Scientific Report 2015

National Institute for Research and Development in Microtechnologies -
IMT Bucharest

From micro to nanotechnologies,
nano-biotechnologies and nanoelectronics

Ministry of Education and Scientific Research

MINISTERUL EDUCAȚIEI ȘI CERCETĂRII ȘTIINȚIFICE

National Institute for Research and Development in Microtechnologies

IMT Bucharest

SCIENTIFIC REPORT
2015

Research and Technological development and experimental infrastructure

Design: IMT Bucharest

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INTRODUCTION

The National Institute for Research and Development in Microtechnologies – IMT Bucharest was set up at the end of 1996, and it is coordinated by the Ministry of National Education and Scientific Research, acting basically as an autonomous, non-profit research company.

In 2015 **IMT Bucharest** continued to be involved in word class research in his area of activity: **micro and nanotechnology.**

The research performed in on-going national and international projects and/or published in ISI publications was mainly oriented to the following fields:

- micro and nanoelectronic devices
- micro and nanophotonics
- micro and nanodevices for medical applications (BIOMEMS)
- micro-electro-mechanical systems (MEMS) including microtraductors, micro and nanofluidics
- advanced materials and nanotechnologies

At European level, IMT Bucharest run as partner 5 FP7 Projects, associated partner in another 2 FP7 projects; 1 H2020-ECSEL, 3 ESA projects, 1 SEE project with Norway and 2 bilateral projects. The institute was also involved in 2 Structural Funding projects: one for a new infrastructure and one for educational activities through ”hands on training”.

The research activity was oriented to the priorities of the Romanian National Strategy for Research and Innovation SNCDI (2014-2020) and of EU program Horizon 2020. The strategic orientation was for the progress in developing **Key Enabling Technologies (KETs) namely: micro and nanoelectronics, photonics, nanotechnologies and advanced materials,** which is unique at national level.

Our expertise and the experimental infrastructure make possible the consolidation of our position in high tech environment at national and international level, based on the four KETs and allowing in the near future the development of a Technological Platform for Knowledge Transfer and Innovation in the field of ICT, space, security (through a project financed by Structural funding). The cooperation with companies can be on the value chain, on all stages starting with materials development, design, layout, technological process, fabrication, device and system, testing, being possible to arrive at TRL6, helping to implement the products to the market.

Another field of interest is related to nanotechnologies, graphene based devices, presented in many high level publications and biosensor applications.

IMT-Bucharest displays a broad range of experimental and computing resources for micro- and nanotechnologies, from simulation and design techniques, to characterization tools, processing equipments (including a mask shop, EBL nanolitography), testing equipments, reliability laboratory. These resources are grouped in the IMT-Bucharest centre for Micro- and NAnoFABrication (IMT-MINAFAB, www.imt.ro/MINAFAB).

2015 was a successful year regarding the implementation of a new research infrastructure with experimental laboratories, equipped with state of art equipments, already operational, IMT finalized the project “Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials”, creating CENASIC, a new R&D centre equipped with the most performing clean room at national level (200 sqm, class 1000 and 100) and 8 new laboratories. CENASIC was inaugurated in December 2015.

The new centre is a new ”gate” for international cooperation and development of new research fields of advanced materials and integrated systems based on carbon as: graphene, nanocrystaline diamond and SiC, one goal being to attract young skilled and talented researchers, PhD students and to perform collaborative work at world class level.

The human resources involving multidisciplinary research staff (electronic engineers, chemists, physicists, materials engineers, mathematicians, biologists), young PhD students, technicians, administrative staff (in total 190), were involved in collaborative work at national and international level, driving new knowledge, innovation and supporting societal challenges.

The figures presented in the report shows a relatively balanced distribution of human resources between young and experimented researchers (also between male and female). During 2015 seven PhD thesis were finished by our employers, which were supervised also by IMT Bucharest senior researchers.

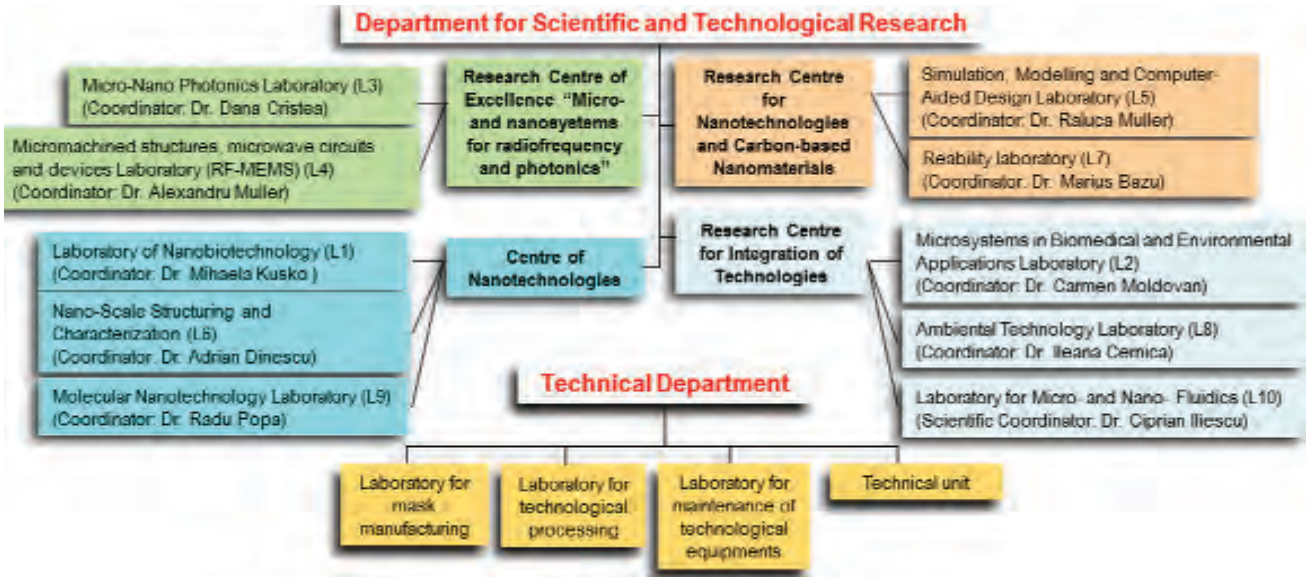
The turnover has a slightly increased of 10%, compared with 2014, considering the number and value of the national and international running projects.

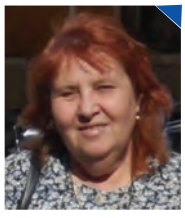
The Scientific Report 2015 presents key area of activities, the most important projects and the research highlights of the 10 research laboratories, grouped in 4 centres; the two most important scientific events, organized by our institute, each year: National Seminar on Nanoscience and Nanotechnologies at its 14th edition and CAS (International Semiconductor Conference), at the 38th edition. CAS is an IEEE event.

Dr. Raluca Müller
CEO and President of the Board

Organization:

Scientific and Technical Departments

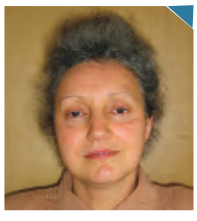




Raluca Müller received the M.Sc (1978) in Electronics and Telecommunications from "Politehnica" Univ of Bucharest, Romania and PhD in Electronics and Telecommunications, from the same university.

From 1978-1994 she was Research Scientist with ICCE-Research Institute for Electronic Components, Romania; since 1994 she is with IMT. She was Scientific Director starting with 2009 and ***General Manager*** startig with July 2011. Her main scientific interests include design, and technological processes (nanolitography) for microelectronic devices, integrated optics, microsensors and microsystems. She is author and co-author of more than 100 scientific papers.

Adrian Dinescu obtained the M.Sc. degree (1993) in Solid State Physics and the PhD degree (2010) in physics, both from University of Bucharest. Between 1993 and 1997, Adrian Dinescu was with the National Institute for Research in Electronic Components, working in the field of optoelectronic devices fabrication. Since 1997 he is with IMT-Bucharest where he is currently involved in micro and nanoscale characterization using FE-SEM and in structuring at the nanoscale using Electron Beam Lithography. His expertise also includes materials processing and device fabrication. He is Technical Director starting with December 2013.



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

Mircea Dragoman 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 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. He was Director of Centre for Research and Technologies Integration and currently is the president of the Scientific Council. He has published 208 scientific papers, 117 ISI papers. The papers are dedicated to the following areas: nanoelectronics, microwaves, MEMS, optoelectronics. He is co-author of several books.

Radu Cristian Popa received a MSc in Electrical Engineering (Applied Electronics) from the Polytechnic Univ. of Bucharest (1989), and a PhD in Quantum Engineering and Systems Science at University of Tokyo (1998). He was assistant professor at the Polytechnic University of Bucharest (1991-1995), and Senior Researcher at the Science Solutions Intn. Lab., Inc., Tokyo (1998-2003), where he conducted competitive industrial research in numerical modeling and analysis of complex phenomena and devices. 2003-2006, he was scientific associate at the University of Tuebingen, Germany and then became Development Director at Neurostar, GmbH, Germany, designing and developing hardware and software solutions for functional neurosurgery and neuroscience. Radu Popa joined IMT Bucharest in 2007 and is presently director of the Center for Integrated Systems Nanotechnologies And Carbon Based Nanomaterials. Main scientific interests include atomistic analysis of electronic transport in molecular junctions in the framework of the rational design paradigm for molecular scale electronics.

Human resources, funding sources and investments

IMT – Bucharest is active in R&D with a number of researchers, engineers, technicians and other support personnel. IMT has become an attraction for skilled and motivated people because of the new infrastructures and the multitude of national and European projects in the field of nano-biotechnologies, ICT, space.

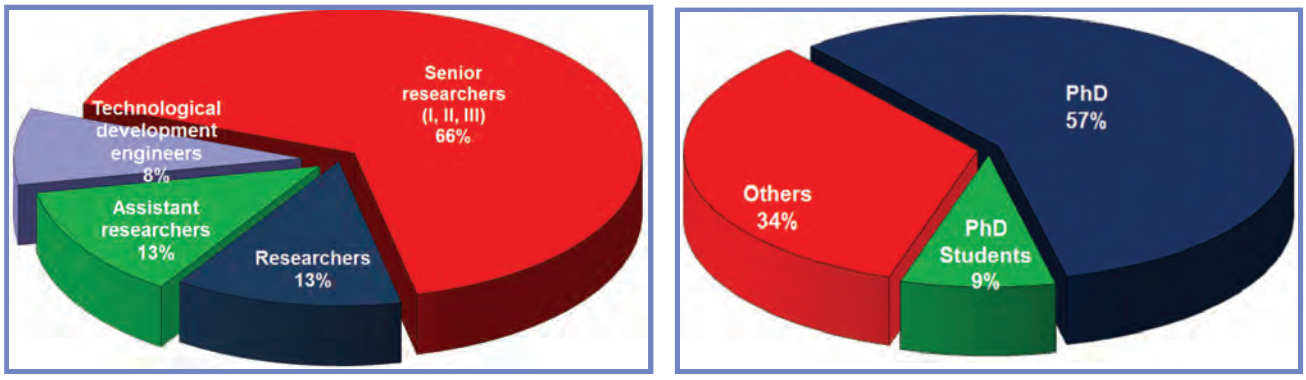


Fig 1 - Researchers active in IMT (94)

Figure 1 (a, b) provides information about the number and distribution of researchers active in IMT in 2015 (94 persons). 66% of them are senior researchers I, II and III and 26% are young researchers. The average age of our researchers is around 41.

Figure 2 presents information about the multidisciplinary background of the specialists active in IMT in 2015 (118 people): researchers and technical engineers, covering most of the research fields and providing also scientifically /technical services. The male (62) - female (55) number is relatively balanced.

IMT – Bucharest offers an opportunity to students, especially from Politechnica University Bucharest, to develop multidisciplinary research, to be in contact with new technologies, by access to practical labs, summer stages, supervising experimental/scientific work of their diploma and PhD thesis.

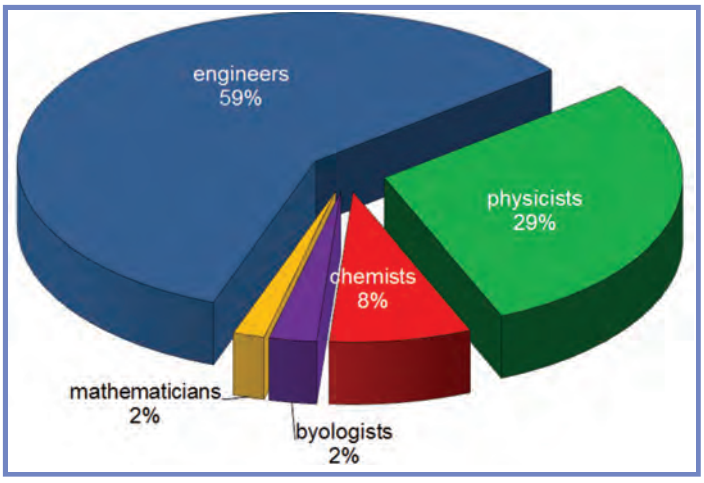


Fig.2 Multidisciplinary background of specialists active in IMT (118)

Funding sources and investments

Fig. 3 presents the funding sources in 2015, which comes from: national R&D programs (competitive funding, through open calls): 32%, Structural Funds 22%, different European Projects and other sources (FP7, ESA, SEE, MNT-ERANET, ENIAC, ECSEL) 10 %.

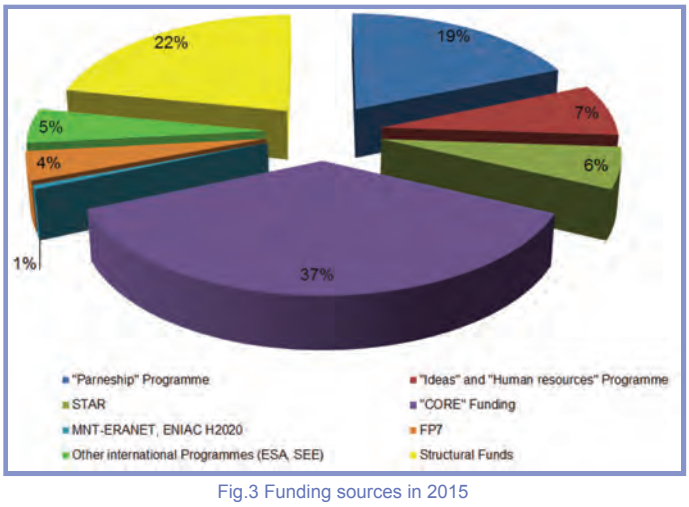


Fig.3 Funding sources in 2015

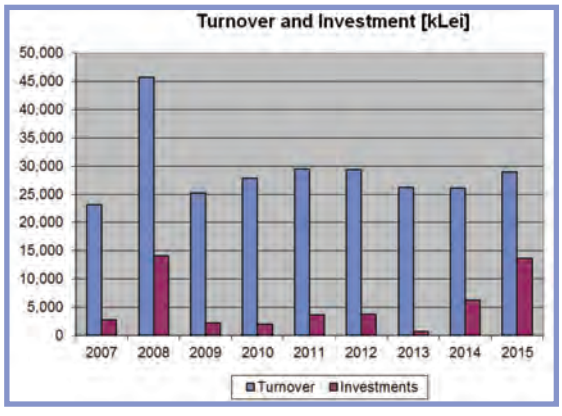


Fig.4 Turnover and investments (kLei)

The next figure (fig.4) presents information about the evolution of the turnover of the last period and the information about the investments in various equipments. The turnover in 2015 increased compared with 2014. with around 10%.

Experimental Facility: IMT-MINAFAB

Constant and coordinated investments in the experimental infrastructure represented a priority of IMT Bucharest. These investments allowed the institute to launch in April 2009 a renewed, state-of-the-art research infrastructure. The technical and administrative user interface of this new, open facility is the IMT-centre for MIcro- NANOFABrication (IMT-MINAFAB), as described on www.imt.ro/MINAFAB.

IMT-MINAFAB provides several clean-room areas with specialized technological and characterization laboratories - totalizing a surface of almost 700 m^2 (including one clean room of class 1.000), and modern equipments worth more than 8 Meuro; part of this facility – devoted to micro- and nanostructuring - is unique at national and regional level. Since June 2011, the services and administrative activities of the centre are SR EN ISO 9001:2008 certified by TÜV Thüringen e.V. A new investment of about 6 Meuro (building and equipments) was finalized in 2015 (see the special pages devoted to CENASIC). The new services provided by CENASIC will be gradually included under the "umbrella" of IMT-MINAFAB. Therefore, IMT Bucharest provides a unique concentration at national level of state-of-the art research equipments for micro-nanotechnology. IMT-MINAFAB is included in the MERIL and ERRIS databases, as described later on.

This research infrastructure enabled IMT to extend its R&D capabilities. The main results achieved by IMT are in the field of the micro-nanoelectronics (more specifically micro-nanosystems) and photonics, two of the Key Enabling Technologies (KETs). The new CENASIC centre will allow IMT to extend its existing capabilities in nanotechnologies and advanced materials, another two KETs. The strategic goal of IMT is to become a technological platform for integration of KETs, which is an important direction of development within EU programme for RDI, "Horizon 2020".

A short presentation of the most important components of the research infrastructure follows.

- A class 1000 clean room (220 m^2) for the mask shop and the most demanding technological processes (in use since September 2008);
- A class 100,000 clean room, the so called "Grey Area" (200 m^2), mostly for the characterization equipments (in use since September 2008);
- A class 10,000 clean room (105 m^2) for thin layer deposition by CVD techniques: LPCVD, PECVD; DRIE; RTP etc. (fully in use since early 2012);

Photolithography (chrome, maskless, wafer double-side alignment and exposure)

Pattern generator - DWL 66fs Laser Lithography System (Heidelberg Instruments Mikrotechnik, Germany)

Double Side Mask Aligner - MA6/BA6 (Suss MicroTec, Germany)

• Nanolithography (EBL, EBID, EBIE, Dip-pen) and SEM

Electron Beam Lithography and nanoengineering workstation - e_Line (Raith, Germany)

Dip Pen Nanolithography - NSCRIPTOR (NanoInk, Inc., USA)

Field Emission Gun Scanning Electron Microscope (FEG-SEM) - Nova NanoSEM 630 (FEI Company, USA).

• Physical depositions of materials in high-vacuum

Electron Beam Evaporation - TEMESCAL FC-2000 (Temescal, USA)

Electron Beam Evaporation and DC sputtering system-AUTO 500 (BOC Edwards, UK)

• Chemical depositions, thermal processing

PECVD - LPX-CVD, with LDS module (SPTS, UK)

LPCVD - LC100 (AnnealSys, France)

Rapid thermal processing/annealing - AS-One (AnnealSys, France)

• Precision etching of materials (plasma reactive ion, humid, shallow and deep)

DRIE- Plasmalab System 100- ICP Deep Reactive Ion Etching System (Oxford Instruments, UK)

RIE Plasma Etcher - Etchlab 200 (SENTECH Instruments, Germany)

• X-Ray diffractometry

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

• Scanning probe microscopy: AFM, STM, SNOM, confocal, Raman mapping

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

Scanning Near-field Optical Microscope, Witec alpha 300S (Witec, Germany)

• Nanomechanical characterization

Nanomechanical Characterization equipment - Nano Indenter G200 - (Agilent Technologies, USA)

• Microarray spotting/scanning

Micro-Nano Plotter - OmniGrid (Genomic Solutions Ltd., UK)

Microarray Scanner - GeneTAC UC4 (Genomic Solutions Ltd., UK)

• Analytical characterization tools

Scanning Electrochemical Microscope

ElProScan (HEKA, Germany)

Zeta Potential and Submicron Particle Size Analyzer - DelsaNano (Beckman Coulter, USA)

Fluorescence Spectrometer - FLS920P (Edinburgh Instruments, UK)

• Interferometry/profilometry; Spectroscopy

High Resolution Raman Spectrometer - LabRAM HR 800 (HORIBA Jobin Yvon, Japan)

White Light Interferometer - Photomap 3D (FOGALE nanotech, France)

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

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

UV-Vis-NIR Thermo-Electric Cooled Fiber Optic Spectrometer - AvaSpec-2048 TEC (Avantes, The Netherlands)

Refractometer for layer thickness measurements - NanoCalc-XR (Oceanoptics, USA)

• Probers, on-wafer; electrical characterization

Semiconductor Characterization System (DC) with Wafer Probing Station - 4200-SCS/C/Keithley

Easyprobe EP6/ Suss MicroTec (Keithley Instruments, USA; Suss MicroTec, Germany

Semiconductor Characterization System - 4200-SCS, C-V 3532-50, DMM 2700-7700, 2002,

6211-2182 (Keithley Instruments, USA

Microwave network analyzer (0.1-110GHz) with Manual Probing Station (Anritsu, Japan; Suss

MicroTec, Germany)

Frequency Synthesizer up to 110 GHz (Agilent, USA)

Spectrum Analyzer up to 110 GHz (Anritsu, Japan)

IMT centre for MIcro- and NAnoFABrication (IMT-MINAFAB) was the first “open” research infrastructure in this field from Eastern Europe (2009), providing access for research, education and industry, as clearly explained on the web page www.imt.ro/MINAFAB. The MINAFAB infrastructure contains a key unit, the so-called „Facility for micro-nanostructuring of devices and systems”, unique in this country. This facility is responsible for mask fabrication, photolithography and also for micro-nanostructuring using Electron Beam Lithography – EBL. IMT is very appreciated abroad for the combined use of photolitography and electron beam litography (the so-called „mix and match” technique). The characherisation techniques (also available in other numerous laboratories accros the country) is here placed in clean rooms, next to technological equipments, allowing immediate evaluation of the materials and structures just processed. In fact, almost all complex equipments and apparatus are operated by researchers and development engineers, and their competence is providing an „added value” to the scientific and technological services their „customers”, both from inside and outside the institute.

IMT-MINAFAB in databases

Registration of IMT-MINAFAB in European database MERIL
(MERIL- Mapping of the European Research Infrastructure Landscape)

Clean room 1

Mask shop - pattern generator photolithography masks

Registration of IMT-MINAFAB in ERRIS
(Engage in the Romanian Research Infrastructure System)
https://erris.gov.ro/MINAFAB

EUROPEAN UNION

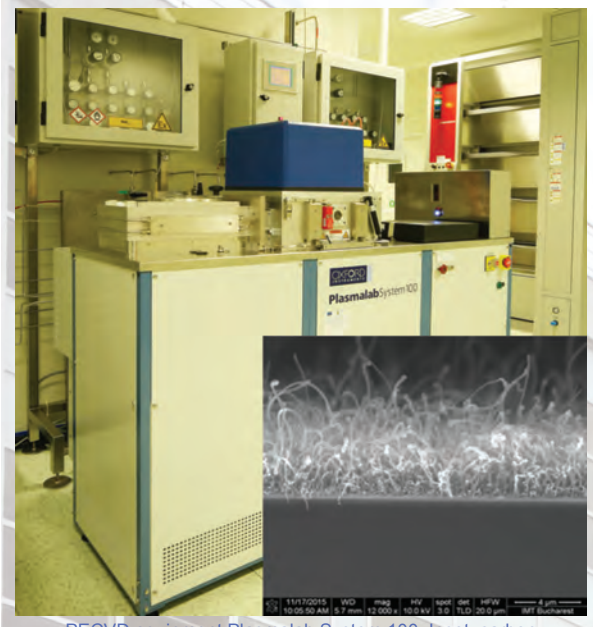
ROMANIAN GOVERNMENT

STRUCTURAL INSTRUMENTS 2007-2013

"Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials"- the so called CENASIC project, POSCCE/ 905/14040/28.09.2010, 2010-2015

Total value of the project/ Non-reimbursable financial assistance value: 26.235.420 lei/ 20.000.000 lei

Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials - CENASIC



PECVD equipment Plasmalab System 100. Inset: carbon nanotubes obtained on this equipment

Horizontal oven Centrotherm E1200. R&D equipment for the fabrication of substrate used for electronic devices based on graphene

What is CENASIC? Short description

The Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials (CENASIC) was a project devoted to the creation of a modern research center focused on applied research, involving highly specialized techniques and experienced researchers. This strategic investment allows access to new equipments, laboratories and state-of-the art technology fully integrated into the existing IMT infrastructure.

CENASIC has provided an investment of 6 MEuro in building, facilities and equipments. The new building has approximately 1000 m2, including 4 levels: the clean room (ground floor), technical level, 2 levels for labs and offices. The 8 experimental laboratories (new or reinforced) will complete technological processes available in IMT in order to develop products and services described in the project.

The list of these ***experimental laboratories*** is:

- Lab for Processing of Carbon based Nanomaterials and Nanostructures
- Lab for Thermal Processes
- Lab for Graphene technology
- Lab for Chemistry of Hybrid Interfaces
- Lab for Thin Layer Spectrometry
- Lab for Electro-mechanical Processes and Sample Preparation
- Lab for Electromechanical Testing & Reliability
- Laboratory for Simulation and design for carbon-based MEMS/NEMS.

The key new technological equipments within the CENASIC labs are:

- Multiprocess Furnace System
- Molecular Beam Epitaxy (MBE)
- Plasma Enhanced Chemical Vapor Deposition (PE CVD),
- Atomic Layer Deposition (ALD) tool
- RF Magnetron Sputtering.

Extending the existing experimental infrastructure organized as a centre of services: IMT-MINAFAB

CENASIC research centre will incorporate also part of the existing experimental infrastructure. The new 200 m2 clean room will extend one of the existing ones, whereas on the other hand the services provided by CENASIC will be included gradually into IMT-MINAFAB. IMT centre for MIcro- and NAnoFABrication (IMT-MINAFAB) was the first "open" research infrastructure in this field from Eastern Europe (2009), providing access for research, education and industry, see www.imt.ro/MINAFAB. What is essential behind the participation of IMT into a proposal aiming at "integration and opening of essential European infrastructures" (not yet funded), it is the scientific expertise of researchers operating most of the more complex equipments (see also the presentation of R&D laboratories on www.imt.ro).

Overview of the CENASIC clean room

Possible cooperation.

Partnership with other research organizations and industrial companies, especially in the areas of SiC and diamond is highly required. IMT is also interested to apply for ERA-Chair and Twinning within the future calls of “Horizon 2020”.
Recruiting scientific personnel. While maintaining at least 33 existing technical positions, the CENASIC project is creating 10 new research positions 5 of them for foreign scientists. Highly skilled personnel is required.
The “philosophy” of CENASIC project is the continuous investment in growing of human potential, by offering access to the new and existing R&D equipment and facilities, developing new partnerships with foreign scientists within the EU and creating new employment opportunities in an international environment.

