National Institute for Research and Development in Microtechnologies -
IMT Bucharest

Scientific Report 2017

From micro- to nanotechnologies,
nano-biotechnologies and nanoelectronics

Ministry of Research and Innovation

National Institute for Research and Development in Microtechnologies

IMT Bucharest

SCIENTIFIC REPORT 2017

Research, 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. The institute is the successor of Institute for Microtechnologies-IMT, founded in 1993 which merged with Research Institute for Electronic Components, founded in 1969. In 2017 the institute was coordinated by the Ministry of Research and Innovation, acting basically as an autonomous, non-profit research company.

IMT – Bucharest is an internationally competitive organization, involved in world class research. In 2017 IMT Bucharest continued its activity in highly innovative research in the field of: micro and nanoelectronic components and systems, smart sensors, micro and nanotechnology, in education, technology transfer, offering services for industry.

IMT-Bucharest is an important actor in Romania and Eastern Europe in micro and nanotechnologies.

The research performed in national and international projects and/or published in ISI publications was mainly oriented, as in the previous years, to 4 of the Key Enabling Technologies:

- **micro and nanoelectronic devices**
- **micro and nanophotonics**
- **nanotechnologies**
- **advanced materials**

At European level, IMT Bucharest run as partner, a **H2020-ECSEL project** and coordinate a **H2020 Marie Skłodowska-Curie Actions- Individual Fellowship**. IMT coordinate or participate in **3 ESA projects**, **4 bilateral and was partner in 5 COST projects**. IMT was involved as coordinator or partner in **M.ERANET and MANUNET projects**, also **EUREKA and 2 FLAG–ERA projects** in the field of health and robotics. IMT run a **Structural Funds project**, dedicated **to knowledge and technological transfer to Romanian companies in the field of smart specialization: ICT, Space and Security**.

In 2017 the research activity was directed to the priorities of the Romanian National Strategy for Research and Innovation SNCDI (2014-2020) and of EU program Horizon 2020.

IMT's infrastructure is organized in two main technological facilities: **IMT-MINAFAB (Facility for Design, Simulation, Micro-nanofabrication of electronic devices and systems) and CENASIC (Research Centre for Integrated Systems, Nanotechnologies and Carbon Based Nanomaterials).**

MINAFAB (www.imt.ro/MINAFAB), inaugurated in 2009, displays a broad range of experimental and computing resources for micro- and nanoelectronics, micro and nanotechnologies, from simulation and design techniques, to characterization tools, processing equipment (including a mask shop, EBL nanolitography), functional and reliability tests.

CENASIC, in use since November 2015, have state of art equipment and his main activity is focused on research in the field of graphene based devices and other carbon based materials, as nanocrystaline diamond and SiC.

Concerning human resources, current research staff involve **multidisciplinary teams (electronic engineers, chemists, physicists, materials engineers, mathematicians, biologists), young PhD students, technicians, administrative staff (in total 190),** which were engaged in national and international research, advancing new knowledge and innovation.

The figures presented in the report show a relatively balanced distribution of human resources between young and senior researchers (also between male and female).

The turnover is relatively similar, compared with 2016, considering the number and value of the national and international running projects.

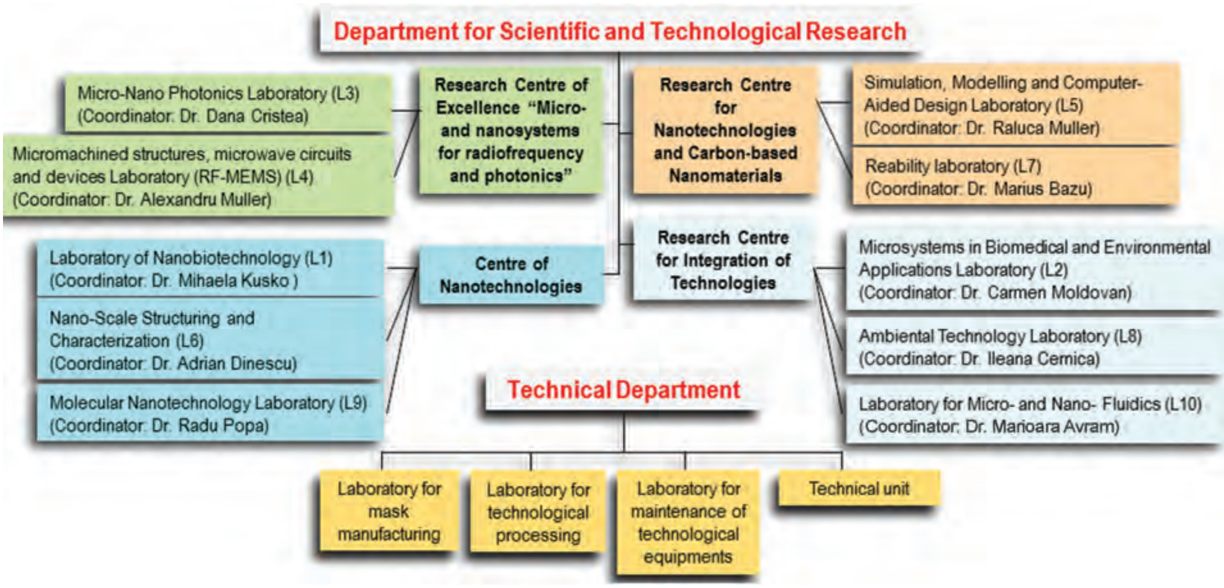
The Scientific Report 2017 presents the most important projects and the research highlights of the 10 research laboratories, grouped in 4 centers; important scientific events, organized by our institute, each year: National Seminar on Nanoscience and Nanotechnologies at its 16th edition and CAS - International Semiconductor Conference- an IEEE event, at an anniversary 40th edition. A list of main scientific publications concludes the report.

I would like to thank to all the staff and their high level work and support during 2017.

Dr. Miron Adrian Dinescu

CEO and President of the Board

Organization: Scientific and Technical Departments



Dr. Adrian Dinescu obtained the M.Sc. degree (1993) and the PhD degree (2010) in Solid State 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. He was the Technical Director of IMT from December 2013-December 2016 and currently (from January 2017) he is the General Manager of IMT.

Dr. 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.

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

Dr. Raluca Müller received the M.Sc (1978) and PhD in Electronics and Telecommunications from "Politehnica" Univ of Bucharest, Romania. From 1978-1994 she was Research Scientist with ICCE-Research Institute for Electronic Components, Romania. Since 1994 she is with IMT. R. Müller was Scientific Director starting with 2009 and ***General Manager*** between July 2011-January 2017. Currently she acts as Scientific Director. Her main interests include design and technological processes for microelectronic devices, integrated optics, microfluidics, MEMS microsensors and microsystems. She was/is involved in many national projects, (including the coordination of a structural funding project related to collaboration to industrial partners in the field of ICT and security) and as scientist in charge or partner EU projects. R. Müller is author and co-author of more than 100 scientific papers.

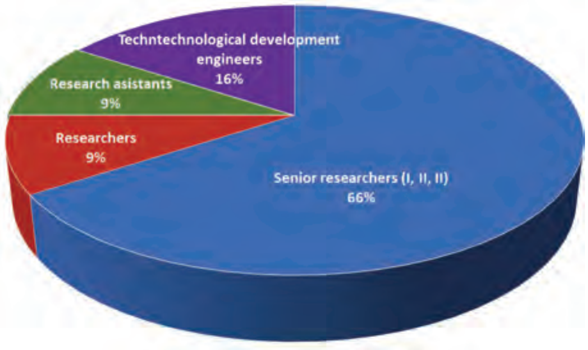
Dr. Radu Cristian Popa received a MSc in Electrical Engineering (Applied Electronics) from the Polytechnic University of Bucharest (1989), and a PhD in Quantum Engineering and Systems Science at University of Tokyo (1998).

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 managed industrial research projects with leading Japanese companies and institutions, 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 department director. Main scientific activity includes theoretical and experimental studies of nanomaterials and nanostructures, experiment planning, rational design of nanomaterials and nanostructures based on atomistic simulations.

Human resources

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 ICT, space, and nanotechnologies, smart sensors, and advanced materials.



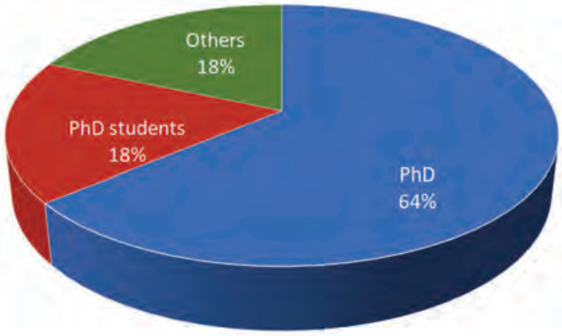


Fig. 1. - Researchers and technological development engineers active in IMT

Figure 1 (a, b) provides information about the number and distribution of researchers and technological development engineers (IDT) active in IMT in 2017 (108 persons). 66% of them are senior researchers I, II and III, 9% researchers, 9% research assistants and 16% technological development engineers. 26% of them are under 35 years. The average age of IMT researchers is around 45.

Figure 2 shows information about the multidisciplinary background of researchers and IDT active in IMT in 2017. The male (54 %) - female (46 %) ratio is relatively balanced.

IMT Bucharest offer opportunities for students from Romania, EU, Associated Counties and South Africa, especially from "Politechnica" University Bucharest, to develop multidisciplinary research, to be in contact with new technologies, by providing access to practical labs, summer stages, supervising experimental/scientific work of their diploma and PhD thesis.

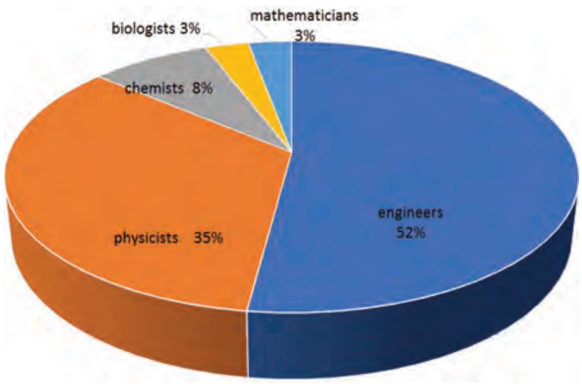


Fig. 2. Multidisciplinary background of researchers and technological development engineers active in IMT

Funding sources and investments

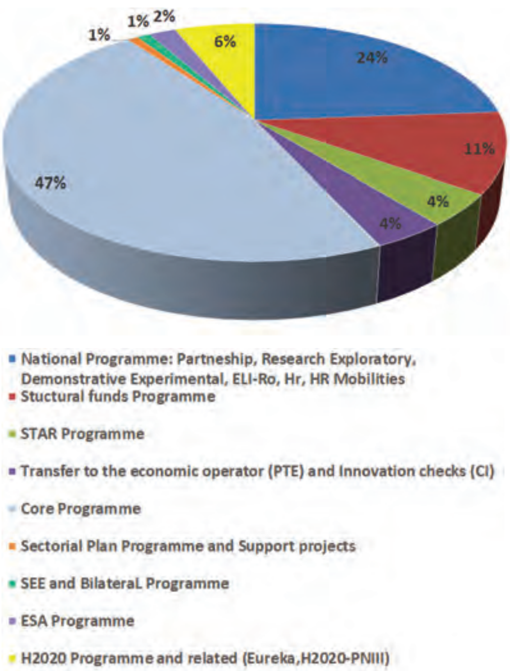


Fig. 3. Funding sources in 2017

Fig. 3 shows the distribution of funding sources in 2017: national R&D programs (competitive funding, through open calls): 33%, Structural Funds 11%, different European Projects and other sources (H2020 and related - EUREKA, ESA, SEE and bilateral) 9%.

The next figure (fig. 4) presents information about the evolution of IMT turnover during the last period and information about investments in various equipment. The turnover in 2017 is relatively the same as in 2016.

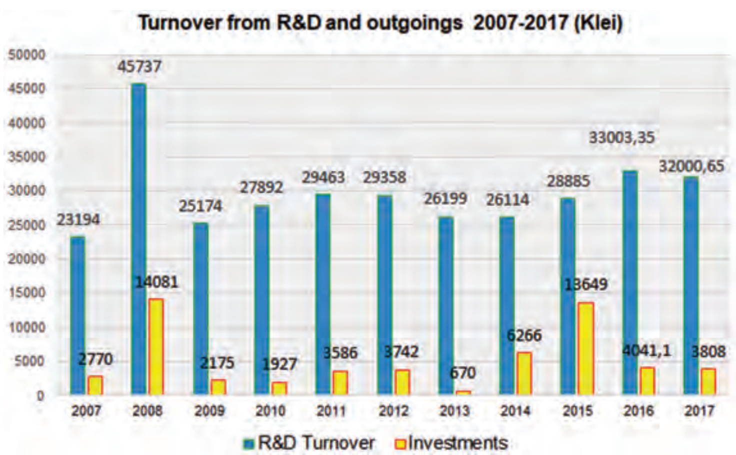


Fig. 4. Graphic representation of IMT Bucharest turnover and investments for the period 2007-2017

Experimental facility: IMT-MINAFAB

IMT-MINAFAB - Facility for design, simulation, micro and nanofabrication for electronic devices and systems is a modern facility, unique in Romania, competitive at European level, for research and development of micro-nanoelectronic devices, sensors and microsystems (www.imt.ro/MINAFAB), launched in April 2009.

The facility provides "open access" to modern, state of arts equipments and is the only facility in Romania where one can fabricate electronic components and systems (including smart sensors and systems), all the manufacturing chain being available: design, modeling, CAD, technological fabrication, micro-physical characterization, functional testing and reliability examinations. The facility is a collaborative platform for research, industry and universities, similar with other EU centers and benefits of the expertise of a multidisciplinary team.

IMT-MINAFAB provides several clean-room areas with specialized technological and characterization laboratories - totalizing a surface of almost 700 m2 (including one clean room of class 1.000), and modern equipments worth more than 8 MEuro. Since June 2011, the services and administrative activities of the center are SR EN ISO 9001:2008 certified by TÜV Thüringen e.VThis research infrastructure enabled IMT to extend its R&D capabilities. MINAFAB infrastructure contains a key unit, the „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. The facility acts as a platform for integrated Key Enabling Technologies (KETs), especially 4 Kets: t micro-nanoelectronics, photonics, nanotechnologies and advanced materials. In 2017, the facility has been upgraded with an area of 280 m^2 of clean room class 10,000, which will accommodate new equipment scheduled to arrive in 2018.

IMT-MINAFAB is included in the MERIL and ERRIS databases (**https://erris.gov.ro/MINAFAB**). Short presentation of the most important components of the research infrastructure follows:

- A class 1000 clean room (220m^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 (105m^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)

TECHNOLOGICAL TRANSFER INFRASTRUCTURES

CENTRE FOR TECHNOLOGY TRANSFER IN MICROENGINEERING

CTT-Baneasa (www.imt.ro/ctt);
Tel/Fax: +40212690771; E-mail: info-ctt@imt.ro
Address: 126A Erou Iancu Nicolae Street, Bucharest, 077190.

THE SCIENCE AND TECHNOLOGY PARK FOR MICRO AND NANOTECHNOLOGIES

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

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; Fax: +40-21-269.07.72; +40-21-269.07.76; E-mail: office@ro-bgmicronanotech.eu

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

The Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials (CENASIC) is a new asset which provides access to new equipment, laboratories and state-of-the art technologies.

The project was financed by Structural Funding Sectorial Operational Programme "Increase of economic competitiveness Project POS-CCE-(2011-2015) and represents an investment of 6 MEuro in a new building for offices, clean rooms and equipment. There are approximately 1000m^2, including 4 levels: the clean room (ground floor), technical level, 2 levels for labs and offices. CENASIC is a unique infrastructure in Romania, competitive at regional and European level, with 8 new modern laboratories, with state of art, complex equipment, dedicated to carbon based materials and devices.

Overview of the CENASIC clean room

The key new technological equipment within the CENASIC are:

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

The center will develop the following research topics:

► SiC technologies and functional micro-nanostructures; Processes for SiC-based micro- and nanostructures

► Technologies for graphene and hybrid MEMS/NEMS

► Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics

In 2017 the new infrastructure CENASIC was an important support for new projects, financed by Core funding or by EU programes. The young scientists, supervised by Dr. Mircea Dragoman focused their research on new technological processes for thin films of advanced materials, new technologies and nanoelectronic devices based on grapheme with the thickness of one atomic layer; Infrastructure direct public link in ERRIS: **https://erris.gov.ro/CENASIC**

Images from the new clean room (class 1000 and 100)

Director of CENASIC: Dr. Adrian Dinescu (adrian.dinescu@imt.ro)

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

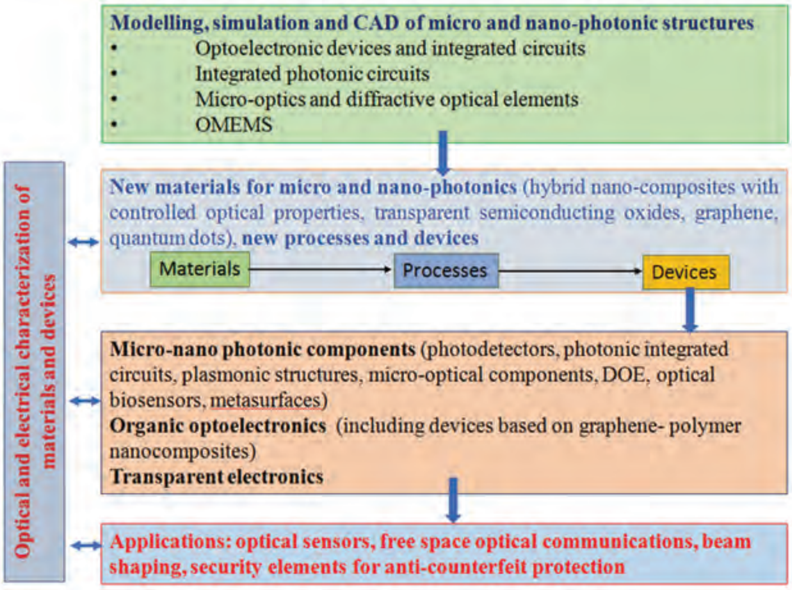
L3 MIMOMEMS European Centre of Excellence Laboratory of Micro/Nano Photonics

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.**

Research activity



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

Dr. Dana Cristea MSc in Electronics and PhD in Optoelectronics from "Politehnica" University, Bucharest, Romania. She is the head of Microphotonics Lab and the manager of the Core program IMT. Between 2002 and 2008 she was the Scientific manager of IMT. Her main research activities are in the fields of optoelectronic devices, photonic integrated circuits, optical-MEMS, micro-optics integration technologies. She is author or co-author of more than 100 papers published in journals and Conference Proceedings and holds 5 patents. Dr. Dana Cristea coordinated more than project 25 national projects, participated in several FP6 and FP7 projects (WAPITI, 4M, ASSEMIC, FlexPAET) and was the vice-coordinator of the FP7 Project MIMOMEMS. She is currently scientific manager in two projects aiming at knowledge transfer to SMEs and in R&I projects on optoelectronic devices based on QDs and nanoplasmonic structures.

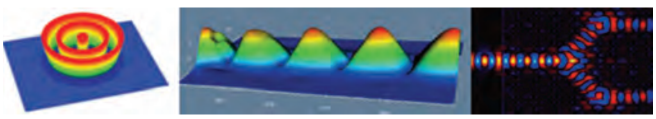
Team

1. **Dr. Dana Cristea** senior researcher, M.Sc. in electronic engineering, PhD in optoelectronics & materials for electronics;
2. **Dr. Munizer Purica** senior researcher, M.Sc. and PhD in physics;
3. **Dr. Cristian Kusko** senior researcher, M.Sc. and PhD in physics;
4. **Dr. Paula Obreja** senior researcher, M.Sc. and PhD in physical chemistry;
5. **Dr. Mihai Kusko** senior researcher, M.Sc. in physics and photonics, Ph.D in optoelectronics;
6. **Dr. Florin Comanescu** researcher, M.Sc. in electronics and PhD in optoelectronics;
7. **Dr. Roxana Rebigan** researcher, M.Sc. in physics and PhD in optoelectronics;
8. **Dr. Roxana Tomescu** researcher, M.Sc. in electronics and PhD in optoelectronics;
9. **Dr. Rebeca Tudor** junior researcher, M.Sc. in Electronics, PhD in Physics.

Specific facilities

Modelling and simulation:

• **Opti FDTD 13.0.2** – design and simulation of advanced passive and nonlinear photonic devices using FDTD (Finite-Difference Time-Domain) method.
• **OptiBPM 13** - design of complex photonic integrated circuits for guiding, coupling, switching, splitting, multiplexing and demultiplexing of optical signals using BPM (beam propagation method) method.
• **OmniSim -** design/simulation 2D/3D of photonic components using FDTD si (Finite Element Time Domain)
• **OptiGrating**, LaserMod
• **3Lit** – design of 3D micro-optical elements.
• **Zemax** – optical design.



Technology:

• **Glove box** for preparation and deposition of nanocomposites and organic layers.

Characterization:

• **Spectrophotometers for UV-VIS-NIR and IR** spectral range;
• **Spectroscopic ellipsometer**;
• **High Resolution Raman Spectrometers LabRAM HR** with module TERS/AFM for nanostructures based on carbon;
• **Alpha300 S System – Scanning Near-field Optical Microscope**, Confocal Microscopy and Atomic Force Microscopy, and Raman Spectrometers.
• **Optical Theta Tensiometer** (KSW Instruments)
• **Experimental set-up** for optoelectric characterization in UV-VIS-IR spectral range.

National and international cooperation

Modelling and simulation:

• Cooperation with European research units and industry (K4-IKERLAN-Spain Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V. [FhG IPMS]- Germany, FundingBox Accelerator sp. z o.o.-Poland, Karlsruhe Institute of Technology-Germany, and new proposals on H2020 and COST action programs, CEA-Liten, LAAS-CNRS Toulouse, industry from Spain, 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 Romanian industry (Optoelectronica 2001, Pro-Optica, Apel Laser), research institutes (INFLPR, ICPE-CA) and universities (Univ. "Dunarea de jos" –Galati, UAIC-Iasi) on national research programs PN II and PN III.

• New national cooperation: with Optoelectronica-2001 S.A. in „Technological transfer to increase the quality and security level of holographic labels", and a new platform for a large variety cooperation with industry –TGEPLAT, Contract no. 77/08.09.2016, Cod SMIS2014+ 105623, project financed by Operational program for economic competitivity POC**.**

New funded projects

• ***IR sensors for infrastructures' security applications,*** Coordinator Dr. Ing. Roxana Tomescu, part of the Complex Project named „Sensors and integrated electronic and photonic systems for persons' and infrastructures' security"– PN-III-P1-1.2-PCCDI2017-0419, partnership with INFLPR.

• ***Development of quantum information and technologies in Romania***, PN-III-P1-1.2-PCCDI2017-0338, 2018-2019, IMT Coordinator: Dr. Cristian KUSKO, Field: Emerging technologies, Consortium: Coordinator: National Institute for Research and Development in Nuclear Physics and Engineering „Horia Hulubei" – IFIN HH. Partners: National Institute for Research and Development for Lasers, Plasma and Radiation Physics – INFLPR; Politechnical University of Bucharest, National Institute for Research and Development for Molecular and Izotopic Technologies INCDTIM.

• ***Multispectral photodetector technology for surveillance and watching optical systems applications***, PN-III-P2-2.1-PED-2016-0307, project duration: 2017-2018, Coordinator: Dr. Dana Cristea (dana.cristea@imt.ro)

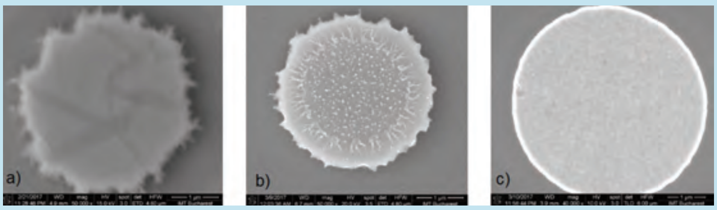
Scientific results

Advanced photonic devices based on plasmonic structures/metamaterials for detection optimization and beam shaping of electromagnetic field, Core Program PN 163201012, 2016-2017 *Project PN-II-PT-Coordinator: Dr. Roxana Tomescu (roxana.tomescu@imt.ro)*

Plasmonic metasurfaces for MIR improved absorption

Plasmonic metasurfaces have been investigated and experimentally fabricated for improved radiation absorption in specific MIR narrow spectral ranges. Photolitographic processes and lift-Off method have been optimized for different plasmonic metasurfaces geometries.

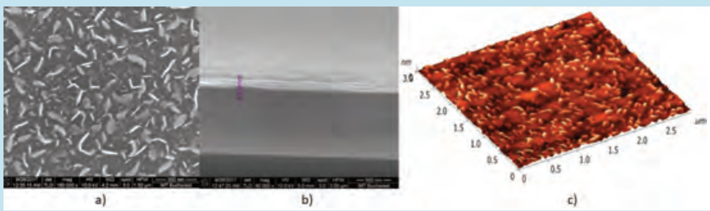
Metasurfaces with improved absorption



SEM top view image of a golden cylinder after: a) wet etching of metallic layer; b) plasma dry etching - RIE; c) Lift-off

3D carbon based structures for improved solar cell efficiency (Dr. Roxana Rebigan roxana.rebigan@imt.ro)

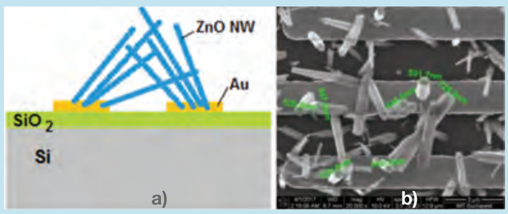
3D carbon based structures (named multilayer vertical graphene or graphene flowers) have been fabricated by plasma assisted chemical vapor deposition (PECVD) featuring controlled size and density. Process parameters have been studied and varied: power, temperature, pressure, gas flow, gas proportion. Further these carbonic 3D structures will be integrated in solar cell for improved efficiency.



