Scientific Report 2016

National Institute for Research and Development in Microtechnologies - IMT Bucharest

From micro to nanotechnologies, nano-biotechnologies and nanoelectronics

Ministry of Education and Scientific Research

MINISTERUL EDUCAȚIEI ȘI CERCETĂRII ȘTIINȚIFICE

National Institute for Research and Development in Microtechnologies

IMT Bucharest

SCIENTIFIC REPORT 2016

Research, Technological development and experimental infrastructure

Design: IMT Bucharest

Table of Contents

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, funded in 1993 which merged with Research Institute for Electronic Components, founded in 1969. In 2016 the institute was coordinated by the Ministry of National Education and Scientific Research, acting basically as an autonomous, non-profit research company.

In 2016 ***IMT Bucharest continued to be an internationally competitive organization***, involved in word class research in his area of activity: micro and nanoelectronic components and systems, including smart sensors, micro and nanotechnology.

The research performed in national and international projects and/or published in ISI publications was mainly oriented, as in the previous years, to the following fields, corresponding 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 ***2 FP7 Projects, 1 H2020-ECSEL*** and coordinate a ***H2020 Marie Skłodowska-Curie Actions- Individual Fellowship***, ***1 SEE project with Norway,*** coordinate or participate at ***4 ESA project, 4 bilateral projects and was partner in 5 COST***. IMT was involved as coordinator or partner in ***M.ERANET and MANUNET projects***. The institute won one project, financed by ***Structural Funds***, dedicated to knowledge and technological transfer to Romanian companies in a high-tech field, corresponding to smart specialization: ICT, Space and Security.

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. The strategic orientation was for developing Key Enabling Technologies (KETs) used in different applications.

IMT-Bucharest displays a broad range of experimental and computing resources for micro- and nanoelectronics, nanotechnologies, from simulation and design techniques, to characterization tools, processing equipment (including a mask shop, EBL nanolitography), functional and reliability tests. These resources are grouped in the **IMT Bucharest facility for Micro- and NAnoFABrication** (IMT-MINAFAB, www.imt.ro/MINAFAB). Constant and coordinated investments in the experimental infrastructure represents a priority of IMT Bucharest.

The **CENASIC- "Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials",** in function since the end of previous year, contribute with its new cleanroom (class 1000 and 100), new equipment and the expertise of our people to the development of many research in the field of graphene based device (presented in ISI journal papers) and other carbon based materials , as nanocrystaline diamond and SiC. The new center captivate young skilled and talented researchers and PhD students to perform collaborative research at world class level.

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 193), 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). During 2016, 13 of our employers were PhD students, supervised also by IMT Bucharest scientific staff.

The turnover has a slightly increased of 12.5% compared with 2015, considering the number and value of the national and international running projects.

The Scientific Report 2016 presents the most important projects and the research highlights of the 10 research laboratories, grouped in 4 centers; three important scientific events, organized by our institute, each year: National Seminar on Nanoscience and Nanotechnologies at its 15th edition and CAS -International Semiconductor Conference- an IEEE event , at its 39th edition and MEMSWAVE Workshop, itinerant European event, at 17th Edition. In 2016 IMT was present in Japan at World Micromachine Summit, the 10th consecutive invitation.

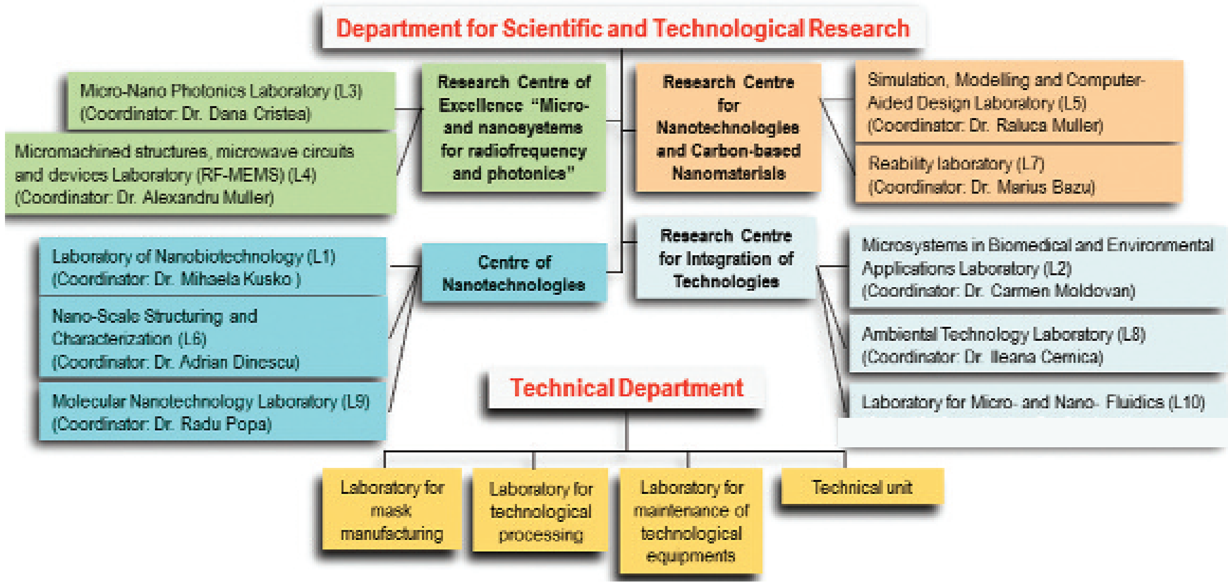
A list of main scientific publications concludes the report.

I would like to thank to all the staff and their high level work and support during 2016.

Dr. Raluca Müller

CEO and President of the Board

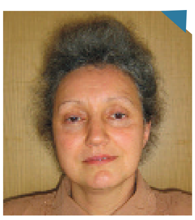
Organization: Scientific and Technical Departments



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

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

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



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

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

Mircea Dragoman is a senior researcher at the IMT-Bucharest, he is working in the laboratory "Microsystems and micromachined circuits for microwaves- (RF MEMS)" where he designed and characterized a series of circuits in the microwave and millimeter range. He was Director of Centre for Research and Technologies Integration and currently is the president of the Scientific Council. He has published 208 scientific papers, 117 ISI papers. The papers are dedicated to the following areas: nanoelectronics, microwaves, MEMS, optoelectronics. He is co-author of several books.

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

Human resources

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.

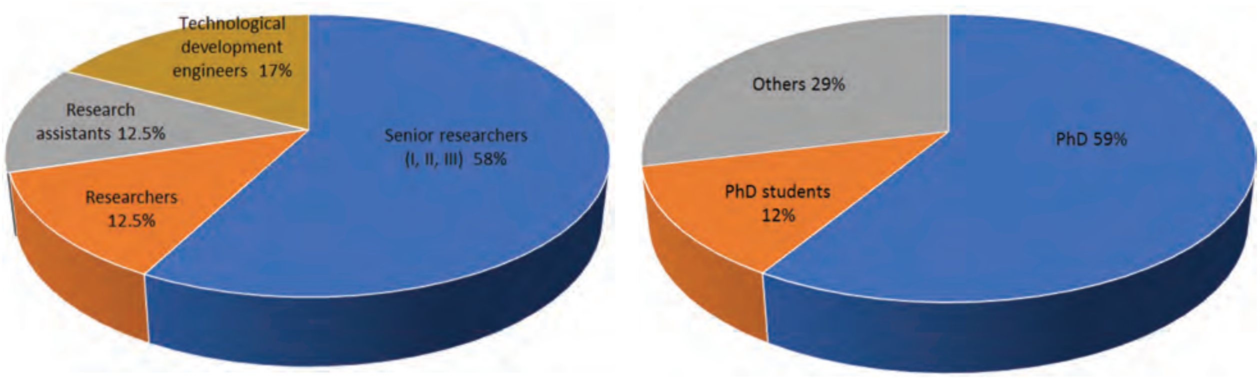


Fig 1 - Researchers and technological development engineers active in IMT

Figure 1 (a, b) provides information about the number and distribution of researchers and technological development engineers (IDT) active in IMT in 2016 (104 persons). 58% of them are senior researchers I, II and III, 12.5% researchers, 12.5% research assistants and 17% technological development engineers. 30% 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 2016. The male (56 %) - female (48 %) ratio is relatively balanced.

IMT Bucharest offers opportunities to students, 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.

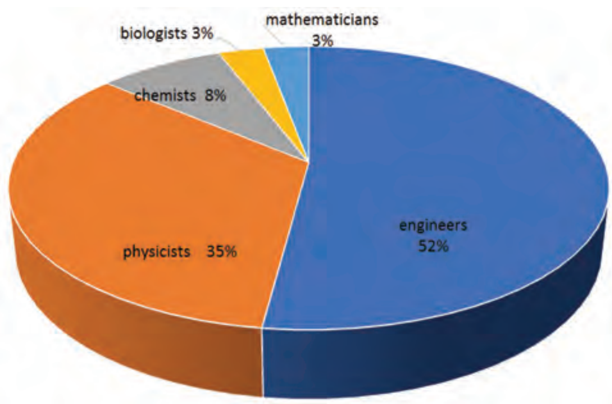


Fig.2 Multidisciplinary background of researchers and technological development engineers active in IMT

Funding sources and investments

Fig. 3 shows the distribution of funding sources in 2016: national R&D programs (competitive funding, through open calls): 28%, Structural Funds 21%, different European Projects and other sources (FP7, ESA, SEE, MNT-ERANET, ENIAC, ECSEL) 8%.

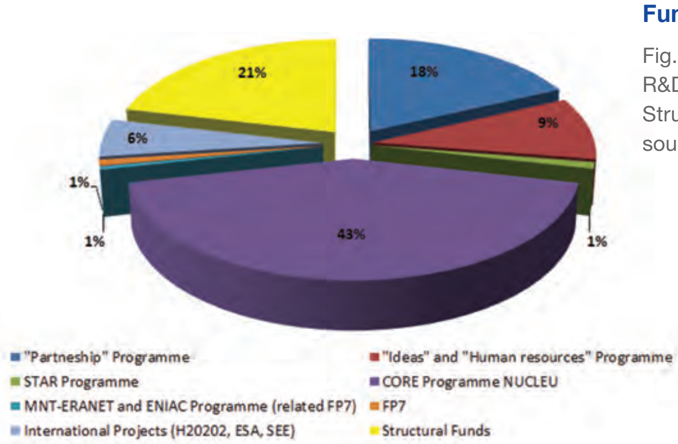


Fig 3. Funding sources in 2016

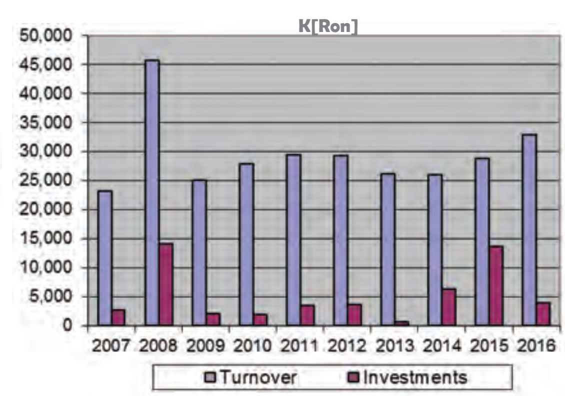


Fig. 4 Graphic representation of IMT Bucharest turnover and investments for the period 2007-2016

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 2016 increased compared with 2015 with around 12.5%.

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 provide "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 m^2 (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.

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.

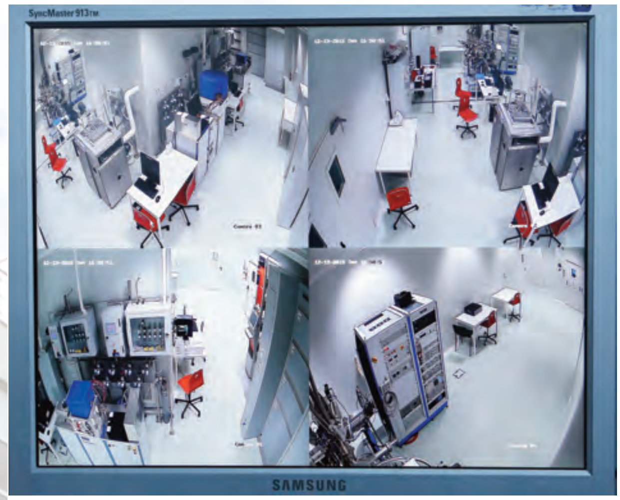
The project was financed by Structural Funding Sectorial Operational Programme “Increase of economic competitiveness Project POS-CCE- (2011-2015) and represents an investment of 6 MEuro in a new building for offices, clean rooms and equipment. There are approximately 1000 m^2, including 4 levels: the 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.

