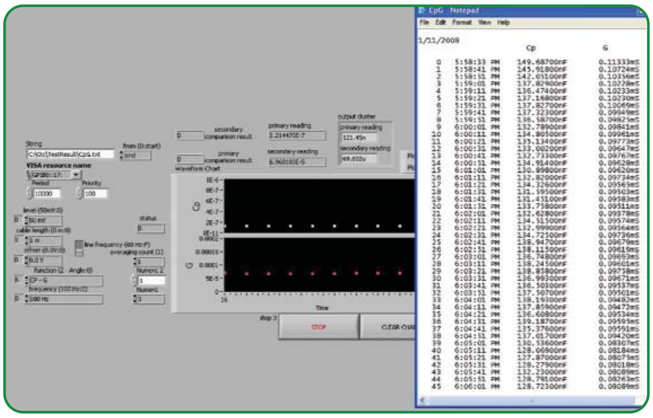


Fig.2. Lab-View 8.2 interface

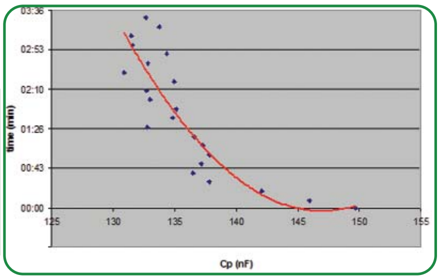


Fig. 3 Time variance of the capacitance at the acetylthiocholine substrate hydrolysis in the Diclorvos insecticide detection experiment

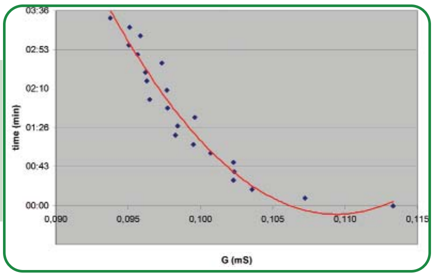


Fig. 4 Time variance of the conductivity at the acetilthiocholine substrate hydrolysis in the Diclorvos insecticide detection experiment

Miniaturized immunosensor arrays technology, for herbicide detection - IMUNOSENSE

The objective of project IMUNOSENSE is to develop the technology to produce an array of integrated immunosensors with optical and electrical detection in the ng/l domain of herbicides in food and water, involving microtechnology techniques on silicon and piezoceramic substrates, and molecular biology techniques available at the consortium level.

The project has led to the development of production techniques for integrated immunosensors on a semiconductor (silicon) substrate and on a piezoelectric (langasite) substrate for ultrafast analysis, with high accuracy, with increased sensibility compared to the ELISA technique (the immunochemical technique currently in use) and with increased specificity towards the detection of: atrazine, hydroxi-atrazine, 2,6-dichlor-benzamide (BAM), 2,6-dichlor-benzenitril (Diclobenil). Testing of SAW devices on a langasite substrate SAW structures were developed on the new langasite substrate, resulting the 4 microns width interdigitated electrodes from figure 5. For surface functionalisation and sensor preparation, a microfluidic channel and pumping system have been used. The sensor's transfer function is presented din fugure 6

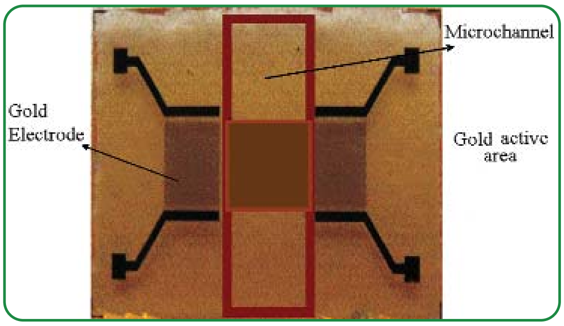


Figure 5. 4 microns SAW sensor on langasit

Fig.6: SAW 40- Transfer characteristic of the SAW device, functionalised with thiols and BSA deposited on active area Legend: red line SAW; blue line SAMs; violet line BSA