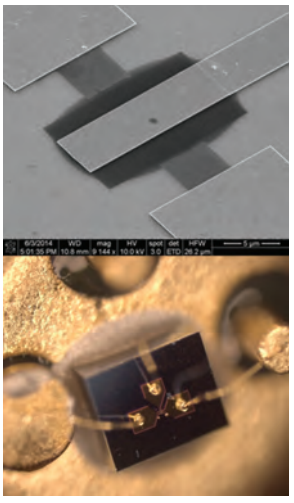
FTIR equipment

CENASIC present and future research activities

CENASIC aims to develop partnerships and collaborations in the area of micro-nanotechnologies, targeting the development of new technologies based on dedicated carbon materials: SiC, graphene and nano-crystalline diamond. The thematic priority is Innovative Materials, Processes and Products (according to the National RDI Programme 2007-2013, the contract for financing was signed in 2010).
From the strategic point of view, the new investment was justified (2009) by the development of the CENASIC research centre along three directions:

- Technologies for silicon carbide and functional micro-nanostructures;
- Technologies for graphene and micro- and nano-electromechanical hybrid systems;
- Technologies for nanocrystalline diamond in MEMS/NEMS and precision mechanics.

Targeting such an ambitious program requires national and international cooperation. On the other hand, a substantial part of the existing research and development personnel of the institute will be involved in using the new investment and developing the long list of new services (processes and technologies).



Field effect transistor on graphene developed by CVD

Exploring activities of the CENASIC

Present exploring activities of the CENASIC research group (coordinated by Dr. Mircea Dragoman):

- graphene monolayer growth at the wafer level (3 and 4 inches);
- transfer of graphene on solid and flexible substrates;
- fabrication of graphene based nanomaterials: aerogel, reduced oxide graphene, graphene oxide;
- the integration of graphene with other two dimensional materials such as MoS2, WS2, BN and fabrication of van der Waals heterostructures;
- shielding cables based on graphene based materials;
- nanoelectronic and nanophotonic devices based on graphene.

Expected future directions of IMT research related to CENASIC are:

- Vapour, temperature and pressure sensors based on graphene;
- GaN devices such solar cell, transistors for high temperature operation;
- Biosensors for DNA hybridization detection;
- SiC gas sensor for harsh environments;
- Diamond thin films for high power electromagnetic.

CENASIC research group (from left to right) Phd. stud. Cosmin Obreja, PhD. Anca Istrate, Phd. stud. Angela Baracu, PhD. Antonio Rădoi, PhD. Adrian Dinescu, PhD. Mircea Dragoman, PhD. Monica Veca, MS st. Bianca Tancu, PhD. Andrei Avram, PhD. Radu Popa.

Director of CENASIC: ***Dr. Adrian Dinescu*** (adrian.dinescu@imt.ro)
Other members of the CENASIC Board: Dr. Raluca Müller (raluca.muller@imt.ro), General Manager of IMT;
Dr. Mircea Dragoman (mircea.dragoman@imt.ro), scientific coordination;
Prof. Dan Dascalu (dan.dascalu@imt.ro),
Dr. Radu Popa (radu.popa@imt.ro). **Domnica Geambazi,** Financial Oficer

Contact: ***Dr. Lucian Galateanu*** (lucian.galateanu@imt.ro), Director of the CENASIC Project
Beneficiary: National Institute for R&D in Microtechnologies - IMT Bucharest; Web page: www.imt.ro, 126A, Erou Iancu Nicolae Street, 077190, Voluntari, Ilfov, Romania,
Phone: +40 21 269 07 78; Fax: +40 21 269 07 72

TECHNOLOGICAL TRANSFER INFRASTRUCTURES

CTT - Baneasa

CENTRE FOR TECHNOLOGY TRANSFER IN MICROENGINEERING

CTT-Baneasa is a distinct, autonomous entity of the National Institute for R&D in Microtechnologies (IMT Bucharest). CTT - Baneasa is a founding member of Romanian Association of Technology Transfer (AROTT). The major mission of the Center is to become an active professional link between research and industry, within the field of micro- and nanotechnology, including participation to various exhibitions.

Examples for 2015 are: • 43rd International Exhibition of Invention Geneva, Geneva, 15th - 19th April 2015 (Gold medal and Special Award of SPWiR, Poland for the invention: Reagent based on gold nanoparticles, recipe for its preparation and its use for mapping of tumor tissue architecture, M. Avram, I. R. Petrescu, A. M. Avram, A. M. Rădoi)

• 13th International Innovation Exhibition ARCA 2015, Zageb, Croatia, 15th - 18th October 2015 (Gold medal for the invention: Reagent based on gold nanoparticles, recipe for its preparation and its use for mapping of tumor tissue architecture, M. Avram, I. R. Petrescu, A. M. Avram, A. M. Rădoi)

• International Exhibition of Invention and Innovation "Traian Vuia" Timisoara, Romania, 11th - 13th June 2015 (Gold medal for the invention: Miniaturized impedimetric sensor for pesticides detection, C. Moldovan, B. Firtat, R. Iosub, D. Necula, R. Cornel, C. Codreanu)

• EXPO MILANO 2015, "Culture of the City", Romania/ROSA–ESA, Romanian participation to European Space Agency Programmes, 20-24 August 2015

• The International Exhibition of Research, Innovation and Inventions PRO INVENT, Cluj-Napoca, Romania, 25-27 March 2015

• The Brokerage event in the field of micro- and nano-electronic technologies, 18 February 2015, Brussels, Belgium

• Forum for Innovation, Brokerage B2B meeting, Bucharest International Technical Fair, 15-16 October 2015

• Potential for future German and Romanian Cooperation in Research and Innovation Workshop (Optotransmitter-Umweltschutz-Technologie (OUT) e.V.; Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT, Fraunhofer Institute for Systems and Innovation Research ISI), 12 November 2015, UPB, Bucharest.

Since 2015 CTT-Baneasa aimed at extending its role in increasing the number of value added services for industrial innovation. A new approach proposed to foster innovation and bridge the gap between R&D and market includes: a) an internal process review aimed at improving the management of intellectual property (IP) of IMT, b) commencement of technical marketing of IMT's IPs and c) industry development liaison actions. The last direction, still in the initial stage, was related to the affiliation to the Magurele High Tech Cluster (MHTC), an innovative cluster of which IMT is a founding member.

However, the most important achievement in 2015 was related to the contribution to the successful proposal TGE-PLAT (related to the knowledge transfer in Key Enabling Technologies – KET/TGE to innovative enterprises). The corresponding project financed (3 MEuro) from structural funding (PoC CDI) will be managed by IMT (including CTT-Baneasa) in the time period 2016-2021.

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Address: 126A Erou Iancu Nicolae Street, Bucharest, 077190.

MINATECH-RO

THE SCIENCE AND TECHNOLOGY PARK FOR MICRO AND NANOTECHNOLOGIES

MINATECH-RO (www.minatech.ro) is a science and technology park devoted to R&D in micro- and nanotechnologies. The initiative of the establishment belonged to a national consortium coordinated by IMT Bucharest and including the "Politehnica" University of Bucharest (PUB). This park (inaugurated in 2006) is located in the IMT premises. MINATECH-RO (Micro- and Nanotechnology Science and Technology Park) received institutional funding during 2004-2005 through the national INFRATECH Programme, managed by the Ministry of Education and Research.

The companies presently located in the main building are: ROMQUARTZ S.A., SITEX 45 S.R.L., D.D.S. DIAGNOSTIC S.R.L., TELEMEDICA S.A. These companies have priority in accessing scientific and technological services provided by IMT-MINAFAB. They are also privileged partners of IMT in national and international projects. A special case is the cooperation with the local subsidiary of the multinational company Honeywell: apart from access to services, they have their own equipments hosted in the technological space of IMT.

Contact data: MINATECH-RO (www.minatech.ro); Tel: +4021269.07.67;
E-mail: team@minatech.ro
Address: 126A Erou Iancu Nicolae Street, Bucharest, 077190.

ROMANIAN-BULGARIAN SERVICES CENTRE FOR MICROSYSTEMS AND NANOTECHNOLOGY

Romanian-Bulgarian Services Centre for Microsystems and Nanotechnology, MIS-ETC Code 587 (RO-BG MicroNanoTech) was created in 2013, due to project coordinated by IMT and it is based on the cooperation of universities, research institutes and SMEs in the RO-BG cross-border area. On the Romanian side, the technological services are provided by IMT-MINAFAB.

The centre is also providing: • Ensuring access to national and international databases about: Company profiles, Business opportunities, Innovation opportunities, auctions and public acquisitions;

• Promoting the companies (advertising, organizing events, etc.);

• Furnishing various documents: origin certificates, external commercial documents, force majeure certificates, certificates proving the quality of SME, signature certificates, recommendations for obtaining Romanian&Bulgarian visa, etc.;

• Elaborating studies, analyses and demands of financing for any type of funds;

• Organizing all kinds of events.

Ro-Bg MicroNanoTech Recipient of Awards

• On 26 June 2015, the prize for "The most effective public-private partnership in the field of research and development". The award was given by the RINNO Project (A Model for Enhancing the Benefits of Romania-Bulgaria Cross Border Region Cooperation by using R&D&I, MIS-ETC Code 168). The event was held at Hotel Riga, Ruse, Bulgaria.

• On 30 October 2015, the prize for "The most innovative partnership in culture and education". The award was given by the RINNO Project (A Model for Enhancing the Benefits of Romania-Bulgaria Cross Border Region Cooperation by using R&D&I, MIS-ETC Code 168) in the first awards ceremony RINNO-Romania (RINNO Awards Romania, 1st Edition). The event was held at the "Ovidius" University of Constanta, Romania.

Contact data: National Institute for Research and Development for Microtechnology IMT-Bucharest, Science and Technology Park for Micro - and Nanotechnologies, MINATECH-RO
Address:126A, Erou Iancu Nicolae Street, 6th Floor, Room 607, 071990, Voluntari City, Ilfov County, Romania
Tel: +40-21-269.07.70; +40-21-269.07.74; +40-21-269.07.78; +40-21-269.07.79;
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MIMOMEMS European Centre of Excellence

MIMOMEMS - "European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors", REGPOT call 2007-1, Contract no. 202897, 2008-2011, Coordinator: IMT-Bucharest, http://www.imt.ro/mimomems

MIMOMEMS is the first centre of excellence created in Romania through the FP7 REGPOT project call of EU. The MIMOMEMS project (2008-2011) joints the effort of two laboratories from IMT Bucharest, the RFMEMS Laboratory and the Microphotonics Laboratory to bring their activity and results at the highest European level. MIMOMEMS has represented a support action for the developing of microwave, millimetre wave devices and circuits, optical devices and sensors based on MEMS technologies, with applications in modern communication systems. This support action helped the development of the two labs in terms of equipment upgrading, high qualified personnel hiring, common scientific research actions together with twining partners and dissemination actions of the results

The MIMOMEMS Centre of excellence remains as a distinct entity in IMT after the end of the EU founded project. The very good results of the MIMOMEMS centre were materialized by a deep involvement in other EU founded research projects (the centre is now partner in 2 FP7 IPs, one STREP, 2 ENIAC projects and one ERA-NET project). The team is prepared for the participation at the Horizon 2020 calls. Also various collaborative research activities with many European teams have been developed by the MIMOMEMS team, in the last years, with results in high quality publications in high ranked journals.

Laboratory of Micro/Nano Photonics

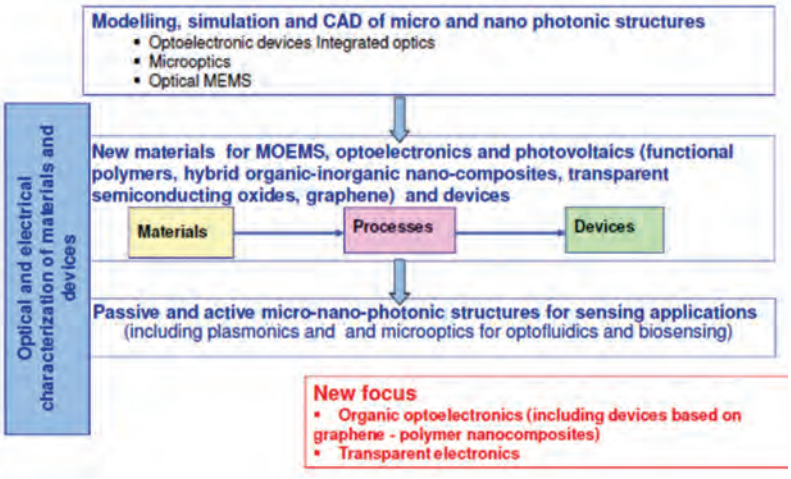
Member of "*European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors" (MIMOMEMS)*, funded (2008-2011) through the "Regional potential" – FP7 REGPOT.

Mission- *Research, development and education* in **micro and nanophotonics**

Team

• **Dr. Dana Cristea** senior researcher, M.Sc. inelectronic engineering, Ph.D.in optoelectronics & materials for electronics;
• **Dr. Paula Obreja** senior researcher, M.Sc. and Ph.D. in physical chemistry;
• **Elena Budianu** senior researcher, M.Sc. inphysics;
• **Dr. Munizer Purica** senior researcher, M.Sc. and Ph.D. in physics;
• **Dr. Mihai Kusko** senior researcher (M.Sc . in physics and photonics, Ph.D in optoelectronics);
• **Dr. Cristian Kusko** researcher , M.Sc. and Ph.D – physics;
• **Dr. Roxana Rebigan** researcher, M.Sc. in physics and Ph.D in optoelectronics;
• **Dr. Florin Comanescu** researcher, M.Sc. in electronics and PhD in optoelectronics at "Politechnica" University of Bucharest;
• **Dr. Roxana Tomescu** researcher, M.Sc. in electronics and PhD in optoelectronics at "Politechnica"University of Bucharest;
• **Eng. Rebeca Tudor** junior researcher, M.Sc. in electronics, PhD student in optoelectronics;

Research areas



Training activities:

-**Master courses:** Optoelectronics/Integrated optics and Microsystems in cooperation with Politehinca Univ. Bucharest
- **Supervising** undergraduate, master and PhD students

Scientific sevices ISO 9001, 2008 certified:

• **Near field optical microscopy:** Transmission, reflection, collection, fluorescence, Spectral elipsometry for national and international research and industrial units
• **RAMAN spectroscopy:** Micro-Raman Spectroscopy of graphene synthesized by CVD on copper and transferred by wet chemical methods to oxidized silicon substrate.

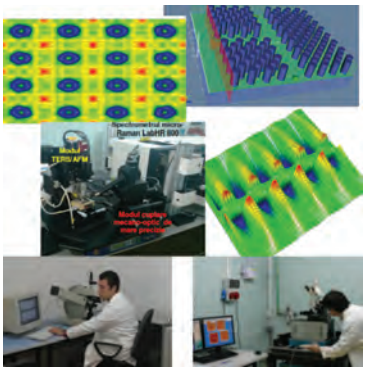
Laboratory head: Dr. Dana Cristea, (dana.cristea@imt.ro)

Dr. Dana Cristea obtained the MSc in Electronics and PhD in Optoelectronics and Materials for Electronics from "Politehnica" University, Bucharest, Romania. She was a research scientist in the Optelectronics Lab from the Research Institute for Electronic Components, Bucharest (1982-1994). Since 1994 she has been a senior researcher in the IMT- Bucharest, Romania, head of Micro- and Nano-photonics Lab since 1997 and head of Department for Multidisciplinary Research between 2002 and 2008. Since 1990 she is also 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, micro-optics (design, processing and characterization), new nanostructured materials for photonics, chemo and bio-sensors, micro-optics. She has been authored more than 90 papers published in journals and Conference Proceedings. She is also a reviewer in Romanian and international scientific journals and evaluator for FP6 and FP7 projects. Dr. Dana Cristea coordinated more than project 20 national projects. She participated in several FP6 projects (WAPITI, 4M, ASSEMIC), coordinated and participated in two FP7 projects (FlexPAET, MIMOMEMS).

Laboratory of Micro/Nano Photonics

Specific facilities



Modeling and simulation:

• **Opti FDTD 12.2.1** - design and simulation of advanced passive and nonlinear photonic devices

• **OptiBPM 11.1**- design of complex photonic integrated circuits for guiding, coupling, switching, splitting, multiplexing and demultiplexing of optical signals.

• **OptiGrating**- design software for modelling integrated and fiber optical devices that incorporate optical gratings.

• **LaserMod** - analysis of optoelectronic devices.

• **3Lit** – design of 3D micro-optical elements.

• **Zemax** – optical design.

Characterization:

• spectrophotometers for UV-VIS-NIR and IR spectral range;

• spectroscopic ellipsometer

• High Resolution Raman Spectrometers LabRAM HR with module TERS/AFM

• Alpha300 S System –Scanning Near-field Optical Microscope, Confocal Microscopy and Atomic Force Microscopy

• Optical Theta Tensiometer (KSW Instruments)

• experimental set-up for optoelectric characterization in UV-VIS-IR spectral range

Technology:

• glove box for preparation and deposition of nanocomposites and organic layers

National and international cooperations

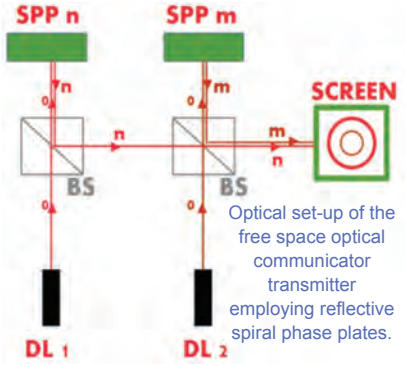
• Cooperation with European research units (Fraunhofer IPT, CEA-Liten, LAAS-CNRS Toulouse, UNINOVA) SMEs and LE from si cu firme din Spania, Germany, Finland , Austria, France EU projects: Flexible Patterning of Complex Micro Structures using Adaptive Embossing Technology **FLEXPAET** (FP7/IP-NMP; European Centre of Excellence **MIMOMEMS** (FP7-SA- Capacities), Multifunctional Zinc-Oxide based nanostructures. (MNT EraNet)

• Cooperation with national research centres (INFLPR, INCDFM), universitiesi (Universitatea " Dunarea de Jos'' Galati , UAIC Iasi, UP Bucharest) si SMEs (Optoelectronica 2001, Pro-Optica) in the frame of national programmes STAR and PN II.

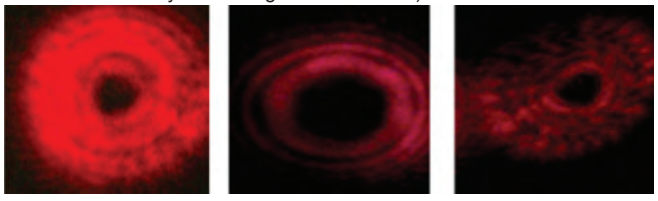
Results

High volume free space optical communications based on computer generated holograms- Project PN-II-PT-PCCA Dr. Cristian Kusko.(cristian.kusko@imt.ro)

We designed and realized an experimental setup that generates a superposition of optical vortices in the same beam in order to achieve a free space optical communicator demonstrator that uses optical vortices which carry orbital angular momentum).



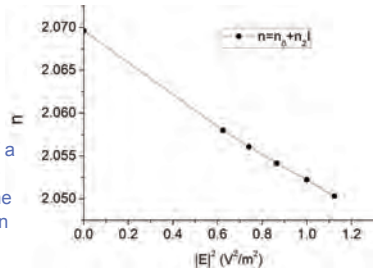
Optical set-up of the free space optical communicator transmitter employing reflective spiral phase plates.



Superposition of two optical vortices the optical vortex (m=3) in, and optical vortex (m=6) out in the transmitter output a) when both lasers are ON experimentally b) when only DL 1 is ON experimentally; c) when only DL 2 is ON experimentally.

Carbon quantum dots: exploring a new concept for next generation optoelectronic devices, CQD-OPTO) – project PNII-ID-PCCE 2011 – 2015., contact person Cristian Kusko

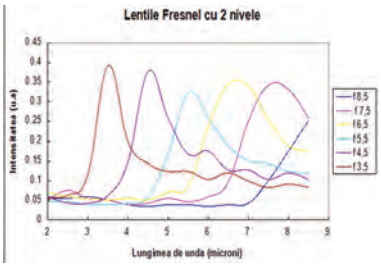
Theoretical and numerical calculations of optical properties of carbon quantum dots. We investigated the possibility to use carbon quantum dots as materials with nonlinear optical properties. We performed finite difference time domain (FDTD) simulations in order to determine the Kerr nonlinearity of a nanocomposite consisting of CQD embedded in polymer with refractive index n=1.5.



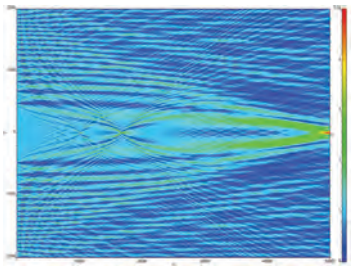
Dependence of the nonlinear refractive of a nanocomposite consisting of 8 nm CQD immersed in a polymer as a function of the square of field intensity |E|2 expressed in units of 10-18V2/m2

Compact Spectrometer in Infrared (PCCA 2013 project Acronym COSPIR) Dr. Mihai Kusko, mihai.kusko@imt.ro

The project aims the fabrication of a compact spectrometer for the detection of various chemical species which present absorption bands in the spectral range of 3-15 micrometers. Filters based on Fresnel lenses have been designed and fabricated. The Fresnel lenses focus the radiation on the detector area at various ratios depending on the wavelength



Spectrum of the power focused on the detector area for a two-level Fresnel lens



BPM simulation of radiation propagation through a Fresnel lens

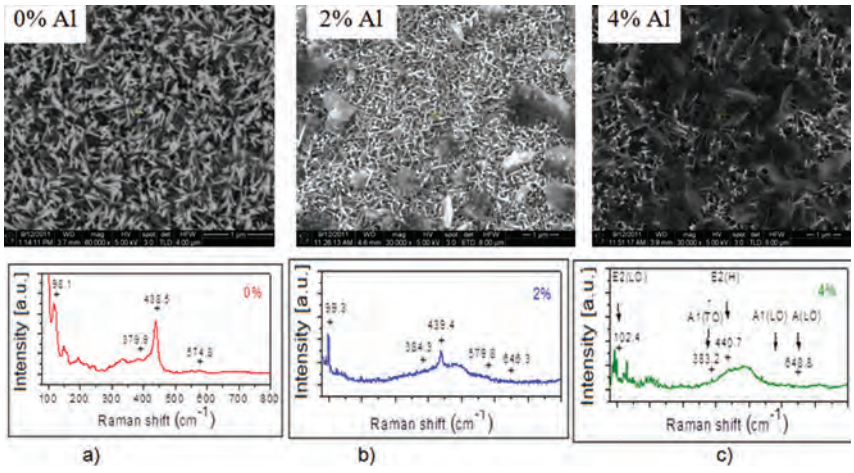
MIMOMEMS European Centre of Excellence

Results

1D and 2D ZnO based nanostructures and innovative processes for direct integration in gas sensing devices and UV radiation detection - Project PN-II-PT-PCCA /2014 (Dr. Munizer Purica , munizer.purica @imt.ro)

• Al doped ZnO nanowires grown by hydrothermal method.

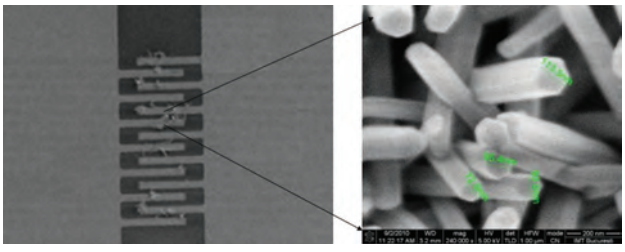
ZnO nanowires have been hydrothermally grown on glass substrate using an equimolar (0.025 M) aqueous precursor solution of zinc nitrate hexahydrate (Zn(NO3)2•6H2O) and hexamethylenetetramine (C6H12N4, HMTA) and aluminum chloride hexahydrate (AlCl3•6H2O) as doping source to obtain 2, 4 and 6 wt. % Al-doping concentrations (colaboration with partner Universitatea " Dunarea de Jos'' Galati).



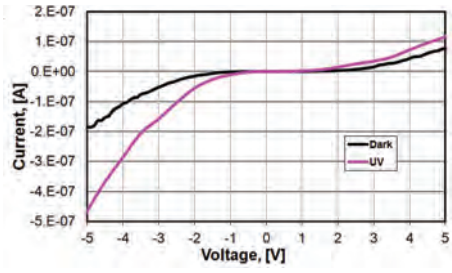
SEM images and Raman spectra of the undoped ZnO nanowires (a) and Al doped with 2% Al (b), 4% Al (c) concentration, grown three hours at T = 80 ^{0}C

• Localized growth in aqueous solution of ZnO nanowires on patterned quartz substrates.

The localized growth of ZnO nanowires on quartz substrate were achieved on patterned substrates with interdigitated electrodes of Cr/Au (8/100 nm) with distance between electrodes of 1 si de 3 μm. The growth region was defined in PMMA (hydrophobic layer which inhibits growth) using e-beam lithography (EBL).



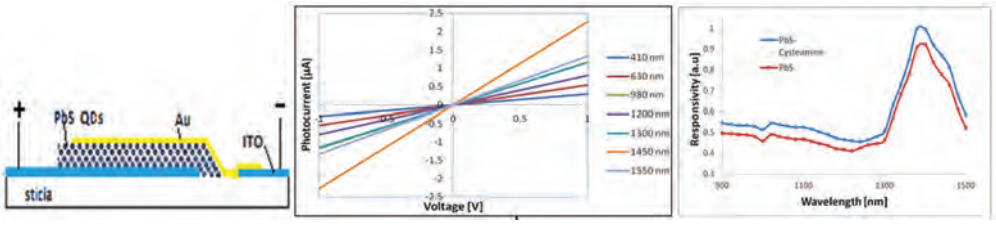
SEM image of the hexagonal ZnO interconnected nanowires of 70 – 100 nm diameters



I-V characteristics of ZnO nanowires grown on patterned quartz substrates in dark condition and under UV radiation.