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



Overview of the CENASIC clean room

In 2016 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

MIMOMEMS European Centre of Excellence Laboratory of Micro/Nano Photonics

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

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

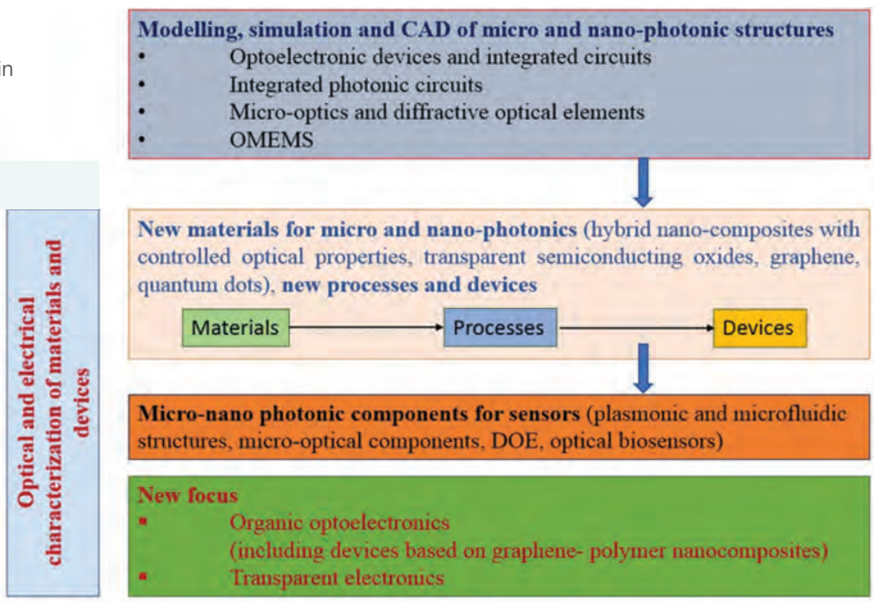
The MIMOMEMS Centre of excellence remains as a distinct entity in IMT after the end of the EU founded project. The very good results of the MIMOMEMS centre were materialized by a deep involvement in other EU founded research projects (the centre is now partner in 2 FP7 IPs, one STREP, 2 ENIAC projects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

Laboratory of Micro/Nano Photonics is 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.

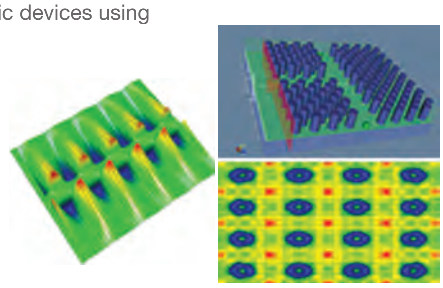
Team

1. **Dr. Dana Cristea** senior researcher, M.Sc. in electronic engineering, Ph.D.in optoelectronics & materials for electronics;
2. **Dr. Munizer Purica** senior researcher, M.Sc. and Ph.D. in physics;
3. **Dr. Cristian Kusko** researcher, M.Sc. and Ph.D – physics;
4. **Dr. Paula Obreja** senior researcher, M.Sc. and Ph.D. in physical chemistry;
5. **Elena Budianu** senior researcher, M.Sc. in physics;
6. **Dr. Mihai Kusko** senior researcher (M.Sc. in physics and photonics, Ph.D in optoelectronics);
7. **Dr. Florin Comanescu** – researcher, M.Sc. in electronics and PhD in optoelectronics at ''Politechnica'' University of Bucharest;
8. **Dr. Roxana Rebigan** researcher, M.Sc. in physics and Ph.D in optoelectronics;
9. **Dr. Roxana Tomescu** – researcher, M.Sc. in electronics and PhD in optoelectronics at ''Politechnica'' University of Bucharest;
10. **Eng. Rebeca Tudor** – junior researcher, M.Sc. in electronics, PhD student in Optics

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)

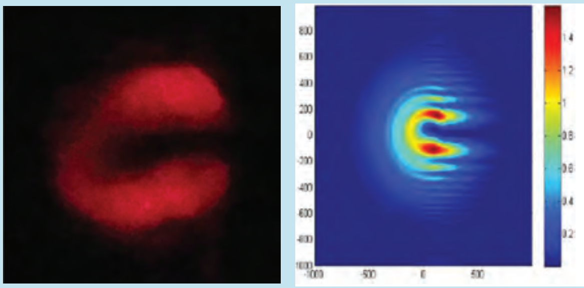
• Cooperation with Romanian industry (Optoelectronica 2001, Pro-Optica, Apel Laser), research institutes (INFLPR, ICPE-CA) and universities (Univ. "Dunarea de jos" –Galati, UAIC-Iasi) on national research programs PN II and PN III.

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.

Scientific results

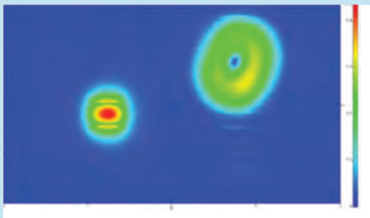
Secured high volume free space optical communications based on computer generated holograms –
Project PN-II-PT-PCCA 2011-2015- Dr. Cristian Kusko.(cristian.kusko@imt.ro)

Technical solutions for wavefront beam shaping with scalar fractional optical vortices and vector vortex beams which carry orbital angular momentum in order to increase the channel capacity and security of the transmitted information in free space optical communications were investigated. Diffractive optical elements for generating, sorting and detecting optical vortices with various topological numbers were designed fabricated and characterized. Functional prototypes of free space optical communicators systems were implemented in order to demonstrate the applicability of the generated optical configurations.



a) b)

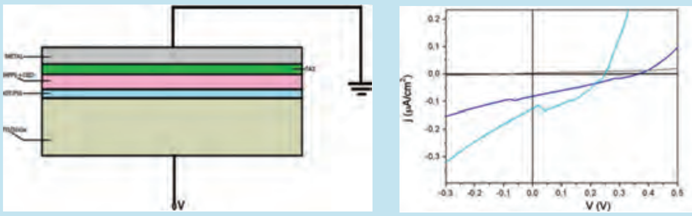
Scalar optical vortex with fractional topological charge m=1/2. Intensity profile from (a) experiment (b) simulation.



Intensity profile at the output of an integrated photonic circuit which generates optical vortices

We have investigated numerically to obtain optical vortices with integer topological charge m=1 and m=-1 in an integrated photonic circuit.

Carbon quantum dots: exploring a new concept for next generation optoelectronic devices, CQD-OPTO) - *project PNII-ID-PCCE 2011–2015. Director Dr. Monica Veca; Coordinator Opto Group Dr. Cristian Kusko*

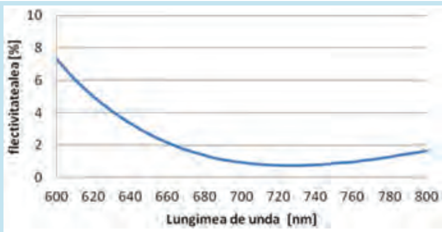


Schematic diagram (a) and j-V characteristics for the heterostructures MEH-PPV/TAZ and MEH-PPV+CQD)/TAZ: The dark j-V for MEH-PPV/TAZ (dark line) and the dark j-V for MEH-PPV+CQD)/TAZ (grey line); j-V characteristics at an illumination with the wavelength of 405 nm for MEH-PPV/TAZ (dark blue line) and for MEH-PPV+CQD)/TAZ (blue line).

The photovoltaic properties of p-n heterostructures based on carbon quantum dots (CQD) nanocomposites were investigated. The p layer consists of CQD embedded in a MEH-PPV p-type polymer while the n layer consists of an n type polymer (TAZ). Various structures MEH-PPV-TAZ and MEH-PPV+CQD were fabricated and characterized. The electro-optical characterizations showed that carbon quantum dots are responsible for the improvement of the photovoltaic characteristics of the heterostructures.

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

PNII-PCCA2014. Director Dr. Mihaela Filipescu INFLPR . Coordinator IMT Dr. Cristian Kusko



Measured reflectivity aş a function of the wavelength for an incidence angle of 22.5°

An antireflective mirror was designed by using transfer matrix method in order to improve the temporal contrast of a high energy laser pulse operating at 780 nm wavelength. Experimentally, the mirror consists of two dielectric layer deposited on a silicon substrate. The first layer is obtained by deposing 43 nm silicon dioxide on the silicon substrate using RF sputtering. The second layer is obtained by deposing 49 nm silicon nitride using CVD. The mirror characteristics were determined from the reflectance measurements with wavelength. We obtained 1.3% reflectivity at 22.5° angle, a result which is consistent with the theoretical predictions.

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)

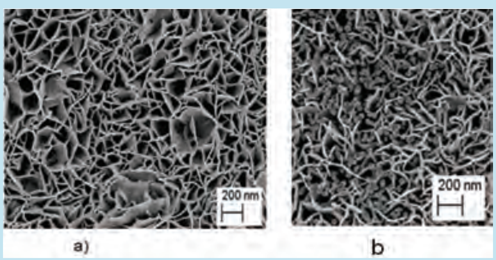


Fig. 1 a, b. SEM images for samples of layered double hydroxide (LDH) of Zn with Al: a) on Al metal substrates; B) on ZnO oxide substrates with grains of different sizes.

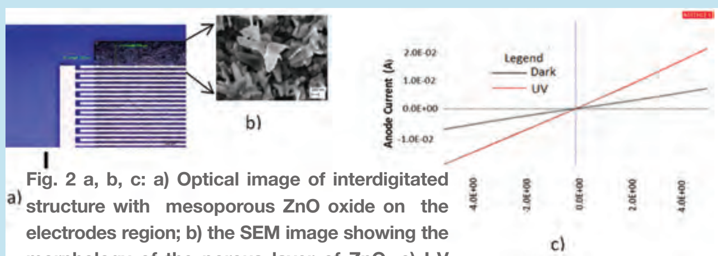


Fig. 2 a, b, c: a) Optical image of interdigitated structure with mesoporous ZnO oxide on the electrodes region; b) the SEM image showing the morphology of the porous layer of ZnO; c) I-V characteristics in dark and UV radiation conditions for obtained structure.

2D nanostructures with various morphologies grown from the solution on different types of substrates. The presented results were obtained in collaboration with the partner "Dunarea de Jos" University Galati.

- 2D nanostructured layered double hydroxide (LDH) of Zn with Al on metallic and oxide substrates, Fig. 1 a, b.
- Mesoporous ZnO layers by thermal oxidation of Zn metal deposited on patterned substrates with Au interdigitated (IDT)electrodes and I-V characteristics in dark and UV radiation conditions for obtained structures, Fig. 2a, b.

Compact Spectrometer in Infrared

project PCCA 2013 COSPIR, Contact person: Dr. Mihai Kusko, mihai.kusko@imt.ro

The optical microscope image of the meander source The optical microscope image of the thermopile in a "star" configuration.

The project aims the fabrication of a compact spectrometer working in the spectral range from 3 to 12 micrometres for detection of various gaseous species. Infrared filters based on Fresnel lenses which focus the radiation preferentially with the wavelength on the detector area have been designed and fabricated.

Active components (thermal sources and detectors) have been experimentally studied. A thermal source based chromium meander resistance which is working on the Joule effect has been fabricated. The thermal detector is a thermopile working on the Seebeck effect - the temperature difference between two junctions of different materials as polysilicon and aluminium creates a voltage drop.

Nanostructures and heterostructures for micro-nano (opto)electronics devices - Core Program TEHNOSPEC 15N/2016-2017, Project Nr.3/2016-2017

Project Stage 3.2: Multilayer heterostructures based on oxide semiconductors: preparation and characterization;
Contact person: Dr. Munizer Purica (munizer.purica@imt.ro)

- Preparation process of copper oxide thin films by Cu thermal oxidation and evaluation their optical, electrical and functional properties, Fig. 3 a, b.

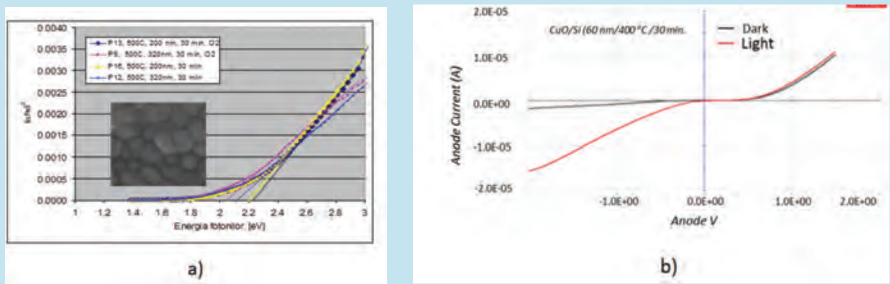
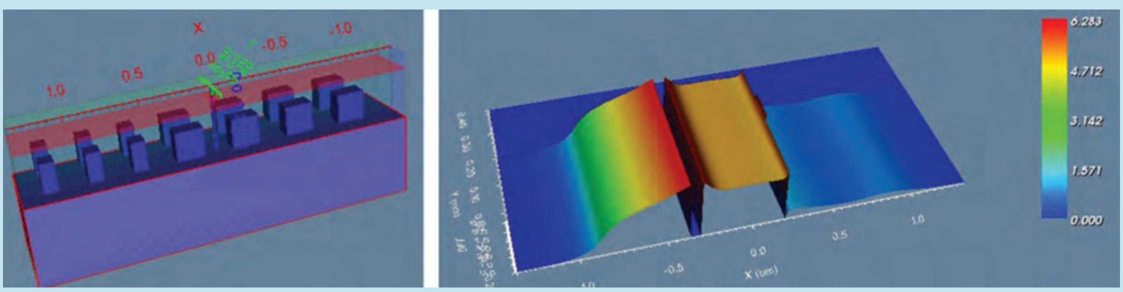


Fig.3. a) Band-gap values of CuO thin films by Cu thermal oxidation at different temperatures; b) I-V characteristics of p-CuO / n-Si heterojunction.