PN II contract no. 51-083/2007; Partners: Romquartz SA, DDS Diagnostic

INKJET PRINT: Inkjet printing technology for microsensor manufacturing, using Dimatix DMP 2800 equipment. The InK Jet printing technology has been developed because is offering an easy to use technology compared to the conventional processes which implied lithography, CVD, PVD processing, and high substrate processing costs; it has the capability to deposit droplets of fluid, of the picolitter magnitude, such as liquid silver or organic inks, on all types of surfaces, including flexible ones, the possibility of using cheap flexible substrates like PET (Poly-Ethylene-Terephthalate) sheets, paper sheets, etc; the possibility of using metallic Inks and polymer inks like: Poly-Ethylene-Di-Oxy-Thiophene doped with Poly-Styrene-Sulphonate (PEDOT:SS) and Poly-ANIline (PANI). The printing of metallic electrodes made on Silver Ink (Figure 7) offered the needed interdigitated electrodes for different sensors development.

Figure 7. Interdigitated electrodes made by silver ink jet deposited on a flexible substrate (images taken with the video camera of the Dimatix DMP 2800 equipment (left), and optical images of the same structure taken with the Leica microscope (right))

L8: Laboratory for ambiental technologies

- Mission
- Main areas of expertise
- Research Team
- Services offer

Mission: • Developing new technologies in the areas of microsystems technologies: technological design, technological simulation and technological development up to the prototype level;
• New materials development (i.e. nanocomposites);
• New assembly techniques for Microsystems (based on MCM);
• Lighting systems development;
• Technological services: technological assistance and consultancy (technological flows design, control gates, technological compatibilities) and defect analysis on technological flow.
• Spectrometric characterization.

Main areas of expertise: Design, simulation and develop individual technological processes for microsystems technology (as piezoelectric integrated microsensors, high speed photodetectors and white LED micromatrix) and technological compatibilities MCM technologies and other nonstandard assembly technologies for Microsystems technological design, mainly on applications in traditional industries.

Our team (from left to right): Maria Cimpoca, Veronica Schiopu, Alina Matei, Ileana Cernica, Andrei Ghiu, Florian Pistritu

Research Team: The team is represented by a senior researcher I (PhD), a senior technological development engineer, two senior researchers III (with background in chemistry), 2 PhD students (with background mechanics and chemistry) and an engineer specialized in electronic applications field. The team seniors have industrial experience and company RD activities in CMOS technologies (IC dice manufacturing and IC assembly techniques).

Services Offer:
• Technological assistance for technological flow design, control gates and technological compatibilities
• Consultancy in technological compatibilities;
• Spectrometric characterization;
• Defect analysis on technological flow;
• Assembly techniques for MST;
• Dicing;

Equipments:
• FTIR Equipment for characterization. Contact person: Veronica Schiopu (veronica.schiopu@imt.ro);
• UV-VIS Spectrometer (AVANTES);
• Chamber furance (CARBOLITE)
• Rapid Thermal Processing RTP (ANNEALSYS) in technological probes;

Packaging equipment:
• Dicing Machines For Silicium Plates (3M225-Russia) with 2,3 and 4 inches, performing assignment of silicon, Si, glass substrates in chips, with diamonded dishes with thickness of 25 and 40µm, until of maximum depth of 600µm;
• Solding Thermosonic Machine With Gold Fibre (ASM – USA)
• Solding Ultrasounds Machine With Connexions Aluminium Fiber (US DRATHBBONDER MDB-11-Germ)

Patents request:
• „Microsystem for detecting humidity, temperature and contaminant in grain storage silos and/or industrial plants for small/medium sized farms", authors: Florian Pistritu, Ileana Cernica – CBI No A/01042, 02.11.2010

Patents
„Lighting semiconductor micromatrix, with white emission, on flexible substrate for indoor lighting systems", authors: Cernica Ileana Viorica, Schiopu Vasilica, Alina Matei, -11 – TPS 08.06.2010- 31.12.2020

Awards:
• iENA 2010 (International Exhibition "Ideas-Inventions-Novelties"), Nürnberg, Germany – Bronze Medal for „Manufacturing method for Yttrium Aluminium Garnet Cerium doped used as phosphorous in emissive optoelectronics applications", authors: Schiopu Vasilica, Cernica Ileana Viorica, CBI Nr.A/00060/25.01.2008
• iENA 2010 (International Exhibition "Ideas-Inventions-Novelties"), Nürnberg, Germany – Bronze Medal for „PIN photodetector micromatrix for optical cable communication manufacturing technology", authors: Cernica Ileana, Manea Elena, Dinoiu Ioana, BI Nr. BI OSIM nr: 122468/30.06.2009

Laboratory Head — Dr. Ileana Cernica (ileana.cernica@imt.ro)

She received MSc. on Electronics and Telecommunication (1981) and PhD in Microelectronics (1998) both from University "POLITEHNICA" of Bucharest. She worked as senior integration engineer in CMOS IC's technologies, CMOS RD activities and as AQ responsible in the sole Romanian CMOS IC's industrial company for 10 years.