Thin film photodetectors for aerospace applications (STAR project)- Dr. Dana Cristea, dana.cristea@imt.ro)

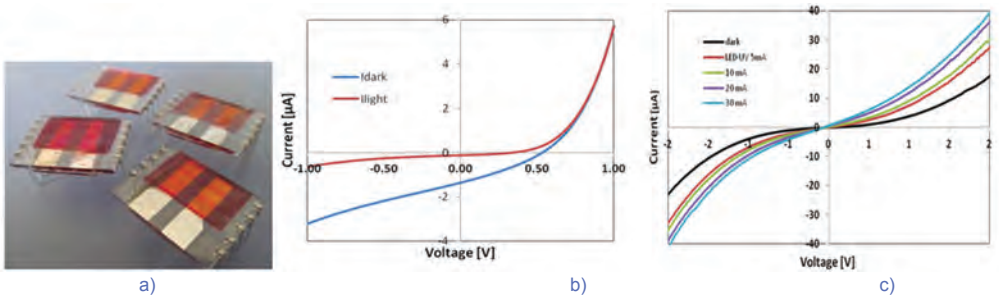
We have developed thin film photodetectors with broad spectral range based on PbS quantum dots.



Photoconductor based on PbS QDs- 5nm diameter: a) Chemati cross section; b) photocurrent under illumination with monochromatic sources; device area: 5 mm^2 μ, input optical power P ~ 1 μW; c) Spectral characteristics

Optoelectronic devices based on ZnO nanoparticles (core project PN 09 29 02 1)Dr. Paula Obreja, paula.obreja@imt.ro)

Components and experimentally devices with sensitivity in visible and UV have been achieved. The experimental structures, based on bulk-heterojunction (BHJ) polymer-based solar cells ITO/ZnO/P3HT:PC61BM/PEDOT:PSS/Ag and ITO/ZnO/P3HT:PC61BM/MoO_3/Ag have applications in UV sensing and organic/hybrid photovoltaic cells for energy conversion.



a) b) c)

a) Images of experimental devices; b) Schematic I-V characteristic for a photovoltaic device based on ITO/ZnO/P3HT:PC61BM/MoO_3/Ag structure with 40 nm thick ZnO layer, 5 mm^2 active aria; c)I-V characteristics for a with structure ITO/ZnO/P3HT:PC61BM/MoO_3/Ag device under UV illumination with a LED with emission in UV

Laboratory of micromachined structures, microwave circuits and devices

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.

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 Descatres prize and the FP 7 REGPOT MIMOMEMS (2008 – 20011) . 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). The laboratory is now involved in the 2 FP7 IPs (NANOTEC, SMARTPOWER), 1 FP7 STREPs (NANO RF) one ENIAC JU project (NANOCOM) and two ESA projects.

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);
- UV photodetectors based on GaN/Si membrane
- Microwave devices based on carbon nanotubes;
- MEMS and NEMS technologies developement;

Laboratory head: Dr. Alexandru Müller,

(alexandru.muller@imt.ro)

Dr. Alexandru Muller obtained the PhD degree in Semiconductor Physics in 1990, Bucharest University.

Career path and current position: 1972-present Senior Research Scientist at IMT Bucharest; 1996-present head of the Micromachined Structures, Microwave Circuits and Devices (L4).

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

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

Dr. Müller has coordinated the ***European Project FP 4 MEMSWAVE (1998-2001), the first ITC EU project*** coordinated by an Eastern country. Also he **coordinated, for IMT Bucharest as the Romanian partner, 4 EU projects (FP4, FP6, FP7), 2 ENIAC-JU projects, 1 COST project**, as well as an important number of national projects.

Currently, he coordinates the ESA project "Micro wave filter based on GaN/Si SAW resonators operating at frequencies above 5 GHz" (2015-2017)

Team:

The research team has multidisciplinary expertise in physics and electronics of microsystems and is composed of 13 senior researchers (9 of them with PhD in physics and electronics), one PhD student in electronics and two PhD students in electronics

Dr. Alexandru Muller, senior researcher, **head of lab**
Dr. Mircea Dragoman, senior researcher
Dr. Dan Neculoiu, senior researcher
Dr. Sergiu Iordanescu senior researcher
Dr. Valentin Buiculescu, senior researcher
Dr. Dan Vasilache, senior researcher
Dr. Alina Cismaru, senior researcher
Dr. Alexandra Stefanescu, senior researcher
Dr. Alina Bunea, PhD. St, researcher
Dr. Martino Aldrigo, researcher
Dr. Gina Adam, researcher
Eng. Ioana Giangu, PhD. St, junior researcher
Eng. Cristina Buiculescu, senior researcher
Phys. Ioana Petrini, senior researcher

Referents and members in committees:

A Muller, Dr M Dragoman, A Cismaru, A Stefanescu, D Neculoiu, S Iordanescu are referents at ISI journals. A. Muller, M. Dragoman and D. Neculoiu are members of the Technical Programme Committee and Paper Review Board, at the International Semiconductor Conference (CAS, an IEEE event). M Dragoman and D Neculoiu are associate editors at ROMJIST.

Dr. A. Muller is reviewer for the FP7 project *„Lifting Up the Research Potential of the Galician Telecomms Center - LIFTGATE".*

Equipment: "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, cryostat Janis Research SHI-4H-1 (5 - 500K temperature range) Measurement accessories, Computers and software for microwave electromagnetic simulations (IE3D, Fidelity, CST);

Laboratory of micromachined structures, microwave circuits and devices

International projects:

FP7: - SMARTPOWER, FP7-ICT-2011-7 IP project No 288801 "Smart integration of high power electronics for industrial and RF applications", Coord. Thales TRT, France, 15 partners 2011-2016, IMT partner.

- **NANOTEC**, FP7-ICT-2011-7 IP project No 288531 "Nanotechnology for Adaptive Communication and Imaging Systems based on RF-MEMS"-, Coord. Thales TRT, France, 17 partners, 2011-2015, IMT partner

- NANO RF, FP7-ICT-2011-8, STREP No 318352 – "Carbon based smart systems for wireless applications", Coordinator Thales TRT, France, 13 partners, 2012-2016, IMT partner

ENIAC JU projects: - **NANOCOM**, ENIAC Call 2010 Nr 270701-2 "Reconfigurable Microsystem Based on Wide Band Gap Materials, Miniaturized and Nanostructured RF-MEMS" Coord: Thales TRT, France; 13 partnrs, 2011-2015, IMT partner

ESA: Contract No. 4000110819/CBi *"0-level encapsulation of reliable MEMS switch structures for RF applications"*, Coord IMT, 2014 - 2016

ESA: Contract No. 40000115202/15/NL/CBi "Microwave filters based on GaN/Si SAW resonators, operating at frequencies above 5 GHz" IMT coord 2015 - 2017

National projects

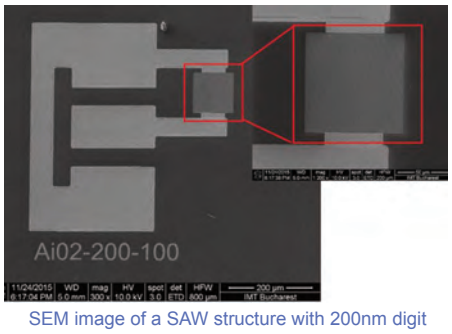
3 projects in the IDEAS (PN II) **programme** (2011– 2016): "Nanoelectronic devices based on grapheme for high frequency applications" (coordinator Dr M. Dragoman), "Novel technologies based on micromachining and nano-processing of GaN/Si, for advanced microwave and photonic devices" (coordinator Dr. A. Muller) and „Millimeter-wave Front-End for Imaging in Security and Medical Applications" (coordinator Dr. D. Neculoiu), **1 project in Partnership** (PN II) programme: "Temperature sensor based on GHz operating AlN/Si SAW structures " (2014-2016, coordinator Dr. A. Muller), **2 projects as partner in Partnership** (PN II) programme (2012 – 2016) and **1 project coordinated by Romanian Space Agency** (ROSA) STAR project "Millimetre and submillimetre wave GaAs Schottky diodes detectors and mixers"(2013 – 2016), coordinator Dr. A. Muller), **2 young research team projects** (PN III) (2015-2017) coordinated by Dr A. Stefanescu and Dr D. Vasilache.

Most important scientific results

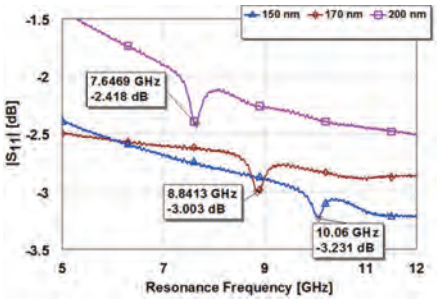
Microwave and temperature characterization of AlN based SAW structures for temperature sensor.

Partnership – ctr 15/2014 „Temperature sensor based on GHz operating AlN/Si SAW structures" Coord. Dr Alexandru Muller, (2014-2017)

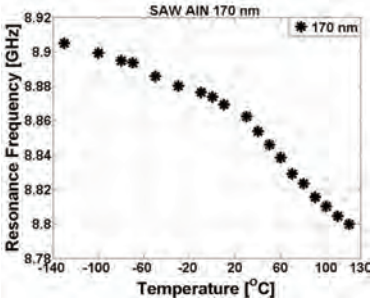
The SAW structures were designed for frequencies over 8 GHz. IDTs having 200nm and 150nm were obtained using nanolithographic techniques. The "On wafer" measurement system (microwave network analyzer Anristu in Karl SUSS Microtec Probe Station) was used for microwave characterization. The temperature characterization was accurate performed in a cryostat (Janis Research SHI-4H-15, 5K - 500K temperature range). The analyzed SAW structures are provided with CPW pads in order to be connected with a custom design system for measuring inside the cryostat.



SEM image of a SAW structure with 200nm digit width, having 150 digits and 50 digits for each reflector.



The resonance frequency at room temperature (T = 23°C) for SAW having IDTs with 200 nm (magenta), 170 nm (dark red) and 150 nm (blue)



Resonance frequency vs temperaturefor the SAW with 170 nm width of the digits

Characterization of coupled structures SAW/UV photodetector

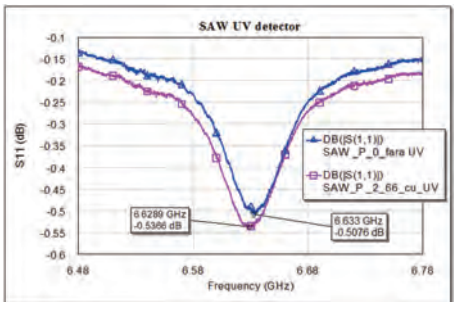
Novel technologies based on micromachining and nano-processing of GaN/Si, for advanced microwave and photonic devices, IDEAS PNII-ID_PCE-2011-3-0513, Coord. Dr. Alexandru Muller, (2011-2016)

The structures were processed by direct writing Electron Beam Lithography and they have 60 digits and 60 reflectors sideway from the IDT at 2.2µm. The digit length is 50µm with 200nm or 300nm width and TiAu metallization of 5/10nm.

SAW resonators response to UV illumination of 341nm wavelength is a frequency shift from the central frequency of 6.63 GHz. This shift was highlighted by S11 measurements vs frequency. The experiments show that the response of the photodetector at UV illumination depend on the UV power density.

For UV illumination having 2.66 µW/mm² power density, the frequency swift is 4 MHz, compared to the resonance frequency measured in the absence of illumination, while for UV illumination having 3.2 µW/mm² power density, the frequency shift is 10.3 MHz.

UV illumination experimental set-up for characterization of the UV detector



S11 for the detector with SAW resonators without UV illumination and with UV illumination having 2.66 µW/mm² power density

MIMOMEMS European Centre of Excellence

Laboratory of micromachined structures, microwave circuits and devices

Most important scientific results

W-Band hybrid integrated direct detection receiver for space applications, *STAR ctr 86 /2013 „ Millimetre and sub-millimetre wave GaAs Schottky diodes, detectors and mixers" Coord. Dr A. Muller, (2013-2016)*

A W-band (75 – 110 GHz) direct detection receiver consisting of a membrane supported folded slot antenna and a detection circuit based on a zero-bias diode (ZBD) was designed and fabricated. The antenna is processed on a 2.1 μm thick SiO_2/Si_3N_4 (1.5/0.6 μm) membrane released through deep reactive ion etching (DRIE) of high-resistivity silicon and the detection circuit is processed on silicon bulk.

In order to get a good estimate of the behavior of the receiver at low temperatures, the detection circuit was placed in a cryostat with an on-wafer measurement setup. The i/v cgharacteristic and the detected signal were determined between 295K and 23K.

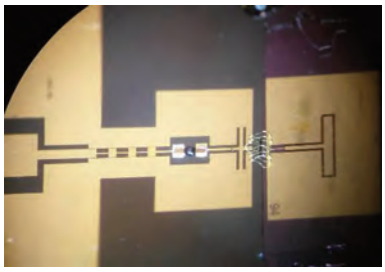


Photo of the hybrid integrated direct detection receiver

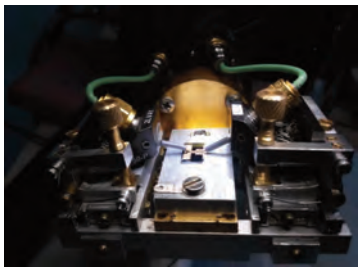
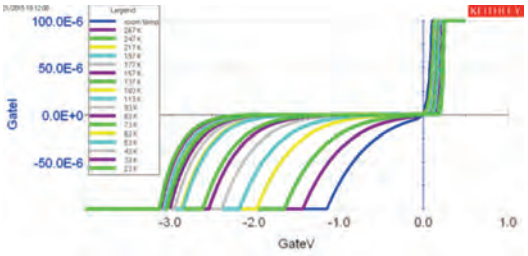


Photo of the device under test in the cyostat



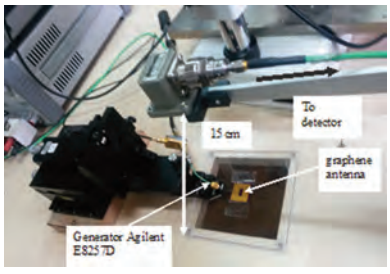
i/v characteristics of the hybrid integrated detector at temperatures between 295 K (room temperature) and 23 K (linear scale)

Measurement of antenna on graphena

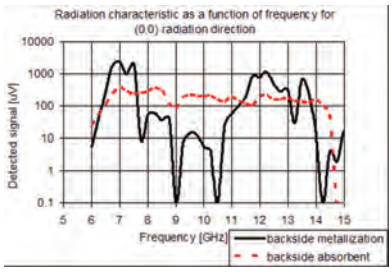
NANO RF - *FP7-ICT-2011-8, STREP No 318352 – "Carbon based smart systems for wireless applications", Coord.Thales TRT, France, 2012-2016, IMT partner*

Antenna on grapheme for 10 GHz was processed on high resistivity substrate, as doped Si does not allow operating in microwave antenna due to large losses. Antenna was measured and the radiation characteristic was determined.

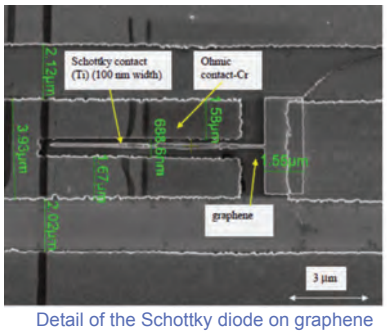
Photo of the wafer with antenna on graphene



Measuring system



Radiation characteristic vs. frequency



Detail of the Schottky diode on graphene with coplanar waveguide configuration.

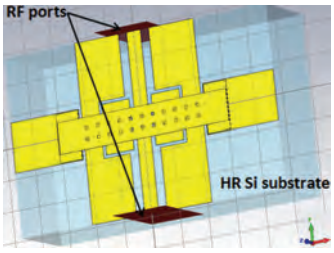
Manufacturing of Schottky diode on graphene

Nanoelectronic devices based on grapheme for high frequency applications, IDEI PNII-ID-PCE-2011-3-0071 Coord. Dr Mircea Dragoman, (2011-2016)

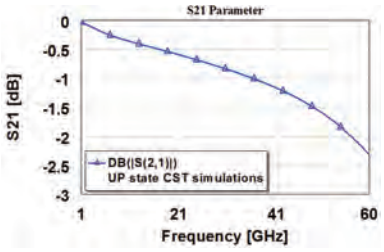
Schottky diode based on grapheme was manufactured using three metals Ti, Cr, Au. These metals cover the entire contacts structure. The diode is a natural phase shifter with the supply voltage for signals in the 40-65 GHz range; therefore it present a 450 phase shift at 4V for 65 GHz.

Electromagnetic simulation of RF MEMS switches, Partnership - ctr 5/2012 - Advanced Tools and Methodologies for the Multiphysics Modelling and Simulation of RF MEMS Switches (2012 – 2016); IMT- partner, IMT coordinator Dr. Alexandra Stefanescu;

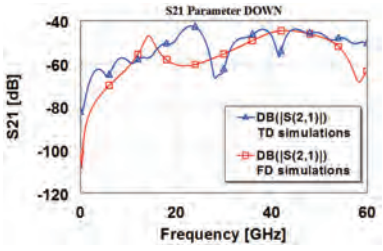
The RF MEMS switches were simulated in both states, up and down, with CST Microwave Studio software. The simulations present good performances: insertion losses between -0.03 dB and -2.3 dB (UP) and isolation smaller than -40 dB for the entire frequency range (DOWN).



The 3D geometry of the RF-MEMS switch simulated with CST MW Studio



S_{21} parameter for the switch in the UP state



S_{21} parameter for the switch in the DOWN state

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Centre of Nanotechnologies

Prof. Dan Dascalu was the founder and the director (CEO) of the Centre for Microtechnology (1991), then of the Institute of Microtechnology (July 1993), and finally (since November 1996) of the National Institute for Research and Development in Microtechnologies (IMT Bucharest). His mandate came to and end in June 2011. Since then, he is the Coordinator of the Centre for Nanotechnologies and President of the Coordinating Board of IMT-MINAFAB. Dan Dascalu is a 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) as well as of many technical papers published in scientific periodicals or conference proceedings. 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 High Level Group (HLG) for Nanotechnologies.

Centre of Nanotechnologies (CNT-IMT) is one of the scientific entities from the Department of Scientific and Technological Research of IMT. CNT comprises three research labs: L1 (nanobiotechnology), L6 (nanoscale structuring and characterization), L9 (molecular nanotechnology) and **it is concentrating most of the research in nanoscience and nanotechnology done in the institute**. The directions of research and the results obtained are described in detail below (follow the Lab presentations). This "center", **coordinated by Academician Dan Dascalu** has a special status: *it operates under the aegis of the* **Romanian Academy** (of Sciences). This supervision is related to the content of the scientific research, with no administrative or financial implications. This kind of "affiliation" provides more visibility to the centre and to IMT in general, as CNT-IMT is also considered part of the system of research institutions of the Romania Academy (mostly basic research, notably in chemistry and biology). This center is the organizer of the National Seminar for NanoScience and Nanotechnology (in 2015 at its 14th edition), developed as an event of the Romanian Academy, with logistic support from IMT. IMT is also involved in publication of a series of books and a periodicals edited by the Romanian Academy.

Laboratory of Nanobiotechnologies

Mission: ***The mission of L1*** is to propose and approach research directions in the field of *nanostructures/nanomaterials /nanocomposites*, aiming both the in-depth understanding of their properties and finding novel solutions for technological development for integration in devices with applications in sensing, medicine, energy. Furthermore, training programmes, as well as technological and characterization services in the field of nano-bio-technologies are carried out.

Research areas: The main areas of activity are:

(i) fabrication of the nanomaterials/functional nanostructures, investigation, control and also, development of specific methods for the chemical surface modification for specific applications;

(ii) supporting the development of some industrial safety nanoproducts for health and enviromental protection by assessing the toxicity and risks associated with nanomaterials;

(iii) design and fabrication of some devices based on silicon, silicon carbide, polymers and also, of some hybrid systems for applications in different fields, from (bio)medicine (optoelectronic biosensors) to energy (miniaturized fuel cells / solar cells as clean energy sources).

Laboratory head: Dr. Mihaela Kusko,

(mihaela.kusko@imt.ro)

Dr. Mihaela Kusko obtained the B.Sc. degree (1998) in Solid State Physics and the PhD degree (2006) in physics, both from University of Bucharest. Since 1998 she joined IMT-Bucharest, where her main research activities are in the field of nanobiotechnologies, from study of nanomaterials and nanostructures to their integration in complex devices. The foreseen applications cover a broad area, including silicon based devices for drug delivery, miniaturized fuel cells, optoelectronic biosensors and lab-on-a chip systems for diagnosis. She coordinated 4 national research projects and currently is the Romanian partner responsible of the FP-7 IP project ***NanoValid*** and LIFE+ project ***i-NanoTool***, both in the nanosafety area.

Team

1. **Adina Boldeiu** (Bragaru), Chemist, Dr., Research Scientist II;
2. **Cosmin Romanitan**, Physicist, Ms., Junior Researcher
3. **Florea Craciunoiu**, Physicist, Research Scientist II;
4. **Iuliana Mihalache**, Physicist, Dr., Research Scientist;
5. **Melania Banu**, Biologist, PhD St., Junior Researcher;
6. **Mihaela Kusko**, Physicist, Dr., Research Scientist I, head of the laboratory;
7. **Mihai Danila**, Physicist, Research Scientist III;
8. **Mihai Mihaila**, Engineer, Dr., Research Scientist I;
9. **Monica Simion**, Physicist, Dr., Research Scientist II;
10. **Razvan Pascu**, Engineer, Dr., Research Scientist;
11. **Teodora Ignat**, Chemist, Dr., Research Scientist III.

Laboratory of Nanobiotechnologies

National collaboration:

• **PNII-PCCA** project *"Improved production methods to minimize metallic nanoparticles' toxicity – less classic, more green, LesMoreNano"* coord IMT, project director Dr. Monica Simion/ Dr. Adina Boldeiu (2014-2016) http://www.imt.ro/lesmorenano/

• **PNII-PCCA** project *"Multiplexed platform for HPV genotyping, MultiplexGen"* – coordinator IMT, project director Dr. Mihaela Kusko (2014-2016) http://www.imt.ro/multiplexgen/index.php

• **PNII-PCCA** project *"Identification of new modulators of calcium-regulated processes using genomic and chemogenomic screens in yeast, CalChemGen"*, resp IMT Dr. Monica Simion (2014-2016) http://www.chimie.unibuc.ro/cercetare/organica/PN-II-PT-PCCA-2013-4-0291/

• **PNII-PCCA** project *"Dispozitiv RFID pentru trasabillitatea alimentară - Food Track"* – resp IMT Dr. Mihaela Kusko (2014-2016)

• **PNII-PCCA** proiect *"Array structures for prevention, individualized diagnosis and treatment in cancers with high risk of incidence and mortality"* – resp. IMT A. Boldeiu (2012-2016) http://www.iob.ro/hrcarraysen.html

• **PNII-PCCA** project *"High Temperature Silicon Carbide (SiC) Smart Sensor for Harsh Environment Industrial Applications"* **– r**esp. IMT F. Craciunoiu (2012-2016) http://www.arh.pub.ro/projects/sicset/

• **PNII-PCCA** project *"Environmental toxic and flammable gas detector based on silicon carbide MOS sensor array"* – resp. IMT F. Craciunoiu (2012-2016) http://www.icpe-ca.ro/en/partnershipsinpriorityareas

International collaboration:

• **Large-scale Integrating Collaborative FP7** *Project - "Development of reference methods for hazard identification, risk assessment and LCA of engineered nanomaterials – NanoValid" (2011 – 2015)* – IMT resp. M. Kusko; THEME NMP.2010.1.3-1 Reference methods for managing the risk of engineered nanoparticles http://www.imt.ro/nanovalid/

• **LIFE+** *(Environment Policy and Governance) Project – "Development of an interactive tool for the implementation of environmental legislation in Nanoparticle manufacturers – i-NanoTool" (2013 – 2015) - IMT resp. M. Kusko http://www.inanotool.com/*

• **Bilateral Cooperation Project Romania** – *Argentina, Instituto de Investigaciones en Fisicoquímica de Córdoba „Development of analytical methods based on supramolecular systems to detect and quantify nanomaterials – DAMS" (2013 – 2015)* – IMT resp. M. Kusko.

• **COST** *(European Cooperation in the field of Scientific and Technical Research) Project - "Raman-based applications for clinical diagnostics (Raman4clinics)"* (2014-2018) - IMT resp. Dr. Mihaela Kusko

Equipments and related scientific results

• **High Resolution SmartLab X-ray Diffraction System** (Rigaku Corporation, Japan); Contact persons: *Phys. Cosmin Romanitan; Phys.Mihai Danila*

• **Micro-Nano Plotter System – OmniGrid**, UK / **Fluorescence Scanning System GeneTAC UC4** - Genomic Solutions Ltd., UK for microarray technology; Contact persons: *PhD St. Melania Banu; Dr. Monica Simion*

• **Electrochemical Scanning Microscope ElProScan** (Heka, Germany); Contact persons: *Dr. Mihaela Kusko; Dr. Monica Simion*

• **Fluorescence Spectrometer,** Combined Time Resolved and Steady State Fluorescence Spectrometer - FLS920P (Edinburgh Instruments, UK); Contact person: *Dr. Iuliana Mihalache*

• **Impedance Spectrometer, Electrochemical analyzer/ workstation**
- Electrochemical Impedance Spectrometer - PARSTAT 2273 (Princeton Applied Research, USA)
- Autolab PGSTAT302N / FRA32N / SPR

Contact persons: *Dr. Mihaela Kusko; Dr. Antonio Radoi*

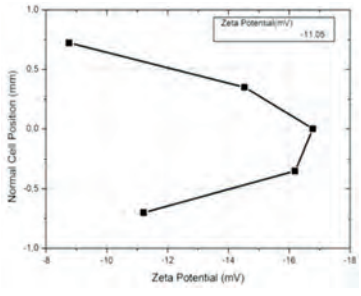
• **Size and Zeta Potential Measurement System DelsaNanoC** (Beckman Coulter, USA)

Contact persons: *Dr. Adina Boldeiu, Dr. Monica Simion*

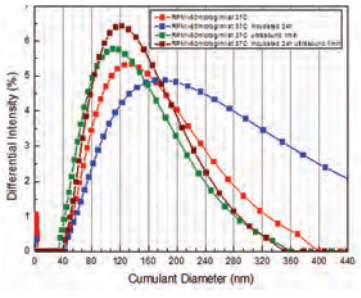
Main scientific results

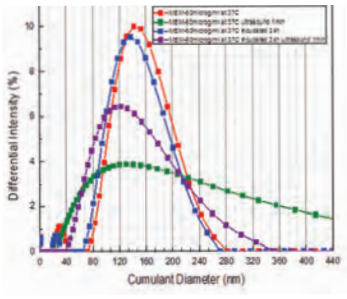
Studies regarding the materials' toxicity risk assessment

In the frame of *NanoValid* FP7 Project, IMT was involved in the development of some standard characterization methods of the nanoparticles and attended the correlation of the results between different research laboratories. Thus, in the frame of the so-called *round robin characterization*, tests regarding the hydrodynamic diameters and zeta potential of nanomaterials of interest were realized in parallel in different laboratories from Project's Consortium, using similar characterization equipments from different suppliers, with the respect of the identical protocols. These procedures, *called the standard operating procedures* (SOP), and the recorded results/data were included in the *9 ISI indexed ArrayExpress Archives*.