Core project PN 163201012: Advanced photonic devices based on plasmonic structures / metamaterials for optimized detection and beam shaping of electromagnetic radiation.

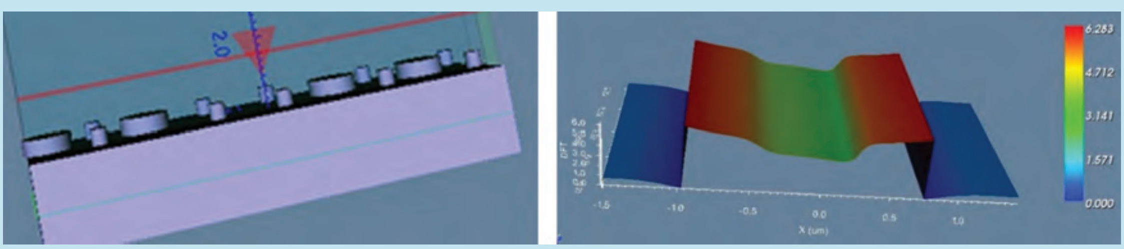
• Plasmonic metasurface structures for beam shaping - Dr. Roxana Tomescu (roxana.tomescu@imt.ro)

Plasmonic metasurfaces where designed and modelled for beam shaping. In order to achieve this, an ample numerical investigation was performed using FDTD method to model the phase of electromagnetic radiation as a function of the geometrical parameters to attain fixe values of the phase displacement.



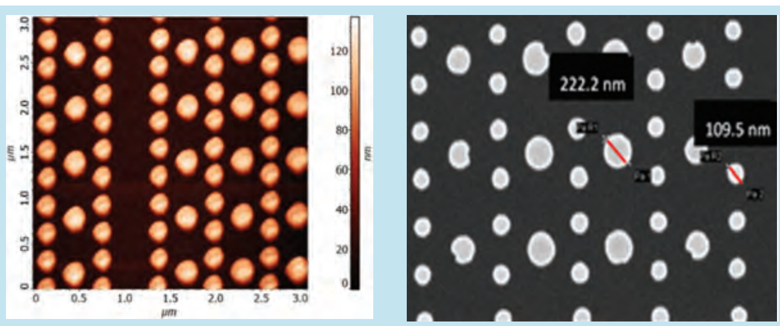
a) b)

Plasmonic metasurfaces with transmission functionality with metallic rectangular resonators: a) layout; b) phase behaviour as a geometrical parameters function – approximatively 2πrad shift.



a) b)

Plasmonic metasurface with reflection functionalities made of metallic cylinders resonators: a) layout; b) phase shit of πrad



SEM and AFM images of plasmonic metasurface with gold pillars patterned on a silicon substrate obtain by electron beam lithography - EBL, metal deposition and lift-off.

• Plasmonic nanostructures for photodetectors with extended spectral range or spectral selectivity

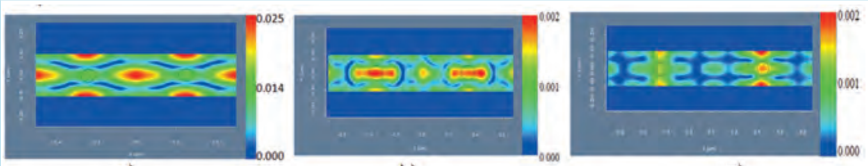
Dr. Dana Cristea (dana.cristea@imt.ro), Dr. Roxana Tomescu (roxana.tomescu@imt.ro)

We developed photodetectors integrated with nanoplasmonic structures to enhance the light absorption either in a wide or narrow spectral range.

We performed absorption investigation with an OptiFDTD software by modelling the geometrical parameters of various nanostructures patterned on a silicon substrate. Our interest was focused on the dependence of the plasmonic resonance of the nanostructure's shape and dimension but also of the surrounding dielectric medium.

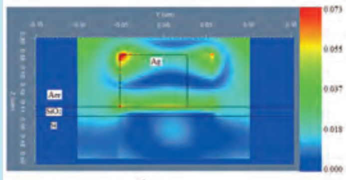
If the plasmonic nanostructures are placed on detector surfaces, or embedded in the active layer, the light absorption is enhanced via either plasmonic effect or light trapping. By appropriate design of palsmonic nanostructures, one can control the plasmon enhanced optical absorption spectra, to obtain spectral selectivity.

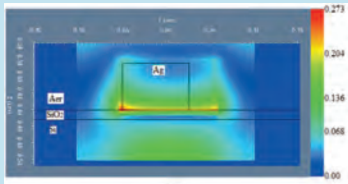
• Nano-apertures



Electromagnetic field distribution on silicon substrate at 632 nm wavelength near plasmonic nanostructures with 150 nm diameter and period of: a) 500 nm; b) 700 nm; c) 900 nm

• Diffraction grating





Electromagnetic field distribution near diffraction grating plasmonic nanostructures for wavelengths of: 505 nm (a) and 650 nm (b)

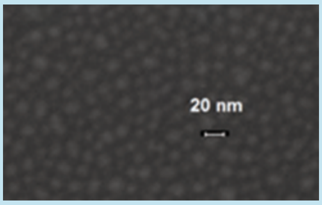
• Ag and Au plasmonic nanostructures fabrication

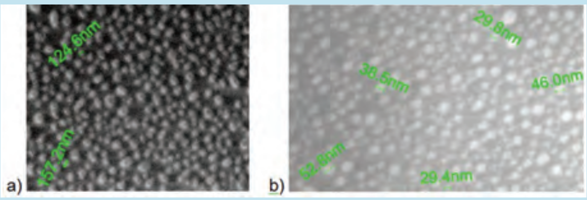
We experimented two techniques for plasmonic nanoparticles fabrication:

- deposition of a silver layer 15-100 nm thick followed by thermal annealing

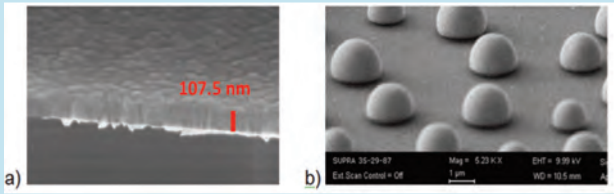
- vacuum deposition of very thin Au or Ag layer (< 2 nm thick):

Ag NP obtained after vacuum deposition with very low deposition rate, to obtain a layer 1.5-1.7 nm thick (mass equivalent)



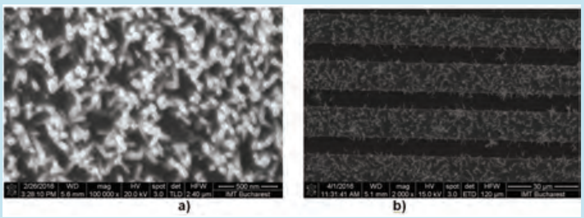


SEM images of the thin Ag NPs obtained from: a) a 30 nm thick layer annealed 1h at 250ºC; b) a 1n nm Ag layer annealed 5 min at 250ºC.



SEM images of a 110 nm thick Ag layer a) as deposited; b) after thermal annealing

• ZnO nanowires (NWs) for plasmonic photodetectors and sensors



SEM images of ZnO NWs: a) grown on Si substrate; b) selectively grown on Au electrodes

Dr. Paula Obreja, paula.obreja@imt.ro

We experimented two techniques for plasmonic nanoparticles fabrication:

- deposition of a silver layer 15-100 nm thick followed by thermal annealing

- vacuum deposition of very thin Au or Ag layer (< 2 nm thick)

Services:

Scientific services ISO 9001: 2008 certified

• **Near field optical microscopy**: Transmission, reflection, collection, fluorescence, Spectral ellipsometry for national and international research and industrial units

• **RAMAN spectroscopy**: Micro-Raman Spectroscopy of graphene synthesized by CVD on copper and transferred by wet chemical methods to oxidized silicon substrate.

Training activities:

• Master courses – Optoelectronics/ Integrated optics and Microsystems in cooperation with "Politehinca" Univ. Bucharest

• Supervising undergraduate, master and PhD students

Laboratory of micromachined structures, microwave circuits and devices

Mission

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

L4 is one of the promoters of the RF – MEMS topics in Europe. The Laboratory 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 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 two ENIAC JU (NANOCOM, MERCURE).

The laboratory is now coordinator two ESA projects, one H2020/Marie Curie project (SelectX) and it is involved in the FP7 STREPs (NANO RF).

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 Muller, PhD in Physics at Bucharest University in 1990. His competences include 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).

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

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

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

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 electromagnetic simulations (IE3D, Fidelity, CST).

Ongoing projects

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

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 proiect Marie Curie nr.705957 "Integrated Crossbar of Microelectromechanical Selectors and Non-Volatile Memory Devices for Neuromorphic Computing", 2016 – 2018, IMT coordinator

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

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

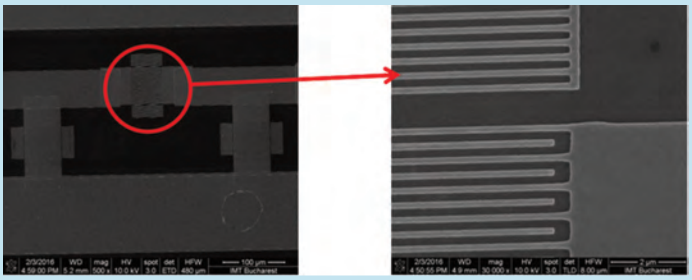
Ongoing projects

***National projects:* 3 projects in the IDEAS** programme (2011-2016):

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

„PI" and „T"-type filter based on GaN/Si SAW resonators, operating at frequency above 5 GHz

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

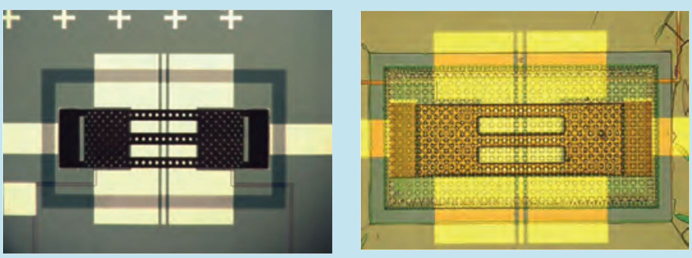


Detail of a test structure

Using advanced nanolithographic processing techniques SAW devices were fabricated with digit/interdigit of 130, 150 and 200 nm, corresponding to operating frequencies between 5 and 8 GHz. Various PI and T-type filter topologies were proposed with simulation results showing insertion losses better than -20 dB. These results are beyond the state of the art for GaN based SAW filters working in this frequency range.

MEMS switches manufacturing for K and W band (20-110 GHz)

ESA Ctr 4000110819/CBi:: "0-level encapsulation of reliable MEMS switch structures for RF applications", Coordinator Dr. Dan Vasilache

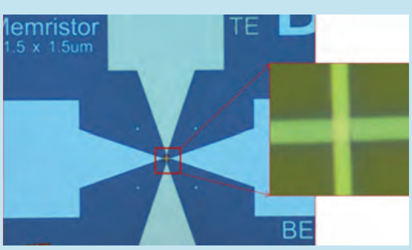


Optical photos of the MEMS structures before and after encapsulation.

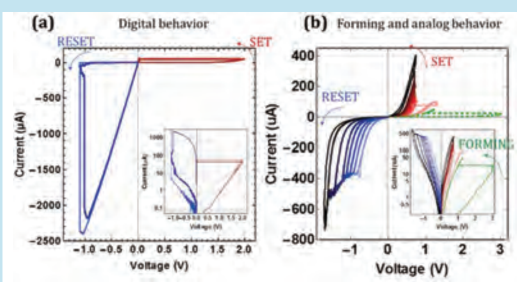
MEMS switch structures have been design for K to W frequency band, to reach insertion losses lower than -0.5dB and an isolation better than -45dB. Simulations of the encapsulated structures show decreasing of the parameters as it was expected, showing still insertion losses lower than -1.5dB and an isolation better than -40dB for the whole frequency range. Manufactured structures (before and after encapsulation) are presented in the figure below.

Fabrication and characterization of memristive devices with applications in non-volatile digital memories and analog neuromorphic circuits.

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)



Memristive device based on Platinum/TiO_2/Platinum with active dimensions of 1.5μm x1.5μm (images from optical microscope)



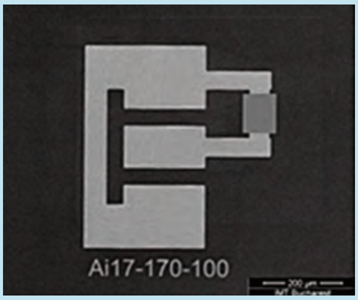
Current-voltage (I-V) characteristics of a typical memristive device measured at room temperature (T = 23°C). This device can have an Roff/Ron ~103 and can be used for digital applications, but also exhibits a tunable resistance in both SET and RESET useful for analog applications.

The memristive device was designed to function at small "forming" and operation voltages (<2-3V) and to have a tunable resistance in a large range (few kΩ to MΩ). As the active material, TiO_2 was deposited through e-beam deposition from TiO_2 rutile crystals. No oxygen was flown in the chamber during the position, which led to a substoichiometric material and a low forming voltage for the device. This TiO_2 gave good tunability to the device on both the SET (from high OFF resistance to low ON resistance) and the RESET (from low ON resistance to high OFF resistance). The devices were characterized using a semiconductor characterization system from Keithley (model 4200-SCS) by applying voltage sweeps for RESET and current sweeps for SET.