Images of 3D carbon based structures grown on Si/SiO_2 substrates: a) SEM top view, b) SEM cross-section and thickness measurement, c) 3D AFM image

ZnO nanowires based UV photodetectors (Dr. Paula Obreja – paula.obreja@imt.ro; Dr. Dana Cristea-dana.cristea@imt.ro)

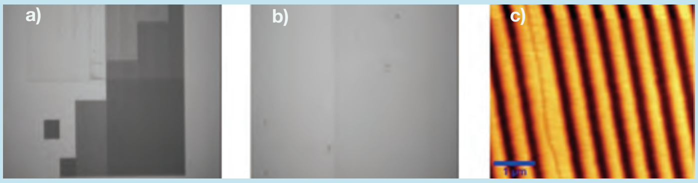
N–type ZnO nanowires have been grown on SiO_2/Si substrates featuring gold pre-patterned electrodes by hydrothermal method, using a chemical solution of $[Zn(NO_3)_2.6H_2O]$ and (HMTA). The aims of this work were to grow thick ZnO nanowires, for response time minimization and long enough to get efficient collection of photogenerated carriers from ZnO-NW grown on adjacent electrodes.



ZnO-NW based photodetectors: a) ZnO-NW based photodetector structure; b) SEM image of ZnO-NW

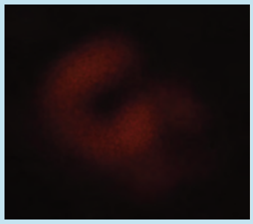
Metasurfaces for beam shaping and wavefront electromagnetic control

A metasurface based optical element has been fabricated using azimuthal domains which generate a phase delay for the reflected wave in the 0 and π rad range value. The variation of phase delay increases linearly as a function of sector azimuth such that the optical element works as a phase spiral mask generating an optical vortex with fractional topological number. Micro-nano fabrication techniques such as EBL, lift-off and RIE have been used for the patterning of the metasurface based optical element.



Optical (a,b) and AFM (c) images of the diffractive optical element

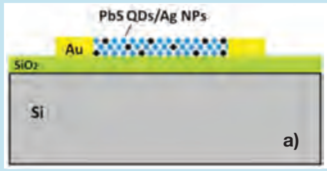
The diffractive optical element has been integrated into an experimental setup using a laser source with 635 nm wavelength and a Gaussian distribution. The results prove a promising potential for DOE fabrication.

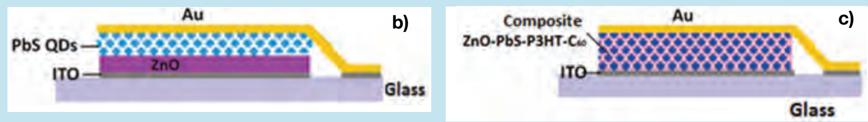

Optical image reflected by the DOE: optical fractional vortex with topological number ½.

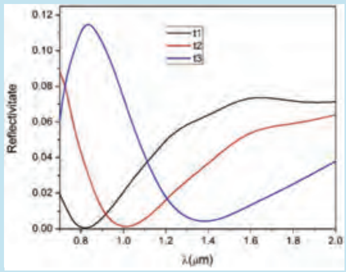
Multispectral photodetector technology for optical systems for surveillance and security application

project: PN-III-P2-2.1-PED-2016-0307, Coordinator: Dr. Dana Cristea (dana.cristea@imt.ro)

The following types of photodetectors have been investigated: a) PbSQDs and PbS QDs-Ag NP composite based photodetectors; b) ZnO-PbS QDs heterojunction based photodetectors; c) ZnO-C60-PbS QDs –P3HT bulk heterojunction based photodetectors;
PbS and C_{60}-PbS QDs–P_3HT composite based active layers have been deposited on thin ZnO and on ZnO nanowires. The composites have improved the uniform covering of ZnO nanowires.





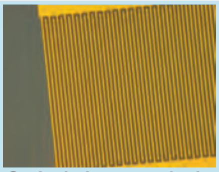


Simulated reflectivity of an antireflective nanostructured configuration for 3 different geometrical parameters

Antireflective coatings for high power laser with ultrashort pulses (ARCOLAS) PNII-PCCA2014

Director Dr. Mihaela Filipescu INFLPR . Coordinator IMT Dr. Cristian Kusko

The interaction of the radiation provided by a high power laser with ultrashort pulses of femto seconds with a dielectric mirror has been simulated using the PIC-FDTD numerical method (particle in cell – finite diference time domain). This method considers the dynamics of electron-ion species from the plasma as a result of the dielectric ionization under electromagnetic influence. Antireflective layers for high power laser mirrors have been designed, simulated and optimized, featuring high mechanical and thermal resistance when interacting with ultrashort high laser puls. SiO_2 and HfO_2 have been considered as antireflective layers. The simulated reflectivity shows near IR spectral ranges where the reflectivity of the system is 0.


Optical image of the bolometer active area

Compact Spectrometer in Infrared (project PCCA 2013 COSPIR)

Dr. Mihai Kusko, mihai.kusko@imt.ro

IR detectors (bolometers) based on interdigital electrodes on amorphous silicon have been fabricated. The interdigital detector structure works as a good absorber in IR, while the temperature increased by the radiation absorption results in the resistivity variation of amorphous silicon, and of the electrical resistence of interdigital electrodes.

1D and 2D zinc oxide nanostructures and innovative technological processes for their direct integration into gas sensing and UV radiation detection devices/NANOZON

project PN-II-PT-PCCA 2013-2017, Contact person: Dr. Munizer Purica (munizer.purica@imt.ro)

Different devices based on 1D and 2D nanostructured ZnO for gas sensing and UV detection have been investigated.

• *UV sensor has been fabricated on glass substrate* with Cr/Au interdigited electrodes with 0,5 x 0,8 mm^2 active area based on nanostructured ZnO from thermal oxidation of Zn - Fig. 1 a,b,c, d.
The electrical resistence has values in the 5.10^2 Ω – 6. 10^2 Ω range in dark conditions and decreases to 3,0. 10^2 Ω - 4,0 10^2 Ω at UV exposure (exposure level - 470 mW/cm^2). The spectral response, defined as the ratio between the photogenerated current and the radiation power is 0,5-0,6 mA/mW.

• *Gas sensing device has been fabricated by localized growth of nanowires from chemical solution on quartz substrate with patterned interdigital electrodes.* The growth area has been patternd by EBL for electrical contact of ZnO nanowires featuring 2-3 µm height - Fig. 2 a, b, c.

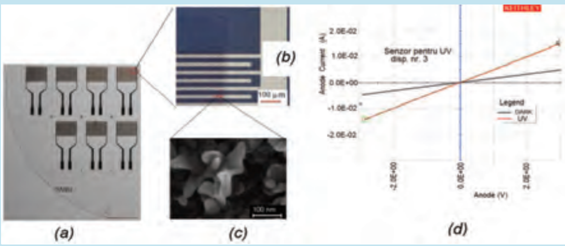


Fig. 1 (a) – optical image of glass substrate with Cr/Au electrodes; (b) – optical image (detail) of the ZnO active layer deposited in electrodes proximity; (c) – SEM image featuring ZnO morphology; (d) – I-V characteristic for dark and UV radiation.

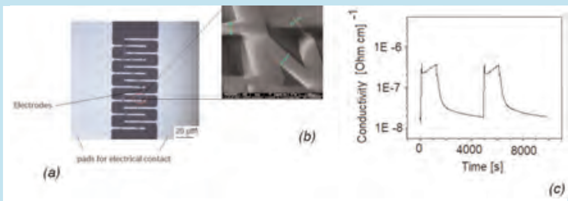


Fig. 2 a, b,c: (a) – SEM image of patterned quartz substrate with Cr/Au electrodes and PMMA area; (b) – detail of ZnO (1D) grown in electrodes area; (c) – Sensor's response – conductivity variation cycles.

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 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

L4 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 was partner in two IP/FP7 (NANOTEC, SMARTPOWER) and one ENIAC JU (NANOCOM). The laboratory is now coordinator of one ESA project and one H2020/Marie Curie project (SelectX).

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 nano-processing 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 development;

Team

The laboratory head is Dr. Alexandru Müller, PhD in Physics at Bucharest University in 1990. His competences includes Silicon, GaAs and GaN micromachining and nanomachining: manufacturing of RF MEMS components and circuits, technological process in GaAs MMICs, design, modelling and manufacturing of microwave passive membrane supported circuits, monolithically as well as hybrid integrated receiver front end modules, acoustic devices (FBARs and SAWs) based on micromachining and nano-processing of wide band gap semiconductors (AlN , GaN).

The research team has multidisciplinary expertise in physics and electronics of microsystems and is composed of 12 senior researchers (10 of them with PhD in physics and electronics) and two young researchers, PhD in electronics.

Laboratory head:
Dr. Alexandru Müller,
alexandru.muller@imt.ro

Dr. Alexandru Müller, 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

Equipments

"On wafer" measurement system in the 0.1-110 GHz range (microwave network analyzer Anritsu and 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), Network analyzer Anritsu up to 40 GHz, Büchiglasuster controlled pressure and temperature chamber, Measurement accessories, Computers and software for microwave electro-magnetic simulations (IE3D, Fidelity, CST).

Ongoing projects

International Projects:

ESA - Contract No. 4000115202/15/NL/CBi "Microwave filters based on GaN/Si SAW resonators, operating at frequencies above 5 GHz" IMT coordinator, 2015 – 2017.

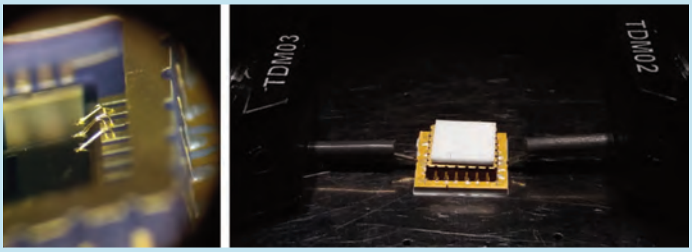
SelectX – H2020, Marie Curie project no.705957 "Integrated Crossbar of Microelectromechanical Selectors and Non-Volatile Memory Devices for Neuromorphic Computing", 2016 – 2018, IMT coordinator

National projects

One project in Partnership (PN II) programme (2014-2017), coordinated by Dr. A. Müller; **two young research team projects (PN III)** (2015-2017) coordinated by Dr A. Stefanescu and Dr D. Vasilache, **one exploratory research project (PN III)** (2017-2019) coordinator Dr. A. Müller, three experimental demonstration projects (PN III) (2017-2018) coordinated by Dr. D. Neculoiu, Dr. M. Dragoman, and Dr. V. Buiculescu and **one project award for H2020 participation**, coordinated by Dr. Alexandru Müller.

Surface acoustic wave resonator based filter structures with an operating frequency > 5 GHz

ESA – Ctr. 40000115202/15/NL/CBi "Microwave filters based on GaN/Si SAW resonators, operating at frequencies above 5 GHz" (2015 – 2017) Coordinated by Dr. Alexandru Müller

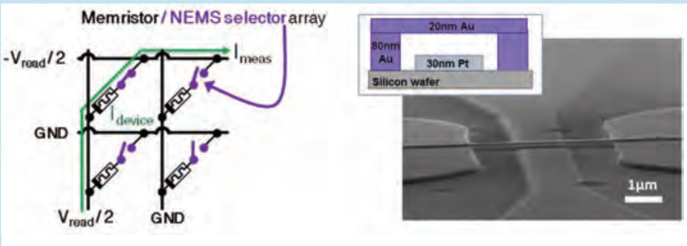


Filter chip integrated in a ceramic capsule — Hermetically packaged filter, integrated on a dedicated fixture for on wafer characterization

Filter structures based on surface acoustic wave (SAW) resonators processed on GaN/Si, with operating frequencies around 5.5 GHz were designed, fabricated and characterized. The filter chips were integrated with 25 micron diameter gold wires in ceramic capsules and hermetically sealed with a metallized ceramic cap. Dedicated fixtures were designed and fabricated for on wafer characterization of the packaged filters. The filters were tested with temperature between -150°C and + 150°C.

TiO_{2-x} based memristors and nano-electromechanical selectors to avoid leakage currents

H2020 – Marie Sklodowska Curie Individual Fellowship - grant 705957 „Integrated Crossbar of Microelectromechanical Selectors and Non-Volatile Memory Devices for Neuromorphic Computing" (acronim SelectX)" Coordinator Dr Alexandru Muller and Researcher Dr. Gina Adam, (2016-2018)



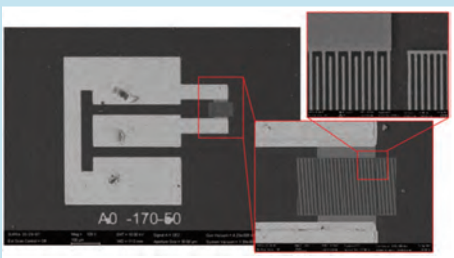
Nano-electromechanical switches to be used as selectors for memristive matrices

Memristive matrices show great potential for artificial intelligence hardware, but suffer from the challenge of leakage paths. This project proposed a novel selector device – a nanoelectromechanical switch – in series with a memristor. The nanoelectromechanical switch has the highest theoretical non-linearity, so the leakage currents are eliminated in such an integrated matrice. Nano-electromechanical structures were designed and fabricated to have very low actuating voltages that are compatible with the memristors in terms of the manufacturing process and operating voltages, for example the NEMS switch from the SEM figure with a Pt/Au beam of 100nm width, 30nm thickness and 3 microns length.

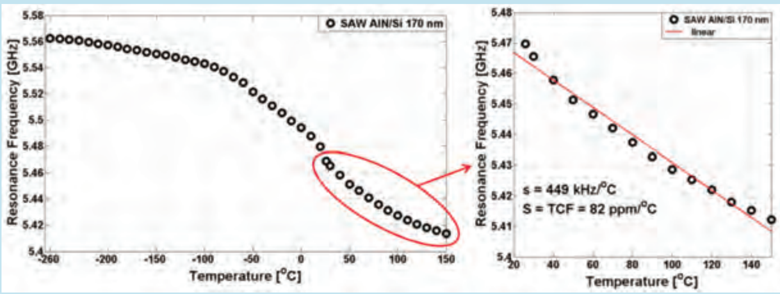
Thermal characterisation for temperature sensors based on SAW resonators on AlN/Si with resonance frequencies in the giga hertz domaines

PATRNERSHIP - PCCA, Ctr. 15/2014 „Temperature sensor based on GHz operating AlN/Si SAW structures – SETSAL" (2014-2017), Project coordinator Dr. Alexandru Müller.

Surface acoustic wave (SAW) resonators have been manufactured on AlN/Si wafers and have been characterized as temperature sensors. A lift-off process, using Ti/Au metallization with a total thickness of 220 nm – 20 nm/200 nm, has been used in order to define the measurement pads that connect the nano-structured interdigitated transducers (IDTs). The lift-off process is the only way to obtain metalized geometries with nano-metric dimensions. The IDTs have been fabricated by using a nano-lithographic process using electron beam (EBL) equipment. SAWs having IDTs with finger/interdigit spacing width of 170 nm and 200 nm have been obtained.



SEM photos of a SAW structure having IDTs with finger/interdigit spacing width of 170nm; detail of nanolitography



Resonance frequency dependence of temperature in the temperature range -260ºC la 150ºC, for the SAW structure having IDTs with finger/interdigit spacing width of 170nm

The characterization of the SAW resonators manufactured on AlN/Si with temperature has been performed using a vector analyzer. The variation of the S11 parameter vs. temperature was obtained by using a cryostat with a wide temperature range from 5K to 500K.

The dependence of resonance frequency vs. temperature could be linearly approximated and the sensitivities of the SAW structure have been calculated. Hence, for the SAW structure with finger/interdigit spacing width of 200 nm a temperature coefficient of the frequency (TCF) of 75 ppm/ºC has been obtained. In the case of the SAW structure having finger/interdigit spacing width of 170 nm the obtained value of the TCF was 82 ppm/ºC.

Investigation of the Sezawa, Rayleig and pseudo-bulk modes in GHz operating GaN based SAW devices

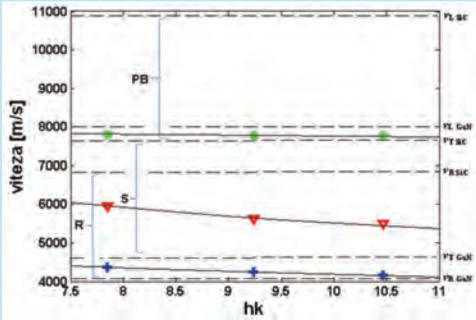
PN III IDEAS PCE, Ctr 147/2017, "Investigation of superior propagation modes in GHz operating GaN based SAW devices targeting high performance sensors and advanced communication system applications" Project coordinator Dr. Alexandru Müller

Higher propagation modes, especially the Sezawa mode, generated by multi-layer GaN/Si and GaN/SiC SAW structures have been investigated. Interdigital transducers (IDTs) with widths between 120 nm and 200 nm have been proposed in order to obtain a wide range of hk parameter (normalized thickness).

Knowing the propagation velocities for the Rayleigh mode as well as the transversal velocities of SiC and GaN, the obtained resonance frequencies have been identified as Rayleigh (R), Sezawa (S) and pseudo-bulk (PB) modes.

For the structures on GaN/Si, a monotonic decrease of the propagation velocity with the increase of the hk was observed for the Sezawa mode. The values of the propagation velocity for Sezawa mode are approx. 15% higher than those for the Rayleigh mode.

SEM photos of a SAW structure with coplanar waveguide type pads manufactured on GaN/Si wafers having IDTs with finger/interdigit spacing width of 200 nm and 100 µm finger length



The propagation velocity vs. hk for the mantioned propagation modes for SAW structures manufactured on GaN/SiC structures having the finger/interdigit spacing width of 150 nm, 170 nm and 200 nm

Design and manufacturing of a test cell for the dielectric properties' measurement using SIW environment.

PN III-YOUNG RESEARCH TEAMS - ctr no. 330/2015: "Use of SIW cells for the measurement of dielectric materials' microwave permittivity", Project coordinator: Dr. Alexandra Stefanescu

A dielectric cell was designed and manufactured for the relative permittivity measurement of both solid and liquid dielectric materials. The cell's operating frequency covers 3.5 – 5 GHz bandwidth, but it can be easily modified for other specifications. The dimensions of the rigid samples are limited to 1.6x1.6 mm cross-section and 32 mm length, while the liquid samples are inserted through a small section pipe. A photograph of the dielectric measrement cell is provided.

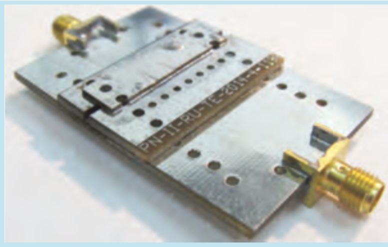
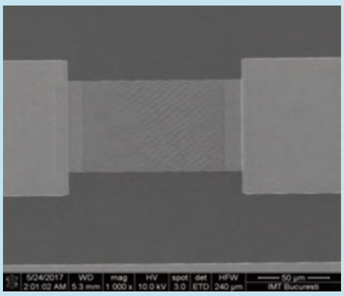


Photo of the measurement SIW circuit

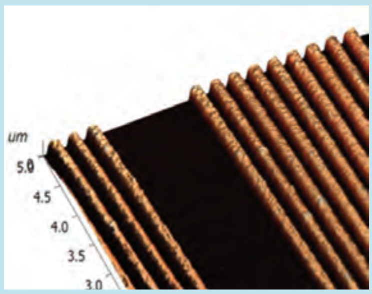
Design, fabrication and characterization of SAW resonators integrated with printed lumped elements

PN-III-PED „High performance Band-Pass Filters based on GaN Hybrid Acoustic Wave Lumped Element resonators for Space Applications (HALE4SPACE")-, Project Coordinator Prof. Dr. Dan Neculoiu

Surface acoustic wave (SAW) resonator block components for band pass filters operating in the 3 – 9 GHz frequency range were designed, fabricated and characterized. 3D electromagnetic models were developed using CST Studio Suite for the simulation of the SAW resonators and printed lumped elements. The models are based on the local modulation of the substrate permittivity, using the Lorentz disperion model. Different structures were simulated, and the effect of an inductive line on the S parameters as well as the effect of the area of the SAW resonator were analyzed.



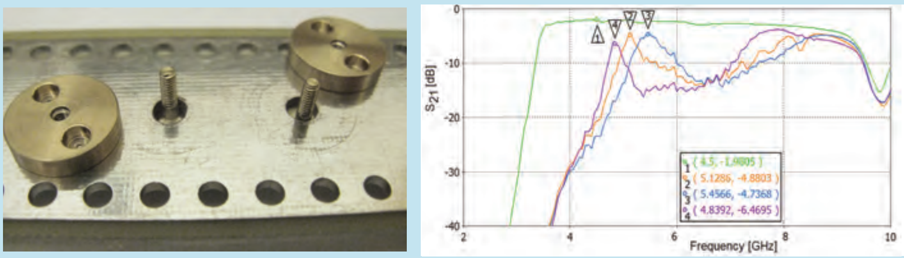
SEM image of a series connected SAW resonator band pass filter component



AFM detail of 130 nm wide digits

Design and manufacturing of a SIW resonator with two mechanical tuning elements

PN III PED ctr 215 PED/2017 "Tunable substrate integrated waveguide band-pass filters", Project Coordinator Dr. Valentin Buiculescu

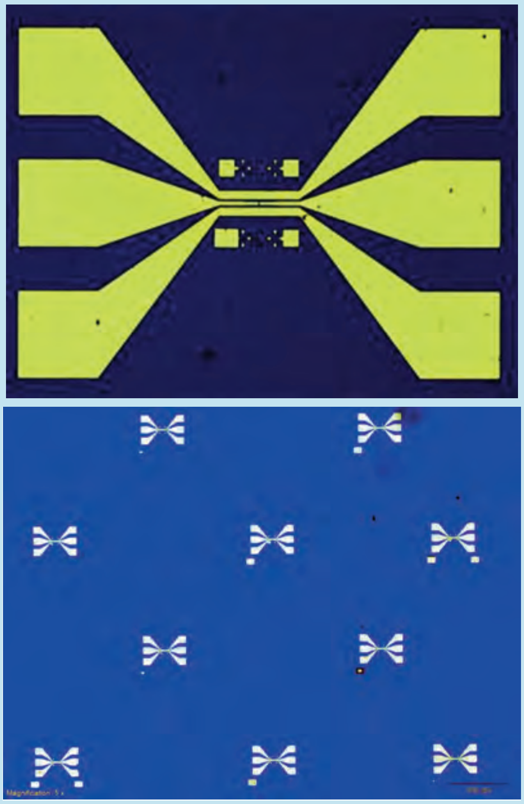


SIW resonator with two mechanical tuning elements and resonance frequency change (experimental results)

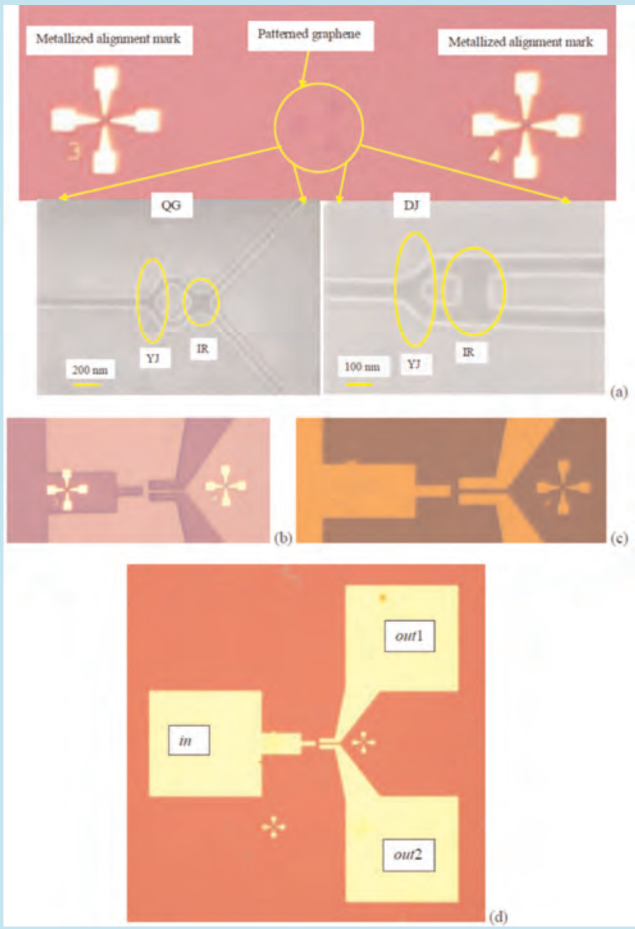
The concept of mechanical tunability of a SIW circuit was proved by means of a fundamental resonator made of a SIW section and a pair of mechanical tuning elements, as shown in the photo. About 620 MHz was obtained by changing the tuning elements' relative axial positions (i.e. along SIW structure) with + 3 mm.