Now she is senior research scientist at National Institute for Research and Development in Microtechnologies, currently coordinates 5 national R&D projects and was responsible person in EUREKA Umbrella project MINATUSE and Romanian-German Centre for Micro and Nanotechnology Project.

She is project evaluator in national RD programs (CEEX, CNCSIS PNCDI II) , and MNT-ERANET, IEEE and SPIE member and associate professor at University "Politehnica" of Bucharest (Faculty of Electronic, Telecommunication and Information Technology). Her scientific activity was published in more than 65 papers in international journals/conferences, 104 technical reports and is author or coauthor of 10 Romanian patents (3 of them won silver and one gold medals at International Inventions Exhibition in Brussels and Geneva) and 3 books.

AREAS OF MULTIFUNCTIONAL MICROTRADUCTORS BASED ON PIEZOELECTRICAL MONOCRISTALINE SUBSTRATE FOR MONITORING THE CONDITIONS FOR STOCKING OF CEREALS AND/OR INDUSTRIAL PLANTS IN SMALL SILOS/FARMS

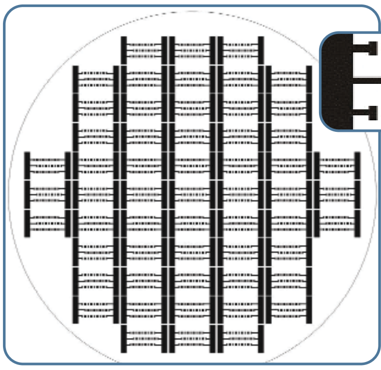
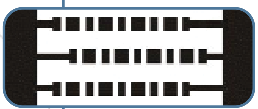

Microsensor signal analysis electronics

The aim of this project is to monitorise the stocking conditions for the crops (grains and/or industrial plants) in small/medium farms silos. The main advantage of such Microsystems is the possibility of miniaturization, high sensibility, low detection limit, answer in short time, more easily handled and calibrated system, minimal training, small dimensions, low cost price.
The main result is: „Microsystem for detecting humidity, temperature and contaminant in grain storage silos and/or industrial plants for small/medium sized farms", authors: Florian Pistritu, Ileana Cernica – CBI No A/01042, 02.11.2010 (patent proposal)
Beneficiaries: The microsystem obtained as result is new on Romanian market and also in S-E Europe.

AGRICOLA, PNCDI 2008-2010, INOVATION PROGRAMME; Coordinator SC SITEX 45 SRL
Partners: IMT Bucharest; Politehnica University Bucharest, UPB-CCO; **Project manager:** Ileana Cernica (ileana.cernica@imt.ro)

SEMICONDUCTOR MICROMATRIX FOR LIGHTING SYSTEMS

Main aim: To obtain a semiconductor micromatrix with white light emission, configured on flexible substrate for indoor illuminating systems.
The originality consists in using flexible substrate and, due to this property, to have a higher versatility of the matrix in applications
The main challenge is the technological one: the development of new technological processes on flexible substrate.
System: A micromatrix is a semiconductor device which converts electricity into light. The white light emission semiconductor micromatrix is configured on flexible substrate, electroluminescence structures of GaN (mounted on substrat) on which it is deposed a suitable phosphor (i.e: yttrium aluminium garnetdoped with cerium) for conversion of blue light emitted by structure in white light.The figure below presents the lay-out of the semiconductor micromatrix (on mask and detail).