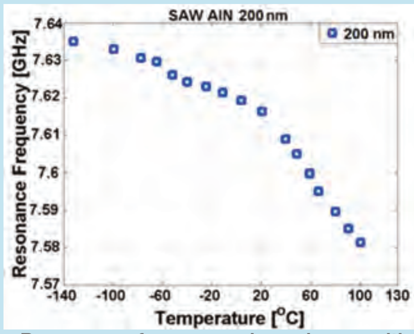
Microphisycal and thermal characterisation for optimised temperature sensors structures based on SAW resonators on AlN/Si with resonance frequencies in the giga hertz domaines

PATRNERSHIP - PN-II-PT-PCCA-2013-4 Ctr. 15/2014 „Temperature sensor based on GHz operating AlN/Si SAW structures – SETSAL” (2014-2017), Coordinator Dr. Alexandru Muller.

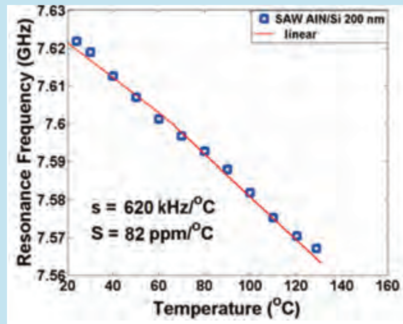
SAW structures having IDTs with fingers and interdigit spacinas of 200nm were manufactured. The variation of the resonance frequency vs. temperature was measured and the sensitivity of 620 kHz/^{0}C was determined in the 20-30 ^{0}C temperature range.



SEM image of a SAW structure manufactured on AlN/Si



Resonance frequency dependence with temperature



SAW resonator temperature sensitivity in the temperature range 20-120ºC

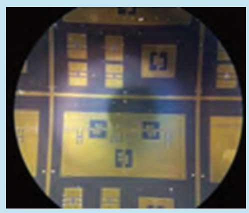
Filters containing CNT varactors

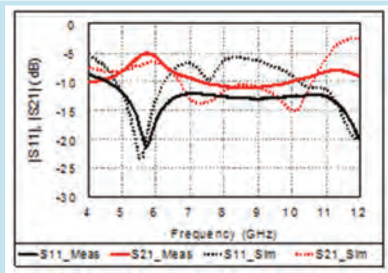
NANO RF - FP7-ICT-2011-8, STREP Nr 318352 – “Carbon based smart systems for wireless applications”,

Coordinator Thales TRT, France, 13 partners, 2012-2016, IMT partner.

IMT coordinator Dr. Mircea Dragoman

X band filters with CNT varactore were manufactured and characterized





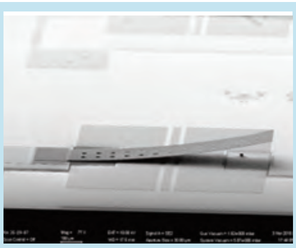
S parametres measurements and simulations

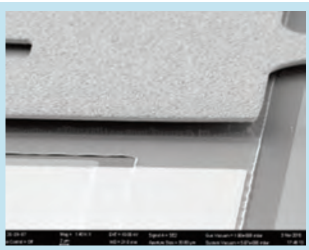
Image of the processed filter and filter detail.

Manufacturing of RF-MEMS switches

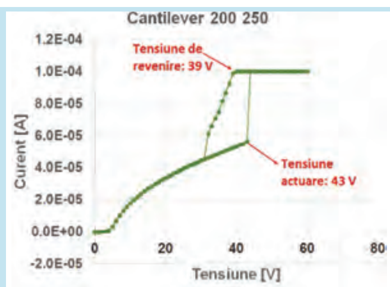
PARTNERSHIP - ctr 5/2012 – “Advanced Tools and Methodologies for the Multiphysics Modelling and Simulation of RF MEMS Switches”, (2012 – 2016); IMT- partner, IMT coordinator Dr. Alexandra Stefanescu

Different bridge and cantilever RF-MEMS switch structures were manufactured. In each case, the widths of the membrane and of the actuation electrodes were varied between 200 µm and 300 µm.





SEM photos of the manufactured switch structures: cantilever type (left), and detail of the clamping method by two metallic stripes (right)



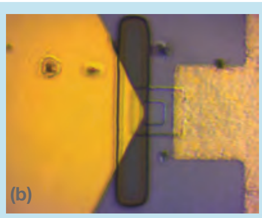
DC measurements for RF-MEMS cantilever switch

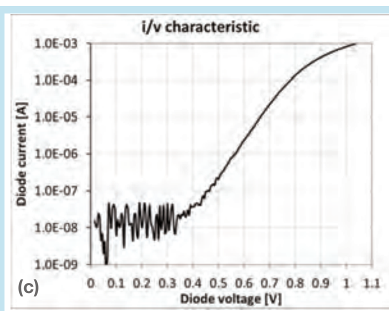
Design and characterization of Schottky diodes

IDEAS PN-II-ID-PCE-2011-3-0830, „Millimeter-wave Front-End for Imaging in Security and Medical Applications (MI-4-SEMA)”,

Dir. Proiect Prof.Dr. Dan Neculoiu (2011-2016)

Schottky diodes test structures were designed on GaAs substrate, manufactured ans characterized.



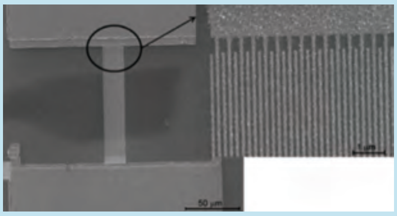


(a) A section through the Schottk diodey; (b) optical photo af an integrated diode structure presenting the DC pads; (c) measured i/v characteristics

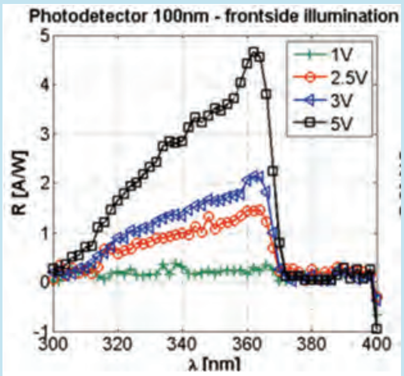
Optimization of MSM photodetectors suspended on membrane

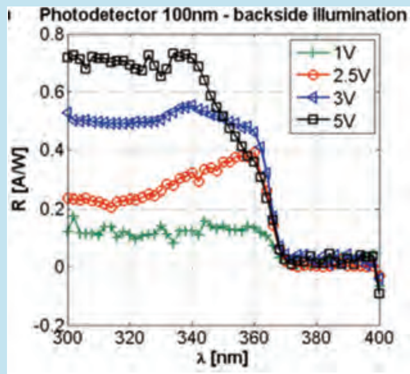
IDEAS PNII-ID_PCE-2011-3-0513 "Novel technologies based on micromachining and nano-processing of GaN/Si, for advanced microwave and photonic devices", Coordinator Dr. Alexandru Muller, (2011-2016)

The structures were processed by direct writing Electron Beam Lithography. An in-house set up was used for responsivity measurement with front side and backside illumination. The total area of the MSM structure (digits and interdigits spaces) was 10000 μm² while the active area was 5000 μm². Since the 5/10 nm Ni/Au contacts were 50% transparency, the "effective" active area is ~ 7500 μm². This area was considered for the front side illumination responsivity estimation. For the backside responsivity, the entire area under the MSM structure is illuminated uniformly (10000 μm²).



SEM image of a photodetector structure manufactured on a thin GaN membrane having 100nm digit/interdigit width





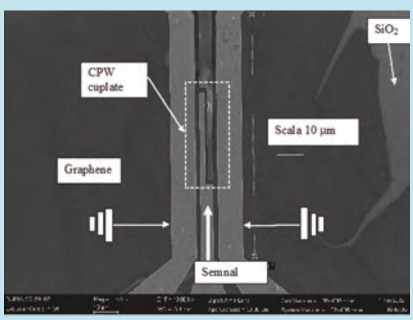
Responsivity vs wave length with front side illumination (a) and backside illumination (b) for UV optimized photodetector having 100nm digit/interdigit width at 1 V, 2.5 V, 3 V and 5 V polarization

The maximum responsivity for our structures has been obtained at λ=362 nm. For the 100 nm wide finger/interdigit spacing structure, front side illumination responsivity was 1.45 A/W and the backside illumination responsivity was 0.37 A/W. For the 200 nm wide finger/ interdigit spacing structure the maximum front side illumination responsivity was 0.127 A/W and the backside illumination responsivity was 0.022 A/W. This corresponds to a front to backside illumination responsivity ratio of 3.9 for the first structure and 5.9 for the second one.

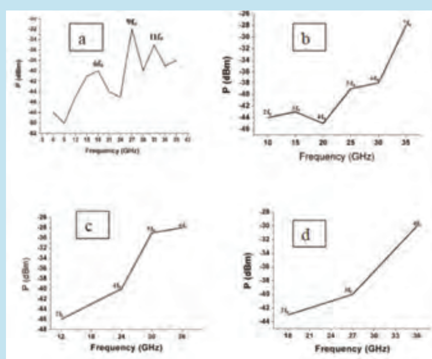
Frequency multiplier for millimeter wave

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

A frequency multiplier on graphene was processed. The multiplier consists in two coupled lines, on graphene, connected to a gold CPW line and was manufactured by e-beam lithography amd metallic deposition.



SEM image of the multiplier

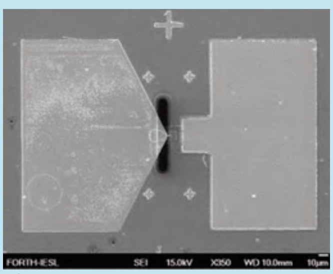


Multiplier frequency respons for: (a) 3 GHz, (b) 5 GHz (c) 6 GHz (d) 9 GHz

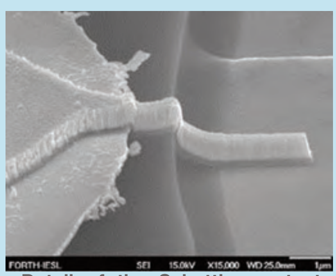
GaAs Schottky type diodes for millimetre and submillimetre wave frequency

STAR ctr. 86 /2013 „ Millimetre and sub-millimetre wave GaAs Schottky diodes, detectors and mixers" Coordinator Dr Alexandru Muller, (2013-2016)

Functional Schottky diodes with 3 THz frequency target were manufactured.



SEM image after the nanolithography

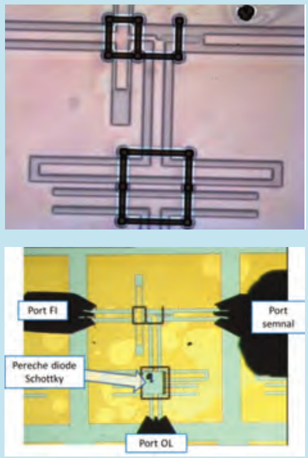


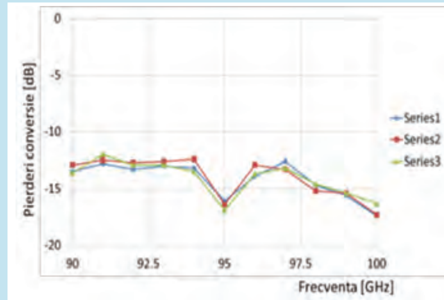
Datail of the Schottky contact area less than 1μm²

Design and manufacturing of hibrid harmonic mixer for W band

STAR ctr. 86 /2013 „ Millimetre and sub-millimetre wave GaAs Schottky diodes, detectors and mixers" Coord. Dr A. Muller, (2013-2016)

An integrated harmonic mixer was designed and manufactured using hybrid technology. Discrete Scottky diodes were assembled on HR Si thin film circuit. About 90-100 GHz bandwidth with good impedance matching and 13 dB conversion loss were measured. The chip area is 2200 µm x 2770 µm (6,1 mm^2).





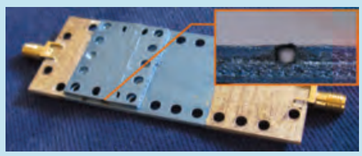
Measured conversion loss of the hybrid harmonic mixer.

Photos of mixer layout before Schottky diodes' assembly (left, top) and complete mixer during measurement (left).

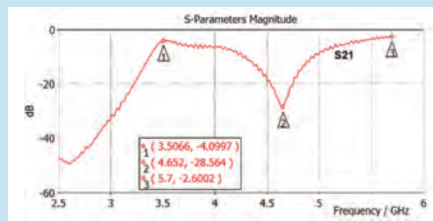
Experimental results for the SIW type measuring cell

PN III-YOUNG RESEARCH TEAMS - ctr. no. 330/2015 - Applications of substrate integrated waveguide structures for measuring the permittivity of dielectric materials in microwave domain, coordinator dr. Alexandra Stefanescu

The sample to be measured is inserted in a channel with the maximum dimensions of about 1.6 mm x 1.6 mm (shown in the inset of the left figure). The frequency response of the measuring cell with undisturbed cavity (without the insertion of the dielectric material) shows an attenuation of about 28.56 dB at the resonance frequency of 4.65 GHz.