Balistic diodes and cuantic gates on graphene

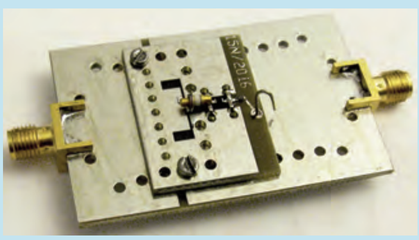
FN Ctr 15N/2016: TEHNOSPEC Key enabling technologies for inteligent specialization priorities



Balistic diodes on graphene (graphene on Si/SiO_2 - 300 nm SiO_2 thickness)



a) patterning of graphene for Hadamard gate and for DJ circuit, b) patterning of the structures, c) pads metallization, d) the final shape Hadamard gate and of the DJ circuit



SIW-based electronically tuned rejection circuit with varactor diode

Design and manufacturing of a specific structure intended for series insertion of „virtual" impedances within SIW components.

FN Ctr 15N/2016: TEHNOSPEC: "Integration of semiconductor devices within substrate integrated waveguide (SIW) circuits"

Series connected components within SIW circuits are exclusively available by means of transitions from SIW to other transmission line types (usually microstrip or coplanar lines), thus increasing their overall dimensions. A specific SIW structure was designed for converting the impedance at the terminals of a passive or active component into a „virtual" impedance connected in series with the main SIW circuit. The functional demonstrator is presented in the attached photograph.

Mission

The mission of L1 is to propose and approach research directions in the field of nanostructures / nanomaterials / nanocomposites, aiming to comprehend their properties and to find novel solutions for the technological development for integration in devices with applications in sensing, medicine and energy. Furthermore, training programmes in collaboration with universities, 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 nanomaterials/functional nanostructures, investigation, control and 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 nanostructures, integrated devices (optoelectronic biosensors, integrated microfluidic platforms) and development of novel biodetection schemes for medical applications;

(iv) design and fabrication of new devices based on silicon, silicon carbide, polymers and hybrid systems, as well as hybrid systems for applications in different fields, from gas/temperature sensors to energy (miniaturized devices as clean energy sources for conversion or storage of energy, such as micro- fuel cells/solar cells/micro-supercapacitors).

Team

1. **Alexandra Purcarea,** Chemist, MSc student, Research Assistant
2. **Adina Boldeiu**, Chemist, PhD., Research Scientist II;
3. **Cosmin Romanitan**, Physicist, PhD student, Research Scientist;
4. **Iuliana Mihalache**, Physicist, PhD, Research Scientist III;
5. **Melania Banu**, Biologist, PhD student, Research Scientist;
6. **Mihaela Kusko**, Physicist, PhD, Research Scientist I, head of L1 laboratory;
7. **Mihai Danila**, Physicist, Research Scientist III;
8. **Mihai Mihaila**, Physics Engineer, PhD, Research Scientist I, Associate Member of Romanian Academy;
9. **Monica Simion**, Physicist, PhD, Research Scientist I;
10. **Pericle Varasteanu**, Physicist, PhD student, Research Assistant;
11. **Razvan Pascu**, Electronics Engineer, PhD, Research Scientist III.

Laboratory of Nanobiotechnologies

Dr. Mihaela Kusko holds a PhD in physics from Univ. of Bucharest (2006). In 1998, she joined IMT Bucharest, where she currently leads the Nanobiotechnology Laboratory. In the last two decades, she was involved in new research directions, with the goal to find new applications of nanomaterials and nanostructures in optoelectronics, energy harvesting and biomedicine. She started investigating the structural and opto-electrical properties of nanoporous silicon, and continued with different metallic/semiconducting nano-assemblies. She led IMT group in FP7-IP-NMP-2010 NanoValid (2011-2016), FP7-NMP-ENV-2019 NanoSustain (2010-2013) and LIFE+ i-NanoTool (2013 – 2015), and was principal investigator in 6 National R&D projects devoted to nanomaterials exploration. Once the graphene and graphene like materials have emerged as advanced materials, she has done intensive work in the exploration of the conduction mechanisms established when they are embedded in polymeric matrices, with new results in the photodetection properties and charge storage capabilities of these nanomaterials.

Laboratory head:
Dr. Mihaela Kusko,
mihaela.kusko@imt.ro

Equipments

- **High Resolution SmartLab X-ray Diffraction System** (Rigaku Corporation, Japan); contact persons: *PhD St.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*
- **Noise and phonon fluctuation spectroscopy measurement system** – New measurement system (designed and realized in 2016, in the TEHNOSPEC project frame); contact person: *Dr. Mihai Mihaila*
- **New equipment - Programmable Dip Coater for layer-by-layer thin film deposition** – Automated Dip Coater PTL-OV5P (MTI Group, USA); contact person: *Dr. Adina Boldeiu*

Programmable system used to modify different surfaces (Si, quartz, Nafion), based on layer-by-layer self-assembling, using up to 5 types of liquid solution, a multilayer structure being finally obtained, having the possibility to set up time and temperature immersion, as weel as the number of assembled layers. Aplications: sensors, supercapacitors.

National and international collaboration

International projects (ongoing projects):

• **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;

• **Bilateral Cooperation Project Romania – Ukraine** (National Technical University of Ukraine "Kyiv Polytechnic Institute") (2016-2017), "New photosensitive materials based on silicon films with various rare-earth metals for sensors and optoelectronic devices applications" – IMT resp. Dr. Mihaela Kusko;

• **Bilateral Cooperation Project Romania - France** (Institut Polytechnique de Grenoble-INP: Grenoble-INP), Integrated Action Program Brancusi, PN-III P3-3.1-PM-EN-FR-2016 (2016-2017), "DNA Biosensing with Silicon-on-Insulator Substrates - BIS-SOI", IMT resp. Dr. Monica Simion.

National projects:

• **PN-III-P4-ID-PCE-2016-0618** „Challenges and issues in engineering nano-systems based on graphene-like materials for supercapacitors – *EnGraMS*" (2017-2019); Project director: Dr. Mihaela Kusko;

• **PN-III-P2-2.1-PED-2016-0974** „Microscale hybrid energy storage devices for integrated portable electronics – *MiStorE*" (2017-2019); Project director: Dr. Mihaela Kusko;

• **PN-III-P2-2.1-PED-2016-0510** – „Dye-sensitised solar cells by molecular engineering of phenoxazine- or phenotiazine- based sensitizers - EngDSSC" - coordinator: Institute of Macromolecular Chemistry "Petru Poni" Iasi; Resp. IMT – Dr. Mihai Mihaila;

• **PNII-PCCA ctr 109/2014**: "Improved production methods to minimize metallic nanoparticles' toxicity – less classic, more green – LesMoreNano" – coordinator IMT, project director Dr. Monica Simion/Dr. Adina Boldeiu (2014-2017) http://www.imt.ro/lesmorenano/;

• **PNII-PCCA ctr 36/2014**: ""Multiplexed platform for HPV genotyping – MultiplexGen" – coordinator IMT, project director Dr. Mihaela Kusko (2014-2017) http://www.imt.ro/multiplexgen/index.php;

• **PNII-PCCA ctr 203/2014**: "Identification of new modulators of calcium-regulated processes using genomic and chemogenomic screens in yeast – CalChemGen" – resp. IMT Dr. Monica Simion (2014-2017) http://www.chimie.unibuc.ro/cercetare/organica/PN-II-PT-PCCA-2013-4-0291/;

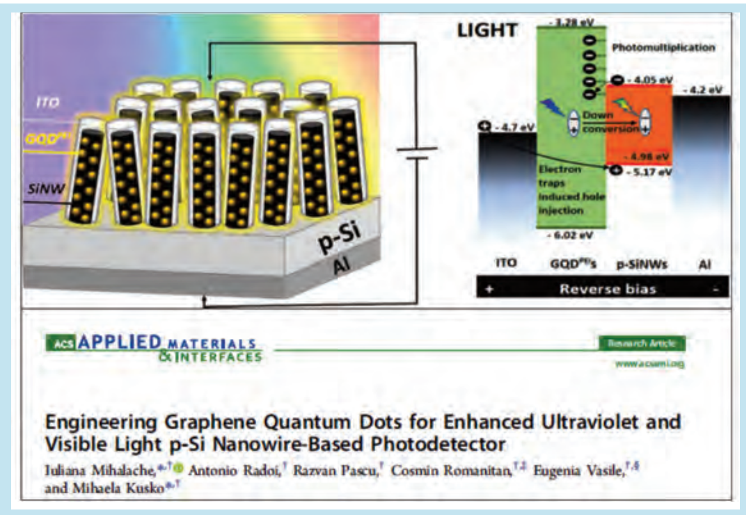
• **PNII-PCCA ctr 142/2014**: "Environmental toxic and flammable gas detector based on silicon carbide MOS sensor array" – resp. IMT Dr. Mihaela Kusko, coord. Faculty of Physics, University of Bucharest (2014-2017) http://www.icpe-ca.ro/proiecte/proiecte-nationale/pn-2011-2013/sic-gas.pdf;

Scientific results

I[st] Research Area – nanomaterials / thin films / physical phenomena in nanosystems

Core-Shell structures based on silicon nanowires (SiNWs) and Graphene Quantum Dots (GQD^{PEI}).

ACS Applied Materials and Interfaces, 9 (34), 29234–29247, 2017.



By incorporating polyethylenimine (PEI) in GQDs synthesis we have obtained optical and electrical properties compatible with the nanostructured silicon platform. Thus, GQD^{PEI} material shows strong photoluminescence in the 400-800 nm spectral range, wide band gap and sufficient supplementary electronic levels inside band gap (compared to as-prepared GQDs) which represents essential properties necessary for the generation and transport of the photocarriers within the type p SiNWs heterojunction.

SiNWs-GQD^{PEI} based heterojunction structures were fabricated and the morpho-structural, optical and electrical properties were investigated. Results shown that the core-shell structures exhibited remarkable photodetection performance: photocurrent to dark current ratio ~ 102, responsivity ~ 25.3 A / W, detectivity ~ 9x1012 cm·Hz1/2/W, along with considerable improvement of external quantum efficiency that far exceeds the 100% threshold.

Based on the experimental results, a number of simultaneous mechanisms responsible for the photodiode charge transfer phenomena have been identified: (i) GQD^{PEI} actively participates in the effective suppression of dark current and the formation of type-I alignment of energy levels in the device; (ii) photo-multiplication occurrence – the generation of electrical charge due to the presence of electron trap states induced by PEI; (iii) GQD^{PEI} promote the UV light down-conversion to the visible domain where the absorption of silicon nanowires is optimal.

Contract PNII-RU-TE-2014-4, "Hybrid flexible interface for energy purposes - HYFLEP" – **Project Director A. Radoi**

New method of identification and quantification of dislocations correlation from heteroepitaxial layers using High Resolution X-ray diffraction methods


Contents lists available at ScienceDirect

Materials Science in Semiconductor Processing

journal homepage: www.elsevier.com/locate/mssp

ELSEVIER

Comparative study of threading dislocations in GaN epitaxial layers by nondestructive methods

Cosmin Romanitan, Raluca Gavrila, Mihai Danila


Contents lists available at ScienceDirect

Solid State Communications

journal homepage: www.elsevier.com/locate/ssc

ELSEVIER

Communication

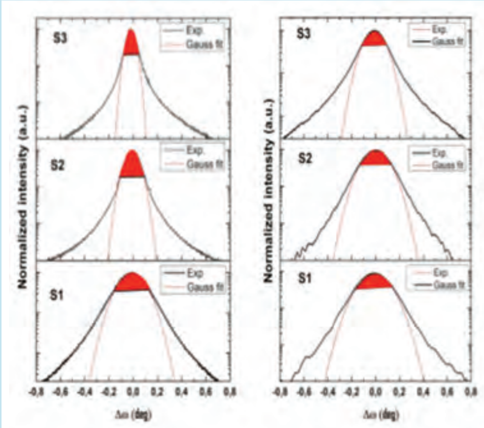
Correlation between threading dislocations in highly mismatched GaN heteroepitaxial layers

Cosmin Romanitan

Edge and screw threading dislocations (TDs) were studied using High Resolution X-ray diffraction techniques in GaN thin layers with different thicknesses, grown on sapphire substrate.

The density of edge and screw TDs was determined and a *new correlation parameter was proposed* - S - in order to quantify the positional correlation between TDs. Moreover, the results were confirmed and explained with the depth profile of TDs. For thin layers (S1, S2), it was evidenced that TDs density is almost constant from the interface with the substrate to surface (~3%), while for thick sample (S3), TDs densities drop four times to the surface (~400%). This fact can be ascribed to the coalescence of adjacent TDs.

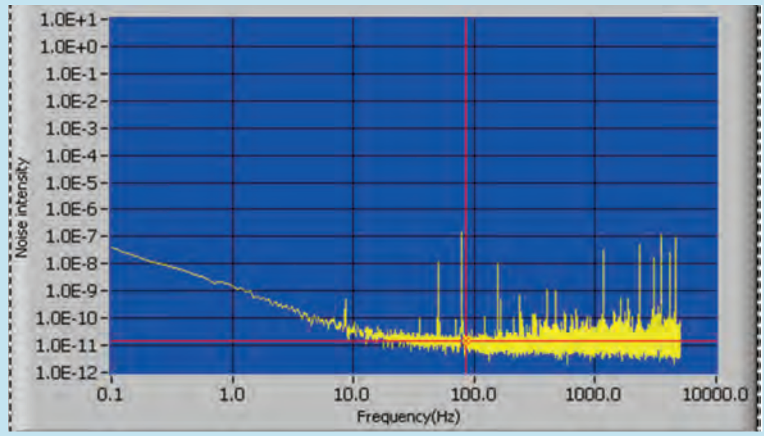
In the figure the experimental profile regions that can be described with a Gauss function are analyzed. (Gauss function is a measure of TDs correlation and new correlation parameter, S, it was defined that the inverse of the integral area of the experimental profile consistent with a Gauss function.)



Proiect 16320102 "*Nano- and heterostructures for micro-nano (opto)electronics components*" – Contact person: **Dr. M. Mihaila**

Defects at SiO_2/SiC interface: investigation by phonon fluctuation spectroscopy

The fluctuation spectrum of the conductivity in the channel of some 4H-SiC lateral MOS transistors was obtained by Fourier analysis of the voltage across the source-drain terminals, at voltages lower than 300mV. 27 noise peaks have been idendified in the voltage dependence of the normalized noise spectral density. Their origin has been investigated by comparison with the atomic vibration spectra (IR and Raman included) of 4H-SiC, SiO_2 polimorphs grown on SiC, local modes of impurities in 4H-SiC and graphite. Some noise peaks have been associated with intrinsic phonon modes of nitrogen-doped SiC, while others have been found to correspond to the phonon modes of quartz and cristoballite, two of the SiO_2 polimorphs on SiC. A local phonon mode of nitrogen in SiC has been identified. Two noise peaks have been atributted to G and D-band of graphite. It indicates the presence of graphitic structures in the transistor channel.

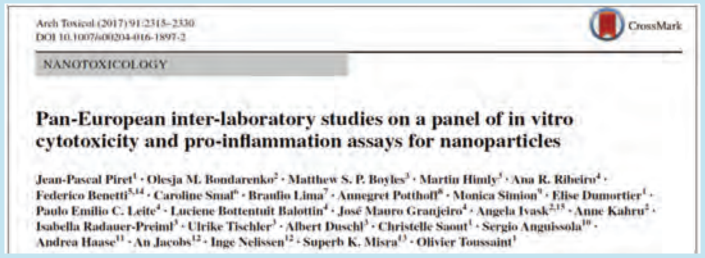


Project 16320102 "*Nano- and heterostructures for micro-nano (opto)electronics components*" – L1 resp.: **Dr. M. Mihaila**

II^nd^ Research Area – physical and chemical studies for hazards and risks evaluation associated of nanomaterials

Ag nanoparticles purchased from Colorobbia in the form of a 4% colloidal aqueous suspension stabilized by polyvinylpyrrolidone (PVP) were investigated.

Ag NPs size distribution was performed using dynamic light scattering (DLS, Delsa Nano Beckman Coulter) measurements in stock aqueous solution at a concentration of 12 µg / ml (the highest concentration used in *in vitro* cell culture assays) in cell culture medium at the beginning and end of the *in vitro* experiment (24 hours). A bimodal size distribution was observed, with primary particles at 20 nm and agglomerated around 116 nm in the stock water solution. In the various culture media, the distribution of Ag NPs was similar regardless of the incubation time.


Arch Toxicol (2017) 91:2315–2330
DOI 10.1007/s00204-016-1897-2

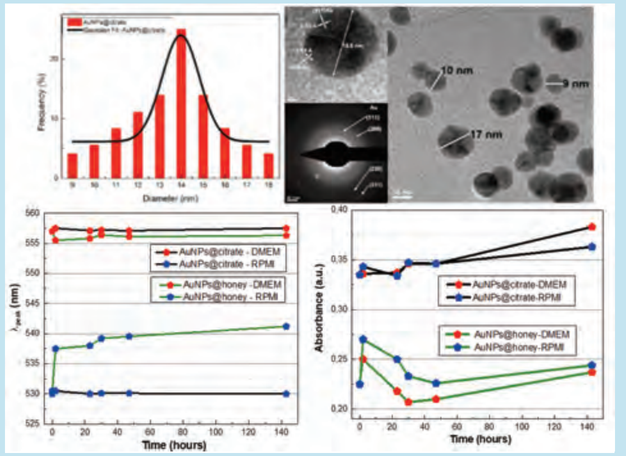
CrossMark

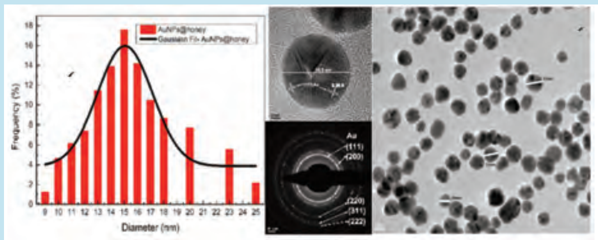
NANOTOXICOLOGY

Pan-European inter-laboratory studies on a panel of in vitro cytotoxicity and pro-inflammation assays for nanoparticles

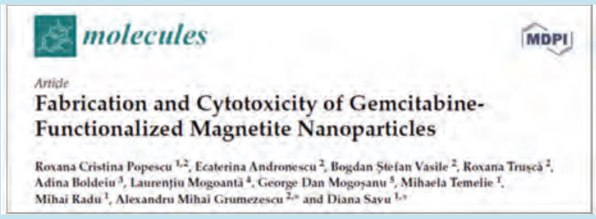
Jean-Pascal Piret[1] · Olesja M. Bondarenko[2] · Matthew S. P. Boyles[3] · Martin Himly[3] · Ana R. Ribeiro[4] · Federico Benetti[5,14] · Caroline Smal[6] · Braulio Lima[7] · Annegret Potthoff[8] · Monica Simion[9] · Elise Dumortier[1] · Paulo Emilio C. Leite[4] · Luciene Bottentuit Balottin[4] · José Mauro Granjeiro[4] · Angela Ivask[2,15] · Anne Kahru[2] · Isabella Radauer-Preiml[3] · Ulrike Tischler[3] · Albert Duschl[3] · Christelle Saout[1] · Sergio Anguissola[10] · Andrea Haase[11] · An Jacobs[12] · Inge Nelissen[12] · Superb K. Misra[13] · Olivier Toussaint[1]

Also, a study of Au NPs behavior with 15 nm in diameter was made, which were purchased from ***Aghoras Invent SRL*** and obtained by using "green chemistry" approaches based on honey, with applications in the field of cosmetics, in relation to Au NPs with the same size, obtained by using the classical Turkevich method.





To evaluate the biological impact of the proteins over these two NPs types, there were used two cell types – B16 melanoma and L929 mouss fibroblasts, in order to study the cell viability, the obtained results showing the AuNPs toxicity dependence with the concentration, cell type and exposure time.


molecules

MDPI

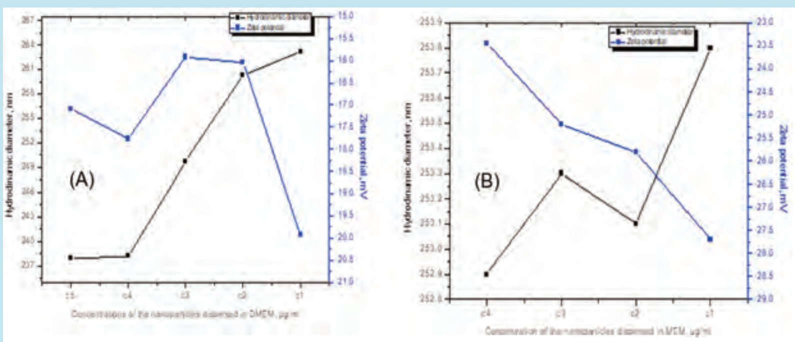
Article

Fabrication and Cytotoxicity of Gemcitabine-Functionalized Magnetite Nanoparticles

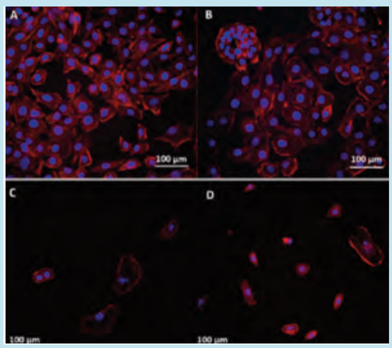
Roxana Cristina Popescu [1,2], Ecaterina Andronescu [2], Bogdan Ştefan Vasile [2], Roxana Truşcă [2], Adina Boldeiu [3], Laurenţiu Mogoantă [4], George Dan Mogoşanu [5], Mihaela Temelie [1], Mihai Radu [1], Alexandru Mihai Grumezescu [2,*] and Diana Savu [1,*]

In the frame of the collaboration between ***IMT*** and ***IFIN HH***, it was evaluated the behavior of magnetic iron oxide nanoparticles functionalized with an anti-tumoral agent, Gemcitabine (**Fe_3O_4@GEM**) using two of the most cell culture media, DMEM and MEM, being monitored their colloidal stability and hydrodynamic diameter.

Moreover, their in vitro assesment was made, using three cell lines –breast cancer BT474, HepG2 hepatocells and ostheosarcoma MG63. In parallel, fluorescence and electron microscopy were employed to investigate the cell morphology, as well as the in vivo biodistribution, for estimating the evolution of the conjugated Fe_3O_4@Gemcitabine system inside the murine body.



Concentration influence over the hydrodinamic diameter and the stability of the Fe_3O_4@Gemcitabine conjugated system during dispersion in MEM (A) and DMEM (B)



Fluorescence microscopy images of BT474 nucleus

The results present an improvement of the citotoxical effects in the case of BT474 and HepG2 cells, by using the conjugated system made of magnetic nanoparticles and gemcitabine, compared to the ones obtained when using only the gemcitabine. ***These promosing results reveal the possibility to use the Fe_3O_4@GEM nanoconjugated system for applications in cancer therapy.***

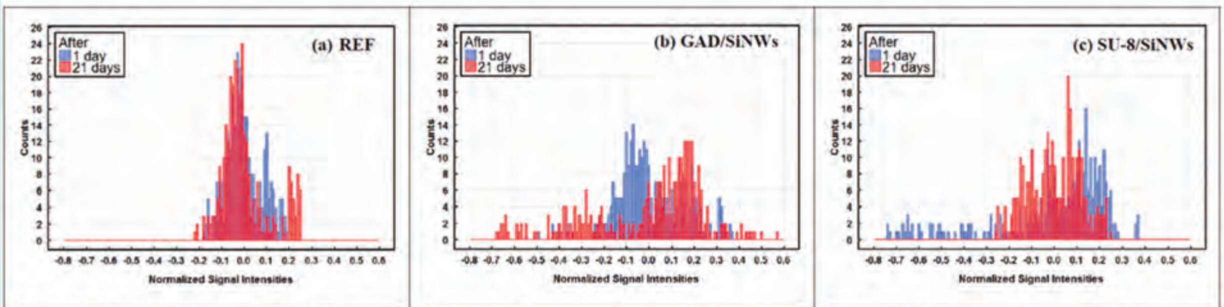
Contract PNII-PCCA ctr 109/2014: *"Improved production methods to minimize metallic nanoparticles' toxicity – less classic, more green – LesMoreNano",* **coordinated by IMT Bucharest**, *partners: UPB, IFIN-HH, Aghoras SRL–* ***Project director: Dr. A. Boldeiu/Dr. M. Simion***

IIIrd Research Area – Nanobiotechnologies / Biosensors

Microarray platform for detection of stable single nucleotide polymorphisms (SNP)

A new microarray platform was developed using SiNWs with chemically modified surface using two alternative methods for obtaining the necessary functional groups. The specificity and stability over time of DNA samples on the SiNWs was compared on substrate modified with: (3-aminopropyl) triethoxysilane (APTES) - glutaraldehyde (GAD) or epoxy-based SU-8 photoresist.