The lay-out of the semiconductor micromatrix (on mask and detail)

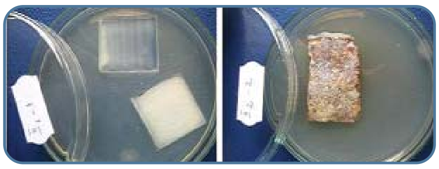
Advantages: Low electrical consumption, more rugged and damage-resistant, applicable for different surfaces (i.e: corrugated), the white light isn't tiring for the eyes and the micromatrix is designed as to be an area of continuous light.
Application: semiconductor micromatrix which emits the white light could replace the bulb with incandescence for local illumination.
Beneficiaries: hospitals (illumination for the night time), car manufacturers (inside illumination for passengers without disturbing the driver), ship manufacturers, autoutilitary (civil and military) - for illumination in closed rooms.

Core Nantional Programme 2010; Coordinator: IMT Bucharest;
Project manager: Veronica Schiopu (veronica.schiopu@imt.ro)

WOOD - POLYMER COMPOSITE WITH COMPONENTS OF NANOSTRUCTURED MATERIALS AND NANOSENSORS FOR IMPROVEMENT OF INDOOR ENVIRONMENT


"Polymer-wood" plates of disintegrated wood type:
a) PAL – PE (polyethylene); b) PAL - PE – AM (maleic anhydride); c) PAL – PE - nanomaterials

Main aim: The walls (plates) of wood-polymer structure using wastes of wood processing and PET-type wastes and plastic bags. To increase the environment protection the walls will be coated with nanomaterials protection.
Results: - *"Wood-polymer" composites* were obtained in 4 variants: PAL-D, PLA-PE (polyethylene), PLA-PE- AM (maleic anhydride) and PLA-PE-nanomaterials, which were used as chips of wood fibers of various shapes and sizes and different agents of
- *compatibility.* The physical-mechanical properties analysis allowed the functionality demonstration of the different experimental models of "polymer-wood" plates.
- *Polymeric matrix* with nanopowders has been obtained in 4 variants: AS–TiO_2, AS-Ag/TiO_2, AS-ZnO, AS-Ag/ZnO, where the polymeric matrix used was maleic copolymers with different coupling agents. The "wood-polymer" composites coated with polymeric matrix proved to have excellent antibacterial activity against a broad spectrum of bacteria.


Antibacterial testing of polymeric matrix containing nanopowders

NANOPROTECT, PNCDI 2007-2010; Coordinator IMT Bucharest; Project manager: Ileana Cernica (ileana.cernica@imt.ro)
Partners: Petru Poni" Institute of Macromolecular Chemistry – ICPAM Iasi; National Institute of Wood – INL Bucharest; INCDO-INOE2000, Research Institute for Analytical Instrumentation Cluj; S.C. NATURA SRL–Biertan, Sibiu; Transilvania University of Brasov;

Papers published in ISI ranked periodicals (with impact factor)

1. **"Negative Differential Resitance in GaN Nanowire Network"**, M. Dragoman, G. Konstantinidis, A. Cismaru, D. Vasilache, A. Dinescu, D. Dragoman, D. Neculoiu, R. Buiculescu, G. Deligiorgis, A.P. Vajpeyi, A. Georgakilas, Applied Physics Letters, 96, 053119, 2010. (impact factor 3.726).

2. **"Microwave Switching of Graphene Field Effect Transistor at and from the Dirac Point"**, G. Deligeorgis, M. Gragoman, D. Neculoiu, D. Dragoman, G. Konstantinidis, A. Cismaru, and R. Plana, Applied Physics Letters, 96, 103105, 2010. (impact factor 3.726).

3. **"Millimeter-Wave Generation Via Frequency Multiplication in Graphene"**, M. Dragoman, D. Neculoiu, ,G.Deligeorgis, G. Konstantinidis, D. Dragoman A. Cismaru, A.A. Muller and R. Plana, Applied Physics Letters, 97, 093101, 2010. (impact factor 3.726).

4. **"Influence of the As2/As4 Growth Modes on the Formation of Quantum Dot Like InAs Islands Grown on InAlGaAs/InP (100)"**, C. Gilfert, E. M. Pavelescu, and J.P. Reithmaier, Appl. Phys. Lett., Vol. 96, 2010, pp. 191903-3, 2010. (impact factor 3.726).

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6. **"Ultrabroadband Photodetection Based on Graphene Ink"**, A. Radoi, A. Iordanescu, Nanotechnology, 21, 455202, 2010. (impact factor 3.137).