Zeta potential of the SiO_2NPs in DMEM cell culture





The hydrodynamic diameter of the AgNPs in different dispersion media used for cells culture– RPMI (a), MEM (b) – at 37˚C, with different SOPs

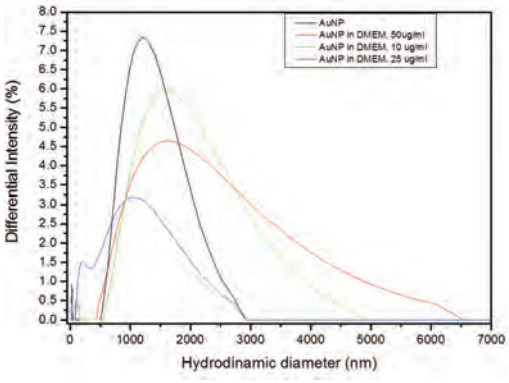
Toxicology and Applied Pharmacology, 284, 16–32, 2015 (M. Simion co-auth.)

The results were obtained in the frame of NanoValid FP7 Project

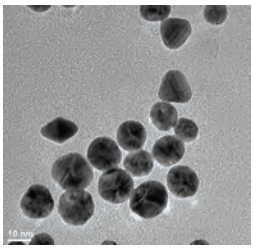
Centre of Nanotechnologies

Nanotoxicology support studies to develop safe synthesis methods for nanoparticles

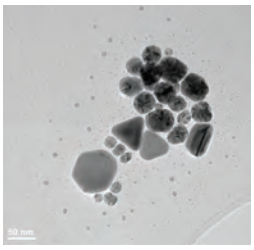
There is a great interest to develop new synthesis methods, by focusing especially on *green-chemistry*, which are important for the IMMs who are interested in fabricating the nanocomposites products. ***Aghoras Invent SRL*** is a small enterprise which develops and markets new cosmetics based on metallic nanoparticles and also, it is interested in assesing the nanoparticles toxicity risk. In this regard, the physico-chemical characterizations of the nanoparticles, made in IMT and UPB were supplemented by the toxicity evaluation tests done by the ***DFVM-IFIN HH***. Gold and silver nanoparticles were obtained using two new synthesis methods, starting from honey and electroerosion processes, and then were analyzed from chemical and physical point of view



Hydrodinamic diameters of the honey based AuNPs at different concentrations



TEM image of AuNPs obtained using honey



TEM image of the AgNPs using electric charge methods

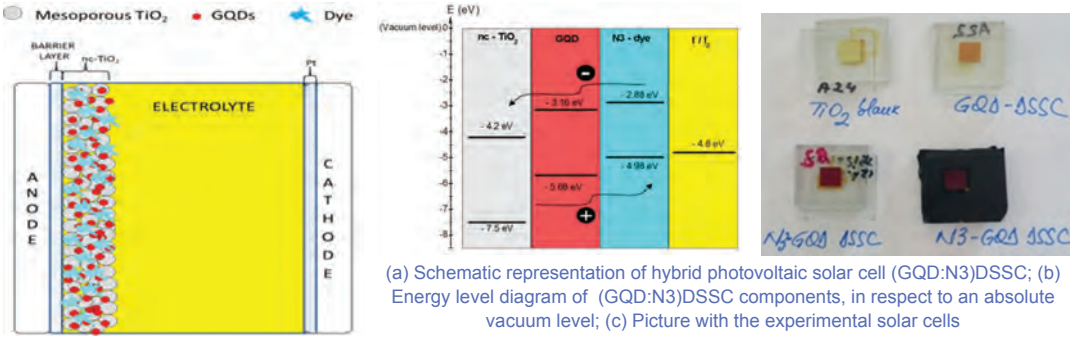
The results were obtained in the frame of National Project PNII-PCCA ctr 109/2014 - LessMoreNano

Studies on the charge transfer mechanism in electrochemical solar cells photovoltaic systems

• In this study, the possibility of employing fluorescent graphene nanoparticles for electrochemical solar cells (Gratzel) has been investigated. It has been observed that the efficiency of light conversion is reduced when the photo-anode is loaded only with this type of nanoparticles; this conclusion relies on the fact that the absorption spectrum of nanoparticles is located in the UV domain.

Some encouraging results have been obtained in the case of hybrid dye-sensitized solar cells, where both graphene nanoparticles and standard Ruthenium dye (II) (N3) are loaded on photo-anode. In this case, an improvement of 12% in the conversion efficiency and 20% increase of short circuit current (ISC) have been obtained.

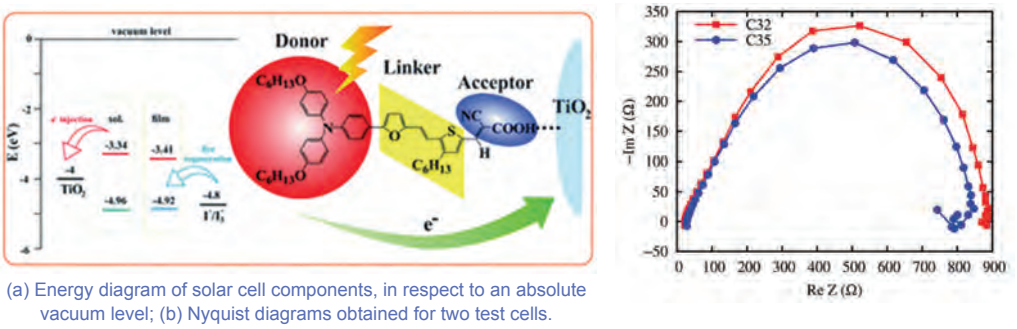
Investigations on these complex nanocomposite systems like the charge and energy transfer mechanism and the role played by nanoparticles, have been performed. The results of optical and electrical characterizations conclude the interplay of both mechanisms mediated by nanoparticles: energy transfer process, dominant in UV region of the spectrum and the charge transfer process dominant in the visible region of the incident light spectrum. Furthermore, by measuring the open circuit voltage decay and dark current characteristics, the grapheme quantum dots (GQDs) role in improving and facilitating the charge collection have been demonstrated.



(a) Schematic representation of hybrid photovoltaic solar cell (GQD:N3)DSSC; (b) Energy level diagram of (GQD:N3)DSSC components, in respect to an absolute vacuum level; (c) Picture with the experimental solar cells

I. Mihalache et al, ***Electrochimica Acta 153**, 306–315,* **2015**

• There have been investigated the photovoltaic properties of a new organic dye, synthetized at ***„Petru Poni" Institute of Macromolecular Chemistry - Iasi***, integrated into Grazel solar cells. For a better understanding of charge transfer mechanism and further corellation of photovoltaic performance with technological parameters of the test cells, I-V measurements were complemented by impedance spectroscopy analyses.



(a) Energy diagram of solar cell components, in respect to an absolute vacuum level; (b) Nyquist diagrams obtained for two test cells.

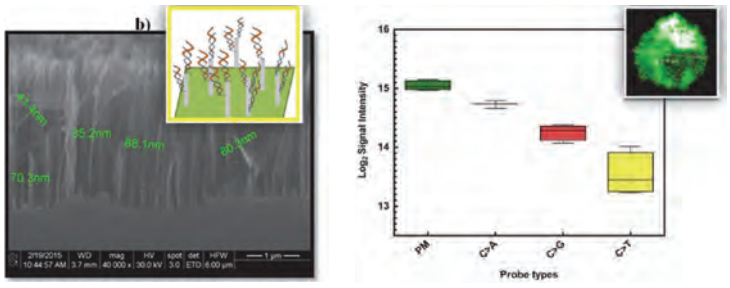
RSC Advances 5, 53687-53699, **2015 (M. Mihaila, M. Kusko** coauth.)

Laboratory of Nanobiotechnologies

Development of a microarray platform built on silicon nanowires

The feasibility of a microarray support based on silicon nanowires was explored in joint effort between IMT, University of Bucharest and the laboratory of genetic analysis GeneticLab, aiming to increase the detection rate of the DNA sequence mismatches with pathological significance occurred in BRCA1 gene. By one-step metal assisted chemical etching (1-MACE), nanowires with an average length of 3.5 μm were obtained, these substrates being subjected to the functionalisation procedure which allows further the covalent attachment of the syntethic oligonucleotides corresponding to BRCA1 sequences which presented a single nucleotide mismatch. The single-base differences were detected by scanning the slides after the hybridization process carried with fluorescently labelled complementary DNA. The nano-structured platform has disclosed a statistical detection between the differences of hybridization signal intensities.

The studies will continue towards the integration of the support into a complex microfluidic system which will be used for dynamic hybridisation.



(a) SEM caption of the silicon nanowires, visualised in cross-section; (b) schematic representation of the hybridisation process, the labelled DNA being attached based on complementarity to the tethered sequences which are present on the surface and also on the length of the functionalised silicon wire; (c) the graphical interpretation of the signal intensities after the hybridisation on nanostructured silicon; (d) the morphology of the genetic material hybridised in the predefined location.

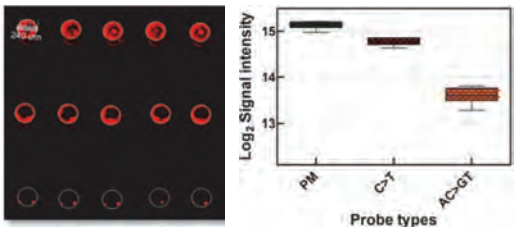
M. Banu et al, **RSC Advances 5**, 74506-74514, **2015**;

The results were obtained in the PNII-PCCA project, contract no. 36/2014 –MultiplexGen

Detection of single nucleotide polymorphisms in KRAS sequence

For achieving microarray structures intended to be used for diagnosing colorectal cancer, series of tests were realised in joint collaboration between IMT and the **Institute of Oncology "Prof. Dr. Alexandru Trestioreanu"** from Bucharest, for determining mutations specific to the above-mentioned type of cancer.

The sensitivity of the hybridisation reaction was quantitatively investigated by analysing the fluorescent signal obtained for sequences which carry single-base mutations. The study was realised in comparison with the hybridisation efficiency between the attached DNA fragments which have perfect complementarity with the labelled DNA sequences. The results highlighted a good sensitivity of detection and were statistically validated with *Student's t test.*



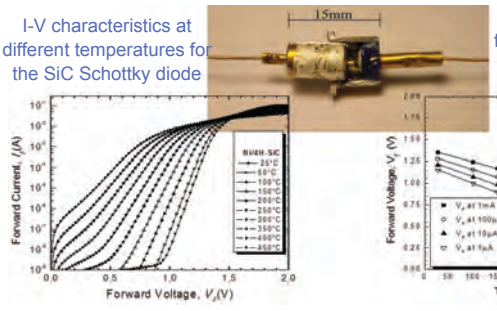
(a) Hybridisation results between the labelled KRAS sequences and perfect matched probes (PM), or probes with single-base mismatch (C>T) and with two-base mismatches (AC>GT); (b) graphical interpretation of the hybridisation signal intensities.

The results were obtained in the PNII-PCCA project, contract no. 4/2012 – HRCarrays.

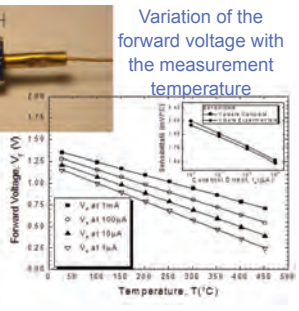
Silicon carbide (SiC) sensors for harsh environment applications

In collaboration with UPB and ICPE-CA, in IMT was developed and optimized a technology for manufacturing two types of sensors: temperature sensor based on a Schottky diode and a gas sensor based on MOS capacitor.

I-V characteristics at different temperatures for the SiC Schottky diode



Variation of the forward voltage with the measurement temperature



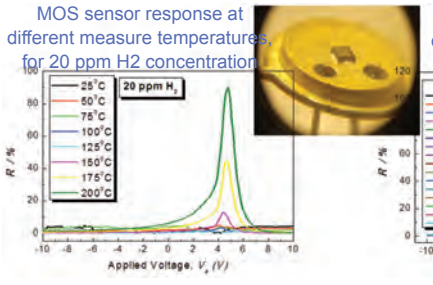
• **Schottky diodes fabricated on SiC** were electrically characterized at high temperatures, by monitoring the variation of the forward voltage with temperature. The I-V characteristics have an exponential variation with temperatures up to 450ºC, which demonstrates a correct operation as high temperature sensor of the SiC Schottky diode. This behaviour is further sustained by the linear variation of the direct voltage (VF) with the measured temperature.

***Appl Phys Lett**106 (26), 261605, **2015 (R. Pascu, M. Danila** coauth);*

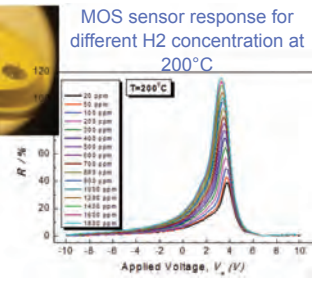
The results have been obtained in the frame of project PNII-PCCA ctr 21/2012-SiC-SET

The fabricated SiC Schottky diodes have been used to create a system for temperature monitoring in a cement furnace from CEPROCIM, in parallel with a classic system. The sensor developed in IMT worked nine months in parameters compared to 1.5 months as is the lifetime of a commercial sensor.

MOS sensor response at different measure temperatures, for 20 ppm H2 concentration



MOS sensor response for different H2 concentration at 200°C



• **SiC MOS capacitors** have been tested as hydrogen sensors, analysing the C-V characteristics obtained for different H_2 concentrations. Accordingly, the packaged MOS sensors have been electrically characterized at different temperatures, in the range of 25-200°C, and different H_2 concentrations (20-1800 ppm) in N_2. The MOS sensor response becomes considerable from a minimum temperature of 150°C for 20 ppm H_2 concentration. The sensor response in capacitance at this temperature is about 13%, significantly increasing up to 200°C, where the maximum value of 90% is reached.

R.Pascu et al, *Materials Science in Semiconductor Processing,* available online Aug. **2015**;

The results have been obtained in the frame of project PNII-PCCA ctr 204/2012 – SiC-GAS

Nano-Scale Structuring and Characterization Laboratory

Mission

The main mission of the lab is to support the research and educational efforts of IMT Bucharest by providing the facilities, tools and expertise in the field of characterization and testing at micro and nano scale and delivering innovative solutions and services for direct nanoscale patterning through electron beam lithography (EBL) based techniques.

The staff of the laboratory collaborates with other teams in IMT Bucharest in planning and developing experiments and implementing solutions for nanoscale fabrication and characterization of materials, processes and structures.

Activity areas

Characterization: • Conventional and field emission Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Spectroscopy (EDX);

• High-resolution surface and interface investigations by Scanning Probe Microscopy (SPM-AFM)

• Small-scale mechanical characterization using depth-sensing indentation (nano-identation) testing.

Structuring: • Nanoscale patterning with Gaussian e-beam lithography used for micro/nano nanostructuring with applications in photonics, MSM-UV photodetectors, high-frequency and microwave circuits etc.

• Fabrication of graphene-based configurations and devices using dedicated EBL techniques.

Team: The scientific team is formed by three senior researchers, three junior researchers (including PhD students) and one economic specialist:

• **Dr. Adrian Dinescu**, physicist, Senior Researcher I
• **Raluca Gavrila**, physicist, Senior Researcher III
• **Dr. Octavian Ligor,** physicist, Senior Researcher III
• **Dr. Marian Popescu**, electronics engineer, Researcher
• **Bogdan Ionut Bita**, physicist, Ph.D. student, Research,
• **Stefan Iulian Enache**, electronics engineer, Technological Development Engineer
• **Mihaela Marinescu**, economist, financial operations specialist

Main equipment

• *Electron Beam Lithography and Nanoengineering Workstation – Raith e_Line (RAITH GmbH, Germany).* It is a versatile nanolithography system by direct patterning of electron resists, electron beam-assisted deposition and etching, with < 20 nm achievable resolution.

• *Dip Pen Nanolitography System - NSCRIPTOR (NanoInk, Inc., USA).* It is employed for ink-and-pen nanolithography, which applications such as: direct printing on substrates for functionalization purposes, photolithographic masks correction, stamp manufacturing for nanoimprint lithography etc.

• *Ultra High resolution Field Emission Gun Scanning Electron Microscope (FEG-SEM) - Nova NanoSEM 630 (FEI Company, USA),* equipped with pattern generator (PG) Elphy Plus (RAITH GmbH, Germany).

• *Scanning Electron Microscope with Thermionic Electron Gun - TESCAN VEGA II LMU TESCAN s.r.o, Czech Republic),* equipped with Energy Dispersive X Ray Spectrometer (EDAX Genesys).

• *Multifunctional Near-field Scanning Probe Microscope (SPM) - NTEGRA Aura (NT-MDT Co., Russia).* It is employed for high resolution 3D imaging and complex characterization of the surfaces by advanced complementary techniques (AFM, STM, EFM, MFM, SKPM, C-AFM, etc.).

• *Nano Indenter G200 (Agilent Technologies, USA).* It is used for high resolution characterization of the mechanical properties of small-volume samples.

L6 encompasses 4 experimental laboratories included in the IMT-MINAFAB support centre for micro - and nanofabrication and certified to ISO 9001:2008 quality management standards: *"Laboratory for SEM characterization", "Laboratory for electron beam litography Raith e_Line", "Laboratory for field emission SEM characterization" and "Laboratory for SPM and nanomechanical testing".*

National and International Collaborations

• **National cooperation:** *Cooperation with Romanian companies, research centres, university departments and institutes:* Honeywell Romania, S.C."IOR-S.A.", Electro Optic Components SRL, Zoomsoft SRL, Storex Technologies Inc., R&D Centre for Materials, Electronic and Optoelectronic Devices (MDEO), Centre for R&D in Polymeric, Mesophase Materials and Nonconventional Methods in Environmental Protection; University of Bucharest, Department of General Chemistry, Department of Bioresources and Polymer Sciences, Engineering and Informatics for Chemical and Biochemical Processes; Faculty of Applied Chemistry and Materials Sciences - University "Politehnica" Bucharest, Department of Physics and Chemistry; Faculty of Materials Engineering and Environment, Technical University of Cluj-Napoca; Faculty of Mechanics – University of Craiova, Department of Chemistry, Physics and Environment; Faculty of Sciences and Environment, University "Dunarea de Jos", Galati, Department of Chemistry; University of Petroleum and Gas Ploiesti, National Centre of Study and Testing of Materials; Chisinau, Laboratory of Materials and Multifunctional Structures, INCDFM, Laboratory of Plasma at Low Temperature, Laboratory of Plasma Physics and Solid State Laser, INFLPR.

National projects running in 2015:

- STAR- Strategy (2012-2015) (Partner)

- Techniques and procedures for nanoscale characterization and structuring, National Program Convert - PN0929

• **International cooperation:** *Collaboration with universities and institutes from Italy* (Instituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati - INFN-LNF) *and Bulgaria* (University of Ruse "Angel Kanchev", Georgi Nadjakov Institute of Solid State Physics - Bulgarian Academy of Sciences).

International projects running in 2015: - Bilateral inter-academic cooperation, Romania-Bulgaria: "Nano structured and amorphous semiconductor films for sensors application" (2013-2015) (Partner).

The laboratory was involved as partner in two international research proposals in 2015: a H2020-FETOPEN and a M-ERA.NET project to be funded in 2016

Laboratory head: Dr. Adrian Dinescu, (adrian.dinescu@imt.ro)

Dr. Adrian Dinescu obtained the M.Sc. degree (1993) in Solid State Physics and the PhD degree (2010) in physics, both from University of Bucharest. Between 1993 and 1997, Adrian Dinescu was with the National Institute for Research in Electronic Components, working in the field of optoelectronic devices fabrication.

Since 1997 he is with IMT-Bucharest where he is currently involved in micro and nanoscale characterization using FE-SEM and in structuring at the nanoscale using Electron Beam Lithography. His expertise also includes materials processing and device fabrication.

Dr. Adrian Dinescu coordinated 10 national research projects and was the coordinator from the Romanian part of the FP-7 STREP project - CATHERINE. He co-authored about 25 papers in refereed international journals.

Nano-Scale Structuring and Characterization Laboratory

Educational and training:

• ***Master courses and laboratory activities*** in collaboration with the Faculty of Electronics, Telecommunications and Information Technology - University "Politehnica" of Bucharest: Microsystems MSc program: "Microphysical Characterization of Micro- and Nanostructures";
Optoelectronics MSc program: "Electronic Technologies for Optoelectronic Applications".
• **Electronics Laboratory, Faculty of Physics** - University of Bucharest.

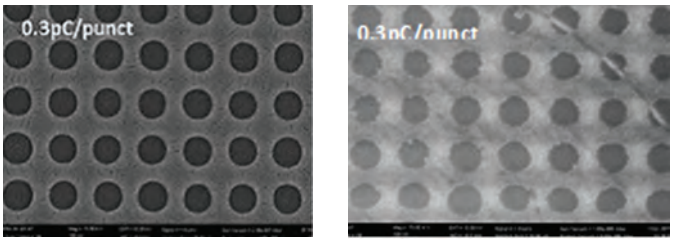
Main results

• Using e-beam litography for fabrication of plasmonic photodetectors on graphene

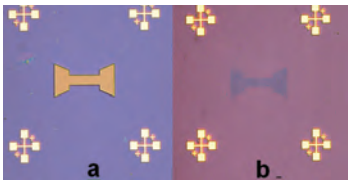
In metal-graphene-metal photodetectors, the junctions between metal and graphene separate the carriers generated by the incident light, electric power being thus obtained through the photovoltaic effect. Except for the case where contacts are fabricated from different materials, the generated photovoltages cancel due to symmetry. A possible solution to the problem consists in enhancing the local electrical field in the vicinity of one of the contacts using plasmonic nanostructures. This will result to an efficient conversion of the energy of incident photons absorbed in the respective area into energy of plasmons.
EBL technique, which ensures the resolution and flexibility required for this application, has been used both for patterning the plasmonic structures at nanometric scale and for configuring the electrical contacting pads. The plasmonic structure consisted in arrays of metallic lines with 230 nm, 300 nm and 400 nm pitch. The plasmonic structures were structurally integrated to metallic contact pads disposed on monolayer graphene ribbons.
The design, characterization and measurements conducted on the respective devices were carried in joint collaboration with benefiting specialized teams in IMT. (Core Project – PN Convert, PN 09290306- 2015).

• Bandgap opening in graphene by nanostructuring and fabrication of a FET transistor with structured graphene channel

The band gap, which controls the electrical conductivity of solids, is a fundamental concept for semiconducting materials. It is known that graphene shows no band gap around the Fermi level, but there are theories asserting the possibility of introduction of a band gap in graphene in a controlled manner.
One recently suggested way to achieve this goal consists in graphene patterning with gratings of circular cavities with diameters in the order of 100 nm and 200-300 nm pitch. Analytical calculations and simulations performed on FETs (Field Effect Transistors) with graphene channel structured in this way predict a value of the band gap around 0.1 eV, which is large enough to induce the saturation of the drain current.
By combining various micro-nano fabrication techniques such as electron beam lithography, reactive ion etching, thermal vacuum evaporation of metal films, lift-off methods etc, we have successfully manufactured graphene FETs with the channel patterned with circular cavities having diameters in the range of 100-200 nm and pitches of 200 nm, respectively 300 nm.



SEM micrographs of circular cavities with periodicity of 200 nm:
(a) fabricated in PMMA mask by e-beam litography,
(b) final view of graphene after RIE-etching



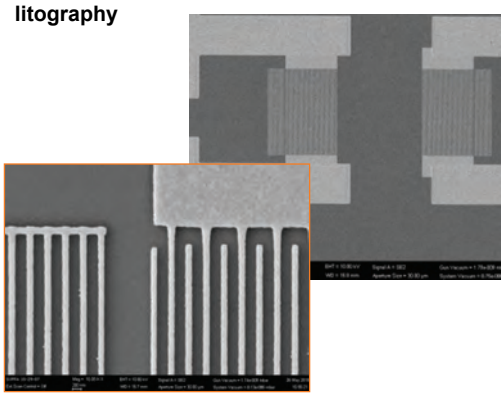
Patterning of graphene channel:
(a) in electron resist, (b) after RIE etching

Fabrication of gate electrode: (a) patterning, (b) metal deposition and lift-off

FET transistor with nanostructured graphene channel, after wire and die bonding

Services:

Nanometric scale structuring by electron beam litography

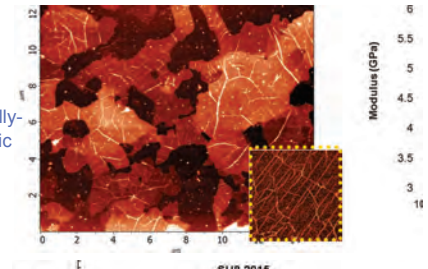


SAW (Surface Acoustic Waves) devices fabricated by EBL patterning of PMMA 950k

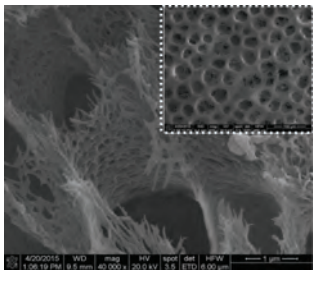
In 2015, L6 team published 17 scientific papers in ISI ranked journals (9 as a first author from IMT) and presented 9 communications at national and international conferences, from which 2 were invited papers and 3 of them were published in Proceedings.

Characterization of various materials and structures:

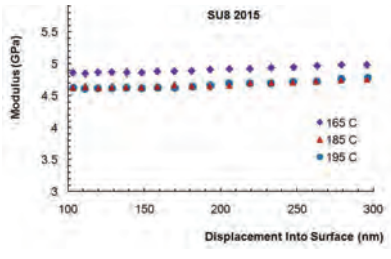
- Scanning Electron Microscope (SEM) (both conventional and field emission gun)
- Atomic Force Microscopy and adjacent techniques (SPM)
- Nano Indentation (Depth-sensing indentation techniques) for mechanical characterization at submicron scale.