The efficiency of hybridization was assessed by statistical analysis of the data obtained from confocal fluorescence scanning of the manufactured biochips and demonstrated using One Way ANOVA that functionalisation with SU-8 leads to a high detection specificity between hybridized probes containing different types of stable mismatches (p * <0.0001).**



(a) REF

1 day			21 days		
Ī	σ	CV	Ī	σ	CV
4.427	0.081	1.8%	4.463	0.099	2.2%

(b) GAD/SiNWs

1 day			21 days		
Ī	σ	CV	Ī	σ	CV
4.359	0.153	3.5%	3.852	0.256	6.6%

(c) SU-8/SiNWs

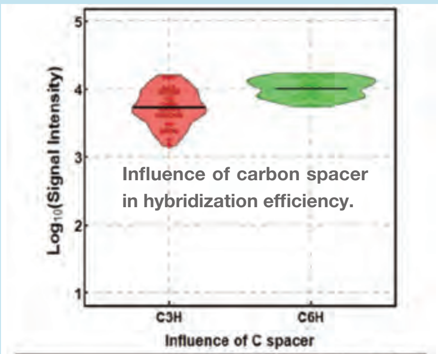
1 day			21 days		
Ī	σ	CV	Ī	σ	CV
4.409	0.248	5.6%	4.140	0.115	2.8%

The stability over time of the samples tethered on SU-8-modified SiNWs was evaluated after 1, 4, 8, and 21 days incubation of the samples, showing values for the coefficient of variation (CV) between 2.4% and 5, 6%. The signal-to-noise ratio based on the standard deviation of SU-8-modified SiNWs was determined to be similar to the commercial support, while SiNWs - APTES-GAD shown the highest signal-to-noise values.

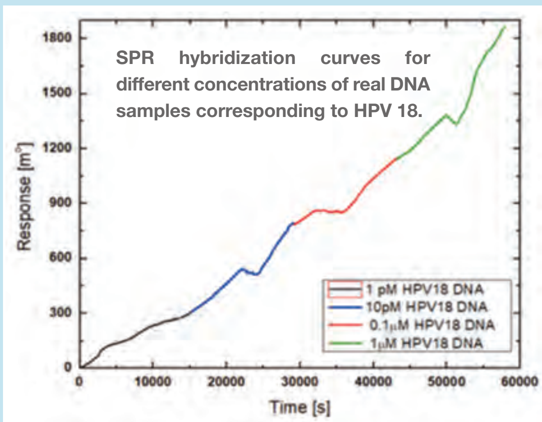
Project PNII-PCCA, contract 36/2014: "Integrated platform for multiplexed genotyping of HPV – ***MultiplexGen*", coordinated by IMT Bucharest**, partners: University of Bucharest, GeneticLab SRL – **Project director: Dr. M. Kusko**

HPV (Human Papillomavirus) genotyping tests based on SPR (Surface Plasmon Resonance) as alternative to classical microarray tests

Oligonucleotide sequences (Biomers.net, Germany) corresponding to E1 gene fragment from HPV 18 were designed to have a –SH modification at 5' end with a 3 or 6 carbon spacer (C3/C6), in order to investigate the spacer influence in the hybridization reaction. Random sequences were designed to to contain at 5' end a –SH group with a C6 spacer and a Cy3 fluorophore at 3' end, in order to investigate the immobilization efficiency using microarray.



	Average	s.d.	CV
C3	3.726	0.266	7.13%
C6	4.005	0.141	3.59%



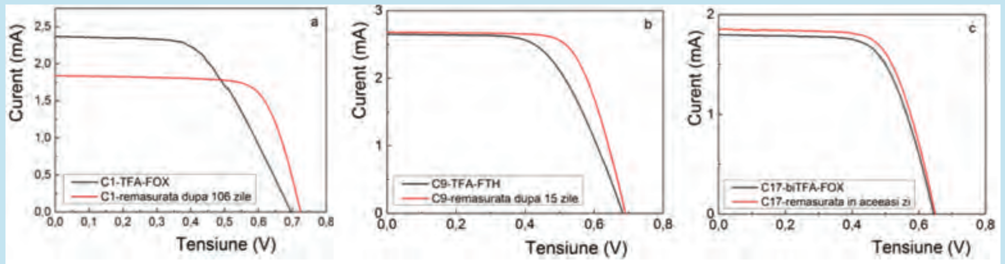
For real DNA samples very good hybridization results were obtained, and the lowest concentration detected was 1 pM.

Project PN16320308: "Nanomaterials and advanced nanotechnologies for applications in opto-electronic biodetection" – ***Project director: Dr. M. Simion***.

Direction IV – Optoelectronic devices based on nanomaterials / thin films

Photovoltaic cells with new, phenothiazine / phenoxazine-based cromophores realized by molecular engineering

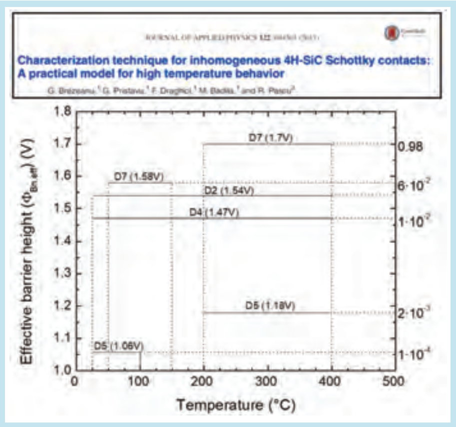
Dye-sensitized solar cells have been manufactured with three new cromophores, designed and synthesized by "Petru Poni" Institute of Macromolecular Chemistry – Iasi (Romania). Two pigments were monoanchor, with combinations of triphenylamine (TFA) and phenothiazine or phenoxazine (FOX) as electron donors, respectively. The third cromophore was similar to the one having TFA + FOX as electron donor but with two cyanoacrylic anchors. Various solvent combinations have been used to functionalize the TiO_2 films, the best result being obtained with dichloromethane. The I(V) characteristics were measured with Oriel LED LSH-7320 solar simulator, at 100mW/cm² (AM 1.5G standard). It was observed that the cell efficiency depends on time, the time behaviour being different.



I(V) characteristics measured at different time lapses forDSSC realized with the new cromophores: C1(TFA-FOX), C9 (TFA-FTH) si C17(biTFA-FOX)

So far, the highest efficiency (4.2%) was obtained for the phenotiazine-based absorber. In time, a decrease in efficiency was observed for the cells realized with phenoxazine (a, C1). It is due to an ISC degradation, accompanied by a slight VOC increase. In the case of the cell with TFA-FTH donor, the efficiency increases in time (b, C9). It was attributed mainly to the filling factor improvement. It points to a possible unstable geometry of the pigment in electrolyte or/and a change of its orientation in time. No improvement in efficiency was found for the cells realized with the bi-anchor pigment (c, C17).

Project PN-III-P2-2.1-PED-2016-0510, 59PED /2017: "Photovoltaic cell with new cromophores based on phenoxazine/phenothiazine obtained by molecular engineering". Coordinator ICMPP- Iasi, IMT- Bucharest - partner; IMT resp.: Dr. Mihai Mihaila

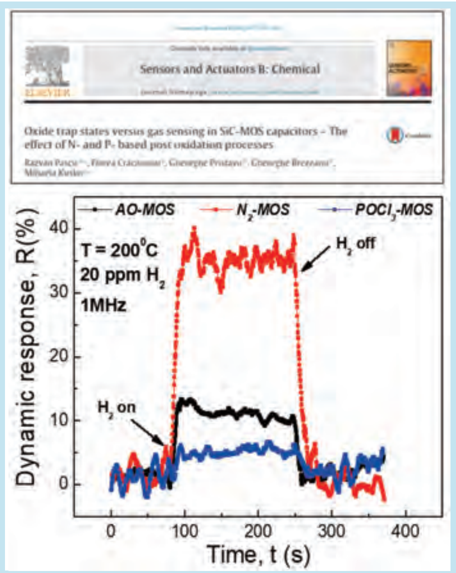


High temperature sensors based on silicon carbide (SiC) for industrial applications in harsh environments

In IMT, Schottky diodes based on SiC have been fabricated using an improved technological flow, with a homogenous Schottky contact between different metals (Ni, Pt) and SiC by using different post-metallization annealing (PMA) treatments. Since the Schottky contacts show series of inhomogenities at the metal/semiconductor interface after a PMA treatment, a macro-model with discrete non-uniform distributions has been proposed in order to determine the temperature and bias ranges for fabricated high temperature SiC sensors, being described by the thermionic emission theory.

Therefore, the main parameters of different Schottky diodes have been determined, both the operating temperature and the bias range for an optimal electrical behavior being obtained.

Project PNII-PCCA ctr 21/2012: "High Temperature Probe Based on Silicon Carbide (SiC) Sensor for Industrial Applications – SiC-SET" coordinator UPB, partner IMT Bucharest – Contact person: Florea Craciunoiu / Razvan Pascu



Hydrogen sensors based on silicon carbide (SiC) for industrial applications

In IMT, SiC MOS capacitors have been fabricated with a high-quality oxide/semiconductor interface using post-oxidation annealing (POA) treatments in various atmospheres, such as nitrogen and phosphorous. In order to find out an optimal technology for the SiC MOS capacitors' fabrication, a comparative analysis has been performed on the fabricated samples in IMT in terms of the used POA treatments.

The studies have been related to both electrical performances of the fabricated SiC MOS capacitors (the operating parameters, the stability with temperature) and the performances in terms of the hydrogen sensors.

A lower interface states density (D_{it}) value, with more than one order of magnitude after a POA based phosphorous atmosphere, and with approximately 40 % for a nitrogen POA treatment, was achieved. Moreover, these POA treatments led to a bigger electric field breakdown. It was demonstrated that the nitrogen-based POA treatment has improved both the MOS oxide quality and the sensor response at hydrogen, **showing extraordinary performances like hydrogen sensor** – the fabricated sensor in IMT having very good performances in terms of both response/recovery time (approx. 10 s), detection limit (0.77 **ppm) and sensitivity (50.5 pF)**

Project PNII-PCCA ctr 204/2012: "Environmental toxic and flammable gas detector based on silicon carbide MOS sensor array– SiC-GAS" coordinator ICPE-CA, partner IMT Bucharest - Contact person: Florea Craciunoiu / Razvan Pascu

Nano-scale structuring and characterization laboratory

Mission

The main mission of the lab is to support research efforts in IMT Bucharest by delivering services and innovative solutions both in characterization and in nanofabrication areas.

The lab provides advanced instrumentation and key expertise for micro and nanoscale imaging and characterization of materials, processes and structures and also for direct nanoscale patterning through electron beam lithography (EBL) – based techniques. The laboratory team is working together with other teams in IMT Bucharest in planning and developing experiments and implementing solutions in various research projects.

Research 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 by Gaussian e-beam lithography for applications in photonics, plasmonics, MSM-UV photodetectors, SAW components for RF/ microwave circuits etc.

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

Team

• **Dr. Adrian Dinescu**, Physicist, Senior Researcher I, Head of the laboratory
• **Dr. Florin Nastase**, Physicist, Senior Researcher II
• **Phys. Raluca Gavrila**, Physicist, Senior Researcher III
• **Dr. Octavian Ligor**, Physicist, Senior Researcher III
• **Dr. Marian Popescu**, Engineer, Senior Researcher III
• **Dr. Silviu Vulpe**, Physicist, Senior Researcher III
• **Ph. D. student Bogdan Ionut Bita**, Physicist, Junior Researcher
• **Ph. D. student Stefan Iulian Enache**, Technological Development Engineer
• **Mihaela Marinescu**, Principal economist

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.

Main Equipments

• ***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 EDX spectrometer (EDAX TEAM ™)

• S***canning Electron Microscope with Thermionic Electron Gun - TESCAN VEGA II LMU*** (TESCAN s.r.o, Czech Republic)

• ***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 embeds 4 experimental laboratories clustered 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 and institutes: ProOptica S.A; S.C. "IOR-S.A."; Sitex 45 SRL.; Optoelectronica 2001 S.A; Faculty of Physics - Univ. of Bucharest; Faculty of Applied Chemistry and Materials Sciences (Department of Chemical and Biochemical Engineering and Department of Bioresources and Polymer Sciences) - Univ. "Politehnica" Bucharest (UPB); Faculty of Medical Engineering; Faculty of Electronics, Telecommunications and Information Technology-UPB; Faculty of Mechanical Engineering and Mechatronics-UPB; Faculty of Dental Medicine-Titu Maiorescu Univ.; The National Inst. for Materials Physics – NIMP; The National Inst. for Laser, Plasma and Radiation Physics – INFLPR (CETAL - Center For Advanced Laser Technologies; Horia Hulubei National Inst. for R&D in Physics and Nuclear Engineering - IFIN-HH (Laboratory of Microbiology); National Inst. for R&D in Electrical Engineering ICPE-CA.

• ***International partnership:*** Collaboration with universities and institutes from the Rep. of Moldova (Academy of Sciences, Institute of Applied Physics, Chisinau), Italy (Università degli Studi di Firenze - Dipartimento di Fisica e Astronomia) and Bulgaria (Univ. of Ruse "Angel Kanchev", Georgi Nadjakov Institute of Solid State Physics - Bulgarian Academy of Sciences).

• ***Running national projects:***

- **"Laser targets for ultraintense laser experiments"/TARGET**, PN-III-/ELI-RO (IMT – Partener) (2016-2018)

- **"Technological transfer to increase the quality and security level of holographic labels"/TSCEH**, P2-2.1-PTE-2016 (IMT – Partener) (2016-2018)

• ***Running international projects:***

- "**High photoconductive oxide films functionalized with GeSi nanoparticles at surface for environmental applications"/PhotoNanoP**, M-ERA.NET Transnational Call 2014 (IMT – Partener) (2016-2018)

- "**Nanostructured and amorphous semiconductor films for sensors application",** JOINT RESEARCH PROJECT Romania Bulgaria (2016-2018)

Education and training

• Master courses and laboratory activities in collaboration with the **Faculty of Electronics, Telecommunications and Information Technology** - University "Politehnica" of Bucharest:

- "Microphysical Characterization of Micro- and Nanosystems" - Master course, Microsystems MSc program

- *"Electronic Technologies for Optoelectronic Applications"*- Master course, Optoelectronics MSc program

- *"Measurements in electronics and telecommunications"* - Laboratory, Year I

- *"Communication Systems"* - Laboratory, Year III, "Microelectronics, Optoelectronics and Nanotechnologies (MON)" specialization

• Master courses and laboratory activities in collaboration with the Faculty of Physics - **University of Bucharest**.

- "*Plasma physics*" – Optional module, Year I, II, III

- "*Electronic Devices and Electronic Circuits*" - Laboratory, Year II

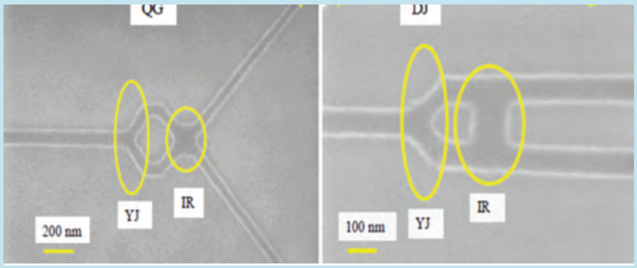
- "*Electronics*" Laboratory - Year II

• *"Analog Electronics"* – Recitation and Laboratory, Year II, **Faculty of Mathematics and Computer Science, University of Bucharest**

MAIN RESULTS - Research Highlights

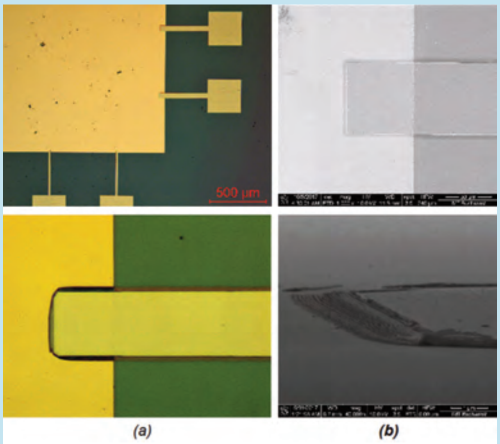
• Engineering logic gates on graphene

The aim of this research was to fabricate at wafer scale two types of graphene logic gates appropriate for implementing quantum computing at room temperature. To this end we have used electron-beam lithography combined with classic microfabrication procedures (optical lithography, selective deposition and etching of thin films, lift-off technique) for patterning graphene layers deposited on silicon oxide wafers. The measurements performed on the final structures confirmed the (quasi-)ballistic nature of charge carrier propagation in the devices with smaller dimensions than the mean free path of these carriers in graphene. As such, these graphene-based configurations are considered appropriate for applications in quantum computing at room temperature. (**„Wafer-Scale Fabrication and Room-Temperature Experiments on Graphene-Based Gates for Quantum Computation", M. Dragoman, A. Dinescu and D. Dragoman, IEEE Transactions on Nanotechnology, vol. 17, nr. 2, 2018**)

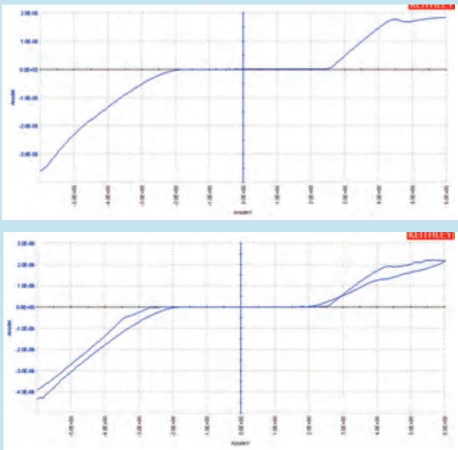


Two types of logic gates based on graphene structures intended for accomplishing quantum computing at room temperature
left: one-qubit quantum gate; right: modified Deutsch–Jozsa algorithm

• Fabrication of MIM (Metal-Insulator-Metal) diodes with dual insulating layer. The insulating layers consist in Al_2O_3 and HfO_2 thin films with precisely controlled thickness, obtained by Atomic Layer Deposition (ALD) technique.



Optical (a) and SEM (b) images of a fabricated MIM diode

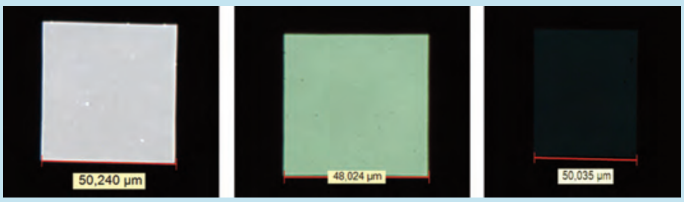


I-V characteristic of a Cr/HfO_2-Al_2O_3/Cr MIM diode

Various configurations of MIM diodes with dual insulating layer have been designed and fabricated. The diodes have symmetric (Cr-Cr) and asymmetric (Cr-Pt) electrodes with thicknesses between 30 – 60 nm. The insulating layers consisted of Al_2O_3 and HfO_2 films, each 3-4 nm thick. The performed current-voltage (I-V) characteristics of the diodes proves the tunneling effect through the dual dielectric layer (Core Project – PN TEHNOSPEC, PN16320202 - 2016).

• Engineering metallic thin foils made of thin Au and/or Pt films with controlled thickness and roughness intended for laser targeting experiments

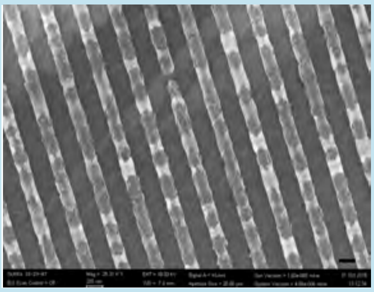
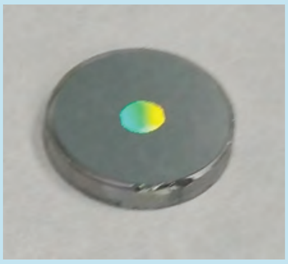
The fabricated targets are intended for research on ultra-high energy particle acceleration by super-intense laser-matter interaction at the future high-power laser infrastructure ELI (Extreme Light Infrastructure).
For these experiments, the layout and thickness of the targets represent critical features when it comes to minimizing losses, maximizing laser absorption and controlling the acceleration mechanism. For manufacturing the foils we have used several metals: Au, Ag, Pt. By means of wet isotropic and anisotropic etch and electron beam evaporation, we have obtained suspended metallic foils, having lateral dimensions between 10 µm and 120 µm and thickness between 25 nm and 100 nm (Core Project – PN TEHNOSPEC, PN16320202 - 2016).



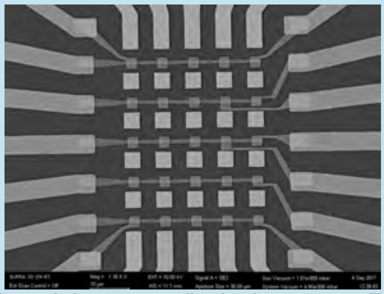
Optical microscopy images of suspended Au foils with tickness of:
a) 25 nm; b) 50 nm; c) 100 nm
Images were obtained in transmitted light, under identical illumination conditions

SERVICES

• Nanometric scale structuring by electron beam lithography

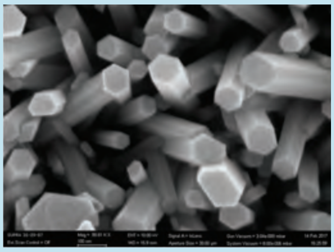



Wire grid polarizer for ultraviolet applications, featuring an array of 400 nm pitch Al wires on MgF_2 substrate. The grating was manufactured using electron beam lithography.
Left: SEM image of Al wires (scale bar: 200 nm); Right: Overall picture of the grating

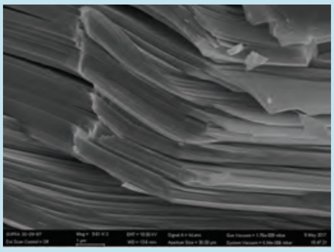


5x5 array of memristive structures lined up between metallic pillars. The structures were fabricated in three electron-beam lithography steps, for a very good resolution (<400 nm minimum dimension) and small alignment error. Contacting the horizontal metal lines is subsequently achieved using optical aligned lithography.

• Characterization of various materials and structures (morphology, composition, material properties)

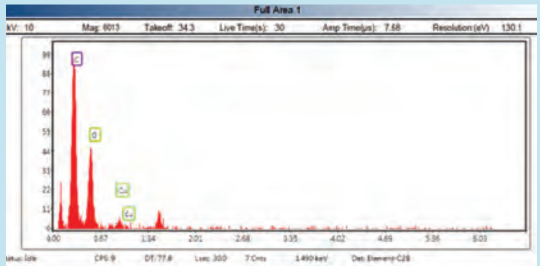


SEM picture of ZnO nanorods Scale bar: 100 nm;



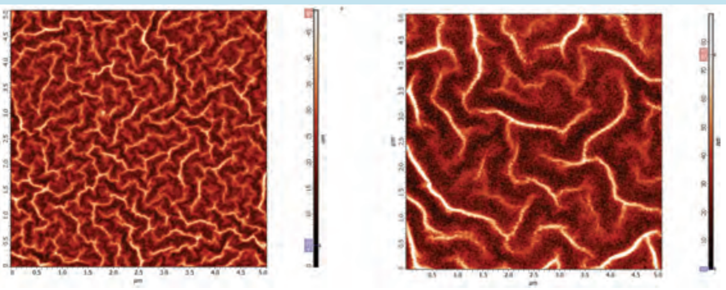
Tin-mono-sulphide (SnS).
Scale bar: 1 µm

• Energy Dispersive X-Ray Spectroscopy (EDX)

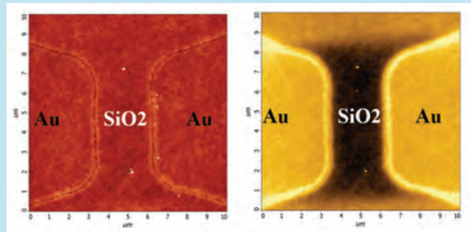


EDX spectrum of graphene deposited on copper substrate via a Plasma-Enhanced Chemical Vapor Process, using CH_4 precursor

• Atomic Force Microscopy and related techniques (SPM)

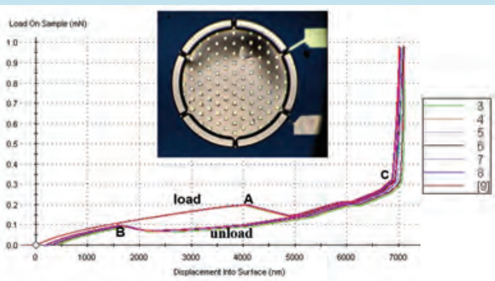


Morphological patterns of ZnO thin films deposited by sol-gel process, for two different deposition conditions - AFM images Scan area: 5µm x5µm

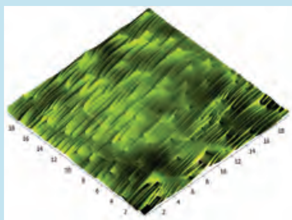


Simultaneous AFM-EFM (Electrostatic Force Microscopy) of a structure consisting in metallic pillars buried by planarization. The contrast-free AFM image (left) reveals the flat topography. The EFM image (right) taken at +5 V bias displays the electrostatic charging of the oxide. Scan area: 10x10 µm²

• Nano Indentation (Depth-sensing indentation techniques) for mechanical characterization at submicron scale



Load-Displacement curves, acquired in a series of mechanical tests performed on a perforated polysilicon membrane, suspended over a single-crystal Si substrate, using a Berkovich indenter. The testing location corresponds to the central perforation. Different sections of the curves are consistent with the characteristic regimes in the test procedure: Points A and B correspond to changes in the buckling mode of the membrane. Indentation of the Si substrate starts at point C.



AFM image of graphene deposited on copper by Chemical Vapor Deposition process (AFM scan). The characteristic steps visible in the morphology are the result of surface "reconstruction" of polycrystalline Cu under the high temperature processes involved in the graphene production.