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8. **"Electrocatalytic Activity of Platinum Nanoparticles Supported on nanoSilicon"**, M. Miu, I. Kleps, M. Danila, T. Ignat, M. Simion, A. Bragaru, A. Dinescu, Fuel Cells, 10 (2), pp. 259 - 269, 2010. (impact factor 2.557).

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13. **"Tunabe Electrical Superlattice in Periodically Gated Beyaer Graphene"**, D. Dragoman, M. Dragoman, R. Plna, Journal Applied Physics, 107, 044312, 2010. (impact factor 2.201).

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15. **"Study of Nanocomposite Metal/Porous Silicon Material"**, M. Miu, I. Kleps, T. Ignat, M. Simion, A. Bragaru, Journal of Alloys and Compounds, 496 (1-2), pp. 265-268, 2010. (impact factor 2.135).

16. **"Highly Textured (001) AlN Nanostructured thin Films Synthesized by Reactive Magnetron Sputtering for SAW and FBAR Applications"**, G.E. Stan, I. Pasuk, A.C. Galca, A. Dinescu, Digest Journal of Nanomaterials and Biostructures, vol. 5, no 4, pp. 1041-1054, 2010. (impact factor 1.750).

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18. **"Electrochemical Characterization of BSA/11-Mercaptoundecanoic Acid on Au Electrode"**, T. Ignat, M. Miu, I. Kleps, A. Bragaru, M. Simion, M. Danila, Materials Science and Engineering B, 169 (1-3), pp. 55-61, 2010. (impact factor 1.715).

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22. "**CRLH CPW Antenna on Magnetically Biased Ferrite Substrate"**, G. Sajin, S. Simion, F. Craciunoiu, A. A. Muller, A.C. Bunea, J. of Electromagn. Waves and Appl. (JEMWA), Vol. 24, pp. 803–814, 2010. (impact factor 1.551)

23. **"Soft chemical methods integration with micro fabrication in developing new scaffolds for tissue engineering"**, R.M. Piticescu, T. Buruiana, N. Plesu, E. Vasile, C. Moldovan, B. Fartat, C. Rusti, Optoelectronics and Advanced Materials, 2010. (impact factor 1.510).

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24. **"Microwave Applications on Graphene"**, M. Dragoman, D. Neculoiu, D. Dragoman, G. Deligeorgis, G. Konstantinidis, A. Cismaru,F. Coccetti, R. Plana, IEEE Microwave Magazine, Vol.11, pp. 81-86, 2010. (impact factor 1.5)

25. **"Nanostructured Silicon Particles for Medical Applications"**, I. Kleps, T. Ignat, M. Miu, F. Craciunoiu, M. Trif, M. Simion, A. Bragaru, A. Dinescu, Journal of Nanoscience and Nanotechnology,10, pp. 2694–2700, 2010. (impact factor 1.435).

26. **"Method of Determination of Light-Scatterer Distribution in Edge-lit Backlight Units Using an Analytical Approach"**, M. Kusko, C. Kusko, D. Cristea, Journal of the Optical Society of America a-Optics Image Science and Vision, Volume: 27 Issue: 9 pp. 2015-2020, 2010. (impact factor 1.410).

27. **"Sensing the Lactic Acid in Probiotic Yogurts Using an L-lactate Biosensor Coupled with a Microdialysis Fiber Inserted in a Flow Analysis System"**, A. Radoi, D. Moscone, G. Palleschi, Analytical Letters, 43(7-8), pp. 1301-1309, 2010. (impact factor 1.317).

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29. **"Activated Carbon Based Electrodes in Commercial Supercapacitors and their Performance"**, V.V.N. Obreja, A. Dinescu, A.C. Obreja, International Review of Electrical Engineering –IREE, vol: 5, 1, pp. 272-281A, 2010. (impact factor 0.570)

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31. **"Preparation and Patterning of Nanoscale Hybrid Materials for Micro-Optics"**, P. Obreja, D. Cristea, V.S. Teodorescu, A. Dinescu, A.C. Obreja, F. Comanescu, R. Rebigan, Journal of Optoelectronics and Advanced Materials, vol. 12, pp. 2007–2013, 2010. (impact factor 0.433).