The experimental measuring cell, with detail of the sampling insertion channel

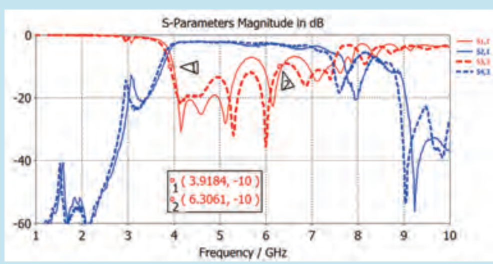


The transfer characteristic measured for the measuring cell (without dielectric material)

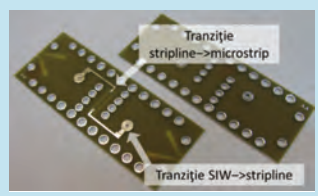
Design and manufacturing of SIW circuits for integration with semiconductor components

Project FN 15N/2016 (TEHNOSPEC), Topic: Semiconductor devices' integration with substrate integrated waveguides (SIW)

Structures with multiple transmission line sections and transitions were analyzed and manufactured. The circuits are intended for integration of passive and active components with SIW environment. First experimental model covers 3.9 - 6.3 GHz band with a return loss better than 10 dB. An attenuator version confirmed the possibility to obtain a 10 dB attenuator in SIW technique with SMD resistors.



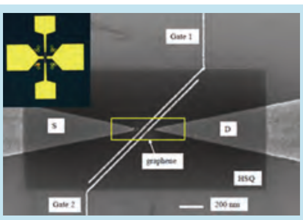
Transfer characteristics measured for two assembly procedures



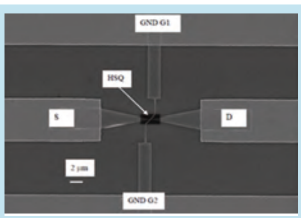
Multiple transitions CPW-SIW-stripline-SIW-CPW structure before assembling

Technological processes for graphene structuring

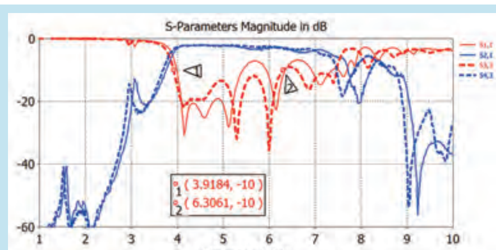
Proiect FN 15N/2016: Key enabling technologies for inteligent specialization priorities (TEHNOSPEC)



FET on graphene with double gate with DC characterization electrodes



FET on graphene with double gate with coupled lines for RF measurements



I_D-V_D characteristics fot the ballistic transistor

Center for Wireless Integrated MicroSensing & Systems

presents

WIMS² SEMINAR

Thurs., June 2, 2016 10:30 am - 12:00 pm 1690 Beyster Bldg.

Progress in Development of GHz Operating Acoustic Devices Based on Micromachining and Nanoprocessing of GaN/Si

Alexandru Müller, PhD

Head of the Laboratory
National Institute for R&D
in Microtechnologies - IMT
Bucharest, Romania

Abstract: The presentation will contain the most important contributions of IMT-Bucharest (together with FORTH Heraklion, Greece) in the development of novel acoustic devices based on micromachining and nanoprocessing of GaN/Si.

The following contributions will be presented:

- Development of first FBAR devices on GaN (resonating in the 2.1…8.3 GHz frequency range). The devices are supported on GaN membranes with thickness in the range of 300 - 1000 nm obtained by micromachining of GaN/Si;
- Development of SAW resonators on GaN. Advanced nano-lithographic processes have been used; finger and finger/interdigit spacing with a width in the 100…200 nm have been used for the IDTs and the reflectors; resonance frequencies up to 8.1 GHz have been obtained;
- Development of single resonator GaN /Si SAW based temperature sensors and a comparison of Rayleigh and Sezawa mode temperature coefficients of frequency(TCF);
- Development of GaN/Si SAW based pressure sensors.

Bio: Alexandru Müller received his PhD in Semiconductor Physics from the Bucharest University. His main area of expertise consists in: microwave and millimeter wave devices, MEMS technologies for microwave and millimeter wave devices and circuits, sacoustic devices based WBG semiconductor materials. He is the head of the microwave and millimeter wave devices and circuits laboratory from the National R&D Institute for Microtechnology, IMT-Bucharest, Romania. Dr Müller had a 6 months Post Doc stage at IMEC Leuven, Belgium in 1991 and a 6 Month Stage as "Director de Recherche" at LAAS CNRS Touluose, France in 2003.

Dr Müller and his team were and are involved in many European projects (in the programs FP4, FP6, FP, Horizon 2020 of the European Commission and European Space Agency). He has coordinated one of the first European projects in RF MEMS "MEMSWAVE" (1998-2001), nominated in 2002 between the 10 finalists for the Descartes Prize of the European Commission. He is now leader of the IMT team in three FP7 and H2020 Projects.

The recent research activity of Dr. Müller is focused on GaN/Si based acoustic devices, operating in the GHz frequency range, with targeted applications in sensors and advanced communication systems. He is author or co-author of more than 150 papers published in high ranked journals and Conference proceedings.

FEM Models for GaN Based Surface Acoustic Wave Structures

Alexandra Stefanescu, PhD

Senior Reseacher
National Institute for R&D
in Microtechnologies - IMT
Bucharest, Romania

Abstract: The presentation proposes an analysis of different Surface Acoustic Wave (SAW) devices composed of interdigital transducers (IDT) in the range of 120 - 200 nm wide on GaN/Si, devoted for GHz applications, such as sensors or filters.

Finite element (FEM) models investigated in COMSOL Multiphysics® demonstrate the frequency characteristics as well as the acoustic mode shapes at different resonances. The different propagation modes of the SAW devices (Rayleigh, Sezawa and Pseudo-bulk) were identified. Furthermore, the influence of the IDTs metallization (Ti/Au and Al) on the behavior of the SAW structures is analyzed through numerical simulations. Significantly higher resonance frequencies have been obtained for the Ti/Au metalized structures than for similar structures with Al metallization. Simulation results are in very good agreement with the experimental values.

Bio: Alexandra Stefanescu received her BSc in Electrical Engineering in 2006, from the Polytechnic University of Bucharest, with the final project at École Supérieure d'Electricité (SUPELEC), France. In 2010 she obtained her PhD in Electrical Engineering from the Polytechnic University of Bucharest.

In 2009 she joins for 18 months the European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors-MIMOMEMS of IMT-Bucharest. Between 2010-2012 she conducted a EU-funded post-doctoral research program in RF-MEMS technologies.

She was and is involved in several European projects (FP6, FP7 and ENIAC). Since 2014 she participates in the team of two European Space Agency projects dedicated to RF-MEMS switches on Si, working at 110 GHz as well as to surface acoustic wave filters on GaN/Si. Currently, she coordinates the IMT team in a national partnership project dedicated to new advanced methodologies for multiphysics modeling of RF-MEMS switches as well as a young independent research team project dedicated to substrate integrated waveguides.

Her research interests focus on modeling, design, 3D electromagnetic simulations and fabrication of devices and microsystems based on MEMS technology for microwave applications.

For information contact: Larry Tuttle, Center for Wireless Integrated MicroSensing & Systems (WIMS²) ▪ http://wims2.org

2214 EECS Bldg., 1301 Beal Ave. ▪ Ann Arbor, MI 48109-2122 ▪ Phone: 734-615-2325 ▪ Fax: 734-647-2342 ▪ lwtuttle@umich.edu

Prof. Dan Dascalu was the founder and the director (CEO) of the Centre for Microtechnology (1991), then of the Institute of Microtechnology (July 1993), and finally (since November 1996) of the National Institute for Research and Development in Microtechnologies (IMT Bucharest). His mandate came to and end in June 2011. Since then, he is the Coordinator of the Centre for Nanotechnologies and President of the Coordinating Board of IMT-MINAFAB. Dan Dascalu is a full member (academician) of the Romanian Academy (of Sciences). He is the author of "Transit-time Effects in Unipolar Solid-State Devices" and "Electronic Processes in Unipolar Solid State Devices" (both published by Abacus Press, Kent, U.K., 1974 and 1977) as well as of many technical papers published in scientific periodicals or conference proceedings. Dan Dascalu is an expert representing Romania in the NMP FP6 and FP7 Programme Committee (since 2002), in the "mirror group" for the European Technological Platform for Nanomedicine and in the High Level Group (HLG) for Nanotechnologies.

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

Laboratory of Nanobiotechnologies

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

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

Mission

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

Research areas

The main areas of activity are:

(i) fabrication of the nanomaterials/functional nanostructures, investigation, control and 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 some hybrid systems for applications in different fields, from sensing (i.e. gas, temperature sensors) to energy (miniaturized devices for conversion or storage of energy as clean energy sources, such as micro- fuel cells / solar cells / micro-supercapacitors.

Team

1. **Adina Boldeiu,** Chemist, Dr., Research Scientist II;
2. **Cosmin Romanitan,** Physicist, PhD St., Research Scientist;
3. **Florea Craciunoiu,** Physicist, Research Scientist II;
4. **Iuliana Mihalache,** Physicist, Dr., Research Scientist III;
5. **Melania Banu,** Biologist, PhD St., Research Scientist;
6. **Mihaela Kusko,** Physicist, Dr., Research Scientist I, head of the laboratory L1;
7. **Mihai Danila,** Physicist, Research Scientist III;
8. **Mihai Mihaila,** Engineer, Dr., Research Scientist I;
9. **Monica Simion,** Physicist, Dr., Research Scientist II;
10. **Razvan Pascu,** Engineer, Dr., Research Scientist III;
11. **Teodora Ignat,** Chemist, Dr., Research Scientist III.

Equipments and related scientific results

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

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

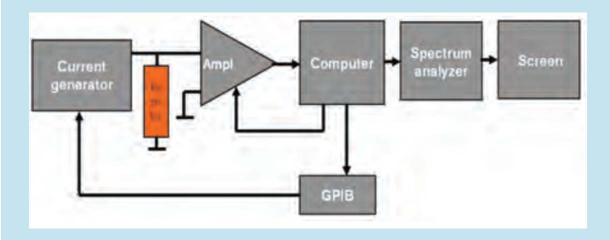
• **Electrochemical Scanning Microscope ElProScan** (Heka, Germany);
contact persons: Dr. Mihaela Kusko; Dr. Monica Simion

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

• **Impedance Spectrometer, Electrochemical analyzer/workstation**
- Electrochemical Impedance Spectrometer - PARSTAT 2273 (Princeton Applied Research, USA)
- Autolab PGSTAT302N / FRA32N / SPR
contact persons: Dr. Mihaela Kusko; Dr. Antonio Radoi

• **Size and Zeta Potential Measurement System DelsaNanoC** (Beckman Coulter, USA);
contact persons: Dr. Adina Boldeiu, Dr. Monica Simion

• **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



Introduced recently [M. Mihaila, US Patent, US 7612551 B2, Nov. 3 (2009)], the fluctuation spectroscopy is a method capable to measure the atomic vibration (phonon) spectrum of a conducting material. In addition, the local vibration modes introduced by impurities or crystallographic defects can be observed.

To obtain the phonon spectrum, one measures the frequency spectrum of a fluctuating voltage which develops across the terminals of a resistor/film fabricated from the material whose phonon spectrum is intended to be observed. The measurement system developed in the Nanobiotechnology Laboratory is schematically presented in the attached figure. The system is controlled by a computer, which is additionally used for data acquisition and signal processing. Current is injected into the resistor to be investigated and the voltage developed across its terminals is amplified and Fourier transformed. In this way, the noise spectrum, SV(f), at a given voltage is obtained. The final result is the dependence of the noise intensity on voltage. Usually, it presents sharp peaks located at voltages corresponding to the phonon energies of the investigated material.

The new method is an electrical one and can be applied at room temperature. It does not require fabrication of a special device and is useful to investigate single small dimensional systems (e.g.: nanowires, nanotubes, etc.).

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

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

• **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. M. Kusko.

National projects:

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

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

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

• **PNII- PCCA project** *"RFID device for alimentary traceability - Food Track"* – resp IMT Dr. Mihaela Kusko (2014-2016) http://www.3nanosae.org/p/foodtrack/

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

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

• **PNII- PCCA project** "*Environmental toxic and flammable gas detector based on silicon carbide MOS sensor array"* – resp. IMT F. Craciunoiu (2012-2016) http://www.icpe-ca.ro/proiecte/proiecte-nationale/pn-2011-2013/sic-gas.pdf

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

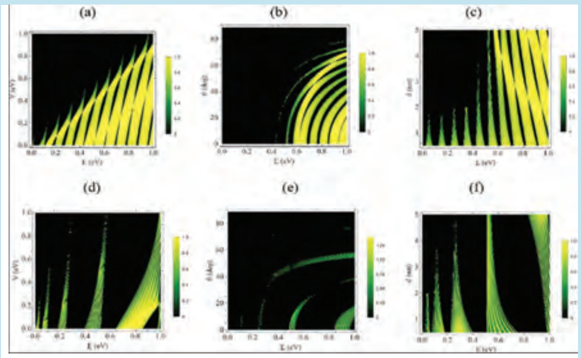
• POSDRU/159/1.5/S/13775 Contract

During doctoral program at Faculty of Physics, University of Bucharest, a theoretical study was conducted on the properties of ballistic electron propagation through periodic few-layer nanostructures consisting of regions of one, two or three layers of stacked graphene. Three types of situations, which are the most common ones, were considered in "all-graphene" devices:

a) Ballistic transport through periodic gated structures in mono- , bi- , or tri-layer graphene;

b) Ballistic transport through periodic structures containing mono-, bi- and tri-layer graphene;

c) Ballistic transport through periodic graphene structures separated by Schrödinger-type materials.