AFM characterization Electrochemically-transfered CVD graphene from metallic substrate to SiO2
[insert: morphological details]



SEM imaging Nanopores into a polysulphone-polyaniline composite membrane [insert: overview of the macroporous surface]



Nano-Indentation The effect of thermal treatments on the Young's modulus of SU-8 negative photoresist used for MEMS devices

Centre of Nanotechnologies

Molecular nanotechnology laboratory

Mission

The lab was established in 2009, based on the necessity to integrate existing practical, analytical and numerical knowledge in areas of chemistry and (supra)molecular structures, functional materials, molecular dynamics, and atomistic modeling / simulation.

The main areas of interest are fundamental research and development of technologies for the fabrication of functional materials and micro / nanosystems based on synthesis and epitaxial MBE growth, physico-chemical modifications and structural optimization. The studies are directed towards understanding, and making use of, the mechanisms that provide new functions by combining the techniques of preparation and synthesis of 3D ... 0D substrates, controlled molecular attachments, theoretical modeling and numerical analysis by ab- initio and (semi)-empirical methods.

Activity areas

• Synthesis, development and characterization of physico-chemically modified nanomaterials, exhibiting properties suitable for applications in sensors, nanoelectronics and optoelectronics: carbon-based nanoparticles (carbon quantum dots, graphene quantum dots), metallic quantum dots, carbon nanotubes, graphene, nanocomposites.

• Development and characterization of micro/nanosystems and devices that integrate functionally optimized (nano)materials: LEDs, (electro)chemical/molecular sensors, solar cells.

• Development and characterization of III-N-(As) materials and related heterostructures of reduced dimensionality with various applications, such as solar cells.

• Analytical-numerical investigation of essential mechanisms responsible for creating new properties and/or for offering solutions for functional optimization of the developed nanomaterials: electronic structure modeling and simulation - DFT, semi-empirical DFT, molecular dynamics, BIE - physical/chemical adsorption mechanisms, absorption/emission spectra, plasmonic resonance modes.

International and National Cooperation:

- Clemson University, USA - Prof. Ya-Ping Sun
- University of Bucharest 3Nano-SAE Research Center, Prof. Ioan Stamatin
-Natl. Institute for R&D in Biological Sciences, Bucharest, Romania - Dr. Sandra Eremia, Dr. Simona Litescu
-"Babes-Bolyai" University, Cluj, Romania - prof. Simion Astilean, prof. Anamaria Elena Terec
-Université Catholique de Louvain, Belgium - prof. Sorin Melinte
-Institute of Physical Chemistry "Ilie Murgulescu", Bucharest, Romania and Forschungszentrum Jülich, Germany - Dr. Viorel Chihaia
-Tampere University of Technology, ORC, Finland – Prof. M. Guina, LAAS-CNRS Toulouse, France – Dr. C. Fontaine, University of Kassel- Prof. J-P Reithmaier
-"Eberhard Karls" University, Tübingen, Germany - prof. Dieter Kleiner, prof. Dieter Koelle
-Karlsruhe Institute of Technology, Karlsruhe, Germany - Dr. Di Wang
-Natl. Institute for R&D in Lasers, Plasma and Radiation Physics, Bucharest, Romania - Dr. Maria Dinescu
-University of Bucharest - prof. Adelina Ianculescu
-Loughborough University, UK - Dr. Boris Chesca
-Regensburg University, Germany - prof. Thomas Niehaus
-Le Havre University, France - prof. Jean-Louis Izbicki

Team:

• **Dr. Lucia Monica Veca** - CS I, PhD in Chemistry, Clemson Univ, USA, 2009

• **Dr. Antonio Marian Radoi** - CS I, PhD in Chemistry, Tor Vergata Univ., Italy, 2007.

• **Dr. Titus Sandu -** CS I, PhD in Physics, Texas A&M Univ., USA, 2002.

• **Dr. Emil-Mihai Pavelescu** - CS I, PhD in Technology, Tampere University of Technology, Finland, 2004.

• **Dr. Cristina Pachiu** - CS III, PhD in Physics, Univ. Le Havre, France, 2007.

• **Dr. Victor Leca** - CS II, PhD in Materials Science, Twente Univ., The Netherlands, 2003.

• **Dr. Radu Cristian Popa** - IDT I, PhD in Quantum Engineering and Systems Science, Univ. of Tokyo, 1998; Laboratory head.

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

Dr. Radu Cristian Popa received a MSc in Electrical Engineering (Applied Electronics) from the Polytechnic University of Bucharest (1989), and a PhD in Quantum Engineering and Systems Science at University of Tokyo (1998).

He was assistant professor in Electrical Engineering at the Polytechnic University of Bucharest (1991-1995), and Senior Researcher at the Science Solutions Intn. Lab., Inc., Tokyo (1998-2003), where he conducted competitive industrial research for various Japanese corporations, companies and universities, mainly in numerical modeling and analysis of complex phenomena and devices.

2003-2006, he was scientific associate at the University of Tuebingen, Germany and then became Development Director at Neurostar, GmbH, Germany, designing and developing hardware and software solutions for functional neurosurgery and neuroscience systems for brain microelectrode exploration and electrophysiological recording, and medical imaging.

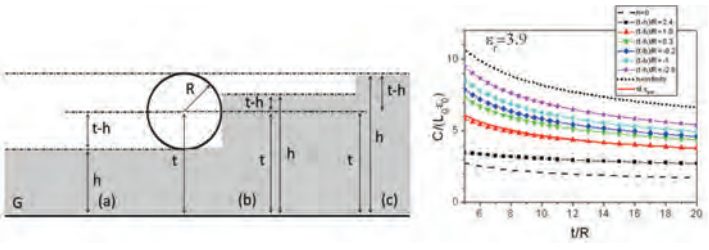
Radu Popa joined IMT Bucharest in 2007 and is presently director of the Center for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials. Main scientific interests include atomistic analysis of electronic transport in molecular junctions in the framework of the rational design paradigm for molecular scale electronics.

Results

The use of Boundary Integral Equation (BIE) method in nanotechnology

Contact Dr. Titus Sandu (titus.sandu@imt.ro)

BIE method can be used in various nanometric devices and applications. We have used this method in (a) numerical simulations and semi-analytical behavior of dielectric sensors based on back-gate capacitance in nanowire FET transistors; (b) calculation of dielectrophoretic force acting on a particle of arbitrary shape, and (c) calculation of surface phonon-polaritons in nanocrystals.



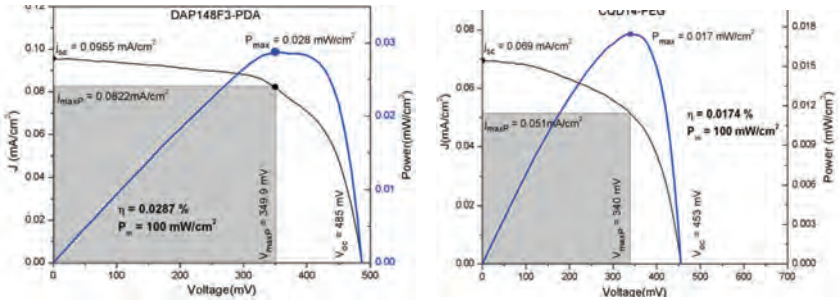
Cross-section view of a dielectric liquid sensor based on nanowire FET transistor (left). Variation of back-gated capacitance as a function of liquid height (right) [G. Boldeiu, V. Moagar-Poladian, T Sandu, "Dielectric Sensing with Back-Gated Nanowires", Rom. J. of Information Sci. & Tech. (ROMJIST), 17 (4), pp. 405–416, (2014)].

Results

Photovoltaic Grätzel devices using carbon quantum dots - CQD-PV

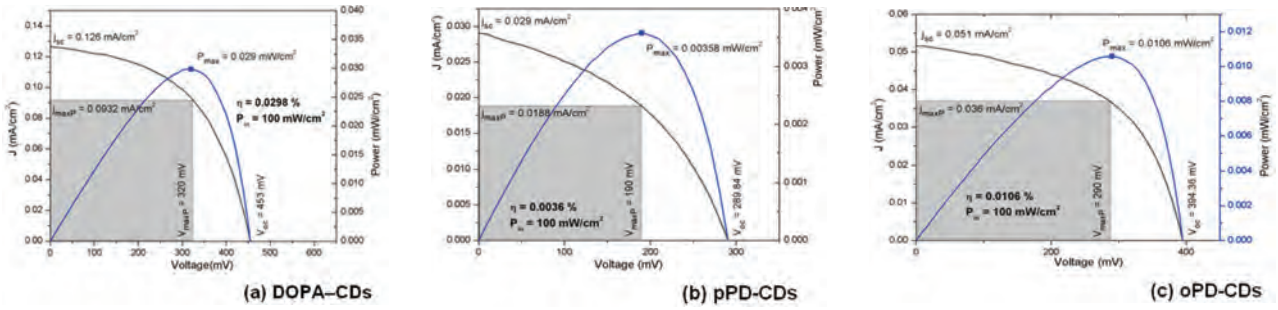
National Complex Ideas Project: PNII- ID-PCCE–2011- 2- 0069 „Carbon quantum dots: exploring a new concept for next generation optoelectronic devices" (2012-2015)

Contact Dr. Monica Veca (monica.veca@imt.ro); Dr. Cristina Pachiu (cristina.pachiu@imt.ro); Dr. Florin Nastase (florin.nastase@imt.ro).



Variations of current density and generated power with the applied voltage for CQD-PV, based on: (a) PDA-CD and (b) PEG-CD, under 100 mW/cm² illumination.

Nanostructured films of a wide-bandgap semiconducting mesoporous TiO2 have been sensitized with carbon quantum dots (e.g. 1,3 diaminopropane – PDA-CD; diamine-terminated oligomeric poly(ethylene glycol) PEG-CDs; p-and o-phenylene diamine – pPD-CDs and oPD–CDs, as well as dopamine – DOPA-CD). The analytical characterizations show various effects of the sensitizing approach on the cell performance.



Variations of current density and generated power with the applied voltage for CQD-PV, based on: (a) dopamine, (b) p-Phenylenediamine, (c) o-Phenylenediamine, under 100 mW/cm² illumination.

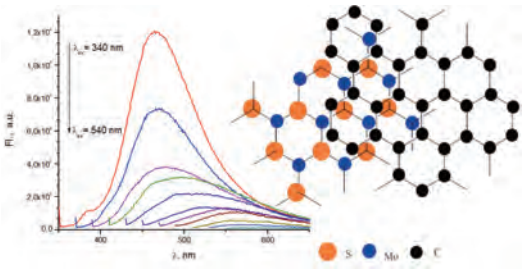
Nanocomposite of MoS2 and GQDs, functionalized with polyethylenimine

Project PN-II-RU-TE-2014-4-1095 "Hybrid flexible interface for energy applications–HYFLEP" (2015-2017)

Contact Dr. Antonio Radoi (antonio.radoi@imt.ro)

We study graphene based materials (Gbm) that can be integrated in new photovoltaic devices such as Gbm/Silicon heterostructures. As functional material, we concentrate mainly on graphene nanoparticles (graphene quantum dots - GQDs).

GQDs modified with $–NH_2$ and polyethylenimine groups were obtained by microwave-hydrothermal processing of glucosamine. The MoS_2 - GQDs nanocomposite confers improved electronic transfer properties when used to modify carbon based electrodes.



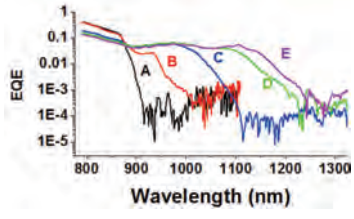
Fluorescence emission spectra of modified GQDs, and the structure of the GQD-MoS_2 nanocomposite.

InAs/GaAs quantum dots for high-efficiency solar cells with strain-engineering Ga(In)Nas layers

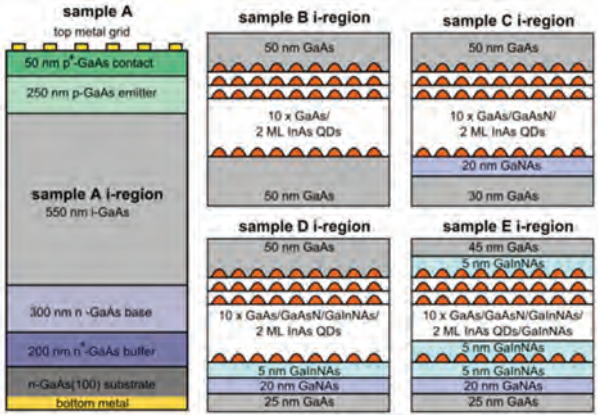
Proiect: 23SEE/30.06.2014 "III-N-(As) alloys and engineered heterostructures for high efficiency intermediate band solar cells" (2014-2016) - contact Dr. Emil-Mihai Pavelescu (emil.pavelescu@imt.ro)

The project objective is related to the MBE-based growth of 3D settings of In(Ga)N/BInGaN/GaN quantum dots with engineered strain for high efficiency intermediate band solar cells (IBSCs).

In pursuit of the validation of mediated strain's concept for the synthesis of quantum dots and its 3D settings used in solar cells, heterostructures containing 10 layers of quantum dots with compensated and mediated strain InAs/(In)GaNAs/GaAs have been synthetized by MBE (at the co-laboratory ORC/TUT, Tampere, Finland). An amelioration of the optical properties of the quantum dots has been noticed, due to the insertion of the mediated strain layer next to the quantum dots layer, hence validating the proposed concept. It has also been noticed that the improvement brought by the mediated strain layer is more effective when the insertion of the mediator strain layer takes place immediately after the synthesis of the quantum dots.



External Quantum Efficiency (EQE) measured on the samples A, B,C,D and E.



The structures of quantum dots solar cells labeled with A, B, C, D and E. The contact layers, the emitter and the base are similar in all the samples, while the intrinsic regions are different.

Simulation, Modelling and Computer Aided Design Laboratory

Mission

Research, development and applications of simulation, modeling and design techniques of micro-electro-mechanical and microfluidic systems oriented to collaborative research projects, **education** (courses, labs), **services** (enabling access to hardware and software tools) and consulting (design/optimization) in the field of micro-nano-bio/info technologies.

The lab L5 plays a key role in supporting the research activities of other laboratories of IMT Bucharest. Further, L5 is developing **techniques for rapid prototyping** from micro- to macro scale, micro-sensors and MOEMS and MEMS actuators and investigate new classes of advanced materials with applications in nanodevices (thin films and nanostructures from oxide semiconductor materials).

Expertise

• **Design (lay-out), simulation and development/optimization of MEMS/MOEMS** devices and components (cantilevers, membranes, microgrippers) and microfluidic (valves, pumps, microchannels, mixers, filters) for microelectronic and biomedical applications;

• **Modeling and simulation for multiphysics problems;** mechanical, thermal, electrical, piezoelectric, **as well as coupled field** (static and transient) **analysis**;

• **Rapid prototyping**: 3D Printer (SLS, respectively, a single-photon-absorbed photopolymerization);

• **Design and manufacturing** of MOEMS and MEMS microsystems/ actuators and microsensors;

• **Characterization of physical phenomena** in wide band gap semiconductors;

• **Technology development** for preparing and doping process for ZnO transparent films and nanostructures, with potential in different device applications, in transparent electronics, photovoltaic cells, functional sensors in UV domain including operating in harsh environments and space.

• **Atomistic simulations** and analysis by ab initio calculations of the electronic structure in the presence of impurity doping and defects for semiconductor materials.

Equipments

■ **Hardware:** - Dual IBM 3750 Server, 8 quad-core Intel Xeon MP 2.93 GHz, 196 GByte RAM and 1 TByte HDD + 876 GByte external storage;

■ **Classroom equipped with computer network for training;**

■ **Software for Modelling and simulation:**

COVENTORWARE 2014 – software package dedicated to design, modelling and simulation for MEMS and microfluidics. It contains modules for design (2D layout, 3D models generator) and simulation modules for main physical phenomena in microsystems functionalities and development.

SEMulator3D – generating complex 3D models for thin films, structures and devices obtained by silicon technology.

COMSOL 5.1 – Software package for simulation of physical phenomena: mechanics of solids, heat transfer, fluidics, acoustics, RF-MEMS.

ANSYS Multiphysics 12.1 – software package for FEM simulations taking into account several physical phenomena (mechanical, thermal, electromagnetic, fluidic and coupled). Ways for realizing complex simulations: Sequential method (thermal-structural, electromagnetic-thermal-structural, electrostatic-fluidic-structural, CFX and FLOTRAN) and, respectively, Direct coupling (acoustic-structural, piezoresistive, piezoelectric, electromagnetic, electro-thermo-structural-magnetic).

MATLAB R2015b – mathematical software: numerical computation, visualisation and programming. It can be used to mathematical calculations, algorithm development, data acquisition, modeling and simulation, data visualization, data analysis, scientific and engineering graphs, application development (including graphical user interface);.

SOLIDWORKS – design software for 2D and 3D complex geometry, capable to export CAD files to other simulation software tools; it has additional modules for projects reporting and for growing the productivity of CAD and PDMWorks. It includes management solutions for design data, suited to single or group management of SolidWorks projects.

MATHEMATICA 7 – Software for numeric and symbolic calculus; suitable for solving linear and non-linear equations, integral and differential equations, statistics, 2D and 3D graphics.

ORIGINPRO 8 – Software for data processing: graphic, interpretation/ interpolation by statistical processing.

■ **Characterization facilities:** - Semiconductor Characterization System Manual Probe Station Model-4200 SCS/C/Keithley, EP6/Suss MicroTec.

■ **Technology:** - 3D Printer Selective Laser Sintering EOS Formiga P100

- 3D Printer based on Single Photon Photopolymerization MiniMultiLens system from EnvisionTEC

- Laser microengraving system

Research team:

PhD. Raluca Muller, senior researcher I, PhD in electronics, laboratory head
PhD. Rodica Plugaru, senior researcher I, PhD in physics
PhD. Gabriel Moagar-Poladian, senior researcher II, PhD in physics
PhD. Oana Tatiana Nedelcu, senior researcher III, MS in mathematics and PhD in electronics
PhD. Franti Eduard, senior researcher III, PhD in electronics
Phys. Constantin Tibeica, senior researcher, physicist
Phys. Victor Moagar-Poladian, technological development Eng. III, physicist
PhD. Rodica-Cristina Voicu, senior researcher III, PhD in mathematics
PhD. Eng. Anca ISTRATE, senior researcher III, PhD in materials engineering
Eng. George Boldeiu, MS in electrical engineering
Eng. Angela-Mihaela Baracu, scientific researcher, PhD student in electronics
PhD. Lucian Petrica, PhD in electronics
Eng. Ramona Corman, MS student in electronics

Laboratory Head: Dr. Raluca Müller (raluca.muller@imt.ro)

Dr. 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. R. Müller is 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 100 scientific papers presented at conferences and published in journals (Sensor & Actuators, J. of Micromechanics and Microengineering, Appl.Optics., Journal of Luminescence, Thin Solid Films, etc).

Simulation, Modelling and Computer Aided Design Laboratory

Services:

● Computer aided Modelling and Simulation (using FEM, FVM, BEM) for MEMS/NEMS and microfluidic systems;

● Electrical I-V and C-V characterization for semiconductor research and test. I-V low current, pulsed I-V, capacitance vs. voltage (C-V), capacitance vs. frequency (C-f), and capacitance vs. time (C-t) measurements, characterization of oxides trapping phenomena. Measurements in the temperature range: 77-400 K;

● Synthesis and deposition by sol-gel-spin coating of thin films with different electrical properties (resistivity), optical properties (transmission, absorption) and photoluminescence for applications in electronics, sensors, transparent conductive coatings of different substrates;

● Rapid prototyping using 3D Printer Selective Laser sintering for the following applications:

- Manufacturing of models for design, architecture, educational purposes;
- Manufacturing of molds;
- Manufacturing of robotic components having certain degrees of freedom;
- Manufacturing of customized housings and encapsulations of different types for MEMS structures;
- Manufacturing of macro scale models of MEMS devices for testing their concept and working principle;

● Trainning for MASTER studens: courses, laboratories and internship

National and International collaborations:

• **ECSEL-H2020: 3Ccar: „Integrated components for control in electrified cars", (2015 – 2018)** Coordonator: Infineon Technologies AG Germany, IMT Partner - Dr. Gabriel Moagar-Poladian;

• **EraNet**: "3 Scale modeling for robust -design of vibrating micro-sensors" (3SMVIB), 2012-2015 – Coorinator Open Engineering SA. Belgium, Project responsible from IMT- Dr. Raluca Müller;

• **IDEAS Project:** "Prospective research regarding rapid prototyping processes for applications in the field of micro and nanosystems realization", (2011–2014), Project Director: Dr. Gabriel Moagar-Poladian;

• **STAR:** „Investigation of semiconductor oxide materials performance for space environment applications" (MATSPACE) Project: nr.94/2013-2015, IMT Coordinator, Project director: Dr. Rodica Plugaru;

• **STAR**: "Reliability design of RF-MEMS switches for space applications" - REDEMS Project, 2012-2015, UTCN Coordinator, IMT Partner - Dr. Raluca Müller

• **STAR**: "Tribomechanical Characterization of MEMS Materials for Space Applications under harsh environments"- MEMSMAT Project, 2013-2016 UTCN Coordinator, IMT Partner; Dr. Raluca Müller

• **Project PN II:** "Micro-electro-fluidic system for biological cells separation and electroporation - MEFSYS", Contract no 30/2014-2017, Coordinator IMT, Project Manager: Dr.Oana Nedelcu;

• **Proiect PN II:** "Development of new electro-insulating nanocomposite materials for increasing durability of electric motors"; Coordinator ICEMENERG, IMT; Partner: Phys.Victor Moagăr-Poladian;

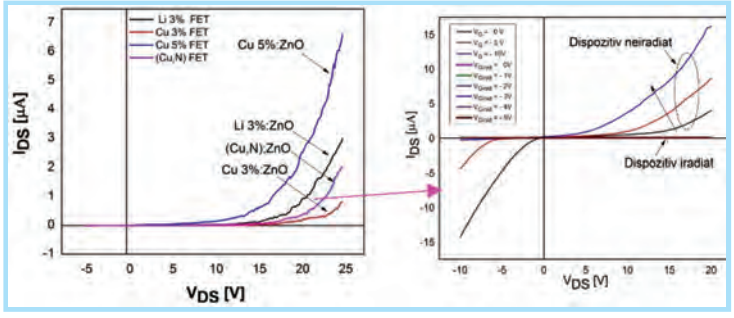
• **Basic Funding Project:** MEMS microsystems for manipulation in micro-robotics, National Program CONVERT-PN0929;

• **POSDRU- "ELAMAN"** Support for students for a successful career in the field of applied electronics in medicine, automatics and nanotechnologies" UPB Coordinator, IMT partner - Dr. Raluca Müller.

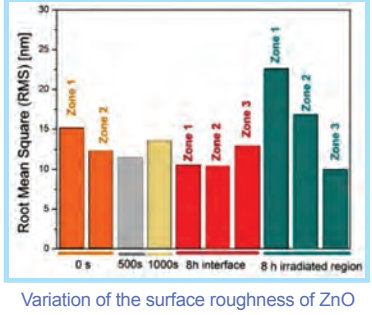
Scientific Results

► **Project STAR** Nr.94/2013-2015; Coordonator IMT, Director: Dr. Rodica Plugaru; Partner INCDFM)

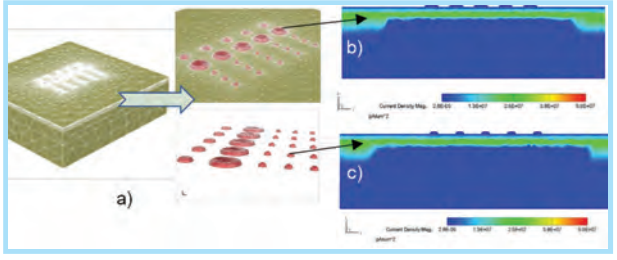
- Assessment of alpha particle irradiation effects, at (3 MeV, 5.3 kGy) for different periods of time (100s – 8 hours) on the micro-nanostructure and opto- electrical properties of undoped and doped ZnO thin films.
- Determination of radiation-induced defects formation mechanisms in ZnO thin films.
- Assessment of gamma radiation effects at (100kGy, 200kGy) on the I-V characteristics of FET devices with ZnO thin films.
- Simulation of defects induced by radiation at the surface of ZnO thin films. Numerical analysis with finite element of the effects of radiation-induced defects on the electric and coupled electro-thermal behavior of FET devices.



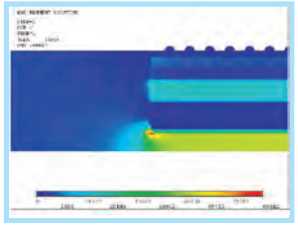
Electrical characteristics of FET devices with channel formed by ZnO thin films doped with Li, Cu, (Cu, N):ZnO, after exposure to gamma radiation at a dose of 200 kGy.



Variation of the surface roughness of ZnO films after irradiation with alpha particles with 3 MeV energy and dose of 5.3 kGy for 100 s, 500s, 1000 s and 8h.



3D structure of a ZnO thin film with surface defects, meshed (Coventorware 2010) (a). Current density distribution in the film cross section, corresponding to defects whose radius are: R = 100 nm (b) and R = 50 nm (c).



Temperature distribution in a ZnO thin film cross section in the presence of surface defects induced by radiation. (ANSYS 12.1.).

Scientific Results

► Project IDEA No. 62 / 2011 (2011 – 2016) (Coordonator: Dr. Gabriel Moagăr-Poladian)

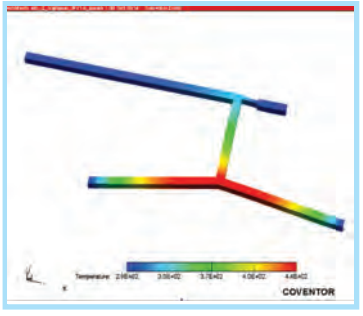
A novel type of device that can be used in nanolithography (including 3D) was conceived. It is a chip that contains a number of independent cantilevers that are controlled from a single computer. These cantilever can provide different nanolithography processes such as dip pen nanolithography, electric field assisted dip pen nanolithography, fountain pen nanolithography, local electrochemical deposition (metal). Each cantilever provides a unique, specific process different from all the others. On the same chip are also a number of independently controoled cantilevers that are used for micro-nanoscale characterization (AFM, MFM, SNOM, etc.). This concept integrates a number of SPL (Scanning Probe Lithography) type processes in a single tool and has as goal the reduction of cantilevers contamination. Subjected to patenting at OSIM. An alignment procedure between the different cantilevers was also devised. The alignment is improved in the case if our chip as compared to teh situation when different machines / sub-assemblies are used, each with its own cantilever.