Scientific Papers and Patents: In 2017, L6 team has co-authored *15 scientific papers in ISI ranked journals* (8 as a first author from IMT) and has *presented 11 communications at international conferences*, among which one invited paper. *One patent* - Co-inventor: Miron Adrian Dinescu (OSIM - BI 129567/ 30.10.2017)

L9 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 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 physico-chemical modifications, structural optimization, epitaxial MBE growth etc.

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 structures, controlled molecular attachments, theoretical modeling and numerical analysis by ab- initio and (semi)-empirical methods.

Research areas

• Synthesis, development and characterization of physico-chemically modified nanomaterials, exhibiting properties suitable for applications in sensors, nanoelectronics and optoelectronics: carbon based thin films and meso/micro/nanostructures (graphene, nanographene, carbon QDs, graphene QDs), nanocomposites.

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

• Development of new materials based on MBE technology: III-N materials, epitaxial graphene etc. and related heterostructures 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.

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. Mihaela Carp – IDT III**, PhD in Engineering, Nanyang Technological Univ., Singapore, 2008.
- **Dr. Radu Cristian Popa - IDT I**, PhD in Quantum Eng. 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 managed industrial research projects with leading Japanese companies and institutions, 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 department director. Main scientific activity includes theoretical and experimental studies of nanomaterials and nanostructures, experiment planning, rational design of nanomaterials and nanostructures based on atomistic simulations.

National and international cooperation

- Clemson University, USA - Prof. Ya-Ping Sun

- Natl. Institute for R&D in Electrical Engineering ICPE-CA, Dept. of Advanced Materials, Bucharest - Dr. Cristina Banciu

- Natl. Institute for R&D in Biological Sciences, Bucharest - Dr. Sandra Eremia, Dr. Simona Litescu

- Natl. Institute for R&D in Lasers, Plasma and Radiation Physics, Bucharest-Magurele - Dr. Catalin Ticos

- Natl. Institute for R&D in Material Physics, Bucharest-Magurele - Dr. Cristian Mihail Teodorescu

- "Babes-Bolyai" University, Cluj, Romania - prof. Anamaria Elena Terec, prof. Simion Astilean

- Institutul de Chimie Fizică al Academiei Române, Bucuresti – Dr. Viorel Chihaia

- Norwegian University of Science and Technology - NTNU - prof. Turid Reenaas

- Optoelectronics Research Centre, Tampere University of Technology, Finland – Prof. M. Guina

- Wroclaw University of Science and Technology, Poland - prof. Robert Kudrawiec

- University of Kassel – Prof. J-P Reithmaier, Dr. Cyril Popov

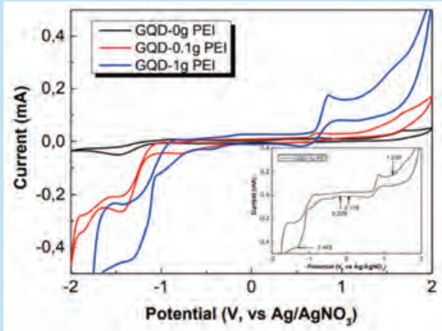
- Université Catholique de Louvain, Belgium - prof. Sorin Melinte

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)

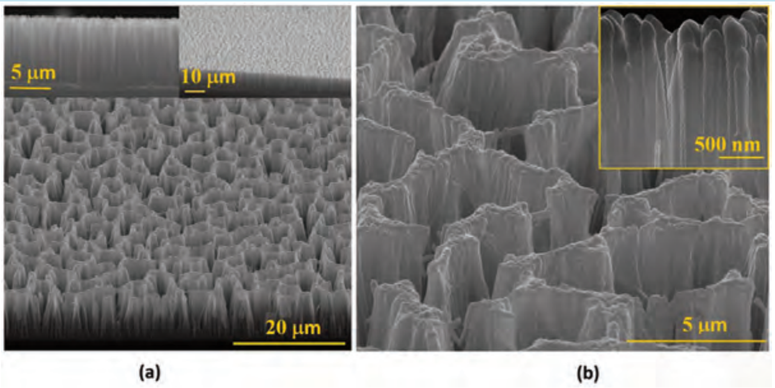
The project explores a class of graphene based materials (Gbm) that can be integrated in photovoltaic devices based on Gbm/Si heterostructures, with a main accent on graphene quantum dots (GQDs).

Hybrid Gbm/Si interface

A silicon nanowire (SiNW) photodetector was developed based on incorporation of polyethyleneimine (PEI)-functionalized GQD nanoparticles. The Iphoto/Idark ratio reaches ~ 0.9 × 102 at 4 V applied voltage. Band energy alignment of SiNW and GQD NPs was ensured based on electrochemical assessment of their HOMO and LUMO levels.



Cyclic voltammograms showing the redox character of pristine GQD nanoparticles and of PEI-functionalized GQD NPs.



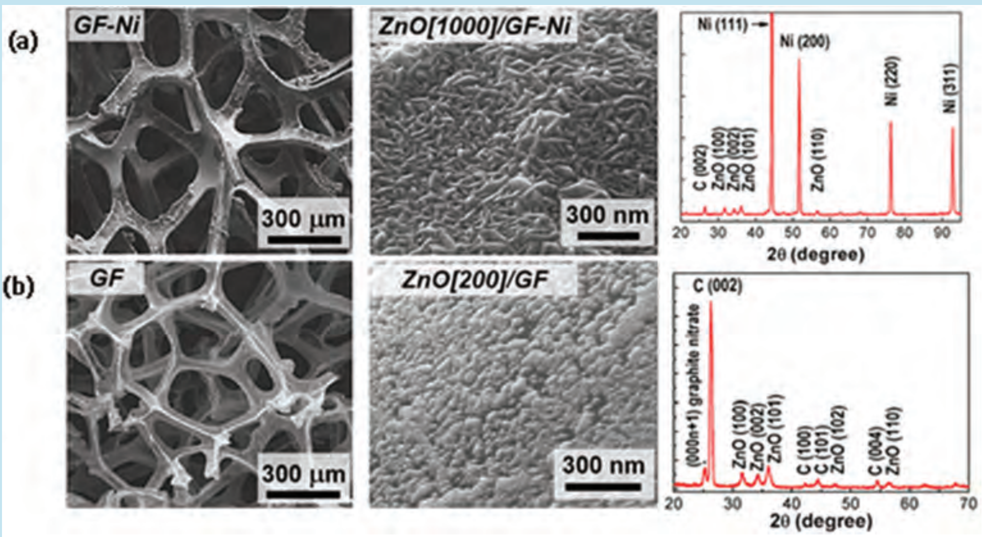
SEM micrographs displaying the morphology of the SiNWs/GQDs hybrid interface, on an ITO film as substrate; a-large view, b-closeup view).

Project PN-III-P2-2.1-PED-2016-1159 "Grätzel solar cells with integrated 3D-graphene structures" (2016-2018) - contact Dr. Monica Veca (monica.veca@imt.ro)

The project addresses the synthesis of 3D-graphene structures and their integration in Grätzel-type solar cells.

Synthesis of 3D graphene - ZnO hybrid monoliths

The 3D-graphene layer was synthesized by the project coordinator - Dr. Cristina Banciu, at ICPE-CA, Bucharest - using atmospheric pressure thermal CVD on macroporous nickel substrate, resulting a Ni-supported graphene foam (GF-Ni). For solar cell integration, the nickel scaffold was first chemically etched in an aqueous solution of nitric acid, obtaining a self-sustained graphene foam (GF) of the same 3D morphology. The GF networks were subsequently functionalized by ALD-based deposition of ZnO films.



Morphological and structural characterizations for: (a-row) nickel-supported 3D-graphene (GF-Ni), and (b-row) self-supported graphene foam (GF). SEM images before (left-column), and after (center-column), the ALD deposition of the ZnO film, using 1000, and resp. 200, ALD cycles. XRD patterns recorded for the synthesized hybrid monoliths (right-column).

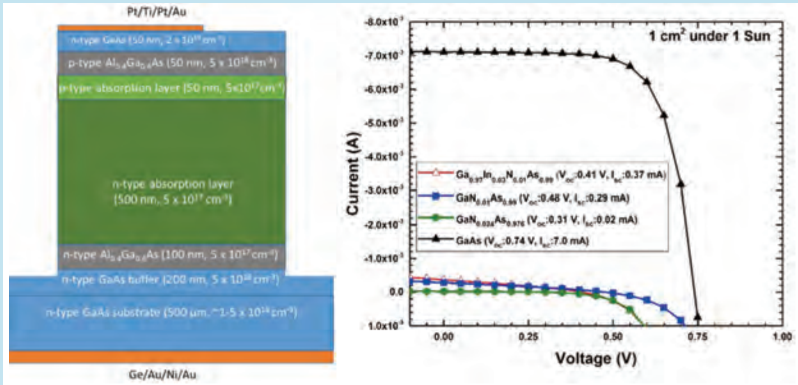
Project: 23SEE/30.06.2014 ”III-N-(As) alloys and engineered heterostructures for high efficiency intermediate band solar cells” (2014-2016) - contact Dr. Emil-Mihai Pavelescu (emil.pavelescu@imt.ro)

The project aims at fabricating high efficiency intermediate band solar cells (IBSCs) that rely on the absorption of photons of lower energy than the bandgap of the active layer by means of an electronic energy band that is located within the host semiconductor bandgap.

Concurrent incorporation of In and N dopants in MBE-grown GaAs favors both the crystalline matching, and the energy band engineering of the resulted GaInNAs quaternary material, rendering the latter the suitable properties for the fabrication of IBSCs that absorb in the NIR range.

Fabrication of IBSCs based on GaInNAs/GaAs

The solar cell structure was devised in IMT and the epitaxial growth was performed in Norway, at the University of Science and Technology, Trondheim. Various area devices were obtained and characterized by cell dicing from the epitaxial wafer and solar cell integration.

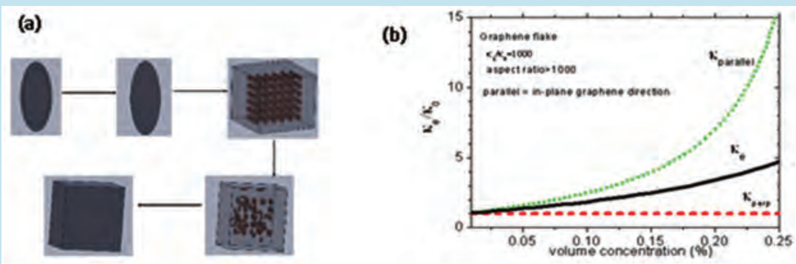


Solar cell heterostructure: the sequence of MBE-grown thin layers (left), and I-V characteristics obtained for various active layers (right).

Numerical modeling of thermal conductivity in composite materials - especially based on carbon nanomaterials

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

Carbon nanomaterials fillers (such as graphene, carbon nanotubes) are used in polymeric matrices to develop composites used for their enhanced thermal conductivity in micro/nanoelectronics as thermal interface materials. Using the so-called homogenization processes, we developed numerical models based on which one could estimate the thermal conductivity of these composite materials.



(a) Schematic with the steps used in the composite homogenization process for the estimation of the effective thermal conductivity. (b) Calculation results showing the dependence of the composite effective thermal conductivity on the graphene content.

Project: 15N/2016-PN16320201–TEHNOSPEC – Carbon nanostructures and films – experimental and applicative investigations

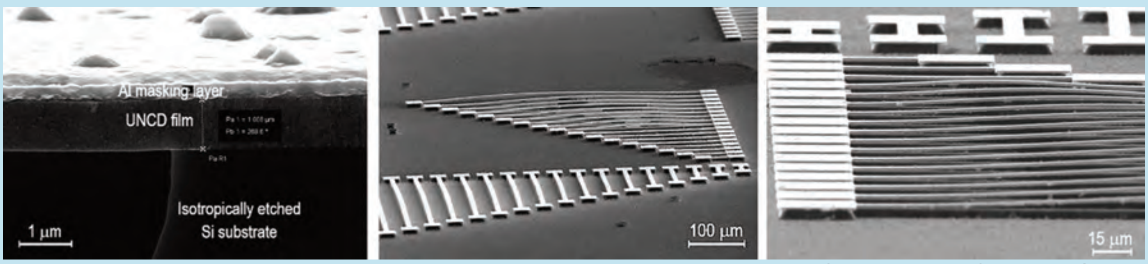
The project aimed at investigating and developing synthesis, micro/nanoprocessing, characterization and integration technologies for nanocrystalline carbon materials.

Microprocessing of ultra-nanocrystalline diamond films for fabrication of micromechanical structures

contact Dr. Cristina Pachiu (cristina.pachiu@imt.ro)

Based on their unique physico-chemical properties, nanocrystalline and ultra-nanocrystalline diamond films are attractive for numerous applications: mechano-acoustic (high-frequency resonators and filters, mass detection cantilevers, SAW devices); electronic (field emission arrays, photodetectors, diodes and transistors, heat spreaders); (electro)chemical (electrodes and coatings); biological (biosensors, cell culture substrates, bioelectrodes, implants); mechanical (protective coatings).

We developed the technology flux for structuring UNCD films and releasing micromechanical structures thereof, with applications in MEMS. The main steps consist of patterning an Al-based selective etching mask, dry-etching (RIE, in O_2 and SF_6 successive steps) of the unprotected diamond film and of the substrate - isotropic O_2+SF_6-based etching for releasing the suspended microstructures -, concluded with the final etching of the Al mask. The detailed spectroscopy analyses performed during this flux enabled its optimization, including the elimination of the residual formations - consisting of Al_2O_3 compound micro-formations acting as micro-masks and of remaining columnar sp^3 carbon - that are resulting after the RIE etching steps.



SEM details of suspended micro-bridge structures of various dimensions, realized in ~600 nm-thick UNCD film grown on Si substrate (MW-PECVD, through collaboration with the Univ. of.Kassel), without the use of a sacrificial layer.

Simulation, Modelling and Computer Aided Design Laboratory L5

Mission

Research, development and applications of simulation, modelling 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. Furthermore, 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 of 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;
- **Modelling and simulation for multiphysics problems;** mechanical, thermal, electrical, electromagnetic, piezoelectric, **coupled field analysis** (static and transient); **microfluidic analyses: CFD, diffusion, mixing, electrokinetics, fluid-structure interaction**
- **Rapid prototyping:** 3D Printer (SLS, respectively, a single-photon-absorbed photopolymerization);
- **Design and manufacturing** of MOEMS and MEMS micro-systems/actuators and microsensors;
- **Design and microfabrication of microfluidic and micro-electro-fluidic systems, electrical and contact profilometry characterization;**
- **Characterization of physical phenomena and defects related phenomena** in ultra-thin films and nanostructures, quantum dots, nanowires, core-shell nanostructures.
- **Technological processes and functional analyzes for advanced materials preparation and integration** in devices for transparent electronics, nano-optoelectronics, sensors.
- **Atomistic modeling** of the electronic structure of wide-band gap semiconductor materials in the presence of dopant impurities and point defects.

Team

1. **Dr. Raluca Müller** - senior researcher I, PhD in electronics, laboratory head
2. **Dr. Rodica Plugaru** - senior researcher I, PhD in physics
3. **Dr. Oana Tatiana Nedelcu** - senior researcher I, MS in mathematics, PhD in electronics
4. **Dr. Gabriel Moagar-Poladian** - senior researcher II, PhD in physics
5. **Dr. Franti Eduard** - senior researcher III, PhD in electronics
6. **Phys. Constantin Tibeica** - scientific researcher, physicist
7. **Phys. Eng. Victor Moagar-Poladian** - IDT III (Technological Development Engineer), physicist engineer (MS)
8. **Dr. Rodica-Cristina Voicu** - senior researcher III, mathematician, PhD in mathematics
9. **Dr. Anca-Ionela Istrate** - senior researcher III, PhD in materials engineering
10. **Eng. George Boldeiu** - IDT III (Technological Development Engineer), MS in electrical engineering
11. **Dr. Angela-Mihaela Baracu** - scientific researcher, PhD in electronics
12. **Dr. Mihai Gologanu** – senior researcher III, mathematician, PhD in mathematics-mechanics
13. **Dr. Florin Victor Lazo** – senior researcher III, PhD in electronics

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).

Laboratory head:
Dr. Raluca Müller,
raluca.muller@imt.ro

International and national collaborations

- **ECSEL-H2020:** 3Ccar: „Integrated components for control in electrified cars“, (2015-2018) Coordinator: Infineon Technologies AG Germany, IMT Partner:Dr. Gabriel Moagăr-Poladian;
- **MANUNET. No. 22 / 2016**: „ROBOGRIP- Microgrippers as end-effectors with integrated sensors for microrobotic applications” (2016-2017), Contract no. 22/2016, Coordinator: IMT Bucharest, Dr. Rodica Voicu; Partners: Technical University of Cluj-Napoca, SITEX 45 SRL, Robotics Special Applications (RoboticsSA) Spain
- **POC-G –** *Operational Competitivity Program 2014-2021, Axa 1: Action 1.2.3,* Contract No. 77/08.09.2016, *TGE-PLAT “Partnership for using Key Enabling Technologies on a platform for interaction with companies”* is a project financed by Structural Funding dedicated to knowledge transfer from IMT to Romanian companies, in a high tech field of the Romanin Strategy (SNCDI 2016-2020): ICT, Space and Security), Coordinator: IMT Bucharest, Dr. Raluca Müller.
- **PN II project**: “Micro-electro-fluidic system for biological cells separation and electroporation - MEFSYS”, Contract no. 30/2014-2017, Coordinator: IMT, Dr. Oana Nedelcu;

International and national collaborations

• **Project PN-II-PT-PCCA-2013-4-1478**, contract nr. 57/2014: “Development of new electro-insulating nanocomposite materials for increasing durability of electric motors - NANOMEL”, PN-II-PT-PCCA-2013-4-1478, Contract no. 57/2014, Coordinator: ICEMENERG, IMT Partner: Phys.Victor Moagar-Poladian;

• **Project PN-III-P2-2.1-PED:** Design and microfabrication of MEMS switch with robust metal contact, Project 33, 2017- 2018, Coordinator: Technical University of Cluj-Napoca, IMT Partner: Dr. Raluca Müller

“Core” funding programme: “Essential generic TECHNOlogies for smart specialization priorities (TEHNOSPEC)” – collaboration in the following projects:

PN16320103 „Nanostructures and heterostructures for micr-nano (opto) electronic components“. Project coordinator Dr. Rodica Plugaru.

- PN16320204 “MEMS based integrated microactuators and sensors”

- PN16320304: “Simulation and manufacturing of microstructures with controlled mechanical instability for obtaining 3D complex geometry devices with applications in biology and medicine”

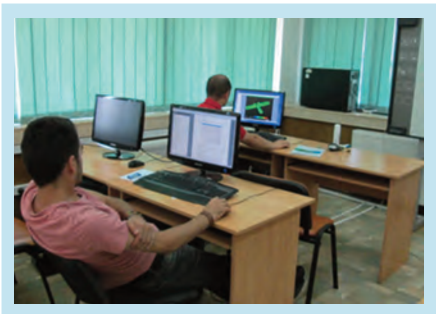
Contribution to projects: – PN16320203 “Nanoelectronics technologies and devices for graphene and other single atomic layer materials”, PN16320202 “Technological processes for thin films advanced materials”

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 2011 – Software for generating complex 3D models for thin films, structures and devices obtained by silicon technology.

COMSOL 5.3 – Software package for simulation of physical phenomena such as: mechanics of solids, heat transfer, fluidics, acoustics, RF-MEMS.

ANSYS Multiphysics 19 – HPC Software package for FEM simulations taking into account several physical phenomena (mechanical, thermal, electromagnetic and fluidic or coupled). Complex simulation methods: 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 for mathematical calculus, algorithm development, data acquisition, visualization and analysis, scientific and engineering graphs.

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 correlation 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, optimisation, 2D and 3D graphics.

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

■ Characterization facilities:

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

Tehnology:

- 3D Printer Selective Laser Sintering EOS Formiga P100

- 3D Printerbased on Single Photon Photopolymerization Mini Multi Lens system from Envision TEC

- Laser microengraving system

Services:

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

• Electrical characterization: -V, C-V, C-t, C-f. Measurements in the temperature range: 77-400 K;

• Masks design, technological design and realization of microfluidic and micro-electro-fluidic systems in silicon and glass, design and fabrication of microfluidic connectors;

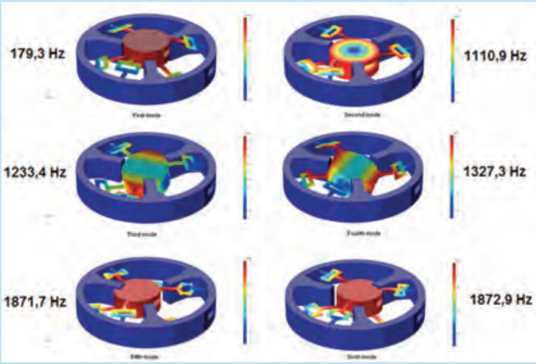
• Development of advanced nanomaterials and oxide semiconductor nanostructures and investigation of their functional properties for applications in nano-optoelectronic components and sensors.

• Rapid prototyping using 3D Printer Selective Laser sintering for the following applications: manufacturing of models for design, architecture, educational purposes; molds manufacturing; manufacturing of robotic components having certain degrees of freedom; manufacturing of customized housings and encapsulations of different types for MEMS structures; manufacturing of MEMS devices models for testing their concept and working principle for MEMS structures and macroscale sensors; manufacturing of mechanical and fluidic functional components;

• Training for design and simulation, students laboratory work, master courses, practical stages for students.

► ECSEL-H2020: 3Ccar: „Integrated components for control in electrified cars“ (2005-2018),
Coordonator: Infineon Technologies AG Germany, Partner L5 din IMT – Dr. Gabriel Moagăr-Poladian;

- We have conceived, simulated and fabricated two types of sensors by using 3D Printing techniques and the „sensor conversion“ concept developed by dr. Gabriel Moagăr-Poladian: – acceleration sensor (team: dr. Gabriel Moagăr-Poladian, fiz. Cătălin Tibeică, ing. fiz. Victor Moagăr-Poladian) and, respectively – prressure sensor (team: fiz. Cătălin Tibeică, dr. Gabriel Moagăr-Poladian).



Results of the modal analysis of the acceleration sensor (its central part), distribution of deflections and frequencies for the first six resonance modes (COMSOL Multiphysics)

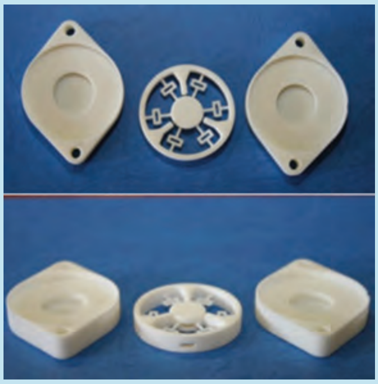


Photo images of the dismantled acceleration sensor (components made by 3D Printing)

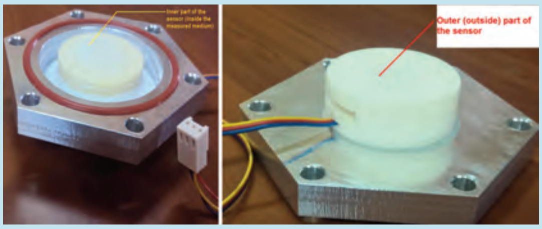
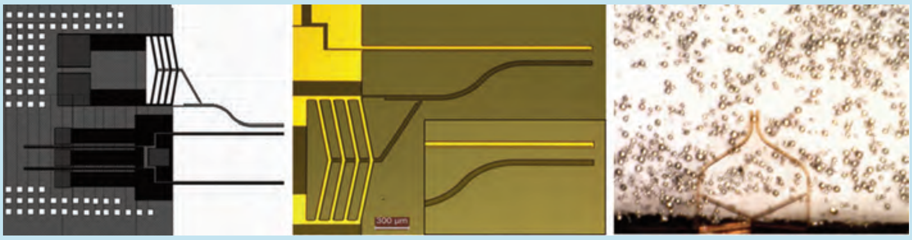


Photo image of the pressure sensor (the pressure sensor is fixed on the support that represents one of the testing cell's walls)

► ERA-MANUNET Project, Contract No. 22/2016: „Microgrippers as end-effectors with integrated sensors for microrobotic applications (ROBOGRIP)" (2016-2017),
Coordinator: IMT Bucharest, Dr. Rodica-Cristina Voicu; Partners: Technical University of Cluj-Napoca, SITEX 45 SRL, Robotics Special Applications (RoboticsSA) Spain

• Design, simulation and fabrication of MEMS micro-tweezers integrated with force/displacement sensors and electro-thermally actuated based on V-shaped actuators with normaly open mode operation. Realization of coupled electro-thermo-mechanical simulations with Coventorware 2014 program in order to analyze the micro-tweezer and the sensor behaviours.

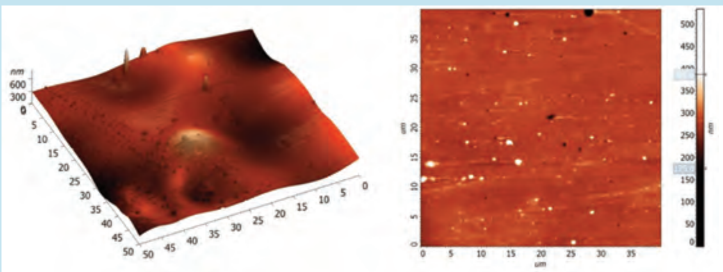
• Realization of a demonstrator of micro-tweezer electro-thermally actuated integrated with a force/displacement sensor (b). Realization and optimization of technological process using as structural material the SU-8 polymer and the metal Au for the metallic heater configuration. We realized microphysical characterisation and electrical tests in order to validate the functionality of the micro-tweezer structures and functional tests regarding the manipulation of different micro-objects with the micro-tweezer arms/tips.



a) b) c)

a) Configuration of a polymeric micro-tweezer integrated with force/displacement sensor; b) Optical image of a micro-tweezer fabricated using SU-8 and Au; c) Optical image of a micro-tweezer structure when the arms grip a micro-object. Contact: Dr. Rodica-Cristina Voicu.