The results of simulations refer to the case of monolayer and tri-layer graphene strips separated by dielectric regions: the dependence of the transmission coefficient in monolayer graphene (top) and tri-layer graphene (bottom) structures separated by semiconductor: applied gate potential (Ad), the incidence angle (be) width of the gated region (cf)

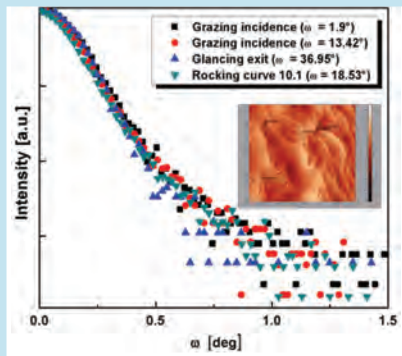
Numerical simulations of the transmission coefficient through mono-, bi-, or tri-layer graphene structures and periodic potential applied through gate electrodes, under low energy conditions and ballistic transport, were calculated for the first time using the transfer matrix formalism. It has been demonstrated that the trace of the matrix of the period is always complex, therefore the transmission coefficient is evanescent and no allowed minibands for electron propagation occur in periodic monolayer/bilayer structures.

The explanation for the occurrence of such behavior relies on the different symmetries of the evolution laws for electrons in few-layer graphene and in the semiconductor, under low energy conditions.

„Ballistic electron propagation through periodic few-layer graphene nanostructures”, Daniela Dragoman, Iulia Mihalache, **Physica E: Low-dimensional Systems and Nanostructures** 84 (2016): 60-70.

• TEHNOSPEC Nucleu Core Programme 15N/2016

Since the threading dislocations generaly have negative effects on optical and electrical properties of GaN-based devices and can also influence device reliability and lifetime, although they might be responsible for useful additional properties when their type and density are controlled, using advanced techniques of high resolution X-ray diffraction (HR-XRD), the incidence of threding dislocations (TDs) was investigated in two GaN thin films grown heteroepitaxially on sapphire substrate.



As a result, the density of edge and screw densities was determined, as well as the mean distance between two TDs. Moreover, recording the X-ray rocking curves profiles at grazing incidence XRD (GI-XRD) and Glancing-Exit XRD (GE-XRD), respectively, allowed us to reveal the depth profile of the TDs – left figure.

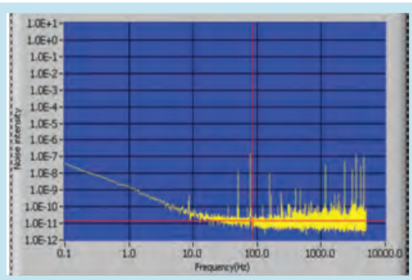
It was shown that the density of TDs is approximately constant from interface GaN-Al2O3 across the surface, confirming that the primary source of dislocations originates from the interface, determined by the mismatch between the sapphire substrate and the GaN layer, and no supplementary nucleation or annihilation centers are present inside the epitaxial film.

A step further is correlation of these micro-structural investigations with optical and electrical ones in such materials in order to correctly balance the required properties with their growth processes and desired devices.

“Comparative study of threading dislocations in GaN epitaxial layers by nondestructive methods”, Cosmin Romanitan*, Raluca Gavrila, Mihai Danila*, **Materials Science in Semiconductor Processing** Accepted 19 September 2016, doi: 10.1016/j.mssp.2016.09.021.

• TEHNOSPEC Nucleu Core Programme 15N/2016

Microscopic origin of 1/f or 1/f-like noise, also known as infrared catastrophe, remained unknown since its discovery, more than 90 years ago. It manifests in solids, liquids, biological systems, etc. and acts as the fundamental source of decoherence in quantum computing.



In this work, we heuristically analyze apparently dissimilar aspects related to the 1/f noise in solid, with the purpose to reveal possible hidden but unifying factors involved in the microscopic mechanism of 1/f noise in solid.

We found that the microscopic nonlinearity is a sine qua non condition for the existence of both thermal and 1/f noise. Violation of the equipartition law is required to have 1/f noise.

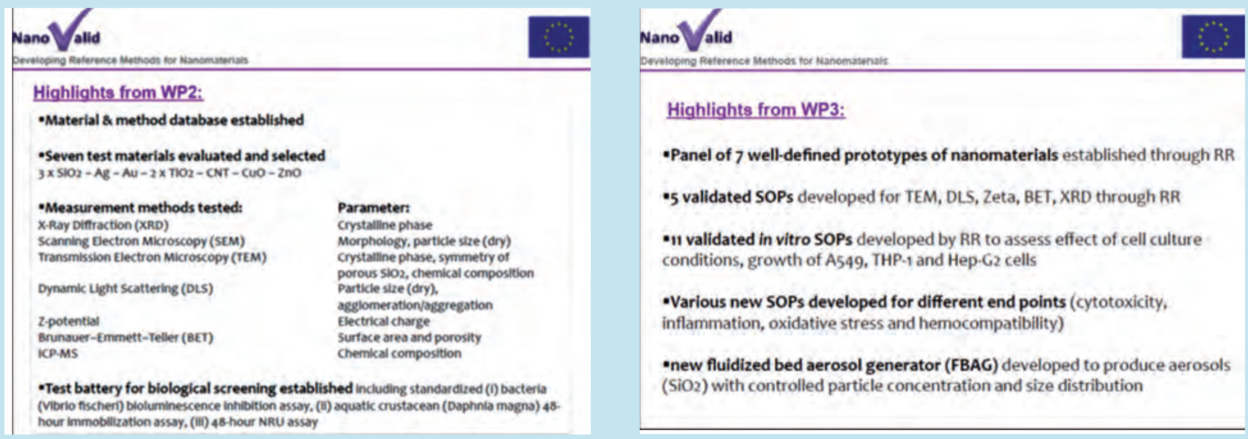
"On the 1/f Noise and Energy Partition in Solid", Mihai Mihaila, **Romanian Journal of Information Science and Technology** 19 (1-2), 175-187, 2016

IInd Research Area – physical and chemical studies for hazards and risks evaluation associated with nanomaterials / nanotechnologies

• FP7 IP Project - “Development of reference methods for hazard identification, risk assessment and LCA of engineered nanomaterials – NanoValid”

In the frame of FP7-IP NanoValid, IMT was involved in setting up some standards methods for nanoparticles characterization and also, took part to the correlation activity of the obtained results, between the involved laboratories. Therefore, within some round robin tests, hydrodynamic diameter and zeta potential measurements were done simultaneously in different research laboratories, having similar equipments from different suppliers, all the partners following the same measurement protocols, in order to establish the protocol with the minimum error which can be induced by the equipment usage. This kind of procedure was further introduced as standard operating procedure (SOP).

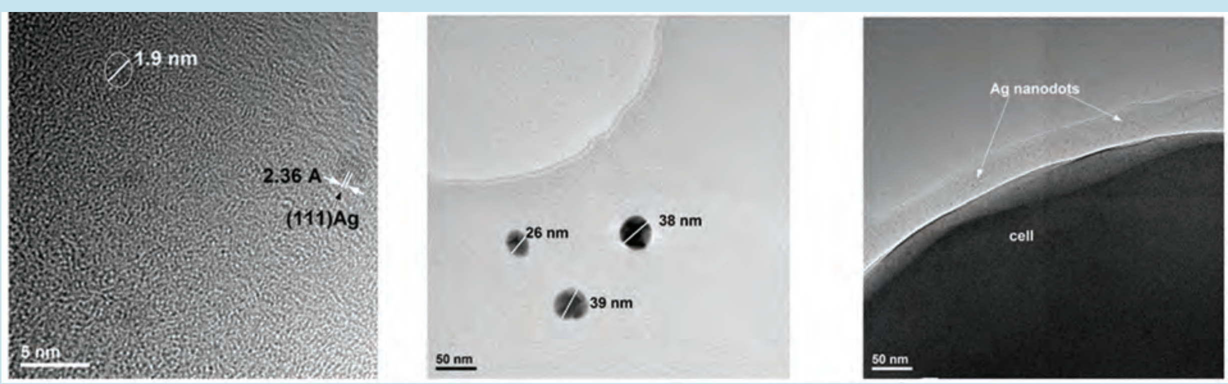
Selections from the presentation of Dr. Rudolf Reuther, NordMijlo AB Sweden, the NanoValid Project Coordinator:



„Pan-European inter-laboratory studies on a panel of in vitro cytotoxicity and pro-inflammation assays for nanoparticles”, Jean-Pascal Piret, Olesja M. Bondarenko, Matthew S. P. Boyles, Martin Himly, Ana R. Ribeiro, Federico Benetti, Caroline Smal, Braulio Lima, Annegret Potthoff, Monica Simion, Elise Dumortier, Paulo Emilio C. Leite, Luciene Bottentuit Balottin, José Mauro Granjeiro, Angela Ivask, Anne Kahru, Isabella Radauer-Preiml, Ulrike Tischler, Albert Duschl, Christelle Saout, Sergio Anguissola, Andrea Haase, An JacobsInge Nelissen, Superb K. Misra, Olivier Toussaint, **Archives of Toxicology,** 10 December 2016, doi:10.1007/s00204-016-1897-2

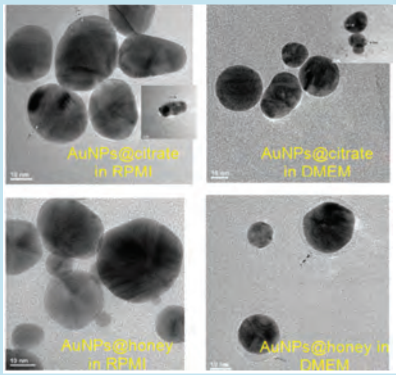
• PNII-PCCA ctr 203/2014: “ Identification of new modulators of calcium-regulated processes using genomic and chemogenomic screens in yeast – CalChemGen”

For extrapolation of the phenotype leading to hiperaccumulation of the heavy metals in yeasts, Saccharomyces cerevisiae cells were obtained in UB, because their artificial hexapeptides can attach metallic ions on the internal part of the plasmatic membrane. Accordingly, the cellular culture media were supplemented with controlled concentrations of metallic ions and the morpho-structural investigations revealed the penetration process of these elements.

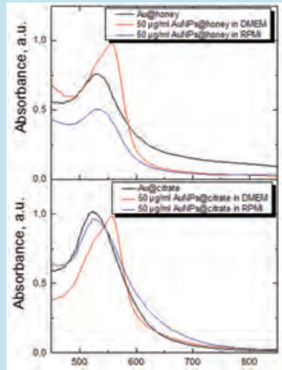


TEM analyses evidencing the metals’ accumulation

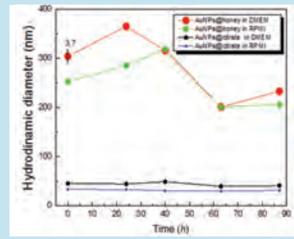
• PNII-PCCA ctr 109/2014: "Improved production methods to minimize metallic nanoparticles' toxicity – less classic, more green – LesMoreNano"



TEM images of the protein corona around the AuNPs dispersed in DMEM si RPMI



UV-vis spectra of the AuNPs at 50µg/ml suspended in DMEM and RPMI



The hydrodynamic diameters variation in DMEM si RPMI over time for the both AuNPs types

The development of new synthesis methods, especially the „green chemistry" related ones, is an important issue for the companies involved in the nanocomposites fabrication field. Aghoras Invent SRL is a small enterprise involved in development and marketing of new cosmetic products based on metallic nanoparticles, and consequently it is strongly interested in performing thorough investigation regarding the toxycity risk assesment before launching a new product.

In the first stage of the project, green methods for obtaining of gold nanoparticles (AuNPs) of 15 nm were developed, using honey as reducing and stabilized agent (AuNPs@honey), in parallel with the experiments for standard synthesis of AuNPs, based on Turkevich procedure (AuNPs@citrate). The resulted AuNPs were comparatively analysed taking into account the possible interactions which can appear during AuNPs dispersion in two of the most cell culture media used, DMEM (Dulbecco's Modified Eagle Medium) and RPMI (Roswell Park Memorial Institute), enriched in FBS (Fetal Bovine Serum), trying to establish the influence of the cell culture media composition over the protein corona which is being observed at the nanoparticles surface. The physical-chemical characterizations were done in IMT and UPB, and then completed in DFVM-IFIN HH, with cell viability tests.

III^rd Research Area – Nanobiotechnologies / Biosensors

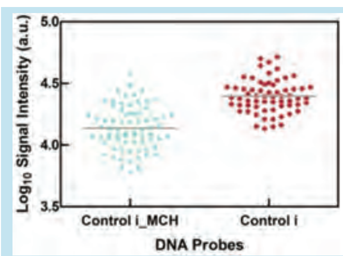
• PNII-PCCA ctr 36/2014: "Integrated platform for multiplexed HPV genotyping – MultiplexGen"

Preliminary HPV (Human Papilloma Virus) genotyping tests

Within the collaboration between IMT-Bucharest, University of Bucharest and GeneticLab, preliminary (a) immobilization and (b) hybridization tests were conducted on gold-coated supports, using HPV-DNA fragments.