► Basic Funding CONVERT- Project PN09290209 - MEMS manipulation microsystems for micro-robotics

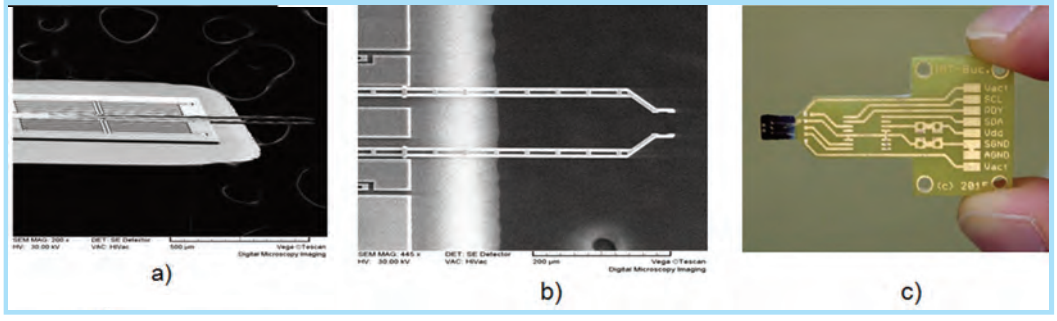
(Contact: Dr. Rodica Voicu; Fiz. Catalin Tibeica, Dr. Raluca Müller)

- Design, simulation and experimental manufacturing for micromanipulation MEMS structures, based on electrothermal actuators with V shape were realized. Coupled thermo-electro- mechanical simulations (Coventorware 2014) were performed, for an actuation voltage.The biocompatible polymer SU8 and a Cr/Au/Cr sandwich were utilized for manufacturing the microgripper. To validate the final structure microphysical characterization and electrical tests were carried out.

- It was realised a micomanipulator demonstraor (microgripper) manufactured using a SOI wafer, with electrostatic actuation.



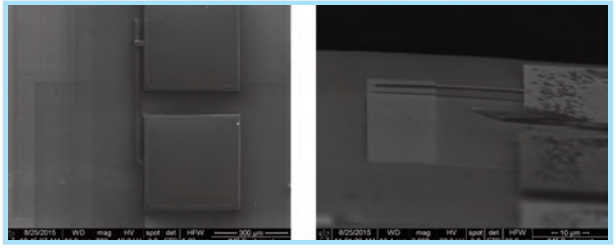
Themperature distribution for a micro-gripper, for a 0.1V actuation voltage-simulation with Coventorware- 2014- Contact Dr. Rodica Voicu



a) andi b) SEM Image of a microgripper realised uisng a SOI wafer
c) Optical Image of the electronic wiring for signal processing and the gripper chip - Contact: Fiz. Catalin Tibeica

► ERANET, nr. 7-063/2012 -3SMVIB (2012-2015); Coordinator Open Engeneering Liege- IMT Partner (Dr . Raluca Müller)

- Fabrication of doped polysilicon cantilevers with 1 µm thickness, used for vibrational measurements.



Polysilicon cantilevers with a thickness of 1 µm, with doped polysilicon actuation electrode (SEM Images)-
contact Drd. Angela Baracu, Dr. Rodica Voicu

► Project PN II "Micro-electro-fluidic system for biological cells separation and electroporation - MEFSYS" (2014-2017)

Coordonator IMT, Dr. Oana Nedelcu; Partners: SC Spital LOTUS SRL Ploiesti; DDS Diagnostic SRL Bucuresti; University of Bucharest, Faculty of Chemistry; University of Politehnica Bucharest, Faculty of Applied Sciences

- Design and coupled simulations of an optimized microsystem with integrated components for two configurations (Fig. 1). Coupled electric, flow under pressure and dielectrophoretic (DEP) simulations were performed for virtual experimental model of microsystem. Simulations were made for Cytofast solution containing cervical cells at various applied voltage between 5-20 V. After electroporation, cells are handled as function of positive/ negative DEP mobility trough exit channels. The porated and unaffected cells can be separated in distinct regions by applying the appropriate frequency.

- **Masks design, glass channels microfabrication and two versions of electrodes on silicon substrate**. (Fig. 2)

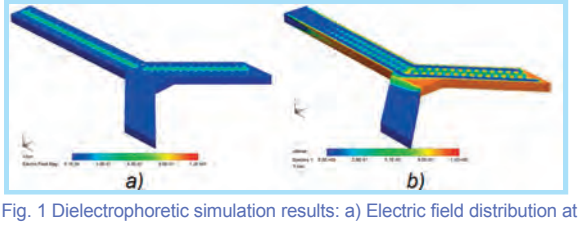


Fig. 1 Dielectrophoretic simulation results: a) Electric field distribution at 10 V; b) Cels distribution (µMoles) after 5s

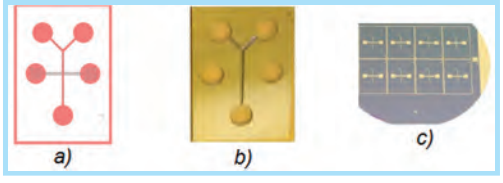
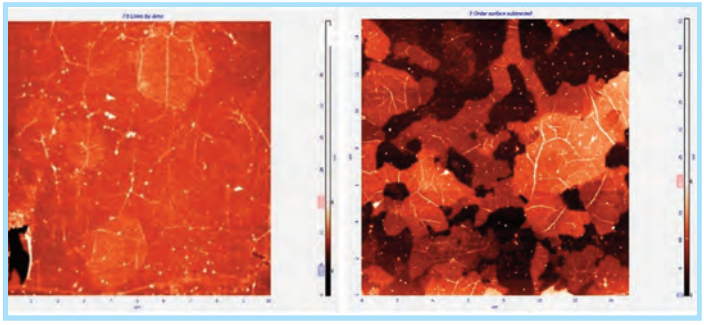


Fig. 2 Structure configuration: a) Mask (Clewin);
b) Glass microfluidic structure c) Electrodes on wafer

Simulation, Modelling and Computer Aided Design Laboratory

Scientific Results

► Basic Funding CONVERT, Project PN09290112: Results for "Advanced methods for transfer of graphene on inorganic and organic substrates" (Contact - Dr. Anca Istrate)



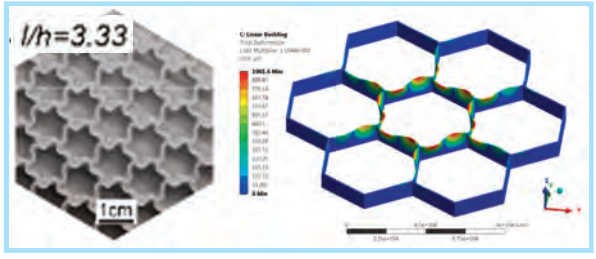
AFM images of graphene surface after transferred from Cu foil (a) and from Ni (b) onto SiO2/Si.

- Experimental realization of a graphene transfer from copper and nickel onto anorganic substrates (Si/SiO2, quartz) by Electrochemical Delamination and onto organic substrates (PVA/PEN) by Laminating (Contact Dr. Anca Istrate, Dr. Monica Veca, Dr. Florin Nastase).
- Synthesis of ZnO nanostructure arrays, nanorods type, by microwave- assisted process.

[1] C. F. Comanescu, A.I. Istrate, L. M. Veca, F. Nastase, R. Gavrila, M. Purica, Micro-Raman Spectroscopy of graphene transferred by wet chemical methods, CAS 2015 Proc. P67-70, ISBN: 978-1-4799-8862-4, ISSN: 1545-827X.

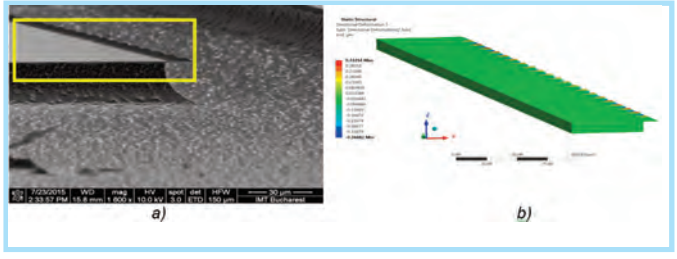
► Simulations performed with ANSYS (Contact: Fiz. Victor Moagar Poladian)

A simulation made in IMT of the deformation caused by a residual compressive force on a celular hexagonal lattice, compared with the experimental result of stress induced by swelling in a similar structure made of silicone rubber and presented in the paper Buckling-Induced Reversible Symmetry Breaking and Amplification of Chirality Using Supported Cellular Structures ; authors Sung Hoon Kang, Sicong Shan, Wim L. Noorduin, Mughees Khan, Joanna Aizenberg,* and Katia Bertoldi; Adv. Mater. 2013.



a) b)

a) Cellular structure with swelling-induced chirality (Adv. Mater. 2013,; b) FEM simulation of a cellular structure made in IMT regarding its defformation as a consequence of the compressive stress



a) b)

a) Cellular structure with swelling-induced chirality (Adv. Mater. 2013,; b) FEM simulation of a cellular structure made in IMT regarding its defformation as a consequence of the compressive stress

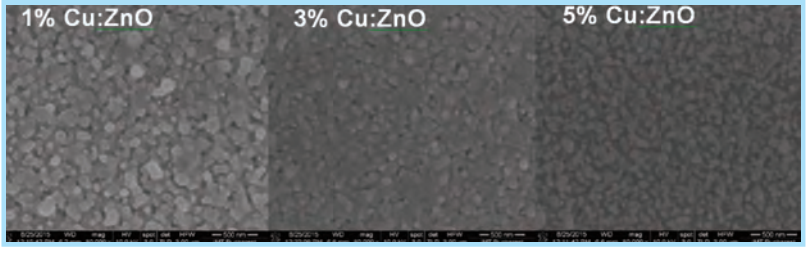
Buckling simulation of a microstructure fabricated in IMT and compared with real sample. The structure is in the post-buckling equilibrum configuration.

► ELAMAN Project, POSDRU/161/2.1/G/135812,

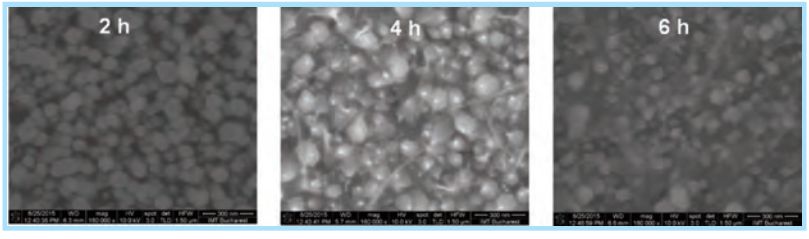
Coordinator UNiv. "polytechnic" Bucharest, IMT Partener: Dr. Raluca Müller (2014-2015) : Internship superviser: Dr. Anca Istrate.

Internships training to achieve a successful professional career in electronics applied in medicine, automation and nanotechnologies.

- ZnO thin films synthesized by sol-gel method and morphological, structural, optical characterization;
- ZnO nanowires synthesized by hydrothermal method and morphological, structural, optical characterization;



FEG-SEM images of thin films surface deposited by spin-coating



FEG-SEM images of ZnO nanowires surface synthesized by hydrothermal process

Activities counseling and career guidance for students within IMT Bucharest: activity domains presented within institute; informative materials presentation; visiting of IMT-MINAFAB infrastructure; student participation at scientific seminars; research on specific topics, personalized, depending on students preference / skills within summer internships.

Mission

Elaborating and using working instruments for assessing, improving and monitoring the reliability of sensors, actuators, micro-systems, nano-structures and electronic components. These actions have to be performed based on a Concurrent Engineering approach, i.e. starting from the project phase and continuing during product development and usage in real life.

Domains of activity

Reliability building: Design for Reliability (DfR), Design for Manufacture (DfM), Monitoring and screening of micro and nanostructures, Reliability of components in Harsh Environment (e.g. space, aeronautics, automotive, geology, nuclear, etc.), Robust Design (e.g. developing biosensors for monitoring the environment quality).

Reliability assessing: Accelerated testing of micro and nanostructures, by using simple or combined stresses (which are simulating appropriately the real life and allow a higher acceleration of the tests), Failure analysis and physics, Analysis of virtual prototyping, Usage of fuzzy logic for reliability evaluation.

Standardization: Certifying, Qualification and periodic tests, Elaborating standards and other documents.

Team

In 2015, our team had six graduated engineers of Politehnica University from Bucharest (the first five followed Electronic, Telecommunications and Information Technology Faculty and the 6-th, Engineering and Technological System Management Faculty):

- **PhD Marius Bâzu** (up to September 2, the former Head of L7), Scientific Researcher 1st degree;
- **PhD Lucian Gălăţeanu**, Scientific Researcher 1st degree;
- **Virgil Emil Ilian,** Scientific Researcher 2nd degree;
- **Niculae Dumbrăvescu**, Scientific Researcher 3rd degree;
- **Dragoş Vârşescu** (from September 24, the new Head of L7), Electronics Engineer;
- **Roxana Marinescu**, Research Assistant.

Development of research infrastructure

In 2015, our Institute IMT ended the implementation of the POSCCE project: Nanotechnologies Research Center dedicated for Integrated Systems and Advanced Nanomaterials based on Carbon - CENASIC. In the framework of this project, L7 coordinated the development of research infrastructure for the reliability domain. New equipements have been bought, new working teams appeared and it has been created spaces for two new labs: Electromechanical and Reliability Testing Laboratory and Electromechanical Probe Preparation Shop. Mr. Dragos Varsescu has been charged to integrated them into L7 (Order no. 85/24.09.2015). Our institute having now a performant research infrastructure in reliability domain, at european level, may sustain advanced research in this field.

Some of our new equipments bought in 2015 are showed as follows:

Data Acquisition System - NI PXIe-1078 with:

- NI PXIe-6341 (X Series Multifunction DAQ);
- NI PXI-2501 (Low-Voltage Multiplexer/Matrix FET Switch);
- NI PXI-5114 (250 MS/s, 8-Bit Oscilloscope/Digitizer);
- NI PXI-4065 (6½-Digit PXI DMM);
- NI PXI-5402 (20 MHz Arbitrary Function Generator).

LRC Bridge – Rohde&Schwarz HM8118

- Measuring range: 20Hz to 200 kHz (69 steps);
- Basic accuracy: 0.05%;
- Measurement rate: up to 12 values/s;
- Automatic or manual selection of circuit type (serial, parallel).

Oscilloscope Teledyne LeCroy - WaveSurfer 3024

- 200 MHz, 350 MHz, 500 MHz, 750 MHz bandwidths;
- Long Memory – upto 10M pts/Ch;
- 10.1" touch screen display;
- WaveScan –Advanced Search and Find;
- LabNotebook Documentation Tool;
- History Mode – Waveform Playback;
- Serial Data Trigger and Decode;
- 16 Digital Channels with 500 MS/s Sample Rate;
- Wave Source Function Generator;
- Digital Voltmeter;
- Mixed Signal Debug Capabilities:

Analog and Digital Cross Pattern Triggering;
Digital Pattern Search and Find;
Analog and Digital Timming Measurements;
Activity Indicators.

Lock-In Amplifier Stanford Research System SR 865

-1 mHz to 2 MHz (operates to 2.5 MHz);
- Low noise voltage and current inputs;
- 1µs to 30 ks time constants;
- High bandwidth outputs;
- Touchscreen data display – large numeric results, chart recordings & FFT displays;
- 10 MHz timebase input and output;
- GPIB, RS – 32, Ethernet and USB;
- HDMI video output.

Reliability Laboratory

Electromechanical and Reliability Testing Laboratory and Electromechanical Probe Preparation Shop

International and National Cooperation

International Cooperation

- With European Space Agency in the project: PROBE-3 ASPIICS OPSE HARWARE - Contract No. 4000111522 / 14 / NL / GLC;

National Cooperation

- With the virtual network ROMNET-LAB.CER.IN composed by 16 legal entities (research institutes and trading companies from Bucharest): R&D Institute for Mechatronics and Measurement Technique, R&D Institute for Microtechnology (IMT), R&D Institute - ECOIND, R&D Institute for Textile and Leather, R&D Institute for Materials Physics, Physics and Nuclear Engineering Institute – Horia Hulubei (IFIN), R&D Institute – MRR, ICECHIM, R&D Institute for Electrical Engineering (ICPE-CA), Computing Technique Institute (ITC), R&D Institute (INMA), GEOECOMAR, CEPROCIM, PRO-OPTICA, INTEC and UTTIS.
- With Microscopy – Microanalysis and Information Processing Centre, supervised by Prof. G. Stanciu from Politehnica University, Bucharest;
- With EUROQUALCOM (Quality, Reliability and Information Technology Centre) supervised by Prof. I. Bacivarov from Politehnica University, Bucharest;
- With Honeywell Romania - Sensors Laboratory Bucharest – SLB, in the field of reliability;
- With ProOptica in the ESA program framework: PROBE-3.

Scientific results

Participation in the project with ESA: PROBE-3 ASPIICS OPSE - Contract No. 4000111522 / 14 / NL / GLC:

• functional OPSE models were manufactured and then sent to INAF Italy for characterization;

• documentation on quality aspects of OPSE was elaborated;

• testing programs for LEDs and OPSE module were defined to proof and demonstrate their quality, in accordance with the requirements of PROBE-3 program. The testing programs will continue until the final accomplishment of OPSE module.

In the framework of the same program we executed on specimens supplied by ProOptica different tests including: sinusoidal/random vibrations, mechanical shock, thermal cycles and damp heat.

Equipment

• Temperature storage: *UFB 400 / MEMMERT*
Temperature: +5°C.…+220°C (above ambient temperature);
Volume : 53 l

• Temperature + Low pressure: *VO 400 / Memmert*
Temperature: +25°C…+200°C (above ambient temperature);
Presssure: 10…1100 mbar; Volume: 49 l

• Temperature + Humidity: *CH 160 / Angelantoni*
Temperature: -40°C…+180°C
Humidity: 20…95% RH : Volume : 160 l

• Temperature + Humidity + High pressure (HAST):
EHS-211M / ESPEC EUROPE GmbH
Temperature: 105°C…142°C; Humidity : 75%...100%:
Pressure : 0.02…0.196 Mpa; Volume: 18 l

• Thermal cycling: *TSE-11-A / ESPEC EUROPE GmbH*
2 Chambers Method with fast switching speed;
Low temperature: -65°C…0 / High tmperature: +60°C…+150°C;
Volume: 11 l

• Vibrations + Temperature + Humidity: *TV 55240/LS / TIRA*
Vibrations DC…3000 Hz; Temperature: -30°C…+150°C;
Humidity: 10%...95%; Maximal weight 100 Kg; Volume: 250 l
Climatic chamber CH250 / Angelantoni temp range: -40°C ... 180°C;

• Mechanical shock (Free fall): *MRAD 0707-20 – Free Fall Shock Machine / Cambridge Vibration*
Transport table: 7 in x 7 in; Maximal height of the specimen: 10 in;
Maximal falling height of the transport table: 60 in;
Maximal acceleration: 4500 g

• Semiconductor characterization System: *4200 SCS / Keithley*
Stimuli: DC voltage: < 100V, DC current: < 1A;
Impuls: analogic signal 30V, <40MHz;
Measurements: voltage 0.5 µV, current 1 fA

• Thermal conditioning: *TP04300A-8C3-11 7 Thermo Stream / Temptronic*
Temperature variations: - 80°C to +250°C, with transition time:
up 7 sec, down 20 sec; Temperature control: +/- 0.1°C

• Thermal analysis: *IR Microscope SC 5600 + G3 L0605 / FLIR Systems*
Sensor: InSb, Resolution (pixels): 640 x 512: Calibrated range of temperature: -20°C … +3000°C

Centre for Research and Technologies Integration

Microsystems for Biomedical and Environmental Applications Laboratory

Mission

The Laboratory's main activity is research and development on microsensors (chemical, bio and mechanical), microstructures and microelectrodes, microprobes for detecting the electrical activity of cells and tissues, integrated microfluidic technologies (in silicon, polymers or biomaterials), signal processing, data acquisition and graphical interfaces, platforms and integrated systems development for food monitoring and biomedical applications, as well as education in micro-chemo-biosensors and technology, design and simulation services for applications using bio-, chemo-, or micromechanical sensors.

Research Team

Our research team is comprised of 14 members, specialising in areas such as Electronics, Physics, Chemistry and Biology:

1. **Dr. Carmen Moldovan** - CS I, PhD in Electronics
2. **Dr. Nicolae Marin** – CS I, PhD in Electronics
3. **Rodica Iosub** - CS III, Chemist;
4. **Cecilia Codreanu** – CS III, Engineer;
5. **Daniel Necula** - CS III, Engineer;
6. **Bogdan Firtat** - CS III, Engineer;
7. **Dr. Marian Ion** - CS, Physicist;
8. **Silviu Dinulescu** – AC, Engineer;
9. **Adrian Anghelescu** - CS III, Engineer;
10. **Costin Brasoveanu** – CS, Engineer;
11. **George Muscalu** – Junior Engineer;
12. **Ioana Ghinea** – Technician, chemical engineer;
13. **Roxana Vasilco** – CS III, Biologist;
14. **Alina Popescu** – CS III, Chemist.

Laboratory head: Dr. Carmen Moldovan,

(carmen.moldovan@imt.ro)

She graduated on Electronics and Telecommunications and she owns a PhD in Microsensors.

She was responsible from IMT side in the TOXICHIP project, 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 IP (IST), dealing with technology convergence and integration and virtual design and manufacturing.

She is the coordinator of PESTIPLAT (MNT-ERANET project) and several national projects in the area of integrated sensors and microfluidic devices for pesticides detection and neural cells monitoring. Dr. Moldovan is also coordinating the Romanian activities within the FP7-HEALTH PARCIVAL project. She is a member of IEEE. The scientific activity is published in more than 70 papers in journals, books and communications in Proceedings.

Main areas of expertise

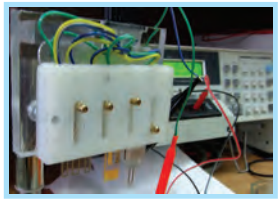
Micro-Nanosensors - Development of microsensors (chemoresistive, resonant gas sensors, accelerometers, micro-arrays, ISFET sensors, nanowire-based sensors, electrodes for biological sensors, microprobes for recording electrical activity of cells and tissues);

MEMS devices for energy harvesting - MEMS based piezoelectric harvester for biomedical applications and space technology;

Modules and microfluidic chips - Simulation, modelling and development of microfluidic platforms: microchannels, tubes, microfluidic connectors, reservoirs and mini pumping systems;

Sensor platforms, Integrated systems - Platforms which integrate microsensors with microfluidic systems, data acquisition, signal processing and grafical interfaces, working autonomously and with autonomous power; Simulation and modelling – simulation/modelling using CAD tools specific to MEMS (CoventorWare, COMSOL, CADENCE).

Equipment



Ink Jet Printer-capable of depositing picoliter droplets of conductive fluids (liquid silver or organic inks) on a wide range of surfaces, including flexible ones: Poly-Ethylene-Terephthalate (PET) substrates, Poly-Ethylene-Naphthalate (PEN) and Poly-Aniline (PANI);

VoltaLAB 10-all-in-one electrochemical laboratory, with all-in-one PGZ100 potentiostat, electrochemical software Voltamaster 4, for cyclic voltammetry analysis, chronoamperometry and impedance spectroscopy;

CNC (Computer Numerical Control)-Miniaturized tool for mechanical processing with design and control software running on Linux machine. The CNC equipement is used to develop microfluidic components and fabricate various mechanical interfaces for connecting our sensors with the measurement instruments.

International and national collaborations

• *International cooperation* with research institutes and renowned companies in the field, from Slovenia, Hungary, Poland, as part of European research projects:

• **PIEZOMEMS** - Piezoelectric MEMS for efficient energy harvesting M-ERA.NET (IMT, ICF, Romelgen, Romania, Jožef Stefan Institute, HIPOT RR, Slovenia), coordinated by our laboratory;

• **WATERSAFE** - Materials for Sustainable and Affordable Low Carbon Energy Technologies – M ERA.NET (ICF, IMT, NANOM MEMS, Transilvania University - Romania, ITE and Pannonia Unversity - Poland) – coordinated by ICF;

• *Cooperation with research institutes and universities* (INFLPR, „Politehnica" University Bucharest) and Romanian firms (ROMELGEN, Telemedica, DDS Diagnostic) in a few national projects which were coordinated by our laboratory:

• **IMUNOPLAT** Micro Immunosensors Platform for Metabolic Syndrome Investigation): DDS Diagnostic SRL, Univ of Medicine& Pharmacy "Carol Davila" Bucharest, Telemedica SRL, Univ. of Bucharest.

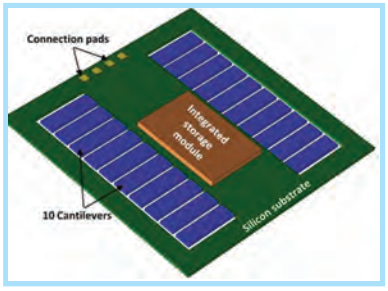
• **AMI_DETECT** (Microbiosensor arrays fabrication and portable DETECTion apparatus development for Acute Myocardial Infarction diagnostic): DDS Diagnostic SRL, „Politehnica" Univ Bucharest, Telemedica SRL, ROMELGEN SRL.

• **E-NOSE** (Electronic nose for detecting small quantities of explosive or environmentally hazardous gasses): ICF „Ilie Murgulescu", IMT, Romelegen.

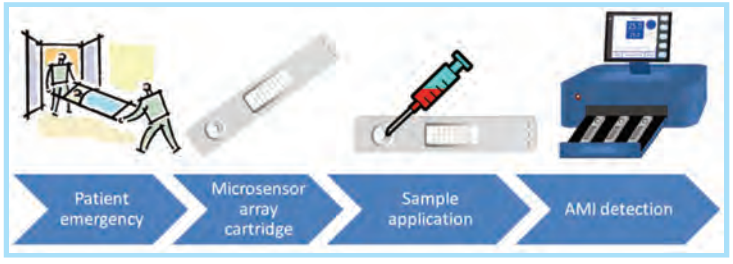
Results

Concept of piezoelectric MEMS devices for efficient energy harvesting

The project proposes to develop an efficient MEMS energy harvester using novel, lead-free piezoelectric materials with high piezoelectric coefficients. The MEMS device will contain a cantilevers array and the piezoelectric materials will be deposited as thin layers on the Si cantilevers. The project will also develop the energy storing device (on the same chip) and the associated electronics.