► Project PN-II: "Development of new electro-insulating nanocomposite materials for increasing durability of electric motors - NANOMEL", 2014-2017,
Coordinator: ICEMENERG, IMT Partner: Phys.Victor Moagar-Poladian;



AFM image of the polymer-nanocomposite mixture sample
a) pseudo 3D; b) chromatic map

Samples characterization of polymer-nano-microparticle mixture in different concentrations regarding the mechanical, electrical and surface structural properties:

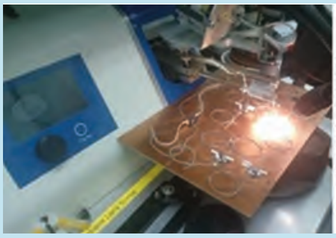
- Nanoindentation investigations
- Investigation of surface layer morphology
- Investigation of the insulating properties of the nanocomposite - polymer mixture

► Proiect PN II: PN II project: "Micro-electro-fluidic system for biological cells separation and electroporation - MEFSYS", (2014-2017);

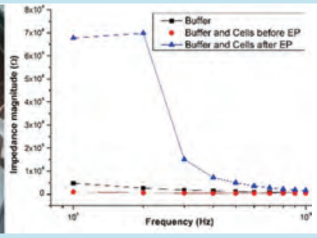
Coordinator: IMT, Dr. Oana Nedelcu.

Prtners: • SC Spital LOTUS SRL Ploieşti; • DDS Diagnostic SRL Bucharest; • University of Bucharest – Facultaty of Chemistry; • University Politehnica of Bucharest – Facultaty of Applied Sciences, Digital Holography Laboratory.

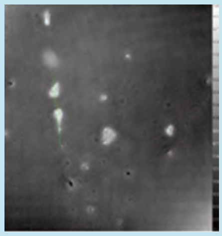
The methodology and set of parameters for testing and characterization of microsystem were deloped. We obtained microphysical characterization results and experimental results related to separation and electroporation of cervical cells and leukocites.



Experimental setup image



Impedance variation as function of frequency for solution with leukocites before and after electroporation

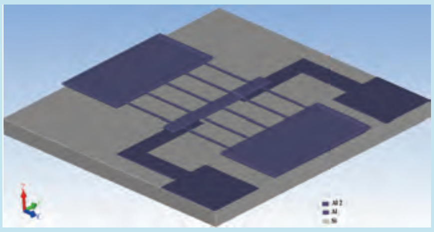


Electroporated cells with modified form and dimensions

► PN-III-P2-2.1-PED: Design and microfabrication of MEMS switch with robust metal contact, Project 33, 2017- 2018,

Coordinator: Technical University of Cluj-Napoca, IMT Partner: Dr. Raluca Müller

Masks design and fabrication of aliminium MEMS switch on silicon substrate for space applications



Technological flow simulation of the MEMS switch (Coventor); Contact: Drd. Angela Mihaela Baracu

► "Core" funding programme: "Essential generic TECHNOlogies for smart specialization priorities (TEHNOSPEC)"

collaboration on the following projects:

- ***PN16320103*** *„Nanostructures and heterostructures for micr-nano (opto) electronic components"*
- ***PN16320104*** *„Actuators and integrated sensors based on MEMS structures"*
- ***PN16320202*** *„Technological processes for thin films from advanced materials"*
- ***PN16320203*** *„Nanoelectronic technologies and devices of graphene and other 2D materials"*
- ***PN16320304*** *„Simulation and fabrication of microstructures with controlled mechanical instability for obtaining complex 3D geometry devices with applications in biology and medicine"*

► PN16320103, „Nanostructures and heterostructures for micr-nano (opto) electronic components". Project coordinator Dr. Rodica Plugaru

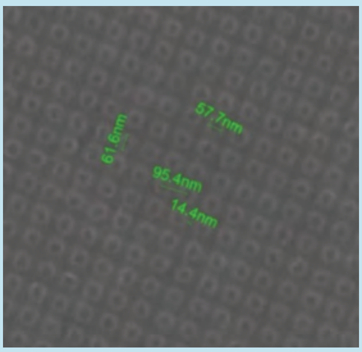
Contributions:

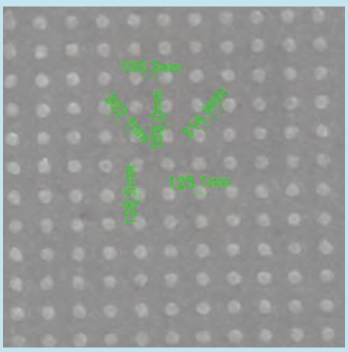
• Development of technological processes for fabrication of core-shell nanostructures of oxide semiconductor materials with applications in nanoelectronics, optoelectronics and ultrasensitive optical sensors.

• Fabrication of FET (field effect transistors) devices with core-shell nanodot arrays. The core-shell nanodot arrays of: a) $Si/SiO_2/(Au)/TiO_2$, b) $Si/SiO_2/(Au)/TiO_2/SiO_2$ şi c) $Si/SiO_2/(Au)/TiO_2/ZnO$ on Si/SiO_2 substrates patterned by ultra high resolution electron beam lithography-EBL.

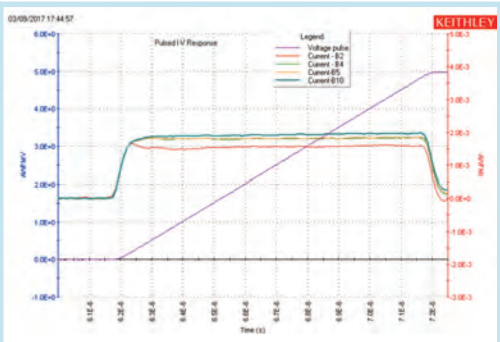
• Development of numerical models to simulate the electrical behavior of nanodot arrays with core-shell structure.

• Fabrication of core-shell nanostructure arrays with semiconductor oxide materials and characterization of their structural and functional, photoconduction and charge transport, properties.



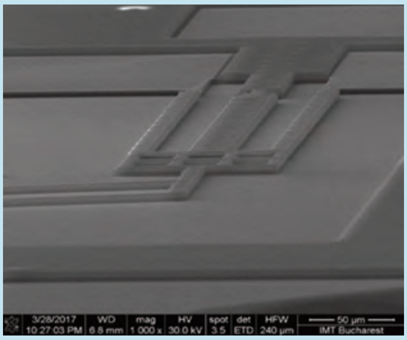


Core-shell nanodot arrays: a) $Si/SiO_2/(Au)/TiO_2$, b) $Si/SiO_2/Au/TiO_2/ZnO$

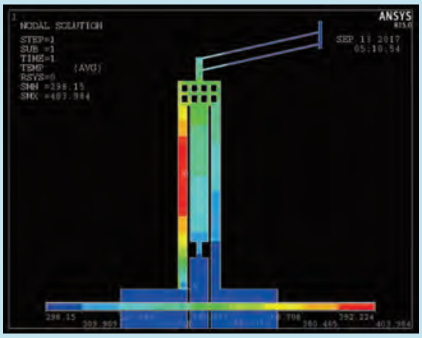


Pulsed I-V characteristics of the FET device with core-shell nanodot arrays of $Si/SiO_2/Au/TiO_2/ZnO$, with various ZnO shell layers. Applied pulse voltage with an amplitude of 5V and rise time 1 μs

►PN16320104 „Actuators and integrated sensors based on MEMS structures”



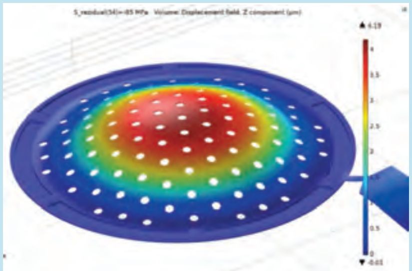
SEM characterization of manufactured switches: electro-thermal actuator: driving mechanism component.



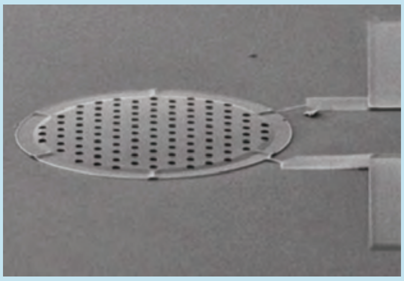
Temperature distribution in the switch (DOE - Design-of-Experiment result)

• *Microfabrication, simulation of aging phenomena and optimization of RF-MEMS switching structures (Contact Ing. Angela Baracu; Dr. Mihai Gologanu)*

The demonstrative structures have been fabricated on Si substrate. The driving mechanism of the switch consists in two SU8 polymer layers (5 µm thickness), inside of which the metallic resistance (Cr/Au) is embedded. The microwave subsystem is also fabricated of Cr/Au. For this demonstrative structure, the potential aging and creep mechanisms (thermal, mechanical, electrical) have been analyzed along with lifetime prediction models.



Simulation of the buckling effect due to the residual compresive stress in LPCVD polysilicon (COMSOL)



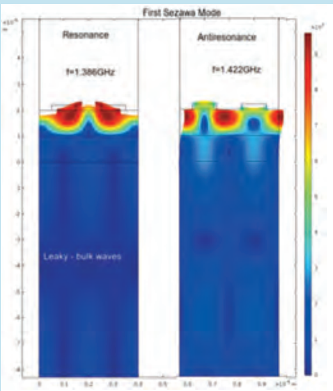
SEM image of a device integrated with a polysilicon membrane

• *Microfabrication, simulation of aging phenomena and optimization of RF-MEMS switching structures (Contact Ing. Angela Baracu; Dr. Mihai Gologanu)*

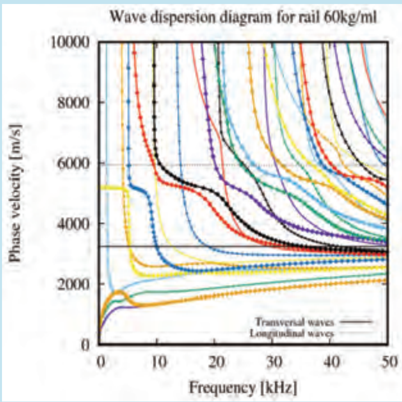
• Experimental realisation and characterization of MEMS devices based on polysilicon membranes. Design and simulation of a MEMS device which integrates a polysilicon circular membrane with a thickness of 1 µm and a diameter of 340 µm. The device can be used as an electrical micro-switch, but also as a capacitive force sensor. Contact Fiz. Cătălin Tibeică; Dr. Rodica Voicu.

►Contributions to M-ERA.NET Manufacturing and characterization techniques for surface acoustic wave devices for sensory applications- PhotoNanoP, Project 33/2016, IMT Partner: Dr. Miron Adrian Dinescu

►Design and fabrication of Al interdigitated structures on SiGe/SiO_2 and SiGe/TiO_2 substrates (Contact: Drd. Angela Baracu)



Propagation of a Sezawa mode or a wave guided in the piezo layer due to the diamond film beneath it.



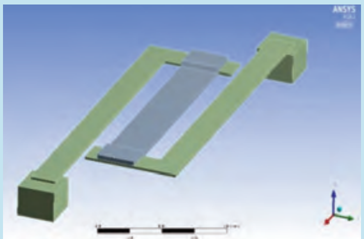
Wave dispersion diagram in a long slab of steel using SAFE (semi-analytical finite element).

► Contributions to “Core” funding programme “TEHNOSPEC” **PN16320201**

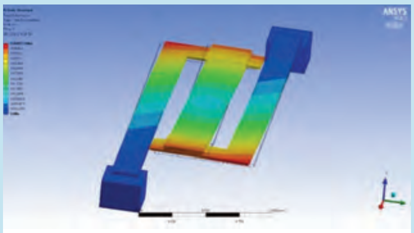
“Essential generic TECHNOlogies for smart specialization priorities”

Phase 5.8 "Applied investigations for sensors, electrodes and micro-acoustical devices on nanocrystalline diamond films". We designed and simulated a Surface Acoustic Wave device build on top of a piezoelectric film (ZnO) sputtered on the diamond film. We devised a new method to simulate wave propagation in a guided or periodical media using a combination of analytical methods and finite element methods (SAFE or semi-analytical finite element) and implemented it in COMSOL (Contact Dr. Mihai Gologanu).

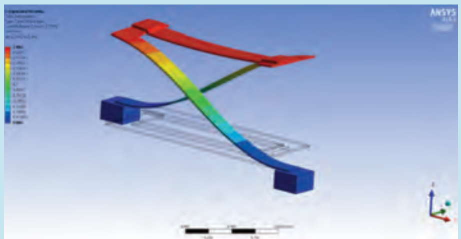
► **PN16320304:** „Simulation and fabrication of microstructures with controlled mechanical instability for obtaining complex 3D geometry devices with applications in biology and medicine“, Coordinator: IMT, Eng. Phys. Victor Moagăr-Poladian



Geometry of optimized structure and materials distribution



Total deformation of the structure due to residual stress obtained in a static simulation



Structure deformation as a result of the buckling process.

L7 Centre for Nanotechnologies and Carbon-based Nanomaterials Reliability Laboratory

Mission

The design, development and implementation of innovative instruments and solutions for the design, testing and monitorization of normal functioning and reliability for: sensors, actuators, microsystems, nanostructures, intelligent systems, and micro – electronic and opto-mechanic components.

These activities have a high interdisciplinary character and are implemented following the specific guidelines of Concurrent Engineering, starting from the conception stage, moving to project definition, followed by the specific activities for the development of the device and monitoring of its functionality in real life applications.

Activity areas / Expertise areas?

2.1 Research – Development - Innovation

Research & Development of innovative solutions for sensors and intelligent sensors systems, using nano – structured carbon and metallic oxide based sensitive layers, for environmental and industrial applications.

Built – in reliability: Design for Reliability – DfR, Robust Design – RD, Design for Manufacturing – DfM,

Selection and monitoring of micro – and nanostructures / devices; reliability for components working in harsh environment environment (automotive, aerospace, nuclear, etc.)

2.2 Testing services

- Accelerated tests (one or more multiple, simultaneous, stress parameters) for micro – and nano – structures; failure analysis; physics of defects and reliability; reliability of virtual prototypes

Team

The L7 team is a multidisciplinary one, including seven specialists, from a variety of domains: micro- and nano - electronics, chemistry, physics, management and engineering of technological systems, automation and computers.

• Dr. ing. Octavian BUIU, CSIII, head of laboratory (starting March 2017);
• Dr. Ing. Cornel COBIANU, CSI (starting February 2017)
• Ing. Niculae DUMBRAVESCU, CS III.
• Dr. Ing. Octavian IONESCU, CS III (starting February 2017).
• Ing. Roxana Marinescu, IDT.
• Dr. Ing. Bogdan–Cătălin Şerban, CSIII (starting February 2017)
• Ing. Dragoş Vârşescu, IDT III.

Results (examples)

• Execution and delivery on contract 67CI/2017 (National call PN-III-P2-2.1-CI-2017-0265): „Intelligent aero based sensing system for monitoring the status of high – voltage electrical stations".

o Supplier: INCD pentru Microtehnologie – IMT Bucureşti. Principal Investigator: Dr. Octavian IONESCU; Beneficiary: Tehnopro Engineering SRL, Bucureşti

o Duration: July 2017 – December 2017

• L7 did contribute – as part of the PROBA-3 ASPIICS OPSE project (ESA Contract No. 4000111522 / 14 / NL / GLC) - to the development of structural models and FEM simulations for the qualification of fixing and mounting devices for the OPSE („Oculter Position Sensor Emitter") and specific vibration testing procedures. Following the approval of the procedures, vibration tests were executed, and the following results were reported to the external partners:

o Development of the OPSE's structural thermal model (STM);
o Development of the vibration testing procedures for OPSE
o Design and realization of mounting device for OPSE vibration testing.
o Execution of vibration tests for OPSE.

National and International Collaboration

International collaborations

• Participation in the PROBA-3 ASPIICS OPSE HARWARE – Contract No. 4000111522 / 14 / NL / GLC ((ESA – European Space Agency) project (coordinator: laboratory L8 – IMT);

National collaborations

• Participation in project „Parteneriat în exploatarea Tehnologiilor Generice Esențiale (TGE), utilizând o PLATformă de interacțiune cu întreprinderile competitive (TGE-PLAT) " – cod SMIS2014+105623. The L7 laboratory prepared and presented to the interested companies its offer for reliability tests and consulting.

• Participation (Dr. O. Buiu) at SIPOCA27 project, as part of the ITC and Security panel.

• A colaboration with several National R&DI Institutes (INOE 2000, INFLPR – Bucureşti; INECMC – Timişoara) and Academic Rsearch groups (Politehnica University of Bucharest, Transilvania University of Brasov) for the preparation and submission of a joint research project, to be submitted in response to the PN-III-P1-1.2-PCCDI-2017 competition call (complex projects). The submitted proposal („Nanocarbon+"), coordinated by IMT- Bucharest (with Dr. Octavian Buiu, head of the L7 laboratory, as project coordinator) was awarded the funding and execution will start in early 2018.

• Development and implementation of vibration tests for piezoelectric sensors, to be used – within the Microsystems for Biomedical and Environmental applications Laboratory – for the further development of „energy harvesting" devices.

• Vibration reliability tests (ADT TU; AGS–WBDL) for Elettra Communications SA, Ploiesti, Romania.

• Services for the development and characterization of materials and electronic modules (graphene aerogel, electronic boards for accelerometer testing), developed within IMT Bucharest and to be used in the automotive industry.

Referees for the European Research programs, publishing houses, journals; members of the National Standardization and Editorial boards

• Octavian Buiu – evaluation expert for EU – H2020 (FET – Open, ICT, Security, Marie Curie Programs RISE and ITN; ViceChair in the ITN's „Physics and Mathematics" panel) and COST programs. Reviewer for the following journals: AIP Advances (American Institute of Physics), Materials Chemistry and Physics (Elsevier)

• Bogdan–Catalin Serban: Associate Editor in MOJ Polymer Science (MOJPS); Reviewer

Hardware capabilities:

The laboratory has several high-performance equipment covering both the reliability testing and general electronics requests. Details for those are given in the table below.

Equipment for reliability testing (see next page).

Reliability Testing equipment:

Test name	Equipment / Manufacturer	Typical parameters of the equipment
High temperature	UFB 400 / MEMMERT	Temperature: +5°C….+220°C ; Chamber volume: 53 l
Temperature + Low Pressure	VO 400 / Memmert	Temperature: +25°C…+200°C; Pressure: 10…1100 mbar; Volume: 49 l
Temperature + Humidity	CH 160 / Angelantoni	Temperature: -40°C…+180°C Humidity: 20…95% RH: Volume: 160
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 cycles	TSE-11-A / ESPEC EUROPE GmbH	Two chambers method, variable displacement speed; Lowest temperature: -65°C…0 / Highest temperature: +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%; Max. weight of the sample: 100 Kg; Volume: 250 l
Mechanical shocks (Free Fall)	MRAD 0707-20 – Free Fall Sock Machine / Cambridge Vibration	Size of the transport mass: 17.78cmx17.78cm; Max. height of the samples: 25.4 cm; Max. fall height: 152.4 cm; Maximum acceleration: 4500 g
Thermal conditioning (during the measurements)	TP04300A-8C3-11 7 Thermo Stream / Temptronic	Temperature variations: - 80oC to +250oC; transition times: 7s (up); 20s (down). Temperature control: +/- 0.1°C
Thermal analysis	Microscope IR SC 5600 + G3 L0605 / FLIR Systems	InSb sensor; resolution (pixels): 640x512. Tempetaure calibration domain: -20°C … 3000°C

Electronic equipment:

Equipment	Specs
Keithley 4200-SCS Semiconductor Characterization System	• Input stimuli: Voltage (CC) < 100V, Current (CC) < 1A • Pulses: analogue signal 30V, <40MHz • Measurements: voltage 0.5 μV, current 1 fA
NI PXIe-1078 data acquisition system:	• NI PXIe-6341 - X Series Multyfunction 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
LCR Rohde & Schwarz HM8118 Bridge/Meter	• Measurement range: 20 Hz 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) • Measurement functions: L, C, R, |Z|, X, |Y|, G, B, D, Q, Φ, Δ, M, N • Transformer measurement: mutual inductance and ratio - Internal: 0 V to 5 V/0 mA to 200 mA (resolution: 10 mV/1 mA) - External: 0 V to 40 V (bias voltage only) • RS-232/USB dual interface for remote control, optionally IEEE-488 (GPIB) • Fan less design
Teledyne LeCroy WaveSurfer 3024 Oscilloscope	• 200 MHz, 350 MHz, 500 MHz, 750 MHz bandwidths • Long Memory – up to 10 Mpts/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 • WaveSource Function Generator • Digital Voltmeter • Mixed Signal Debug Capabilities - Analog and Digital Cross Pattern Triggering; - Digital Pattern Search and Find - Analog and Digital Timing Measurements; - Activity Indicators
Stanford Research Systems SR865 Lock-in Amplifier	• 1 mHz to 2 MHz (operates to 2.5 MHz) • Low noise voltage and current inputs • 1 μs to 30 ks time constants • High bandwidth outputs • Touchscreen data display - large numeric results, chart recordings, & FFT displays • 10 MHz time base input and output • GPIB, RS-232, Ethernet and USB • HDMI video output

L2 Centre for Research and Technologies Integration Microsystems for Biomedical and Environmental Applications Laboratory

Mission

The main mission of laboratory is **research – development**, focused on the development of microsensors (chemical sensors, biosensors, mechanical sensors), microstructures and microelectrodes, microprobes for recording of electrical activity of cells and tissues, microfluidic and integrated technologies (silicon, polymers, biomaterials), signal processing, data acquisition and graphical interfaces, development of integrated systems and platforms for food monitoring and biomedical applications, education in the field of micro – chemo - biosensors, and services in design, simulation and technology for bio - chemo and micromechanical sensors applications.

Team

The research team consists of 14 people, specialists in Electronics, Physics, Chemistry and Biology

1. **Dr. Carmen Moldovan** - CS I, PhD in electronics, head of laboratory;
2. **Cecilia Codreanu** – CS III, engineer;
3. **Bogdan Firtat** - CS III, engineer;
4. **Dr. Marian Ion** - CS, PhD in Physics;
5. **Silviu Dinulescu** – AC, engineer;
6. **Adrian Anghelescu** - CS III, engineer;
7. **Costin Brasoveanu** – IDT, engineer;
8. **George Muscalu** – AC, engineer;
9. **Ioana Ghinea** – technician, chemist;
10. **Alina Popescu** – CS III, chemist.

International and national collaborations

1) *International cooperation* with research centers and renowned companies in the UK, Germany, France, the Netherlands, Switzerland, Hungary, Poland, in the framework of European research projects:

o **PiezoMEMS** - Piezoelectric MEMS for efficient energy harvesting – M-ERA.NET (ICF and Romelgen - Romania, Jožef Stefan Institute and HIPOT RR – Slovenia, ITE and Medbryt - Poland) - coordinated by the laboratory;

o **iBracelet** - Inteligent bracelet for blood pressure monitoring and detection of preeclampsia – EUROSTARS (InforWorld and "Politehnica" University Bucharest – Romania, Cherry Biotech and Elvesys – France);

o **RoboCom++** - Rethinking Robotics for the Robot Companion of the future – FLAG-Era.net (24 partners from Italy, Belgium, France, Switzerland, Spain, The Netherlands, Croatia, Estonia, UK, Slovakia, Greece, Romania);

o **CONVERGENCE** - Frictionless Energy Efficient Convergent Wearables For Healthcare And Lifestyle Applications – FLAG Era.net (17 partners from Switzerland, Italy, France, Belgium, Latvia, Estonia, Turkey and Romania);

o **WaterSafe** - Sustainable autonomous system for nitrites/nitrates and heavy metals monitoring of natural water sources – M-ERA.NET (ICF, Univ. Transilvania Brasov and NANOM MEMS – Romania, Institute for Technical Physics and Materials Science, Centre for Energy Research, Hungarian Academy of Sciences and University of Pannonia – Hungary).

2) Cooperation with research institutes and universities (INFLPR, "Politehnica" University) and Romanian companies (ROMELGEN, Telemedica, DDS Diagnostic) within the national programs through several projects coordinated by the laboratory:

o **AMI-DETECT** (Micro Immunosensor Platform for Detection of Acute Myocardial Infarction): DDS Diagnostic SRL, "Politehnica" University of Bucharest, Telemedica SRL, Romelgen;

o **PiezoHARV** (Efficient Piezoelectric Energy Harvesters to Power Supply Inaccessible Sensors Networks and Low Power Devices for Aerospace Applications): ICF „Ilie Murgulescu", NANOM MEMS;

o **E-NOSE** (Electronic nose for detecting small concentrations of pollutants and explosives): ICF „Ilie Murgulescu", Romelegen;

o **BioSIM** (Portable analyzer biochips for the assessment of insulin resistance and metabolic syndrome), technology transfer project in partnership with DDS Diagnostic;

o **NUCLEU** (Technology for biochemical sensor systems on thin organic films).