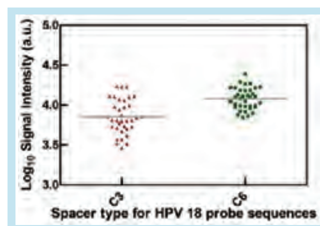
In IMT, on the one hand, the microfluidic technology was adapted for enhancing the immobilization and hybridization conditions – (c) the microfluidic system was fabricated using PDMS (polydimethilsiloxane). On the other hand, our studies were focused on PCR amplification and cloning of the HPV strains extracted from cells isolated from cervix (d). The purified PCR amplicons were ligated into a cloning vector and transformed into competent E. coli cells, the recombinant DNA technology having applications in the preparation of a large number of identical DNA molecules. *A continuation of the experiments will consist in fluorescent labeling of the cloned DNA sequences and in evaluating the hybridization efficiency by fluorescence / electrochemical measurements.*

(a) The immobilization signal before the biochip processing steps



In the present case, it is observed that the incubation of the DNA mix with mecaptohexanol leads to a dispersion of the immobilisation values, whereas in the case of incubation of the DNA control without MCH, the immobilization intensities given by the technical replicas more uniform.

(b) Influence of the spacer length on the hybridization efficiency

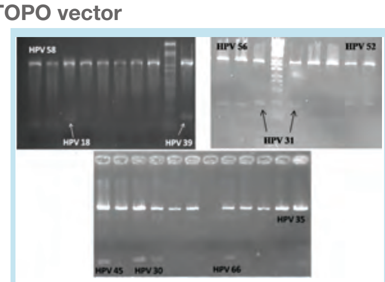


From the graphical analysis it is observed that the 6 carbon atomizer had a positive impact on the hybridization, in that the fluorescent signal intensity was higher (more target molecules were attached to the DNA probes) and more uniform.

(c) Silicon matrix with defined channels for obtaining microfluidic systems

The defining of the channels geometry was achieved by a photolithographic process, by developing the channels through which the silicon dioxide /glass was etched. The PDM channels were defined thereafter using the silicon / glass matrix.

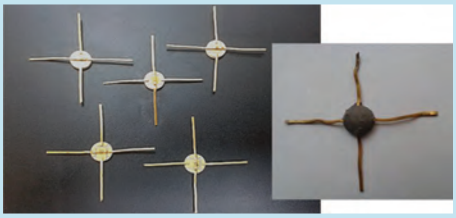
(d) Agarose gel electrophoresis of the DNA sequences cloned into pCR 2.1 TOPO vector



The corresponding genetic sequences were amplified, purified, transformed into the 2.1 TOPO pCR vector and subsequently cloned into competent E. coli cells. The cloning of DNA sequences corresponding to HPV 58, 18, 39, 56, 31, 52, 45, 30, 66 and 35, respectively, was confirmed by gel electrophoresis.

IVth Research Area – Dispozitive opto-electronice pe baza de nanomateriale / filme subtiri

• PNII-PCCA ctr 21/2012: "High Temperature Probe Based on Silicon Carbide (SiC) Sensor for Industrial Applications – SiC-SET"



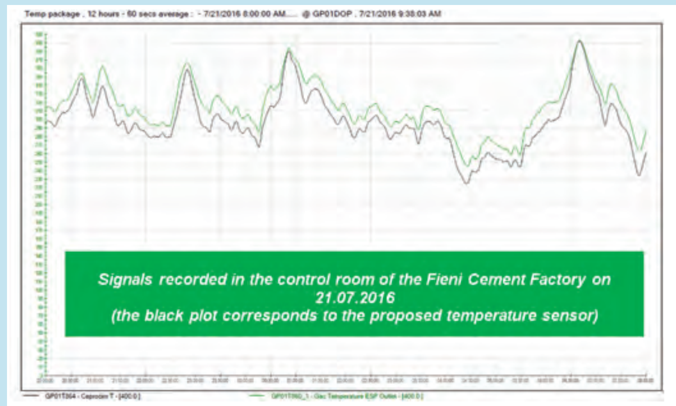
Berilia capsule before and after chip packaging

The probe with SiC sensor at output of the electrofilter from the grill cooler and the input in the heat exchanger of the recovery facility at cement factory from Fieni

Schottky diodes based on SiC were fabricated in IMT, developing an improved technological flow, where the Schottky metals (Ni and Pt) were subjected to rapid thermal annealings at different temperatures in order to obtain an homogenous Schottky contact. The final packaging of the devices was realized using "berilia" case, where the anode contact was achieved by wire bonding technology. An index card has been realized for the fabricated SiC Schottky diodes, containing the following parameters:

- Output current: 4 - 20 mA (in temperature range: 0 - 400 °C);
- Range linearity: 0 - 400 °C, with relative deviation under 1%;
- Power-supply voltage: 12 – 25 Vcc, in the range of industrial standard;
- Bias current for temperature sensor: 100 μA.

Next, an electrical circuit to amplify the voltage from the output of the sensor and to make the conversion of this signal into a current corresponding to the industrial standard 4 – 20 mA was realized in UPB and the functional model was tested directly during the industrial processes at the Cement Factory Fieni.



Signals recorded in the control room of the Fieni Cement Factory on 21.07.2016 (the black plot corresponds to the proposed temperature sensor)

The tests clearly demonstrate that the proposed functional model of both the SiC based temperature sensor and the processing circuit realized by the IMT and UPB Bucharest successfully worked in parallel with a standard commercial sensor.

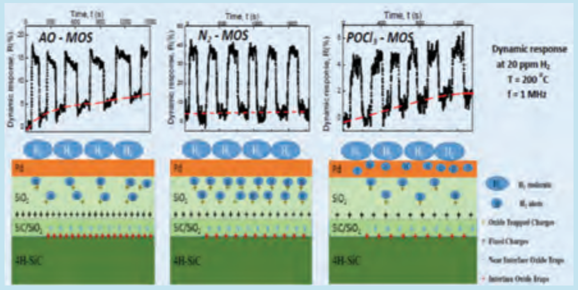
The differences between the temperatures indicated by the two probes were of maximum 10°C.

Besides the accuracy of sensing, it is also remarkable that the IMT' sensor worked continuously, over 1000 hours, up to the end of august, 2016.

• PNII-PCCA ctr 204/2012: "Environmental toxic and flammable gas detector based on silicon carbide MOS sensor array– SiC-GAS"

SiC based MOS capacitors were fabricated in IMT with an improved oxide/semiconductor interface, using post-oxidation annealing treatments in different atmospheres based on nitrogen and phosphorous. In order to optimize the technology for SiC MOS capacitors fabrication, a comparative analysis has been realized on the fabricated MOS devices performances, taking into account the applied post-oxidation annealing treatments. The studies were focused on both electrical performances of the fabricated SiC MOS capacitors (operating parameters, stability with temperature) and their performances as hydrogen sensors.

It has been demonstrated that the interface traps density were reduced by more than one order of magnitude after a post-oxidation annealing treatment in $POCl_3$ atmosphere. Moreover, this treatment led to a double electric field breakdown in comparison with the grown oxide without a post oxidation annealing treatment. Regarding the the rapid thermal annealing in N_2 atmosphere, it improves the quality of the MOS oxide, and furthermore, leads to remarkable performances like hydrogen sensor.



The hydrogen sensor developed in IMT shows outstanding performaces regarding both the response/recovery times (cca. 10 s), detection limit (0.77 ppm) and sensitivity (50.3 pF).

"A new 4H-SiC hydrogen sensor with oxide ramp termination", R. Pascu, M. Kusko, F. Craciunoiu, G. Pristavu, G. Brezeanu, M. Badila, V. Avramescu, **Materials Science in Semiconductor Processing** 42 (2), 268-272, 2016.

Accepted manuscript: "Oxide trap states versus gas sensing in SiC-MOS capacitors – the effect of N- and P- based post oxidation processes", R. Pascu*, F. Craciunoiu, G. Pristavu, G. Brezeanu, M. Kusko*, **Sensors and Actuators B: Chemical**, http://dx.doi.org/10.1016/j.snb.2017.02.044.

Centre of Nanotechnologies

Nano-scale structuring and characterization laboratory

Mission

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

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

Research areas

Structuring:

• Nanoscale patterning with Gaussian e-beam lithography used for micro/nano nanostructuring with applications in photonics, MSM-UV photodetectors, high-frequency and microwave circuits etc.
• Fabrication of graphene-based configurations and devices using dedicated EBL techniques.

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.

Team

The laboratory team is composed of senior and junior researchers, PhD students and an economic specialist:
1. **Dr. Adrian Dinescu**, Physicist, Senior Researcher I, Head of the laboratory
2. **Dr. Florin Nastase**, Physicist, Senior Researcher II
3. **Phys. Raluca Gavrila**, Physicist, Senior Researcher III
4. **Dr. Octavian Ligor**, Physicist, Senior Researcher III
5. **Dr. Marian Popescu**, Engineer, Senior Researcher III
6. **Ph. D. student Bogdan Ionut Bita**, Physicist, Researcher
7. **Ph. D. student Stefan Iulian Enache**, Technological Development Engineer
8. **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 ™)
• Scanning 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 encompasses 4 experimental laboratories included in the IMT-MINAFAB support centre for micro - and nanofabrication and certified to ISO 9001:2008 quality management standards: "Laboratory for SEM characterization", "Laboratory for electron beam litography Raith e_Line", "Laboratory for field emission SEM characterization" and "Laboratory for SPM and nanomechanical testing".

National and International Collaborations

• ***National cooperation***
Cooperation with Romanian companies, research centres, university departments and institutes (Honeywell Romania; ProOptica S.A.; S.C. "IOR-S.A."; Zoomsoft SRL; Storex Technologies Inc.; Faculty of Physics -Univ. of Bucharest; Univ. “Politehnica” Bucharest (Department of General Chemistry, Department of Bioresources and Polymer Sciences, Engineering and Informatics for Chemical and Biochemical Processes; Faculty of Applied Chemistry and Materials Sciences); Univ. of Craiova - Faculty of Mechanics; “Dunarea de Jos” Univ. of Galati - Faculty of Sciences and Environment (Department of Chemistry, Physics and Environment); University of Petroleum and Gas Ploiesti (Department of Chemistry); Faculty of Dental Medicine - Titu Maiorescu Univ.; INFLPR (CETAL - Center For Advanced Laser Technologies, Laboratory of Plasma at Low Temperature, Laboratory of Plasma Physics and Solid State Laser); NIMP (Laboratory of Materials and Multifunctional Structures); IFIN-HH).
National projects running in 2016:
- **“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)
- **“Technological processes for advanced material thin films”**, Core National Project **TEHNOSPEC** (2016-2017).

National and International Collaborations

• *International partnership*

Collaboration with universities and institutes from Italy (National Institute for Astrophysics (INAF) - Arcetri Astrophysical Observatory) and Bulgaria (University of Ruse "Angel Kanchev", Georgi Nadjakov Institute of Solid State Physics - Bulgarian Academy of Sciences).

International projects running in 2016:

- "**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 Nanostructures" Master course, Microsystems MSc program;
- "Electronic Technologies for Optoelectronic Applications" Master course, Optoelectronics MSc program.
- "Measurements in electronics and telecommunications" Laboratory, Year II
- "Communication Systems" Laboratory, Year III, "Micro-electronics, Optoelectronics and Nanotechnologies (MON)" specialization

• "Electronics" Laboratory - Year II, **Faculty of Physics - University of Bucharest.**

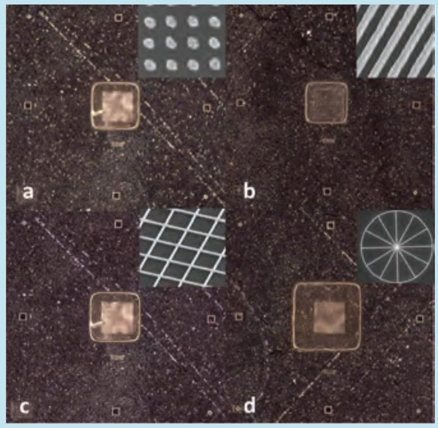
MAIN RESULTS

Engineering free-standing Si_3N_4 foils "doped" with metallic nanostructures for use as laser targets

The foils are to be used for experiments at the future high-power laser infrastructures ELI (Extreme Light Infrastructure), mainly for applications in ultra-high energy ion beam generation from laser-plasma interactions.

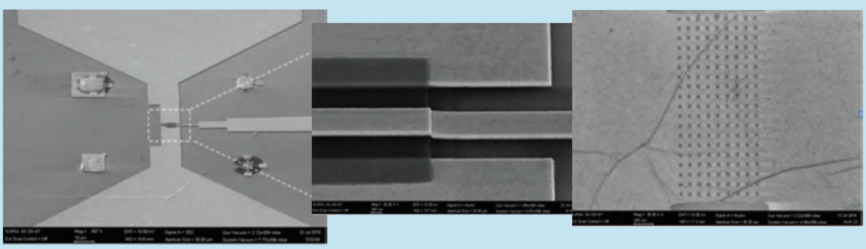
The target composition and geometry influence the electron density in plasma and consequently the electric field accelerating the ions, their energetic and angular distribution, plasma temperature etc. In order to increase laser absorbtion in thin targets, the foils are „doped" with high density electron nanostructures, such as Au or Ag nanoparticles, capable of inducing plasmonic resonance.