Concept of the resonanting micro-cantilevers for efficient energy harvesting



Apparatus and microsensor concept for detecting myocardial infarction

Microbiosensor array fabrication and portable detection of Acute Myocardial Infarction

We have designed the microsensor array and the fluorescence detection device for the acute myocardial infarction and determined initial specifications and operating conditions, so that we are able to further develop fabrication technology for microsensors with fluorescence detection and to build a POC (point of care) apparatus which follows the protocol illustrated in the following figure.

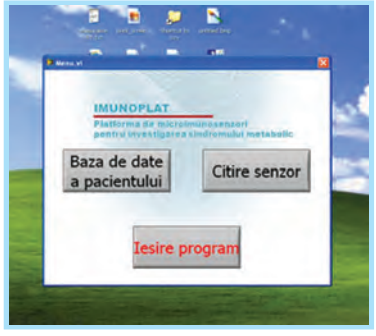
Bio-chemical sensors systems on organic thin films

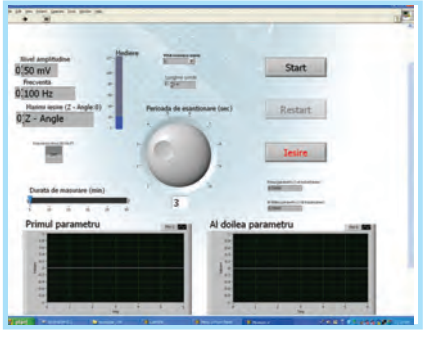
We have developed the technology to fabricate bio-chemical sensors on organic thin films. We have designed our sensors on a flexible substrate and designed various test structures to optimize the printing process for our proposed sensors. After our tests, we have found various solutions for our bio-chemical sensors which will be developed for this project (temperature sensor, impedimetric sensor and pH sensor). The interdigitated Au sensor (50 µm wide, 0.4 µm thick) was printed on a PET foil and was thermally treated at 1200C for 90 minutes. Specific biomaterials (enzymes, antibodies etc.) will be printed on the Au electrodes, depending on the specific application requirements.

Layout for our impedimetric and pH sensors (distance between electrodes is 50 µm)

The InkJet-printed Au impedimetric sensor, on PET susbstrate

Software modules for reading data from our sensors



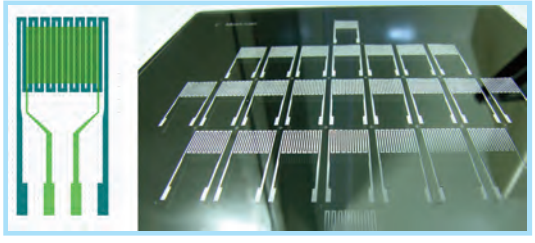


User interface for the micro-immunosensors platform for metabolic syndrome investigation

We have created a program to process measured data coming form our micro-immunosensors platform for metabolic syndrome detection. The program has a user graphical interface that allows access to the patient's database and accesses the sensor readout panel. The latter allows the user to adjust the measurement system's parameters such as amplitude, frequency, sampling period or measurement time. The sensor's behavior is plotted accordingly on graphs.

Layout and mask set for gas sensors

We have developed and realised the layout of a test sensor for detection of pollutants and explosive gasses at very low concentrations. We have created the masks needed for fabrication and processed the test structures. Thermo-electric design was designed, optimized and validated.



Sensor's layout (left) and a picture of mask (right)

Education and Training

Co-organizing courses and training sessions for international projects like Euro-Training in micro- and nano-technologies;

Supervised bachelor and master's thesis projects of students form the Faculty of Electronics of „Politehnica" University of Bucharest.

Mission

❖ *Research, development and innovation of new technologies of micro/ nanosensors*

• Technological design, technological development to the level of the prototype

• Development of technological new individual processes

• Development techniques for assembly(based on MCM)

❖ *Research, development and innovation of new materials (e.g.:nano-composits)*

• Sintesis of new materials

• Development of devices/structures based on new materials (nanomaterials)

❖ *Technological Services/Characterisation*

• Support and technological consultance(design technological flows, gates of control etc.)

• Analysis of technological compatibility and faults on the flow

• Technical assistance to pass from the prototype at zero series

• FTIR, UV-VIS characterization

• Technological Processes RTP- processes of oxidation and nitride fast nitride, densification, annealing

• Annealing, calcinations at high temperatures

❖ *Education, dissemination*. The Didactic Personal associated to Polytechnic University of Bucharest, Faculty of Electronics and TC

• Organizing of workshops, presentations on the profile of the laboratory(contact with industry). All the activity mentioned above is carried out with the aim of improving the ambient conditions (including applications in health) and for up-grading in traditional industries.

Areas of activity

❖ Design and modeling of technologies and technological individual processes for micro/nano technologies (e.g. Micro sensors integrate piezoelectric actuators, micro matrix with white light, photo detectors high-speed on coupling optical fiber)

❖ Technological compatibilities for technologies and technological lines

❖MCM Technologies and other technologies the non-standard technology for M/NST in particular for applications in traditional industries

❖ Synthesis of Nano-Composite materials and nano structured materials and applications in which it is using these materials (e.g. coverings with various features)

❖ FTIR and UV-VIS spectroscopic characterization

❖ Design and processing of thermal specific processes (calcinations, RTP)

New direction for the future :

• applications of micro/nano technologies and nano structured materials in agriculture;

• devices for spatial industry;

• applications of the nano structured materials and M/N sensors in research and aerospatiale industry (in both directions: aeronautics and space);

Equipments (selection)

Tehnologies

- RTP- Rapid Thermal Processing system for silicon, compound semiconductors, Photonics and MEMS process (ANNEALSYS, France) , Fabrication in 2010

Aplications: Rapid Thermal Oxidation (RTO); Rapid Thermal Nitridation (RTN); Crystallizationd and/or annealing; Densifications Compound Semiconductors annealing

- High temperature furnace, Carbolite used for: sintering, annealing, calcination, etc. Fabricat ion in 2011

Aplications: Semiconductor field include: annealing silicon, silicon carbide and nitride samples and solid state synthesis; Ceramics fields include: desintegration, calcinations, long therm high temperature, firing and sintering of ceramic samples.

Characterization:

- FTIR Spectrometer Tensor 27, Bruker Opticks

- UV-Vis Spectrometer AvaSpec-2048 TEC, AVANTES

Research Team

1. **Dr. Ileana CERNICA** - CS I, dr.ing. in microelectronics , laboratory chief
2. **Drd. Alina MATEI** -CS III, MST in chemical enginering ;
3. **Chem.Vasilica TUCUREANU** - CS III, chemist;
4. **Eng. Florian PISTRITU** – electronics principal enginer;
5. **Eng. Ec. Andrei GHIU** – enginer-economist in Fine Mechanics;

Education and training:

Courses and laboratories for the program of master in Optoelectronics & in collaboration with UPB.

Supervision works of the diploma and master from UPB.

Services:

Scientific services for materials characterization usig FTIR and technological processes using RTP and the oven of calcination in accordance with ISO 2008 for IMT and research institutions in the framework of collaboration.

Laboratory head: Dr. Ilena Cernica, (ileana.cernica@imt.ro)

Ileana Cernica, received msc. on electronics and telecommunication and phd in microelectronics 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 scientific researcher, currently coordinates national and international R&D projects as responsable from IMT. She is project evaluator national RD programs (CEEX, CNCSIS) and associate professor at University "Politehnica" of Bucharest (faculty of electronics, telecommunication and information technology- OMEMS course in OPTOELECTRONICS Master Programme).

Her scientific activity was published in more than 72 papers in international journals/conferences, 110 technical reports and is author or co author of 12 romanian patents (3 of them won silver, 2 gold medal at international inventions exhibition in Brussels and Geneva and 2 bronze medals international exhibition "ideas-inventions-novelties"IENA, Nurnberg) and 3 books.

Ambiental Technologies Laboratory

National and international collaborations

Partners Univeristies: 6

The Polytechnic Institute of Bucharest (The Center of Optoelectronics &, Department DCAE-ETTI Faculty; CEM - Science of Materials Faculty; Faculty of Mechanics); Transylvania University of Brasov, Technical University of Timisoara, Military Technical Academy in Bucharest ,Bucharest University

Partners Institutes of R&D and Romanian Academy: 5

National Institute for Electrochemistry and Condensed Matter Timisoara, ICIA Cluj, Institute of Chemistry of Timisoara Academy, ICECHIM Bucharest

Partners IMM and IND: 3

ECONIRV, ROMAERO, MIRA Telecom

Partners from other countries : 3

ESA, CSL Liege, INAF Torino

Most important scientific results

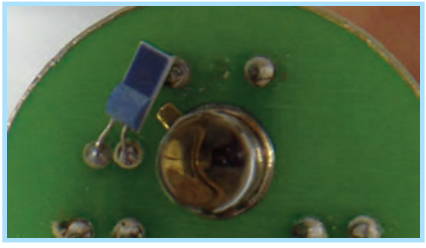
Demonstrator Model of Oculter Position Sensor Emitter (OPSE)

Project Mission sample -3 Coronagraph System – OPSE (ESA)

Prime Contracture: Centre Spatial de Liège

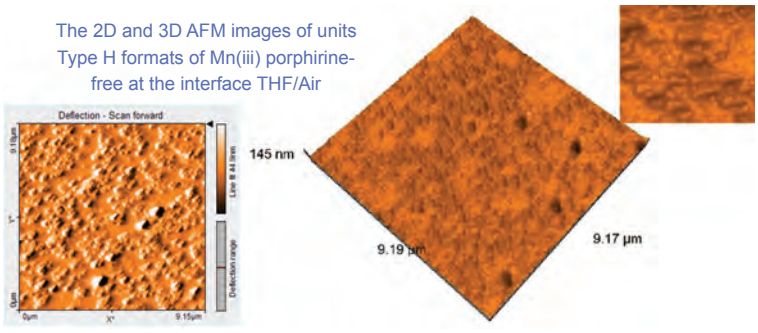
Subcontractor for OPSE: National Institute for R&D in Micro technologies - IMT Bucharest

Accomplishments: Demonstrator Model of Oculter Position Sensor Emitter (OPSE)



Details PCB

The 2D and 3D AFM images of units Type H formats of Mn(iii) porphirine-free at the interface THF/Air

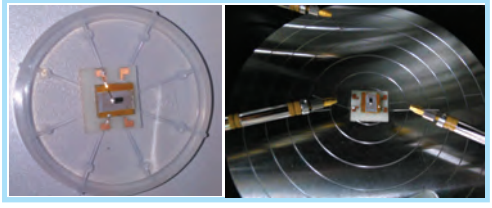


Achievements: Testing the detection of O2 on substrate the Mn-(III)-porphyrine

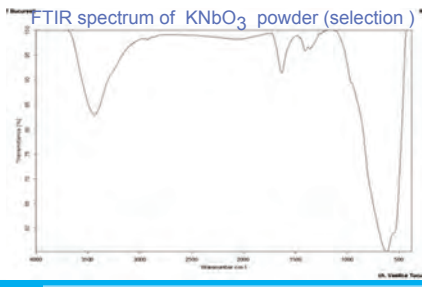
Project: the development of a sensor for multi-detection and selective representative of explosives (SENZOREX)

Partners: INCD for Electrochemistry and Condensed Materials INCEMC Timisoara; Military technical Academy; INCD in Chemistry and oil chemistry ICECHIM Bucharest; MIRA TELECOM; IMT Bucharest

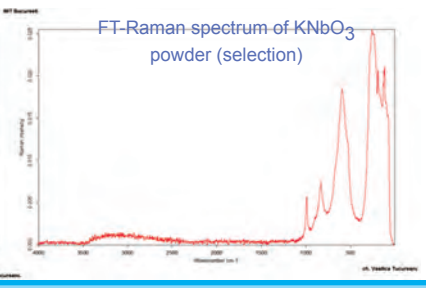
Achievements: The structure of the sensor and electrical characterization of the structure;



FTIR spectrum of $KNbO_3$ powder (selection)



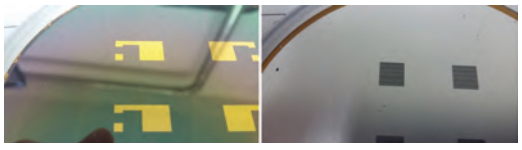
FT-Raman spectrum of $KNbO_3$ powder (selection)



Project: Array of micro sensors for the control of the quality of the air in the inhabited spaces in space missions-SAFEAIR (star-ROSA)

Coordinator: National Institute for Research for Micro technology IMT- Bucharest

Partner : Institute of Chemistry Timisoara of the Romanian Academy



Demonstrator Model of Oculter Position Sensor Emitter (OPSE)

Area of micro sensors and details of micro channels

a. face b. back

The measurement of the dimensional micro channels (micro meters 59/40)

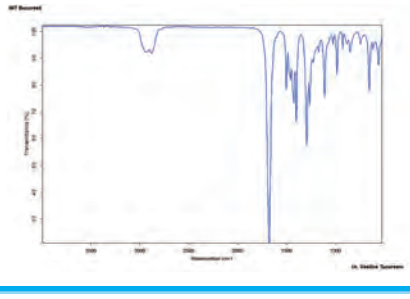
Project: Advanced Researches on the development for methods and rapid techniques for the detection of pesticides in the food chain (FISH-SENS)

Partners: • National Institute for Research for Electrochemistry Condensed Materials (INCEMC)Timisoara - Coordinator

• IMT- Bucharest; • University of Bucharest; • S.C. ECONIRV SRL

- Characterization by atomic spectrometry in the infra-red with Fourier Transformation (FTIR), and FT-Raman spectrometry for powders of $KNbO_3$, $NaTiO_3$, $KTiO_3$, $NaNbO_3$, respectively of a homogeneous dispersion of polymer matrix PVDF-powder of $NaTiO_3$, $KTiO_3$, $NaNbO_3$, $KNbO_3$.

FTIR spectrum of $KNbO_3$ powder (selection)



The Micro- and Nano-Fluidics laboratory is the result of the multidisciplinary project POSCCE, O.2.1.2 Nr. 209, ID 665, Microfluidic Factory for "Assisted Self-Assembly" of Nanosystems (MICRONANOFAB), which gathered experts from micro-nanotechnology and chemistry, and had the objective the realization of a prototype of an integrated microfluidic system able to dose, encapsulate and deliver different chemicals for medical treatment.

Mission

Research, development and education in the micro and nano-fluidics domain. The primary focus of our research is the design of microfluidic devices for applications in clinical diagnostics and regenerative medicine.

Field of activities

Computational Fluid Dynamics (CFD) modeling of Newtonian and non-Newtonian flow, e.g. single- and multiphase flows, mixing, turbulence, heat transfer, user defined function implementation for additional flow parameters setting, magnetohydrodynamics, etc.

Design of microfluidic devices for applications in clinical diagnostics and regenerative medicine.

Investigation of fluid flow and rheology at the microscale, and its application to optimize lab-on-a-chip devices. Experimental nano- and microtechnology, cleanroom processes (e.g. glass silicon and polymer micromachining, plasma based processes), design, simulation, fabrication and characterization of MEMS and biosensors.

Development of micron-resolution particle image velocimetry (≒-PIV), micro-mixing devices and protocols, particle manipulation using dielectrophoresis and magnetophoresis and analysis of boundary conditions at the microscale.

Bioengineering: Cellular uptake of gold-coated maghemite superparamagnetic nanoparticles; studies of cells apoptosis induced by magnetic hyperthermia; tumor cells investigation using UV fluorescence, microscopy (SEM, SNOM) and spectroscopy (FTIR, Raman, Impedance).

Microchannel Flow Physics: Hydrodynamic focusing of liposomes (e.g. a three-inlet and one outlet design) has been studied from experimental&numerical viewpoints.

Molecular transport in microfluidic devices: Magneto-phoretic system for detection of magnetic marked biomolecules; active magnetophoretic systems for cell separation through magnetic fields; filters for separation of microparticles with different morphological, electrical and magnetic properties; nanoparticles separation microfluidic devices.

Visualization and flow characterization: our experimental methods used for microscopic flow investigations are based on (i) contrast substances for the path lines distributions (ii) μ-PIV measurements for local hydrodynamic behavior of a steady fluid flow and quantitative measurements of the velocity profiles and vortex identification.

International and national cooperation

• ***International cooperation*** with European university research centers and companies from England, Spain, Germany, France, Austria, Norway.

• ***National cooperation*** with research institutes, universities and Romanian companies (SUUB, DDS, Spital LOTUS, SANIMED, UPB, UTBv).

Team

Dr. Marioara Avram - Senior researcher, simulation, design, microfabrication and characterization of lab-on-a-chip devices with integrated biosensors;

Dr. Cătălin Valentin Mărculescu - Principal researcher, simulation of Newtonian and non- Newtonian fluid flows, single and multiphase flows, fluid mixing, induced fluid turbulences, heat transfer, implementation of user defined functions for additional flow parameters, magnetohydrodynamics, manipulation of particles by dielectrophoresis and magnetophoresis;

Dr. Andrei Marius Avram - Principal researcher, physicist, Experimental nano and microtechnolgoy: plasma assisted etching and deposition processes, design, fabrication and characterization of lab-on-a-chip microfluidic devices;

Drd. Tiberiu Alecu Burinaru – Reasearch assistant, nanofluidic modeling of biomolecular interactions.

Stud. Cătălina Bianca Tîncu – Junior reasearch assistant, experimental characterization and measurements of biosensors integrated on microfluidic platforms.

Equipment

Technology:

ICP-RIE: Plasmalab System 100- ICP - Deep Reactive Ion Etching System - Etching: Bosch process for silicon and SiC, Cryogenic process for silicon

Reactive Ion Etching (RIE) Plasma Etcher, Etchlab 200

Etching: dielectrics, semiconductors, polymers, metals

Plasma-enhanced chemical vapor deposition (PECVD): LPx CVD - Deposition: silicon oxide, silicon nitride

Wafer Bonder System- SB6L- Wafer - Substrate Bonder System - Bonding: Si on Si, glass on Si, Pressure/heat assisted polymer bonding

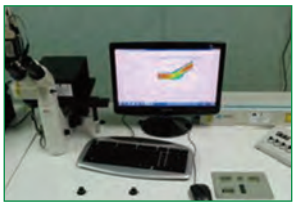
Characterization:

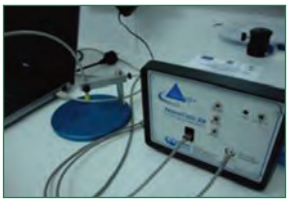
Micro-PIV- PIV for Microfluidics (Particle Image Velocimetry)

Velocity fields measurements, temperature and concentration distributions in microfluidic flows

Refractometer for layer thickness measurements - NanoCalcXR

Material layer and thin films thickness measurements, refractive index measurements.





Results

1. Electrochemical biosensor characterization using electrochemical impedance spectroscopy

The cells characterization with the device developed in the project, was performed using the electrochemical impedance spectroscopy. Our impedance results model the membrane conductance in the nano-electrodes matrix area. Applying +350mV and -350mV, respectively, of electric voltage between the electrodes, an electron release oxidation reaction takes place on the digits of one electrode (anode) and an electron caption redox reaction is initiated on the other electrode, thus solid-liquid interface performing as a condenser. The greater the interface, the capacitance increases, which determines a flattening of the initial droplet, and a decrease of the contact angle, respectively.

The accumulation of different electrical charges species at the membrane interfaces with low conductivity leads to Maxwell-Wagner interfacial relaxation processes. This is observed experimentally as dielectric permittivities dispersion in the high frequency region, close to 1 MHz as observed in the Cole-Cole diagram for the cell solution sample (Figure 1). At 1 MHz frequency the Clausius -Mossotti (Figure 2) factor has the value 0 for the reference sample and -0.49 for the cells sample, value for which the cells dielectric constant is comparable to the reference sample dielectric constant. This indicates that at very high frequencies the cell membrane becomes permeable for ions and with the frequency increase the lipid membrane becomes more conductive. In conclusion, at high frequencies the membrane behaves pure dielectric and conductive at low frequencies.

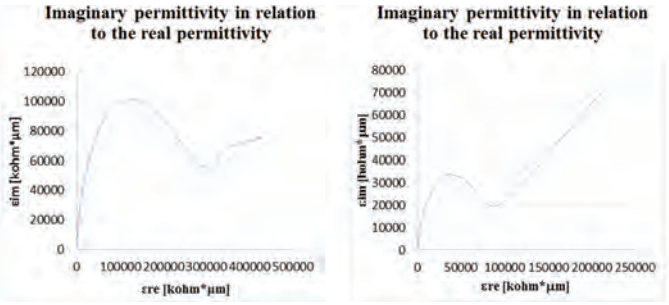


Figure 1. Dielectric permittivities Cole – Cole diagram for cell sample determined from impedance measurements using the impedance device. In the left semi-plane are presented the permittivities at high frequencies, where the charge transfer is dominant, and the right semi-plane are presented the permittivities at low frequencies, where the species diffusion is dominant.

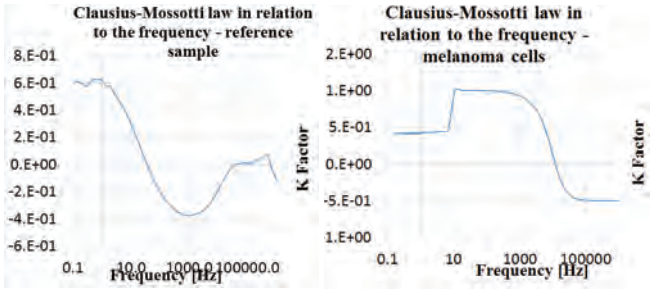


Figure 2. Experimental modeling of the cells dielectric polarizability behavior based on the Clausius – Mossotti law variation in relation to frequency.

2. LAB-ON-A-CHIP device design and microfabrication

The microfluidic platform has been designed to be fabricated both on silicon substrate covered with silicon oxide (the lower part of the microchannels) and on the glass cover (upper half of the microchannels with the entry and exit fluid reservoirs). Considering the micro-processing facilities of IMT Bucharest, evaluating and selecting the technological options for fabrication of the lab-on-a-chip integrated microfluidic platform, we have chosen the following equipment for our experiments: PECVD with both silan and TEOS source, DRIE, anodic bonding system for the biochip encapsulation.

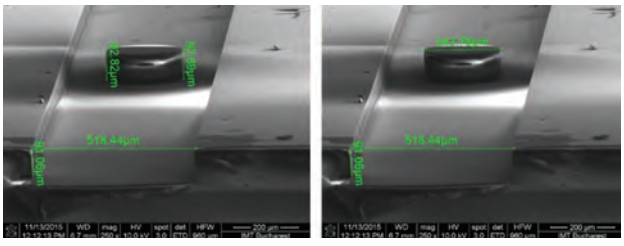


Figure 2. SEM image of microchannel with diameter D = 244 µm, B = 518 µm and H = 91 µm.

In this stage the first channel were fabricated (width B0 = 500 µm and depth H0 = 100 µm) with symmetric positioned cylinders: 50 µm, 100 µm, 150 µm, 200 µm and 250 µm in diameter (Figures 1). The testing of these geometries along the analysis of the particle loaded fluids behavior in the microchannels will complete the specified activities for the last stage of the project.

1, 2 Project: Immunoassay Lab-on-a-chip for cellular apoptosis study, CELLIMMUNOCHIP, 2012-2015, Project Director: Dr. Marioara Avram

3. Biosensors and microfluidic system modeling, simulation and optimization

The flow modeling and simulation in the microfluidic system was performed with FLUENT™. For proper computational resource allocation the microfluidic system has been split in several working geometries, necessary for flow characterization: {1} symmetric bifurcation, {2} lateral bifurcation, {3} microfluidic channel with electrochemical biosensor and {4} microfluidic channel with Plasmon biosensor, all present in the microfluidic system project. All the geometries present a “hele-shaw” cross-section, with one dimension much larger than the other. In our case, the cross-section has 500 µm in width and 30 µm in depth. In this manner, the two sensors can be successfully integrated in the fluidic microchannels. The finite volumes number used for the geometries varies in relation to the channel length and the integrated structures complexity.

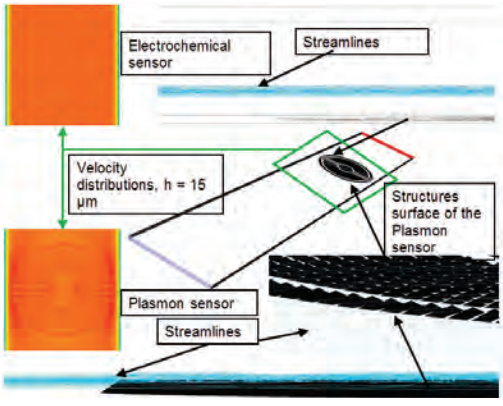


Figure 1 details of the velocity distributions in the sensors active area in median plane (h = 15 µm). We can observe the clear and strong influence of the pyramids from the Plasmon sensor structure (h = 5 µm) on the velocity gradients. This influence can almost reach the upper wall up to h = 25 µm. The influence on the flow was expressed also through the streamlines in the microstructures area. Unlike the Plasmon sensor, the electrochemical sensor nanostructures (h = <300 nm) exert no influence on the flow.

Project: Lab-on-a-chip for label free detection of cancer cells CANCELLAB, 2014-2016, Project director: Dr. Catalin Marculescu

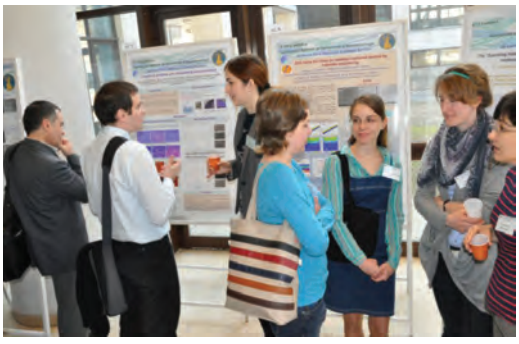
International Semiconductor Conference - CAS 2015

The 38th edition of International Semiconductor Conference (CAS), organized by the National Institute for Research and Development in Microtechnologies - IMT Bucharest, www.imt.ro/cas took place in Sinaia, 12-14 of October, 2015. Since 1995, CAS is also an IEEE event, publishing Proceedings in the IEEE system. In 2015, the main topics have been: Nanoscience and Nanoengineering; Microwave and Millimeter Wave Circuits and Systems; Microsensors and Microsystems; Modelling; Semiconductor Devices; Integrated Circuits; Physics of Materials. The general Chairman of the conference is Prof. Dan Dascalu, member of the Romanian Academy and the Vice-Chairs of the Program Committee are Prof. Gheorghe Brezeanu (University "Politehnica" of Bucharest) and Dr. Mircea Dragoman (IMT Bucharest).