Areas of activity

Micro-Nanosensors – Microsensors development (chemorezistent, resonant gas sensors, accelerometers, micro-arrays, ISFET sensors, nanowire based sensors, electrodes for biological sensors, microprobes for recording electrical activity of cells);

Microfluidic modules and chips – Simulation, modeling and development of microfluidic platforms: microchannels, tubes, microfluidic connectors, tanks and mini-pumping systems;

Sensor platforms, Integrated systems - Platforms that integrate microsensors with microfluidic systems, with data acquisition, signal processing and graphical interfaces, operating automatically and autonomously.

Simulation and modeling - simulation / modeling using MEMS specific CAD tools (CoventorWare, COMSOL, CADENCE).

Laboratory head:
Dr. Carmen Moldovan
carmen.moldovan@imt.ro

Dr. Carmen Moldovan graduated on Electronics and Telecommunications and she owns a PhD in Microsensors. Her current research activity is focused on development of chemosensors and biosensors, micro-nanoelectrodes, ISFETs, nanowire transistors, MEMS, NEMS, BioMEMS, microfluidic platforms, readout design, signal processing, data acquisition for microsensor arrays and energy harvester for self-autonomous systems and Platforms and systems (e.g. Platform for pesticides detection; Portable device for early detection of acute myocardial infraction; Optical Platform for detection and monitoring of metabolic syndrome) Dr. Carmen Moldovan is / was a partner or coordinator of 15 EU Projects (FP6, FP7, ERA-NET) and 20 National Projects. She is currently coordinating two ERA-NET and three National projects.

Her scientific activity was published in more than 120 papers in journals, books and Proceedings.

Equipments

Ink Jet printer – offers the capability to deposit droplets of fluid, of the picoliter magnitude, such as liquid silver or organic inks, on all types of surfaces including flexible ones: PET (Poly-Ethylene-Terephthalate), PEN (Poly-Ethylene-Naphthalate) and Poli-Aniline (PANI).

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

CNC (Computer Numerical Control) – Miniaturized machine, consisting of miniaturized system for mechanical processing and a special design and control software. CNC equipment is used to develop microfluidic components and fabricate various mechanical interfaces that connects sensors to different measuring devices.

Ultimaker 2+ 3D Printer - designed and built for fused deposition modeling for various high-quality plastics like PLA, ABS, CPE. The mixture of precision and speed makes the Ultimaker 3D printer the perfect machine for concept models, functional prototypes and also the production of small series.

MICROSENSORS AND MICROTRANSDUCERS

Micro-Immunosensor Array for the Acute Myocardial Infarction Detection (AMI-DETECT)

The industrial partner, DDS Diagnostic, together with the coordinator (IMT), designed and developed the final version of the microbiosensors. The laboratory model of the fluorescence apparatus was developed by UPB, which allowed us to obtain the first determinations for h-FABP and CK-MB. Romelgen sweep movement module for optical scanning provided the opportunity for a small handling time when inserting and replacing the sample box and conducting the measurements with the optical and acoustic signalling of the analysed channel.

Fig. 1. The experimental setup of the AMI-DETECT sensing platform, including: the mechanical support, the sensors capsule, the laser module and the optical components

Fig 2. Sensors capsule containing the sensing strips

The developed microbiosensors allows the identification of two biomarkers in AMI: hFABP and CK-MB. For these, a linear dependence was obtained between the normalization of the fluorescence intensity in the test area (Ip - obtained from reading the intensity in the test area minus the PBS buffer intensity) relative to the normalized fluorescence intensity in the control zone (Ic - obtained after reading the intensity in the control area minus the intensity of the buffer solution) and the logarithm of the biomarker concentration. The calibration curves thus obtained allowed the determination of concentrations from patients selected by Telemedica partner. Validation determined that these biomarkers were highly accurate when the reference methods were ELISA for hFABP and Immunoturbidimetry for CK-MB.

The obtained results allow us to continue the validation and optimization tests for the other two IMA biomarkers (cTnT and myoglobin) as well as parallel testing with the software and the fluorescence apparatus developed in this project.

The implementation of this analysis system has the potential to accelerate the selection of patients in the emergency medical units and also, rapid and efficient diagnosis of patients with cardiovascular disease.

Sensors for pollutant and explosive gases detection (eNOSE)

We designed and developed an optimized gas sensing system for monitoring very low concentration of pollutant and explosive gases to in domestic or industrial environments. The microsensors, based on nanostructured metal oxides (SnO_2, ZnO, SnO_2:ZnO, SnO_2:ZnO:Fe_2O_3), have been fabricated and tested for CO, C_3H_8 and CH_4 detection.

The sensor is heated at the optimum working temperature, thus providing maximum sensitivity for a certain gas, using an integrated resistive heater, patterned on the back side of the sensing chip.

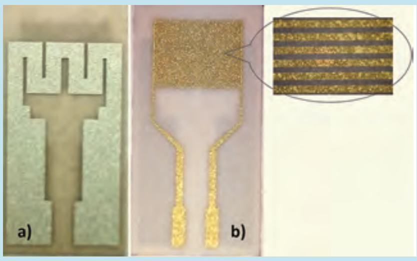


Fig. 3 The sensor chip: micro-heater (a) and interdigitated electrodes (b)

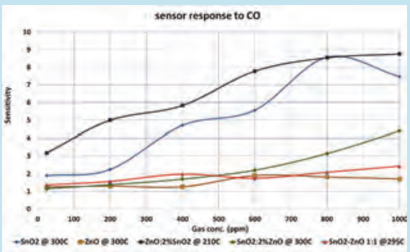


Fig. 4 Different sensor response for CO, at the corresponding working temperatures

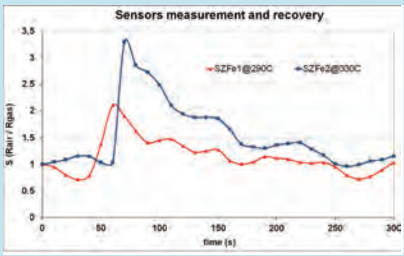


Fig. 5 Sensor measurement and recovery time

Portable biosensors for insulin resistance and metabolic syndrome evaluation (BioSIM)

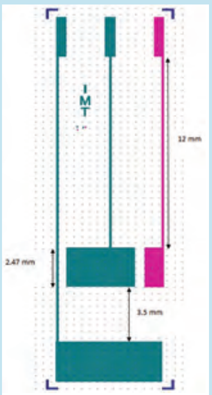


Fig. 6 Lay-out of the sensing chip

Metabolic Syndrome (MS) is an independent risk factor for three of the first 10 causes of death in the world at this moment (diabetes, heart disease, cerebrovascular disease). Early identification of biomarkers of metabolic disorders in obesity and insulin resistance is the first step in the fight against this disease.

The biosensors will allow the development of an accessible, fast, cost-effective and easy-to-use technology for the early identification of the patient's insulin resistance and the presence of the metabolic syndrome.

Autonomous sensors for monitoring nitrites/nitrates and heavy metals in natural water sources (WaterSafe)

The electrochemical microsensors for nitrates/nitrites and heavy metals will be miniaturized, fully integrated, fabricated by micro–nano technology and connected to the electronic module that provides detection, data acquisition and interpretation. The sensitive layer deposited on the working electrode are metal oxides and/or polymeric membranes.

Fig. 7 Schematic of the detection cell (a), the measurement device (b), powered up by solar cells (c)

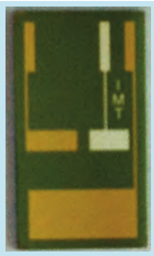


Fig. 8 The amperometric transducer

Current stage tests of the sensors provided good results for different nitrates and nitrites, below the legally allowed concentrations, proving the general

ENERGY HARVESTING DEVICES

Piezoelectric MEMS devices for efficient energy generation (PiezoMEMS)

The project aims to develop an energetically efficient MEMS harvester in the form of a piezoelectric cantilever made with clean piezoelectric materials (without Pb), with high piezoelectric coefficients, deposited in thin layers on Si substrate and exhibiting low losses. The harvester will include only lead-free piezoelectric materials, making it suitable for biomedical applications (e.g. powering-up implantable devices).

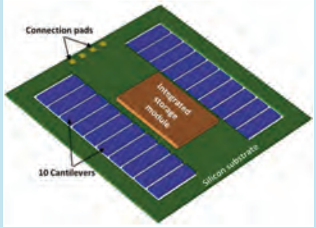


Fig. 9 The concept of resonating microbar area for efficient energy generation

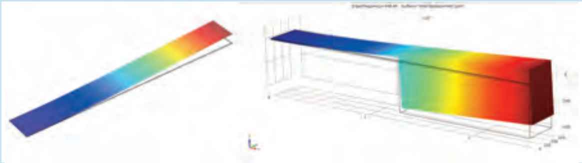


Fig 10. Simulations on the resonating beam for power generation: simple (left) and inertial (right)

In addition, the project also aims to build the energy storage device and the afferent electronics. The concept of the device was developed and it's consisting of an area of 20 resonating piezoelectric bars.

The modelling and simulation techniques provided us with the optimum geometrical dimensions of the cantilevers, specifically designed to meet the application field requests. Additionally, an inertial mass resonant bar has been optimised, with the purpose to further improve the harvester's efficiency.

Piezoelectric Energy Harvesters for Inaccessible Sensors Networks and Low Power Devices for Aerospace Applications (PiezoHARV)

The piezoelectric harvester, based on micro-electro-mechanical system (MEMS) devices and piezoelectric material fabrication, thick film deposition and patterning (screen printing), together with storage module and power circuitry is focused on powering inaccessible sensors networks and low power devices on board of helicopters and other aircrafts.

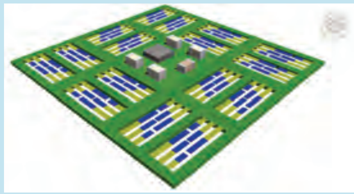


Fig. 11 Schematic of the energy harvesting device, including the storage electronics

The harvesting cell includes several resonant micro-cantilevers, covered with a piezoelectric thick film having the role to convert the mechanical energy into electrical energy (direct piezoelectric effect). The device is using a variation of PZT-type materials (PZT-5H, PZT-5A, and PMN-PZT), for maximising the harvesting efficiency.

The cantilevers have variable geometries, in order to increase their efficiency for a wider frequency range.

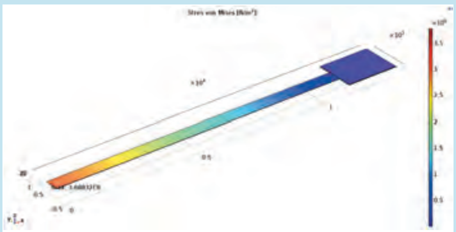


Fig. 12 Simulations of one energy harvesting structure

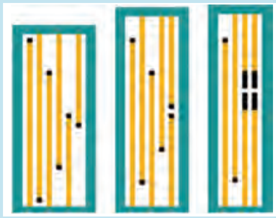


Fig. 13 Design of the different dimensional energy harvesting cells

Micro-nanotechnology-based devices / IoT applications

Intelligent bracelet for blood pressure monitoring and detection of preeclampsia (iBracelet)

A sensor system for the early detection of hypertensive disorders of pregnancy such as pre-eclampsia and other blood pressure as well. The system consists of a bracelet that incorporates a pressure sensor for continuous recording of the blood pressure wave form across the wrist artery. The sensing element consists of a resistive sensor with a microfluidic solution placed between transparent membranes (PDMS, PET).

Fig. 14 Cross section of the blood pressure sensor

Robotic components for the Robot Companion of the future (RoboCom++)

RoboCom++ will lay the foundation for a future global interdisciplinary research programme (e.g., a FET-Flagship project) on a new science-based transformative Robotics, to be launched by the end of the H2020 Programme.

RoboCom++ will pursue a radically new design paradigm, grounded in the scientific studies of intelligence in nature. This approach will allow achieving complex functionalities in a new bodyware with limited use of computing resources, mass and energy, with the aim of exploiting compliance instead of fighting it. Simplification mechanisms will be based on the concepts of embodied intelligence, morphological computation, simplexity, and evolutionary and developmental approaches.

The IMT group is involved in "Soft technologies for wearable and mobile robots", by using soft and compliant technologies to enable the development of sensors, structures, and actuators suitable for operating in unstructured environments, in proximity to users and for tasks requiring high dexterity or conformability, such as manipulation, locomotion, rehabilitation and surgical operations.

Frictionless energy efficient convergent wearables for healthcare and lifestyle applications (CONVERGENCE)

The wearable sensor platform proposed in CONVERGENCE is centred on energy efficient wearable proof-of-concepts at system level exploiting data analytics developed in a context driven approach (in contrast with more traditional research where the device level research and the data analytics are carried out on separate path, rarely converging).

Fig. 9 The concept of resonating microbar area for efficient energy generation

IMT is involved in the development of microelectrodes for physiological parameters measurements and sensors for Acute Myocardial Infarction diagnostic, with dedicated reader. Also, the group in IMT will provide the system with gas sensors and will offer support for the signal processing from wearable human body sensors.

Education and training services

Supervision of bachelor's and dissertation papers at the "Politehnica" University of Bucharest, Faculty of Electronics.

Mission

Research, Development, Innovation of new micro / nanosensor technologies (Technological design, technological development up to prototype level)

Research, development, innovation of new nanostructured materials (Synthesis of new materials, Development of devices/structures based on new materials)

Technological and characterization services

• Assistance and technological consultancy (design of technological flows, control gates etc.)

• Analyze of technological compatibility and defects, on the technological flow

• Technological assistance at transition from prototype to zero series (technological transfer)

• Development of individual technological processes (oxidation, dielectric and metal deposition, ion implantation, photogravure, liquid and solid source doping, surface preparation processes (chemical cleaning)

• Troubleshooting individual technological processes and technologies

• Assistance in the synthesis of nanostructured materials and nanocomposites

• FTIR, UV-Vis characterization and Electrical device characterization

• RTP technological processes - fast oxidation and nitriding processes, densification, annealing

Dissemination:

• Organization of workshops, presentations in the field of the Ambiental Technologies Laboratory expertise (link with industry)

Education and training:

• Associate teacher at University "Politehnica" Bucharest, Faculty of Electronics and Telecomunications;

• Courses and laboratories for the master program in Optoelectronics in collaboration with University Politehnica Bucharest.

Supervision of diploma and master papers at University Politehnica Bucharest

Services: Scientific services of material characterization using FTIR and technological processes using RTP and calcining furnace accordingto ISO 9001: 2008 adresing IMT and research institutions collaboration activities.

All activities of the Ambiental Technologies Laboratory are being carried out with the aim of improving the ambiental conditions and increasing the individual and social security (including health applications) and upgrading the traditional industries in order to make them more efficient. In the last years the Laboratory activities were focused also in space domain applications (ESA,ROSA)

Domain activity

Research-Development-Innovation Expertize:

• Advanced technologies for solar cells manufacturing (including for space applications) - elena.manea@imt.ro

• Surface and Bulk microprocessing technologies - elena.manea@imt.ro; ileana.cernica@imt.ro

• Integration signal electronics with sensors technologies - ileana.cernica@imt.ro

• Micro / nanosensors technologies (including sensor areas) - ileana.cernica@imt.ro; elena.manea@imt.ro; alina.matei@imt.ro

• Optoelectronic technologies (eg photodiodes, suppression diodes, optical alignment systems) - ileana.cernica@imt.ro; elena.manea@imt.ro

• Optical elements manufacturing technologies (areas of microlens , thin lenses, thin mirrors) - elena.manea@imt.ro

• Technologies for manufacturing wood-polymer composites with components of nanostructured materials - alina.matei@imt.ro

• Development of advanced nanocomposite materials with antibacterial properties technologies for civil constructions applications - alina.matei@imt.ro; ileana.cernica@imt.ro

Characterization Services and Technological Processes

• FTIR, UV-Vis characterization - alina.matei@imt.ro

• Electrical device characterization - florian.pistritu@imt.ro

• RTP technological processes: rapid oxidation and nitridatization processes, densification, annealing - alina.matei@imt.ro; ileana.cernica@imt.ro

• Sintering, calcinations at high temperature - alina.matei@imt.ro

• Specific technological processes for applications of optical alignment systems in space - ileana.cernica@imt.ro

Team

- Ileana CERNICA - CS I, PhD in microelectronics, head of laboratory;

- Elena Manea, CSI, PhD in phisics;

- Alina MATEI - CS III, PhD. in chemical enginering;

- Florian PISTRITU – principal electronics engineer;

- Andrei GHIU – engineer in Mecatronics;

- Edwin Alexandru Laszlo - engineer in Technological Physics, master student;

Laboratory head:
Dr. Ileana 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, 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 at international inventions exhibition in Brussels and Geneva and 2 bronze medals international exhibition "ideas-inventions-novelties"IENA, Nurnberg) and 3 books.

New directions for the future

❖ Nanostructured materials and micro / nanosensors for building applications for environ- mental and safety improvement.

‣ Nanostructured materials and micro / nanosensors for applications in agriculture
‣ Nanostructured materials and micro / nanosensors for 'smart textile' applications.
‣ Nanostructured materials and micro / nanosensors in aerospace research and industry

Focusing IMT-Bucharest strategy:

•Applications of micro / nano technologies and nanostructured materials in security

• Microsensors andmicrosystems for cross-border protection (eg explosion detection, aflatoxindetection, anti-explosive securedevices)

• Devices for the spaceindustry (eg: Fields of opticalalignmentdevices for correlatedflights and for detection and capture of waste in space, incubators for plant growth for long-term missions or space stations)

• Applications of nanostructuredmaterials and micro/nano sensors in aerospace research in both directions: aeronautics and space (eg:nano composite coatings for space shuttles and / or combat aircrafts)

International and national collaborations

University Partners: 6
University Politehnica Bucharest (Center for Optoelectronics, Department of DCAE-Faculty of ETTI, CEM- Science of Materials Faculty, Faculty of Mechanics); Transilvania University of Brasov, Technical University of Timisoara, Military Technical Academy Bucharest, University of Bucharest

Partners CD Institute and Romanian Academy Partners: 5
National Institute for Electrochemistry and Condensed Matter Timisoara, ICIA Cluj, Institute of Chemistry of Timisoara Academy, ICECHIM Bucharest

IMM and IND Partners: 3
ECONIRV, ROMAERO, MIRA Telecom

Partnerships: 3
ESA, CSL Liege, INAF Torino

Equipments (selection)

Tehnologies

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

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

- **High temperature furnace,** Carbolite used for: sintering, annealing, calcination, etc.

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

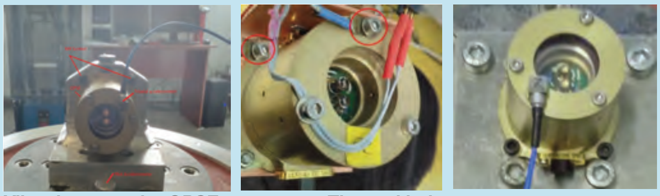
- UV-Vis Spectrometer AvaSpec-2048 TEC, AVANTES

Project: PROBE-3 Coronagraph System Mission-OPSE (ESA)

Prime Contractor: Centre Spatial de Liège;
Subcontractor for OPSE: IMT Bucharest

Purpose: to create 3 Occulter Position Sensor Emitter (OPSE) systems for aligning the coronograph in the space mission PROBE 3 (2019 launch in space)

OPSE tests made in cooperation with L7, Ionescu Octavian Narcis, PhD



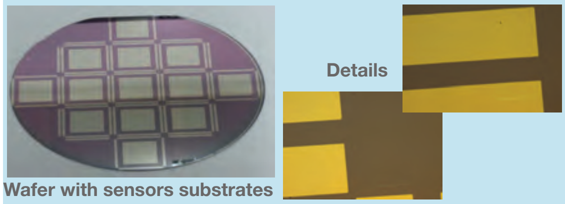
Vibration tests for OPSE; Thermal balance tests;

Project Director Ileana Cernica (ileana.cernica@imt.ro)

Project: Advanced researches on the development of rapid methods and techniques for the detection of pesticides in the food chain (PESTI-SENZ)

Partners: INCEMC Timisoara; IMT Bucharest; Bucharest University; S.C. ECONIRV SRL

The main goal of the project is to create films and membranes based on lead-free piezoceramic materials in order to develop devices for the analysis and detection of biochemical compounds using innovative laboratory processes and technologies. The specific objectives of the project will aim to solve important theoretical and experimental aspects that will contribute to the development of microsensors incorporating a demonstration device based on the new nanocrystalline piezoceramic materials with PZT-like features that will ensure the safe operation of the environment.



Wafer with sensors substrates

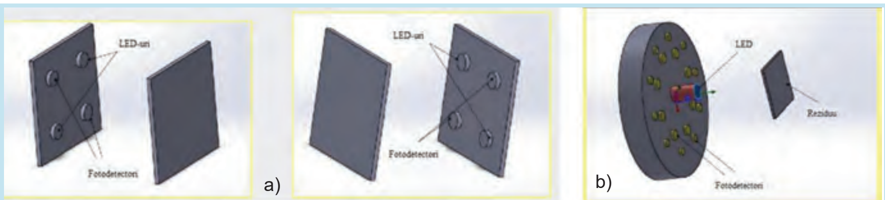
IMT Project Manager: Alina Matei (alina.matei@imt.ro)

Project (STAR): Precise optical alignment systems for spacecraft formation flying and active debris removal– OASYS

Partners: Space science Instirute-Bucharest; Military Technical Academy
Project Coordinator: IMT Bucharest

The project main aims are:

-to develop an optical alignment system (OAS) for autonomous missions to intercept and deorbit space debris. A major component of this type of missions is entering a coordinated flight orbit with an uncooperative debris in order to safely perform the rendezvous.

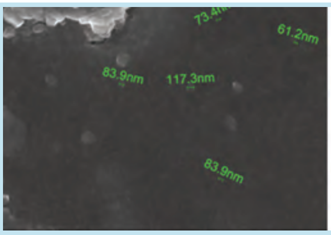


optical alignment system (OAS): a) used in rendezvous or formation flying missions and b) for autonomous missions to intercept and deorbit space debris

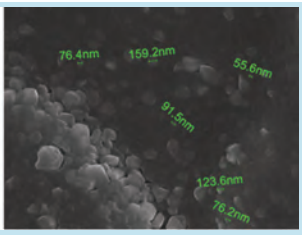
- to develop an optical alignment system (OAS) to be used in rendezvous or formation flying missions

IMT Project Manager: Ileana Cernica (ileana.cernica@imt.ro)

Project (PN16 32 02 06): "Technological processes for thin layers of advanced materials"
Project manager: Dr. Adrian Miron DINESCU



TiO_2 anodized film with annealing-SEM Image



Ag doped TiO_2 film anodized-SEM image

Stage 6.4 - Technological Processes for Obtaining Electrochemical Anodizing and RF Sputtering of TiO_2 Nanostructured Oxidized Film, doped and undoped

TiO_2 films, obtained by anodizing the Ti film Deposited on Si type p substrat, characterization

For SEM characterization was used an equipmen model FEI Nova Nano SEM 630. The SEM images reveals pores dimension for TiO_2 anodized, doped with silver, after a 425^{0}C treatment in hidrogenated nitrogen atmosphere.

Phase manager : Elena Manea(elena.manea@imt.ro)

Centre for Research and Technologies Integration
Micro- and nano-fluidics laboratory L10

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 fundamental 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.*

Domains of activity

• *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* (μ-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.

Team

1. **Dr. Marioara Avram** - CS I, modeling, simulation, design, microfabrication and characterization of lab-on-a-chip microfluidic devices with integrated biosensors.

2. **Dr. Cătălin Valentin Mărculescu** - CS III, Newtonian and Non-newtonian fluid flow modeling and simulation, mono and multiphase flows, mixing, turbulence, heat transfer, user defined function implementation for additional flow parameters setting, magneto-dynamics, particle manipulation using dielectrophoresis and magnetophoresis.

3. **Dr. Andrei Marius Avram** - CS III, physicist, experimental microtechnology; DRIE, polymer, glass and silicon microprocessing, design, microfabrication and characterization of lab-on-a-chip microfluidic devices.

4. **Ph.D student Vasilica Tucureanu** – CS III, chemist, synthesis of nanostructured inorganic materials, hybrid nanocomposites study, thermal processes, optoelectronics, electrochemistry, analytical chemistry, substrate cinfuguration;

5. **Ph.D student Tiberiu Alecu Burinaru** – research assistant, nanofluidic modelling of biomolecular interactions.

6. **Master student Cătălina Bianca Ţîncu** – research assistant, experimental set-up for the characterization and testing of the biosensors integrated on microfluidic platforms; synthesis and characterization of carbonic nanomaterials.

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

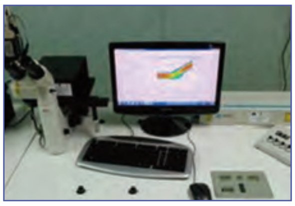
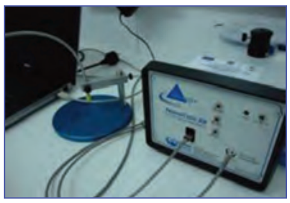
Wafer Bonder System- SB6L- Wafer - Substrate Bonder System - Bonding: Si on Si, glass on Si, Pressure/heat assisted polymer bonding

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.