32. **"Optical Linear and Third-order Nonlinear Properties of Nano-Porous Si"**, T. Bazaru, V.I. Vlad, A. Petris, M. Miu, Journal Optoelectronics Adv. Mat., vol.12, iss.1, pp. 43–47, 2010 (impact factor 0.433).

33. **"SU8 polymer Materials used in Integrated optic Microsystems"**, R. Muller; D. Cristea, M. Kusko, P. Obreja, D. Esinenco, V. Damian, P.C. Logofatu, Optoelectronics and Advanced Materials-Rapid Communications, vol. 4, pp. 228-233, 2010. (impact factor 0.224).

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1. **"Electrochemical Investigation of Porous Silicon/Gold System in Biological Electrolyte"**, M. Simion, M. Miu, L. Cortojan, I. Kleps, L. Savu, M. Danila, A. Bragaru, ECS Transactions, 25 (31), pp. 59-68, 2010.

2. **"About Reliability Modelling of Electronic Components and Systems"**, M. Bazu, T. Bajenescu, Quality Assurance", Year XVI, no. 61, January-March, pp. 27-33, 2010.

3. **"About Using Failure Analysis for Building and Assessing the Reliability of Electronic Components and Systems"**, M. Bazu, T. Bajenescu, Quality Assurance", Year XVI, no. 64, October-December, pp. 35-39, 2010.

4. "**Synthesis and Characterization of Nanoporous TiO2 Films on Silicon Substrates for Solar Cells Applications"**, E.C. Manea, A.C. Obreja, A. Popescu, M. Purica, V. Schiopu, L. Staicu, F. Comanescu, C. Parvulescu, ECS Trans., vol. 25, no. 15, 57, 2010.

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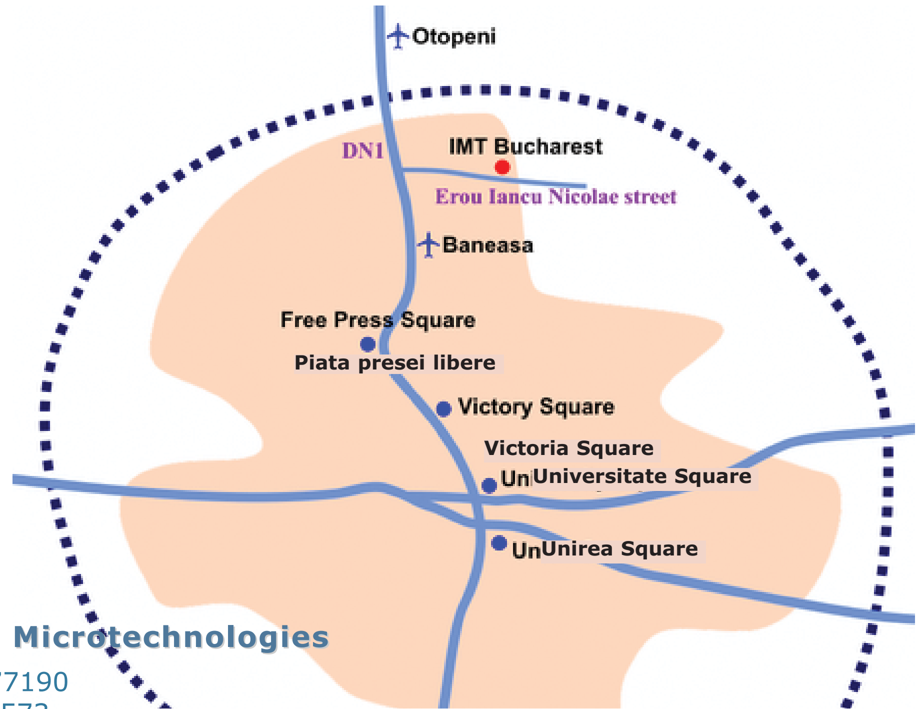

National Institute for R&D in Microtechnologies

126A, Erou Iancu Nicolae Street, R-077190
Mailing address: PO-BOX 38-160, 023573,
Bucharest, ROMANIA
Tel: +40-21-269.07.70; +40-21-269.07.74; +40-21-269.07.78;
Fax: +40-21-269.07.72; +40-21-269.07.76;