The invited papers presented in plenary sessions were focused on: design and characterization of electronic components on SiC, nano-devices modeling, microwave devices, silicon friendly materials and device, materials for sensing progress in maskless nanotechnologies; graphene. The 10 invited speakers have been from France, Germany, Italy, Republic of Moldavia, Romania, Singapore, Spain, Switzerland, Ukraine.

National Seminar for Nanoscience and Nanotechnology 2015

The 14th Edition of National Seminar for Nanoscience and Nanotechnology (an event initiated by Acad. Dan Dascalu in 2000) was organized by the Centre for Nanotechnologies (under the aegis of the Romanian Academy) from IMT Bucharest. The event took place on 26th of March 2015, at the Library of the Romanian Academy. The participation was at the level of 137 people from 38 organizations (R&D institutes, universities, companies etc.), with 36 papers (oral and poster presentations) presented by authors from 19 institutions. The wide majority of papers have been devoted to applications (such as bio-medical and energy).



Dr. Nicoleta Lupu, National Institute of Research & Development for Technical Physics, Iasi

All details about the event (scientific program, presentations, photo gallery, echoes in the press) can be found at the address: http://www.romnet.net/nano/SNN2015_26.03/.
A number of papers have been selected for publication in English (extended version) in a new volume (due to appear in 2016) of the series "Micro- and nanoengineering", coordinated by acad. Dan Dascalu, and edited by the Publishing House of the Romanian Academy.

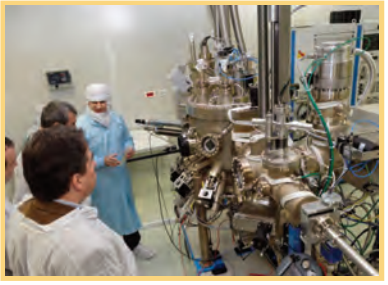
A world-wide recognition of IMT competence in Microsystems:

10 years of participation to World Micromachine Summit (MMS).

2015 edition, in Berlin, Germany, 10 - 13 May 2015 (http://www.mms2015.org/)

Since 2006 IMT is representing Romania to World Micromachine Summit, presenting a country report in the micro and nanotehnologies. For a long time, Romania was the only participant from Eastern Europe. In 2015, the 21st edition (www.mms2015.org) was organized in Berlin, Germany, from 10 to 13 of May. This year, 18 delegations (70 participants) attended the Summit. Romania was represented by Dr. Alexandra Stefanescu. The first two days were dedicated to the reports on the country/region (Australia, Benelux, China, European Commission, France, Germany, Iberia, Italy, Japan, South Korea, Latin America, Northern Europe, Romania, Russia, Singapore, Switzerland, Taiwan, USA) and to another 25 technical presentations. Special interest topics for MMS 2015 were "SMART SYSTEMS FOR MANUFACTURING AND FACTORY AUTOMATION". The last day was dedicated to technical visits to Fraunhofer IZM and First Sensor AG. This annual Summit contributes to the exchange of ideas and the establishment of connections between different countries/regions.

Visits and Educational activities at IMT Bucharest



"Open door day" (14th of December 2015), The event marked the completion of the project "Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials – CENASIC". This investment in the research infrastructure, already completely functional, was presented in the previous pages of this report. The event started with four presentations (R. Muller, A. Dinescu, M. Dragoman, D. Dascalu), highlighting the results of the project and the development strategy of the CENASIC R&D centre and continued with a visit to the research infrastructure, fully operational. The visitors have been executives and specialists from various organizations (universities, research institutes, companies) potentially interested in collaborating with CENASIC centre or using its infrastructures. Officials and companies involved in the execution of the project have been also invited. Among guests we are mentioning:

• Tudor Prisecaru, President of ANCSI; • Antoaneta Popescu, Director ANCSI

• Florin Buzatu, Director, IFA; • Razvan Popescu, Technical Director, ELI- IFIN HH

• Manuela Elisabeta Sidoroff, Director, INSB ;

• Traian Visan, Director, Infineon Romania

• Ionut Enculescu, Director, INCDFM;

• Octavian Buiu, Director, Honeywell Romania

• Alexandru Aldea, INCDFM

Visit of a delegation from Portugal, 8 July 2015

• Dr. Rodrigo Martins, President of E-MRS Senate, Prof. the Faculty of Science and Technology, New University of Lisbon, Portugal

• Elvira Fortunato, Director CENIMAT - Centre for Materials Research, Department of Materials Science, FCT, Professor Universidade Nova de Lisboa, Department of Materials Science, Faculty of Sciences & Technology, Universidade Nova de Lisboa, Portugal

Visit of Dr. Raul Calavia, 28 July 2015, Universitat Rovira i Virgili, Tarragona, Spain, Materials Chemistry, Nanotechnology, Analytical Chemistry.

Visit of Dr. Guillaume TRESSET, 15 October 2015, CNRS Research Scientist, Laboratoire de Physique des Solides, Université Paris-Sud. France

Educational activities developed inside IMT Bucharest

IMT Bucharest at Researcher's Night, 25 September 2015

The Researcher's Night is one of the most popular initiatives of the European Union. In 2015 it is the 10th edition and takes place in over 300 cities in Europe and is targeted to the general public, aiming to facilitate interaction with science in a fun way.

Master Courses held in IMT-Bucharest

(teaching and laboratory classes)

M. Sc. Courses at the Faculty for Electronics, Communications and Information Technology, University "Politehnica" of Bucharest since 2009, (with access to experimental facilities). Specialization fields and courses are listed below):

▶ **Microsystems**

→ Intelligent sensors and microsystems;

→ Microphysical characterization of structures;

▶ **Micro- and Nanoelectronics**

→ Advanced Technological Processes;

▶ **Electronic Technology for Medical Applications**

▶ **Micro- and Nanotechnologies for Medical Applications**

Laboratory classes for undergraduate and M.Sc. courses:

▶ **"Microsensors",** Applications lab using MINAFAB Facility. For year IV students at Faculty of Electronics, Telecommunications and Information Technology, "Politehnica" University of Bucharest.

▶ **Applications lab for RF-MEMS - M. Sc. Course**.

POSDRU- "ELAMAN" *Support for students for a successful career in the field of applied electronics in medicine, automatics and nanotechnologies; UPB Coordinator, IMT partner*

IMT Bucharest is hosting internship in micro and nanotechnologies for students.

Papers published in ISI ranked periodicals (with impact factor)

1. *3D direct laser writing of Petabyte Optical Disk Pavel*, Pavel, E.; Jinga, S. I. ; Vasile, B. S. ; **Dinescu, A**. ; Trusca, R.; Tosa, N.; OPTICS AND LASER TECHNOLOGY Volume: 71 Pages: 45-49 Published: AUG 2015 IF: 1.647

2. *A model to non-uniform Ni Schottky contact on SiC annealed at elevated temperatures* Pristavu, G.; Brezeanu, G.; Badila, M.; **Pascu, R.; Danila, M.**; Godignon, P; APPLIED PHYSICS LETTERS Volume: 106 Issue: 26 Article Number: 261605, JUN 29 2015 IF: 3.302

3. *A new sensitizer containing dihexyloxy-substituted triphenylamine as donor and a binary conjugated spacer for dye-sensitized solar cells* Damaceanu, Mariana-Dana; **Mihaila, Mihai**; Constantin, Catalin-Paul; Chisca, Stefan; Serban, Bogdan-Catalin; Diaconu, Cristian; Buiu, Octavian; **Pavelescu, Emil Mihai; Kusko, Mihaela**; RSC ADVANCES Volume: 5 Issue: 66 Pages: 53687-53699 Published: 2015 IF: 3.84

4. *A tunable microwave slot antenna based on graphene,* **M Dragoman, D Neculoiu, A C Bunea,** G Deligeorgis, **M Aldrigo, D Vasilache, A Dinescu,** G Konstantinidis, D Mencarelli, L Pierantoni, M Modreanu, APPLIED PHYSICS LETTERS Volume: 106 Issue: 15 Article Number: 153101 APR 13 2015 IF: 3.302

5. *An electrochemical DNA-based biosensor to study the effects of CdTe quantum dots on UV-induced damage of DNA*, L Hlavata, I Striesova, **T Ignat**, J Blaskovisova, B Ruttkay-Nedecky, P Kopel, V Adam, R Kizek, J Labuda, Microchim Acta (2015) 182:1715-1722 IF: 3.741

6. *Analysis of the surface effects on adhesion in MEMS structures* Rusu, F.; Pustan, M.; Birleanu, C.; **Mueller, R.; Voicu, R.; Baracu, A.**; Conference: 9th International Conference on Materials Science and Engineering (BRAMAT) Location: Transilvania Univ, Sergiu T Chiriacescu Aula, Brasov, ROMANIA, March 2015 APPLIED SURFACE SCIENCE Vol 358 Pages: 634-640 Part: B Published: DEC 15 2015 IF: 2.711

7. *Antibacterial efficiencies of TiO2 nanostructured layers prepared in organic viscous electrolytes* Dumitriu, C; **Popescu, M** ; Ungureanu, C; Pirvu, C; APPLIED SURFACE SCIENCE Volume: 341 Pages: 157-165 Published: JUN 30 2015 IF: 2.711

8. *A probabilistic model for predicting the uncertainties of the humid stiction phenomenon on hard materials*, T.V. Hoang, L. Wu, S. Paquay, A. C. Obreja, **R. Voicu, R. Muller**, J.-C. Golinval, L. Noels, JOURNAL OF COMPUTATIONAL AND APPLIED MATHEMATICS 289, pp. 173-195, 2015. DOI: 10.1016/j.cam.2015.02.022, Published: FEBRUARY 2015, Impact Factor: 1.266.

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10. *Charge and energy transfer interplay in hybrid sensitized solar cells mediated by graphene quantum dots* **Mihalache, I; Radoi, A ; Mihaila, M**; Munteanu, C; Marin, A; **Danila, M; Kusko, M ; Kusko, C;** ELECTROCHIMICA ACTA Volume: 153 Pages: 306-315 Published: JAN 20 2015 IF: 4.504

11. *Correlation of Physicochemical Properties with the Catalytic Performance of Fe-Doped Titanium Dioxide Powders* Molea, A; Popescu, Vi; Rowson, N A.; Cojocaru, I ; **Dinescu, A**; Dehelean, A; Lazar, M; INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH Volume: 54 Issue: 30 Pages: 7346-7351 Published: AUG 5 2015 IF: 2.587

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14. *Determination of the antiradical properties of olive oils using an electrochemical method based on DPPH radical* Vasilescu, I; Eremia, S . V. ; Albu, Camelia ; **Radoi, A**; Litescu, S-C; Radu, G-L; FOOD CHEMISTRY Volume: 166 Pages: 324-329 Published: JAN 1 2015 IF: 3.391

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16. *Disposable dual sensor array for simultaneous determination of chlorogenic acid and caffeine from coffee* Vasilescu, I; Eremia, S; Penu, R; Albu, C; **Radoi, A**; Litescu, S C. ; Radu, G-L; RSC ADVANCES Vol: 5 Issue: 1 Pages: 261-268 Published: 2015 IF: 3.84

17. *Enhanced nucleotide mismatch detection based on a 3D silicon nanowire microarray* **Banu, M; Simion, M**; Ratiu, A C; **Popescu, M**; Romanitan, C; **Danila, M; Radoi, A**; Ecovoiu, A; **Kusko, M**. RSC ADVANCES Vol: 5 Issue: 91 Pages: 74506-74514 Published: 2015 IF: 3.84

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19. *Fluorescent carbon 'quantum' dots from thermochemical functionalization of carbon nanoparticles* Rednic, Monica I; Lu, Zhuomin; Wang, Ping; LeCroy, Gregory E; Yang, Fan; Liu, Yun; Qian, Haijun; Terec, Anamaria; **Veca, L. Monica**; Lu, Fushen; Sun, Ya-Ping; CHEMICAL PHYSICS LETTERS Volume: 639 Pages: 109-113 Published: OCT 16 2015 IF: 1.897

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21. *Graphene-based room-temperature implementation of a modified Deutsch-Jozsa quantum algorithm* Dragoman, D; **Dragoman, M,** NANOTECHNOLOGY Volume: 26 Issue: 48 Article Number: 485201 Published: DEC 4 2015 IF: 3.821

22. *Hetero-epitaxial growth of TiC films on MgO(001) at 100 degrees C by DC reactive magnetron sputtering* Braic, M; Zoita, N. C; **Danila, M;** Grigorescu, C. E. A; Logofatu, C; THIN SOLID FILMS Vol: 589 Pages: 590-596 Published: AUG 31 2015 IF: 1.759

23. *Impact of RF and DC plasma on wood structure*, **Avram, A.**; Covlea, V.; **Matei, A.**; et al., ROMANIAN REPORTS IN PHYSICS Volume: 67 Issue: 3

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31. *Optical properties and thermionic emission in solar cells with InAs quantum dots embedded within GaNAs and GaInNAs*, Polojarvi, V; **Pavelescu, E-M;** Schramm, A; Tukiainen, A; Aho, A; Puustinen, J; Guina, M; SCRIPTA MATERIALIA Vol:108 Pages: 122-125 Published: NOV 2015 IF: 3.224

32. *Optical properties of pbs crystals obtained on glass substrate from solutions containing hydroxylamine hydrochloride in an ultrasonic baths*, Popescu, V; Molea, A; **Dinescu, A**.; **Rusu-Trisca, C**.; Moldovan, M.; Popescu, G. L.; CHALCOGENIDE LETTERS Volume: 12 Issue: 7 Pages: 363-373 Published: JUL 2015 IF: 0.913

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33. *Photovoltaic structures based on biologic/polymeric semiconducting thin films*, Iftimie, S.; Barbinta-Patrascu, M. E.; Gazdaru, D.; Radu, A; **Bita, B**; Staicu, D; Korganci, N; Ion, L; Antohe, S, DIGEST JOURNAL OF NANOMATERIALS AND BIO-STRUCTURES Vol: 10 Issue: 4 Pages: 1249-1255 Published: OCT-DEC 2015 IF: 0.945

34. *POCl3 annealing effect on the flat band voltage instabilities for a SiC based MOS capacitor at high temperature*, **R Pascu**, G Pristavu, **F Craciunoiu**, M Badila, M Kusko, G Brezeanu, J Neamtu, **R Gavrila**, Romanian Journal of Information Science and Technology, Vol. 17, 340-352, 2015 IF: 0.304

35. *Sezawa Propagation Mode in GaN on Si Surface Acoustic Wave Type Temperature Sensor Structures Operating at GHz Frequencies*, **Mueller, A; Giangu, I;** Stavrinidis, A; **Stefanescu, A;** Stavrinidis, G; **Dinescu, A**; Konstantinidis, G; IEEE Electron Device Letters Vol: 36 Issue: 12 Pages: 1299-1302 Published: DEC 2015 IF: 2.754

36. *Silver Nanoparticles Influence on Photocatalytic Activity of Hybrid Materials Based on TiO2 P25*, Kodom, T; Rusen, E; Calinescu, I; Mocanu, A; Somoghi, R; **Dinescu, A**; Diacon, A; Boscornea, C; JOURNAL OF NANOMATERIALS Article Number: 210734 Published: 2015 IF: 1.644

37. *Study of the influence of capping agents on the structural and optical properties of ZnO nanostructures*, **A. Matei**, L. Dumitrescu, **I. Cernica**, **V. Tucureanu, I. Mihalache, B. Bita, M. Danila**, I. Manciulea, Journal of Optoelectronics and Advanced Materials 17 (7-8), 952 – 957, 2015 IF:0.429

38. *Switching microwaves via semiconductor-isolator reversible transition in a thin-film of MoS2* **Dragoman, M; Cismaru, A; Aldrigo, M; Radoi, A;** Dragoman, D; JOURNAL OF APPLIED PHYSICS Volume: 118 Issue: 4 Article Number: 045710 Published: JUL 28 2015 IF: 2.183

39. *Synthesis and characterization of YAG:Ce phosphors for white LEDs,* **Tucureanu, V.; Matei, A.; Avram, A. M.** OPTO-ELECTRONICS REVIEW Volume: 23 Issue: 4 Pages: 239-251Published: DEC 2015 IF: 1.667

40. *Synthesis and characterization of YAG:Ce,Gd and YAG:Ce,Gd/PMMA nanocomposites for optoelectronic applications* **Tucureanu, V; Matei, A; Mihalache, I; Danila, M; Popescu, M; Bita, B**; JOURNAL OF MATERIALS SCIENCE Volume: 50 Issue: 4 Pages: 1883-1890 Published: FEB 2015 IF: 2.371

41. *The RABI hamiltonian in the dispersive regime,* **Sandu, T,** Conference: 2nd Conference on Advanced Many-Body and Statistical Methods in Mesoscopic Systems Location: Transilvania Univ Brasov, Brasov, ROMANIA Date: SEP 01-05, 2014, Sponsor(s): IFIN HH; Romanian Natl Author Sci Res, ROMANIAN JOURNAL OF PHYSICS Volume: 60 Issue: 5-6 Pages: 711-715 Published: 2015 IF: 0.924

42. *The Role of Ambient Gas and Pressure on the Structuring of Hard Diamond-Like Carbon Films Synthesized by Pulsed Laser Deposition*, Popescu, A C.; Stan, G E.; Duta, L; Nita, C; Popescu, C; Surdu, V-A; Husanu, M-A; **Bita, B**; Ghisleni, R; Himcinschi, C; Craciun, V; MATERIALS Volume: 8 Issue: 6 Pages: 3284-3305 Published: JUN 2015 IF: 2.651

43. *Ti surface modification with a natural antioxidant and antimicrobial agent,* Dumitriu, C; Ungureanu, C; Popescu, S; Tofan, V; **Popescu, M**; Pirvu, C; SURFACE & COATINGS TECHNOLOGY Volume: 276 Pages: 175-185 Published: AUG 25 2015 IF: 1.998

44. *Tunable dielectric properties in polyacrylonitrile/multiwall carbon nanotube composites*, S. Palade, A. Pantazi, S. Vulpe, C. Berbecaru, **V. Ţucureanu**, O. Oprea, R. F. Negrea, D. Dragoman, Polymer Composites, 6 aug [2015], doi: 10.1002/pc.23744, IF = 1.632

45. *Using permalloy based planar hall effect sensors to capture and detect superparamagnetic beads for lab on a chip applications* Volmer, M; **Avram, M** JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS Volume: 381 Pages: 481-487 Published: MAY 1 2015 IF:1.97

46. *X-ray Diffraction Study and Texture Evolution for a Ti-Nb-Ta Biomedical Alloy Processed by Accumulative Roll Bonding*, Nocivin, A; Raducanu, D; Cinca, I; **Trisca-Rusu, C;** Butu, M; Thibon, I; Cojocaru, V D. JOURNAL OF MATERIALS ENGINEERING AND PERFORMANCE Volume: 24 Issue: 4 Pages: 1587-1601 Published: APR 2015 IF: 0.998

47. *IxFIZZ: Integrated Functional and Fuzz Testing Framework based on Sulley and SPIN*, **L PETRICĂ**, L VASILESCU, A ION, O RADU, pp. 54– 68, Vol 18, Number 1, 2015, Romanian Journal of Information Science and Technology (ROMJIST) IF: 0.304

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1. *Electrical characterization of Ni-silicide Schottky contacts on SiC for high performance temperature sensor,* **R Pascu**, G Pristavu, G Brezeanu, F Draghici, M Badila, I Rusu, **F Craciunoiu**, Materials Science Forum 821-823, 436-439, 2015

2. *Barrier non-uniformity of annealed Ni/4H-SiC Schottky contacts with temperature*, G Pristavu, G Brezeanu, M Badila, A Vasilica, **R Pascu,** Ph.D. Research in Microelectronics and Electronics (PRIME), 157-160, 2015 (pdf)

3. *Emerging carbon-based nanosensor devices: structures, functions and applications*, Adv. Manuf., DOI 10.1007/s40436-015-0100-y S. Manzetti, **D. Vasilache**, E. Francesco

4. *Conductive-Atomic Force Microscopy Investigation of the electrical properties of low temperature deposed ZnO transparent thin films*, A. Alexa, A. Pimentel, T. Calmeiro, **A. Istrate**, E. Fortunato, V. Mușat, The Annals of "Dunarea de Jos" University of Galati, Fascicle IX. Metallurgy and Materials Science, Vol 2 No. 2, 22-26, Pub: June 2015.

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1. *2D materials nanotechnologies between great expectations and lost illusions*, 3rd International Conference on Nanotechnologies and Biomedical Engineering, p.47, Chisinau, Moldova (2015). **M. Dragoman**

2. *A novel tunable microwave filter based on carbon nanotubes varactors*, Proceedings of Memswave 2015, Barcelona, Spain, pp 60-63 **M. Aldrigo, M. Dragoman**, S. Xavier and A. Ziaei

3. *Adhesive and frictional properties of ultrathin polysilicon films,* M Michałowski, Z Rymuza, **R Voicu, C Obreja, A Baracu, R Muller**, Proceedings of Turkeytrib'15 - 1st international conference on tribology, 7 - 9 October 2015, Yildiz Technical University,Istanbul – Turkey;

4. *An Investigation of SiC Schottky Contact Barrier Inhomogeneity for Temperature Sensing Applications*, G. Pristavu, G. Brezeanu, M. Badila, F. Draghici, **R. Pascu, F. Craciunoiu,** ICSCRM 2015, 4 - 9 octombrie, Giardini Naxos, Italia

5. *Analysis of temperature dependence of resonance frequencies for surface acoustic wave modes on GaN*, Proceedings of Memswave 2015, Barcelona, Spain, pp 17-20 A. Müller, I. Giangu, G. Stavrinidis, A. Dinescu, A. Stavrinidis, A. Stefanescu, M. Pasteanu and G. Konstantinidis

6. *Assessment of structural, optical and conduction properties of ZnO thin films in the presence of acceptor impurities*, **R. Plugaru**, N. Plugaru, Advances in Nanophysics and Nanophotonics, workshop at National Institute of Materials Physics (NIMP, Romania) August-September 2015, Bucharest, Romania;

7. *Back-gate bias of a graphene antenna via a smart background metallization*, Proceedings of International Semiconductor Conference CAS 2015, 12-14 Oct 2015, Sinaia , Romania , p. 131-134, 2015. **M. Aldrigo, M. Dragoman**, L. Pierantoni, D. Mencarelli, and G. Deligeorgis,

8. *Biologic/polymeric semiconducting thin films based photovoltaic cells*, S. Iftimie, M.E. Barbinta-Patrascu, A. Radu, **B. Bita**, N. Vasile, N. Korganci, L. Ion and S. Antohe, THE 8TH INTERNATIONAL CONFERENCE ON ADVANCED MATERIALS: ROCAM 2015, 7-10 July 2015, Bucharest, Romania, Abstract Book, Editura Granada 2015, p. 16

9. *Calculation of dielectrophoretic force acting on biological cells and on micro-and nanoparticles*, **T. Sandu**, 38th IEEE International Semiconductor Conference – CAS 2015, Sinaia, Romania, 12-14 Oct. 2014, Proceedings,pp. 215 – 218, 2015

10. *Carbon-based nanodevices bumpy routes:inks, flakes, spaghetti, wafers, 8th International Conference on Advanced Materials*, ROCAM 2015, 7-10 July 2015, Bucharest, Romania **M. Dragoman**

11. *Charge storage, memory effect and energy transfer in graphene quantum dots*, **A. Radoi, I. Mihalache, C. Obreja, C. Kusko, M. Kusko,** C. Munteanu, 2nd Optical Nanospectroscopy Conference, March 18 - 20, UCD Dublin, 2015

12. *Co and Mn-doped ZnO 1D and 2D nanostructured films grown by hydrothermal method,* V Musat, N Tigau, M Ibanescu, V Ghisman, **F Comanescu, A Dinescu, M Purica,** EMRS'2015-Spring Meeting, Symposium I- Semiconductor nanostructures towards electronic and opto-electronic device applications – V, Lille, France, May 11 to 15, 2015.

13. *Computational prediction of capillary number impact on droplets formation in microchannels*, **C Marculescu*, B Tincu, A Avram, T Burinaru and M Avram**, EENVIRO Conference on ,,Sustainable Solutions for Energy and Environment" 18-20 November 2015, Bucharest, Romania.

14. *Defects network and transport properties in electron-doped Sr1 xLaxCuO2 thin films grown by laser ablation*, **M. Danila, V. Leca**, J. Tomaschko, D. Wang, W. M. Arnoldbik, R. Kleiner, D. Koelle, 28th International Conference on Defects in Semiconductors, Helsinki, Finlanda, 26 – 31.07.2105

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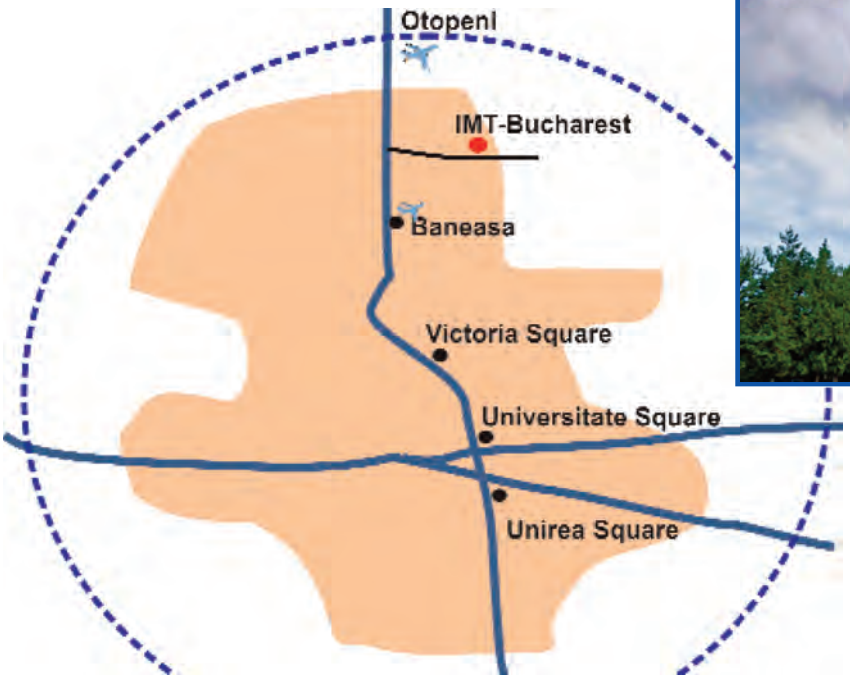

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