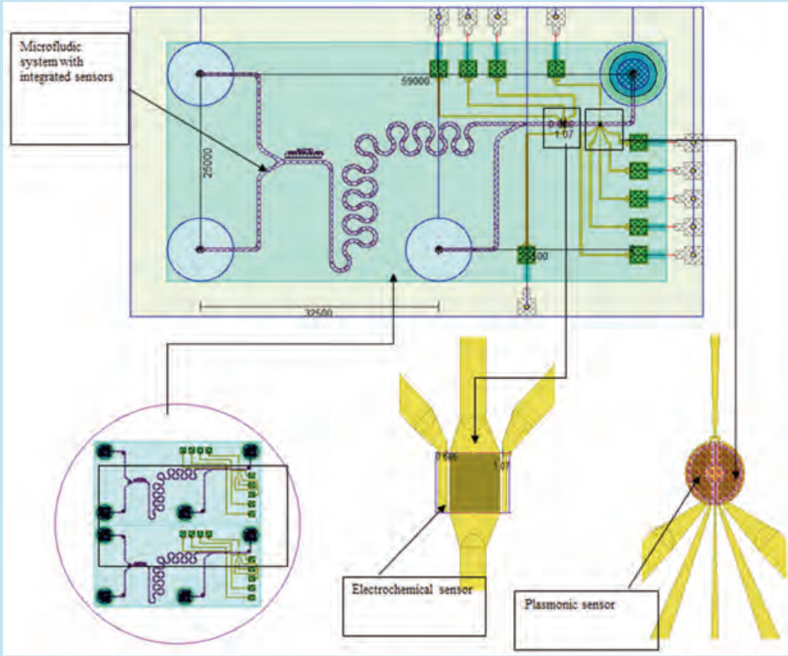
International and national cooperation

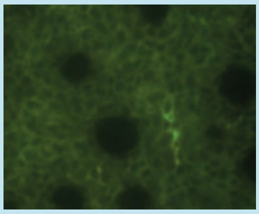
• International cooperation with European university research centers and companies from England, Spain, Germany, France, Austria, Norway.

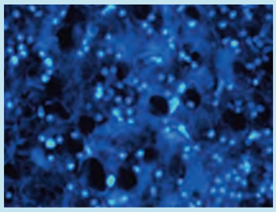
• National cooperation with research institutes, universities and Romanian companies (SUUB, DDS, Spital LOTUS, SANIMED, UPB, UTBv).

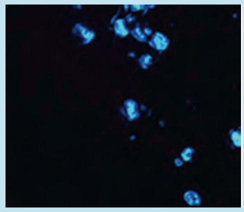
The optimization, fabrication and characterization of the lab-on-a-chip device - CANCELLAB

The design, modeling, simulations and optimization of the lab-on-a-chip device according to the microfabrication technologies and experimenting conjugation techniques for nanoparticles – antibody – fluorophore – tumor cells. The attachment of the tumor cells determines the variation of the charge transfer resistance, Warburg impedance, complex dielectric constant, double electric layer capacitance, but also the variation of the refraction index, the propagation constant of the superficial plasmons, the coupling angle, wave length, the intensity and the phase of the coupling wave with the superficial plasmons. Both biosensors, the impedimetric and the plasmonic are based on the detection of the nanostructures spectral change detection, when the tumor cells or tumor markers attach. The attachment leads to the variation of impedance, peak width of the plasmon resonance, but also to the resonance displacement. The fabricated devices were characterized using electrochemical impedance spectroscopy, localized surface plasmon resonance and plasmon amplified molecular detection. Also, experimental studies were performed for the integration of the three modules on the microfluidic platform.




UV picture of melanoma, without AuNPs

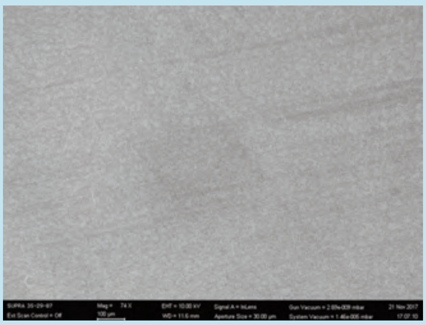

UV picture of melanoma, with AuNPs

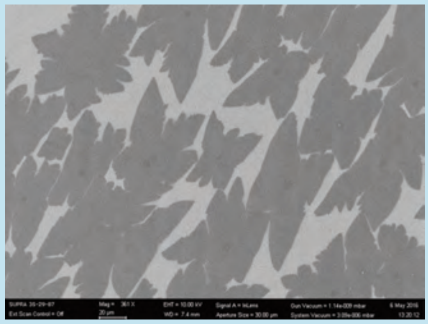

Tumor cells with infiltrated AuNPs in healthy tissue

Graphene synthesis for microfluidic applications - INTEGRAPH

For the graphene growth processes, 35 µm thick Cu foils (Graphene Platform Corporation, Japan) have been used as substrate, with 210 mm x 300 mm delivery dimensions. For the CVD processes the foils have been cut to 20 mm x 20 mm pieces. Before processing, each substrate has been cleaned 10 minutes in acetic acid for surface scouring, followed by deionized water and isopropyl acid rinsing. To maintain the surface stability and to avoid the oxidation, the samples have been stored in isopropyl acid, being dried with a nitrogen jet before inserting them in the equipment. The precursor gases used for the graphene fabrication process were methane and hydrogen (CH_4 and H_2, 9N purity, Linde Gas Romania). For chemical scouring and surface preparation, acetic acid and isopropyl acid were used (electronic grade EG, Sigma Aldrich). The following parameters: temperature, pressure, gas flow rate, deposition time, were gradually modified to obtain monolayer graphene, with large crystalline domains, on a wide area and with a quality compared to the commercial graphene. The optimized process parameters are: temperature - 1080°C, thermal treatment time in H_2 (10%) atmosphere increased from 20 to 30 minutes, the growth step has been increased up to 60 minutes, and the precursors concentration was modified to CH_4 (0.6%) and H_2 (3%). The following figures present the representative image of the samples of the graphene grown with the optimized recipe, followed by a detail.

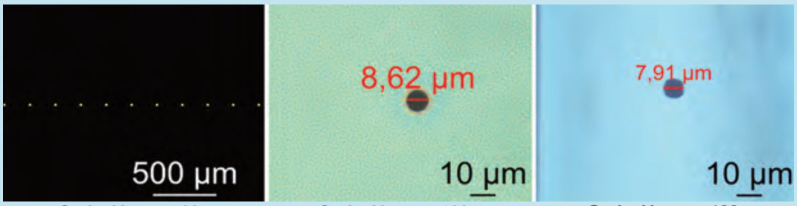
The optimized samples had a coverage degree of over 90%, with graphene domains between 50 µm and 150 µm. the Raman spectra confirm the monolayer graphene, with minimum defects and very good quality. The Raman bands G and 2D are specific to monoatomic graphene, while the lack of D band in the investigated areas is a quality indicator. The value of the I2D/IG is between 3.16-3.6. This value that over exceeds 2, indicated without a doubt the existence of monolayer graphene. Full width at half maximum (FWHM) of G band is between 10.92-16.38 cm^{-1}, being close to the equilibrium value of 15 m^{-1}. FWHM of 2D band is between 30.57-21.62 and certifies that presence of monoatomic graphene in the investigated areas.


SEM image of the experimental sample grown for 45 minutes. The image contains the full growth process, the graphene domains forming a continuous film on the surface. The graphene domains fully cover the catalyst surface.


The obtained domains diameters vary between 50 µm and 150 µm.

The fabrication of graphene membranes - INTEGRAPH

For the graphene membranes fabrication, used on the microfluidic devices, an essential step is their transfer from the growth substrate (Cu), on the working substrate (Si and Si/SiO_2). The graphene transfer control is the most important aspect for membrane fabrication. To successfully obtain this result, this step requires transfer experiments, etching the Cu substrate. The substrates we are interested on are Si and Si/SiO_2, because those will be the base for future devices, containing pores, used to check the graphene transfer. To maintain the orifices diameters as close to the designed value, the SiO_2 etch will be performed in 2 steps: one step of dry etching, followed by a short wet etching process. The dry etching has been performed with RIE – Reactive Ion Etching system using a 4:1 ratio of Ar:CHF_3, at 10 Pa pressure and 250 W RF power. The process is competitive etching-deposition, as CHF_3 having the tendency to dissociate and to form (CFx)n type of fluoro-polymeric film, which is inert and etch inhibitor. In this process, Ar has the role to destroy the film formed on the horizontal surfaces. Therefore, the fluoro-polymeric film forms only on the vertical surfaces, e.g. lateral walls of the oxide that are exposed to the etching. The last 30 nm of oxide have been etched in BHF solution (NH_3 : HF, 6:1) for 30s. Another advantage of CHF_3 plasma usage for oxide etching is the photoresist fluorination, process that strengthens and increases the resistance to chemical agents. Both the photoresist used initially for the oxide etching and the oxide layer can be used as masking layers.



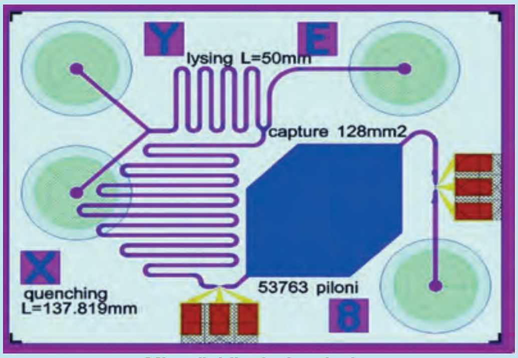
Optical image, 20x magnification, illumination from below. Series of 9 µm orifices with 200 µm spacing.

Optical image, 100x magnification, etched orifice on the wafer's face.

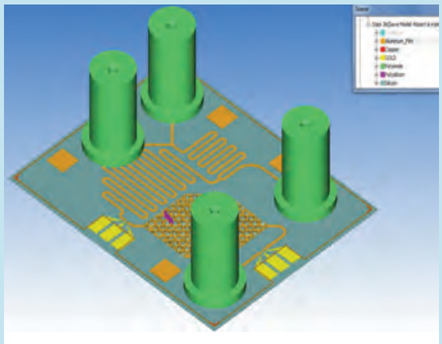
Optical image, 100x magnification, etched orifice on the wafer's back.

Designing and technological modeling of the microfluidic device for determining the lymphocytes number - BIOLIMF

The design of microfluidic system for detection and counting of the T lymphocytes contains: erythrocytes lysis module, lysis stop module, 128 mm^2 capture chamber that contains 53763 silicon pylons with a diameter of 40 µm and distance of 12 µm between them, and two electrochemical sensors with interdigitated microelectrodes, placed one at the entrance and one at the exit of the capture chamber.



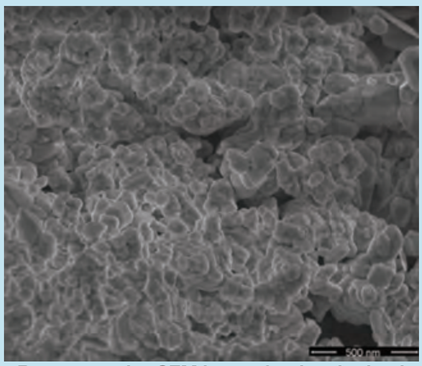
Microfluidic device design



Technological modeling of the microfluidic device

Multifunctional nanocomposites based on oxides of the transitional metals with applications in aerospace domain - OXITRANS

The results obtained in the preliminary research of the OXITRANS project consisted on: (1) Theoretical study of oxides types identification (YAG and M_2Ox garnets, doped and undoped with rare earths), methods of synthesis and improvement of OXITRANS nanoparticles properties, by surface modification, methods of nanoparticles incorporation in polymeric matrices and the compatibility mode with certain types of specific substrates from the aerospace domain; (2) Using sol-gel and co-precipitation methods YAG and Y_2O_3 oxide nanostructured particles have been developed. The main advantage of the developed techniques is the improvement of the morphologic and structural properties simultaneous with sintering temperature of around 1000°C; (3) Using in situ processes we managed to integrate YAG and Y_2O_3 nanoparticles in polymeric matrices (PMMA, PVDF).



Representative SEM image for the obtained YAG sample

Awads

1. Gold Medal at the Barcelona International Inventions Salon (INNOVA): „Microfluidic system with type ”Y” and type ”T” junctions for the assembly of bacterial cells in drops of controlled dimensions”, May 2017

2. Gold Medal at the Barcelona International Inventions Salon (INNOVA) „Procedure for realization of the dielectrophoretic device for electrical impedance spectroscopic study of self-assembled tumor cells in the microfluidic channels” , May 2017

3. Gold Medal with the congratulations of the jury at the Geneva International Inventions Salon: „Systéme micro fluidique de type „Y” et „T”pour l`assemblage de cellules bactériennes en gouttes de dimensions contrôlées”, March-April 2017

4. Special Award for exceptional results & performance presented by the innovative invention „Microfluidic System with „Y” and „T” Junctions for the Assembly of Bacterial Cells in Drop of Controlled Dimensions” from the Association of Portuguese Inventor's Innovator's Creatives, 31 March 2017

5. Special Award of First Institute Researcher and Inventors in Iran (FIRI) for the Best Invention „Development of a Microfluidic System”, 2017

Scientific events and Education activities

International Semiconductor Conference - CAS 2017

The International Semiconductor Conference (CAS) (www.imt.ro/cas) celebrated in 2017 its 40th edition. The conference is an annual event organized by the National Institute for Research and Development in Microtechnologies - IMT Bucharest, taking place in 2017 in the period 11-14 October, in Sinaia, Romania. Since 1995, CAS is also an IEEE event, with Proceedings published in the IEEE system.


CAS 2017 participants

The main topics of CAS 2017 were: nanoscience and nanoengineering; micro- and nanophotonics and optoelectronics; microwave and millimeter wave circuits and systems; microsensors and Microsystems; modelling; semiconductor devices; Integrated Circuits.

The Conference Chairman was Dr. Adrian Dinescu, the Vice-Chairs of the Program Committee were Prof. Gheorghe Brezeanu (University "Politehnica" of Bucharest) and Dr. Mircea Dragoman (IMT Bucharest).

CAS 2017 gathered 142 specialists from research institutes, universities and companies. 62 regular papers were presented at the conference, including 51 oral presentations and 11 posters. The plenary sessions comprised 18 invited talks with authors originating from Belgium, Canada, France, Germany, Greece, Ireland, Rep. of Moldavia, Romania, Spain, Sweden, UK.

The awards for best student papers and the ones for young researchers were sponsored by University of Cambridge, Dept. of Engineering, UK. Last day of the event was dedicated to the anniversary session of conference - CAS '40, with presentations that remembered exciting moments from the conference history, key people who assured the success of the conference over time, the evolution of the semiconductors field.


Dr. Lucian Puiu Georgescu, Secretary of State at the Ministry of Research and Innovation

National Seminar for Nanoscience and Nanotechnology 2017

The 16th edition of the National Seminar for Nanoscience and Nanotechnology (an event initiated by Acad. Dan Dascalu in 2000) was organized by the Centre for Nanotechnologies from IMT Bucharest, under the aegis of the Romanian Academy, on June 16, 2017.

This edition of the Seminar consisted of scientific sessions based on following topics: nanoelectronics and nanofotonics, nano- bio- technologies and nanomedicine, nanotechnologies and nanomaterials for energy application, other application of nanotechnologies, management and risk assessment in nanotechnologies. During the scientific sessions were delivered 16 papers and 16 poster presentation.

All details about the event (programme, presentations, photo gallery) are available at the address: http://www.romnet.net/nano/SNN2017/ (information in Romanian only).

Information and publicity event: "Public offer of TGE-PLAT project - services for the benefit of SMEs"

Information and publicity event. Thematic event. October 9, 2017, Ramada Majestic Hotel, Bucharest

TGE-PLAT "Partnership for using Key Enabling Technologies on a platform for interaction with companies" is a project financed by Structural Funding (POC-G), dedicated to knowledge transfer from IMT to Romanian companies, in a high tech field of the Romanin Strategy (SNCDI 2016-2020): ICT, Space and Security).

IMT presented the projects objectives, IMT infrastructure, the services offer, the structure of the project and the procedure to follow in order to become a partner.

Many companies active in the field of ICT and security were present at the event and express their interest to participate and to develop their ideas in cooperation with IMT.

All details about the event are available at the address:

http://www.imt.ro/TGE-PLAT/eveniment_9.10.2017.php

Educational activities developed inside IMT Bucharest

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**.

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

1. 3-D Memristor Crossbars for Analog and Neuromorphic Computing Applications, **G. C. Adam**, B. D. Hoskins, M. Prezioso, F. Merrikh-Bayat, B. Chakrabarti, D. B. Strukov, IEEE TRANSACTIONS ON ELECTRON DEVICES Volume: 64 Issue: 1 Pages: 312-318 Published: JAN 2017 IF: 2.605

2. A multiply-add engine with monolithically integrated 3D memristor crossbar/CMOS hybrid circuit, B. Chakrabarti, M.A. Lastras-Montaño, **G.C. Adam**, M. Prezioso, B. Hoskins, M. Payvand, A. Madhavan, A. Ghofrani, L. Theogarajan, K-T. Cheng, D.B. Strukov Scientific Reports, 7, 42429, 2017 IF: 4.259

3. A new method for myoelectric signal acquisition: preparing the patients to efficiently use an artificial arm, **Milea, Petru Lucian**; Barbilian, Adrian; Moga, Marius; Pogarasteanu, Mark Edward; Oproiu, Ana Maria; Lazo, Victor; Stoica, Cristian Ioan; ROMANIAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY Volume: 20 Issue: 2 Pages: 115-123 Published: 2017 IF: 0.365

4. A perfusion incubator liver chip for 3D cell culture with application on chronic hepatotoxicity testing, Yu, Fang; Deng, Rensheng; Tong, Wen Hao; Huan, Li; Way, Ng Chan; IslamBadhan, Anik; **Illiescu, Ciprian**; Yu, Hanry. SCIENTIFIC REPORTS Volume: 7 Article Number: 14528 Published: NOV 6 2017 IF: 4.122

5. An Experimental Study on Nano-Carbon Films as an Anti-Wear Protection for Drilling Tools, C. Popescu, **D. Cristea, B. Bita**, R. Cristescu, D. Craciun, G. D. Chioibasu, C. Luculescu, I. Paun, L. Duta, A. C. Popescu, Coatings 2017, 7(12), 228; DOI:10.3390/coatings7120228 IF: 2.175

6. Analytical results regarding electrostatic resonances of surface phonon/plasmon polaritons: separation of variables with a twist, **Voicu, R. C.; Sandu, T.** PROCEEDINGS OF THE ROYAL SOCIETY A-MATHEMATICAL PHYSICAL AND ENGINEERING SCIENCES, Volume: 473 Issue: 2199 Article Number: 20160796 Published: MAR 1 2017 IF: 2.146

7. Atomically thin semiconducting layers and nanomembranes: a review, **M Dragoman,** D. Dragoman; I. Tiginyanu, SEMICONDUCTOR SCIENCE AND TECHNOLOGY Volume: 32 Issue: 3 Article Number: 033001 Published: MAR 2017 IF: 2.305

8. Characterization of optical fields with quantized orbital angular momentum by invariants of higher order moments of radial coordinates, D. Dragoman, **R. Tudor,** JOURNAL OF MODERN OPTICS Volume: 64 Issue: 21 Pages: 2328-2335 Published: 2017 IF: 1.328

9. Characterization technique for inhomogeneous 4H-SiC Schottky contacts: A practical model for high temperature behavior, Brezeanu, G.; Pristavu, G.; Draghici, F.; Badila, M; **Pascu, R**; JOURNAL OF APPLIED PHYSICS Volume: 122 Issue: 8 Article Number: 084501Published: AUG 28 2017 IF: 2.068

10. Comparative study of threading dislocations in GaN epitaxial layers by nondestructive methods, **C. Romanitan, R. Gavrila, M. Danila**, MATERIALS SCIENCE IN SEMICONDUCTOR PROCESSING Volume: 57 Pages: 32-38 Published: JAN 2017 IF: 2.359

11. Correlation between threading dislocations in highly mismatched GaN heteroepitaxial layers, **C. Romanitan**, Solid State Communications, 268, 51-55, 2017 IF 1.554

12. Effect of Key Technological Parameters on GaN/Si SAW Resonators Operating Above 5 GHz, **A.C. Bunea, A.M. Dinescu**, L.A. Farhat, **C. Pârvulescu, D. Neculoiu**, Romanian Journal of Information Science and Technology, vol. 20, No. 4, 2017, pp. 354-368, ISSN: 1453-8245 IF: 0.365

13. Electrochemical Deposition of Zinc Oxide on the Surface of Composite Membrane Polysulfone-Graphene-Polystyrene in the Presence of Water Soluble Polymers, A. Mocanu, E. Rusen, A Diacon, C. Damian, **A. Dinescu, M. Suchea,** JOURNAL OF NANOMATERIALS, Article Number: 1401503 Published: 2017 IF: 1.871

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15. Engineering Graphene Quantum Dots for Enhanced Ultraviolet and Visible Light p-Si Nanowire-Based Photodetector, **I. Mihalache, A. Radoi, R. Pascu, C. Romanitan**, E. Vasile, **M. Kusko**, ACS APPLIED MATERIALS & INTERFACES Volume: 9 Issue: 34 Pages: 29234-29247 Published: AUG 30 2017 IF: 7.504

16. Extraordinary tunability of high-frequency devices using Hf0.3Zr0.7O2 ferroelectric at very low applied voltages, **M. Dragoman, M. Aldrigo**, M. Modreanu, et al. APPLIED PHYSICS LETTERS Volume: 110 Issue: 10 Article Number: 103104 Published: MAR 6 2017 IF: 3.411

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19. Generation of optical vortices in an integrated optical circuit, **R. Tudor, M. Kusko, C. Kusko**, JOURNAL OF OPTICS Volume: 19 Issue: 9 Article Number: 095801 Published: SEP 2017 IF: 1.741

20. Iono-molecular Separation with Composite Membranes II. Preparation and characterization of polysulphone and composite nanoparticles, Al Ani, Hussam Nadum Abdalraheem; Cimbru, Anca Maria; **Trisca-Rusu, Corneliu**; et al. REVISTA DE CHIMIE Volume: 68 Issue: 2 Pages: 203-209 Published: FEB 2017 IF: 1,412

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28. Nanostructured metal oxides semiconductors for oxygen chemiresistive sensing, **Serban, B. C.**; Brezeanu, M.; Luca, A. D.; Ali, S. Z.; **Buiu, O.; Cobianu, C.**; Stratulat, A.; Udrea, F.; **Avramescu, V.; Varachiu, N.; Ionescu, O.**; Ionescu, G., ROMANIAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY Volume: 20 Issue: 2 Pages: 86-100 Published: 2017 IF: 0.365

29. Near-infrared energy bandgap bismuth oxide thin films and their in-depth morpho-structural and optical analysis, Condurache-Bota, S.; Tigau, N.; Praisler, M.; Prodan, G; **Gavrila, R**. ROMANIAN REPORTS IN PHYSICS Volume: 69 Issue: 3 Article Number: 507 Published: 2017 IF: 1.758

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31. Oxide trap states versus gas sensing in SiC-MOS capacitors - The effect of N- and P- based post oxidation processesm, **Pascu, Razvan**; Craciunoiu, Florea; Pristavu, Gheorghe; Brezeanu, Gheorghe; **Kusko, Mihaela**; SENSORS AND ACTUATORS B-CHEMICAL, Vol: 245, Pg: 911-922, Published: JUN 2017 IF: 5.401

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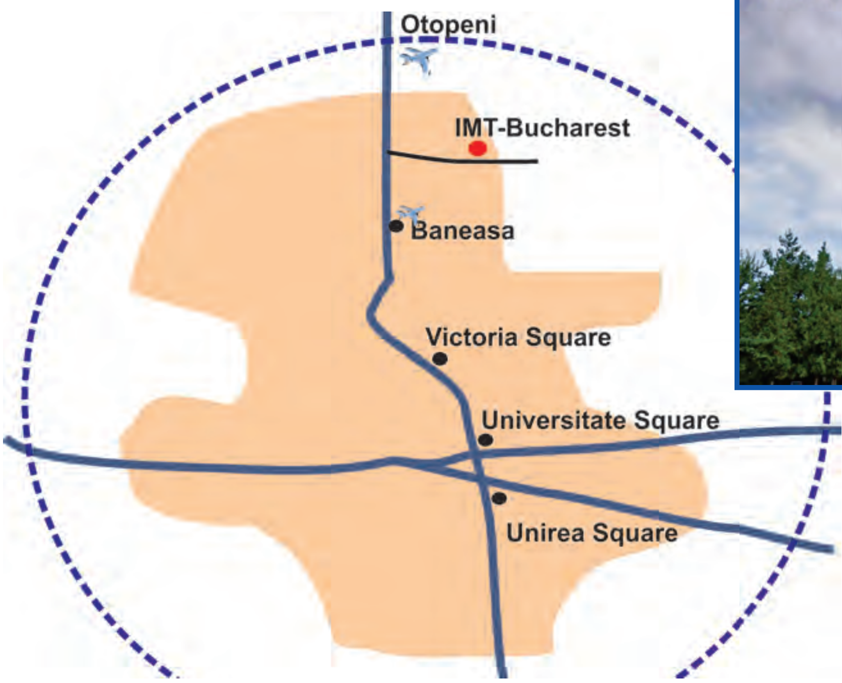

National Institute for R&D in Microtechnologies
Mailing address: 126A, Erou Iancu Nicolae Street, R-077190, Voluntari, Ilfov, ROMANIA
Tel: +40-21-269.07.70; +40-21-269.07.74; +40-21-269.07.78;
Fax: +40-21-269.07.72; +40-21-269.07.76;