Laser targets consist in 1 cm^2 Si chips, provided with Si_3N_4 central free-standing membranes having areas between 200x200 μm^2 and 700x700 μm^2. With the use of electron beam lithography (EBL), together with metallic deposition and lift-off, four types of metallic nanostructures have been patterned on the membranes:
a) nanodots, 100 nm pitch; parallel grating lines; perpendicular grating lines; star-type structures (*Core Project – PN TEHNOSPEC, PN16320202 - 2016*).



Dark field optical microscopy images and SEM micrographs (insert) of thin Si_3N_4 laser targets covered with Ti/Au nanostructures: a) nanodots; parallel grating lines; perpendicular grating lines; star-type structures

Graphene nanostructuring using e-beam litography (EBL) for fabricating a FET transistor with nanoperforated graphene channel.

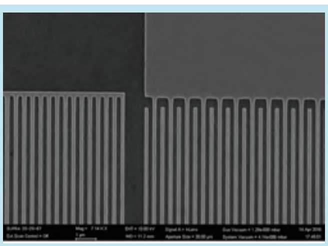


SEM images of the nanoperforated graphene gate GFET. Left: overview; Center: detail from the graphene channel Right: perforated channel. The perforations are 30 nm diameter and 100 nm pitch. *(„Room temperature nanostructured graphene transistor with high on/off ratio", M. Dragoman, A. and D. Dragoman, Nanotechnology, vol. 28, nr. 1, 2016)*

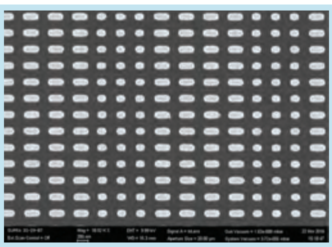
Using EBL in combination with classic microfabrication procedures (optical lithography, selective deposition and etching of thin films, lift-off technique), a graphene field-effect transistor (GFET) with the channel consisting of nanoperforated graphene was fabricated and encapsulated. The GFET features saturation regions that can be tuned by modifying the top gate voltage. The on/off ratios is at least 2×10^3 at room temperature and at small drain and gate voltages

Scientific Services:

Nanometric scale structuring by electron beam litography



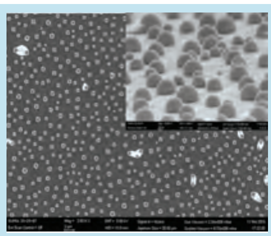
Lines, 300 nm pitch, fabricated by EBL for applications in Surface Acoustic Waves (SAW) devices



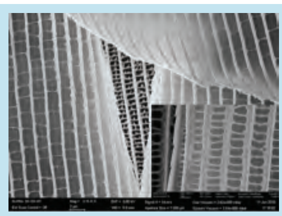
EBL patterning in PMMA 950k for plasmonic applications. The size of the structures lies between 100 si 300 nm.

Scanning Electron Microscope (SEM)

(both conventional and field emission gun)



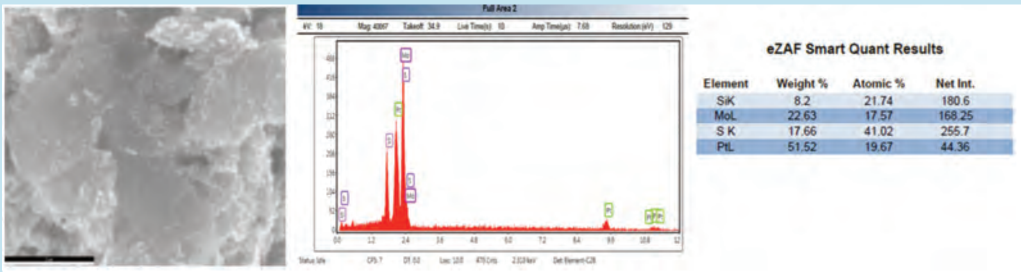
Overview and detail (insert) of Ag nanoparticles with ~ 100 nm diameter



Replicated biometric structures (butterfly wing) for applications at solar cells and catalysis (insert: detail)

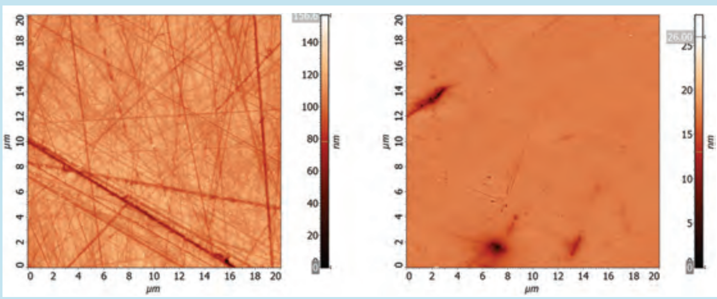
SERVICES

• Energy Dispersive X-Ray Spectroscopy (EDX)

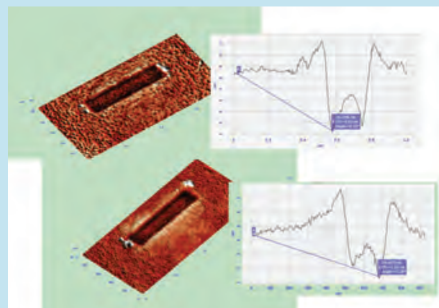


SEM image and EDX analysis for Pt nanoparticles on MoS_2

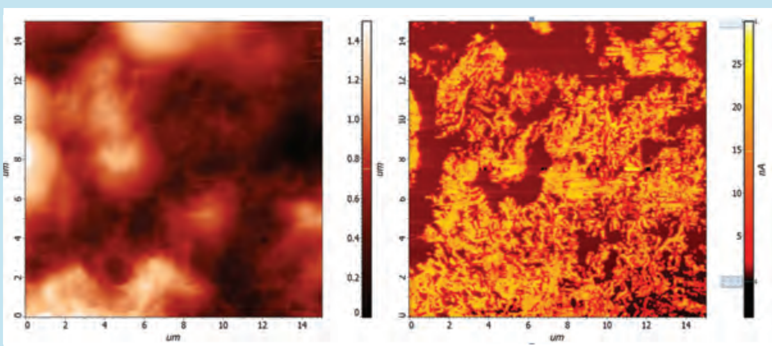
• Atomic Force Microscopy and related techniques (SPM)



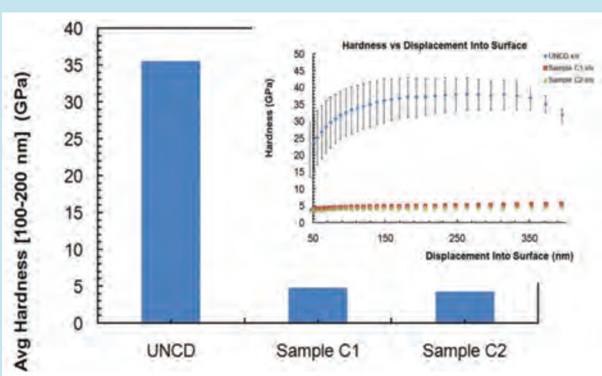
AFM measurements of a MgF_2 optical crystal
Left: as received Sy = 156 nm; Sq = 7.5 nm;
Right: after mecano-chemical polishing Sy = 28 nm; Sq = 0.8 nm;



Adherence evaluation by AFM-based scratch testing for two nanometer-thick layers



Morphology (height, left) and conductive properties (current, right) for a conductive polimer - graphene composite, registered simultaneously by SPM techniques.
Scan area: 15x15 μm²; Bias voltage: 2 V



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

Hardness measurements by nano-indentation for three carbon-based thin films grown by CVD:
- UNCD: nanocrystalline diamond, HFCVD tehcniques
- C1 and C2: diamond-like carbon films, grown by PECVD in CH4 and H2 atmosphere

Scientific Papers

In 2016, L6 team has co-authored 16 scientific papers in ISI ranked journals (11 as a first author from IMT) and has presented 10 communications at national and international conferences, among which 2 invited papers and 3 published in Proceedings.

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 (supra)molecular structures, functional materials, molecular dynamics, and atomistic modeling / simulation.

The main areas of interest are fundamental research and development of technologies for the fabrication of functional materials and micro/nanosystems based on synthesis and epitaxial MBE growth, physico-chemical modifications and structural optimization. The studies are directed towards understanding, and making use of, the mechanisms that provide new functions by combining the techniques of preparation and synthesis of 3D...0D 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, LEDs, transparent functional electrodes, MEMS.

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

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

Team

- **Dr. Lucia Monica Veca - CS I,** PhD in Chemistry, Clemson Univ, USA, 2009
- **Dr. Antonio Marian Radoi - CS I,** PhD in Chemistry, Tor Vergata Univ., Italy, 2007.
- **Dr. Titus Sandu - CS I,** PhD in Physics, Texas A&M Univ., USA, 2002.
- **Dr. Emil-Mihai Pavelescu - CS I**, PhD in Technology, Tampere University of Technology, Finland, 2004.
- **Dr. Cristina Pachiu - CS III,** PhD in Physics, Univ. Le Havre, France, 2007.
- **Dr. Victor Leca - CS II**, PhD in Materials Science, Twente Univ., The Netherlands, 2003.
- **Dr. Radu Cristian Popa - IDT I**, PhD in Quantum Engineering and Systems Science, Univ. of Tokyo, 1998; Laboratory head.

Laboratory head:
Dr. Radu Popa
radu.popa@imt.ro

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

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

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

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

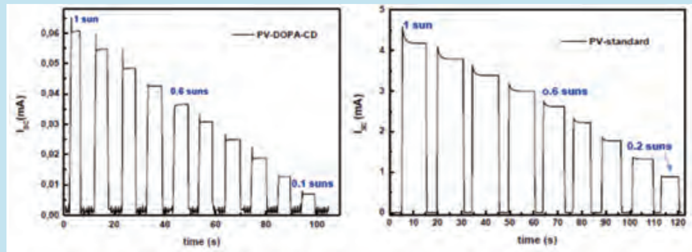
National and international cooperation

- 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
- "Babes-Bolyai" University, Cluj, Romania - prof. Anamaria Elena Terec, prof. Simion Astilean
- University of Bucharest 3Nano-SAE Research Center - Prof. Ioan Stamatin
- 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
- LAAS-CNRS Toulouse, France – Dr. C. Fontaine
- University of Kassel, Germany- Prof. J-P Reithmaier
- Natl. Institute for R&D in Lasers, Plasma and Radiation Physics, Bucharest - Dr. Catalin Ticos
- Université Catholique de Louvain, Belgium - prof. Sorin Melinte
- Inst. of Physical Chemistry "Ilie Murgulescu", Romanian Academy, Bucharest - Dr. Viorel Chihaia
- University of Bucharest - prof. Adelina Ianculescu

National Complex Ideas Project: PNII-ID-PCCE–2011-2-0069 „Carbon quantum dots: exploring a new concept for next generation optoelectronic devices" (2012-2016) - contact Dr. Monica Veca (monica.veca@imt.ro).

Carbon quantum dots sensitized solar cells

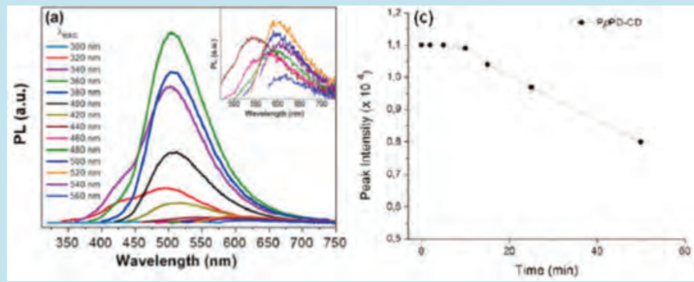
Transient photocurrent measurements at different illumination intensities revealed that the solar cell fabricated with DOPA-CD has a rapid, stable and reproducible response. This indicates the absence of photobleaching, frequently observed in conventional QD sensitized solar cells. While the collection rate of the injected electrons is approaching 98% at irradiation power of 1.4-1.5 suns, the stabilization time is about 0.6–1 seconds and the collection rate of the injected electrons is ~93% when decreasing the illumination power to 1 sun. Comparatively, for the standard solar cell (dye-sensitized solar cell) the conversion was 91% at 1 sun, and only a decrease of the intensity to 0.7 suns has shown a conversion rate of 99%.



Photocurrent response of the PV-DOPA-CD (left) and standard dye-sensitized solar cell (right) under white light illumination at indicated input power.

Spectroscopic studies of PpPD-carbon dots (synthesized by the UBB-Chem partner)

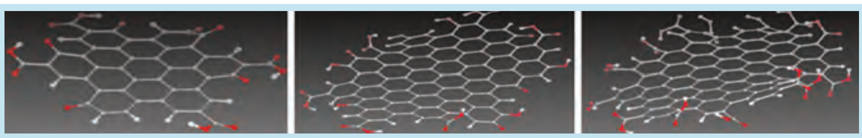
Steady-state fluorescence of PpPD-CD synthesized by surface passivation of the carbon nanoparticles with p-phenylenediamine (pPD) has unveiled an emission maximum centered at 505 nm, whose position is independent of the excitation wavelength in the 320–420nm range. The phenomenon is a direct indication of efficient passivation of the nanoparticle surface with the pPD oligomer. The relative fluorescence quantum yield was 14%, and the emission intensity shows a maximum at 360nm excitation, in correlation with the absorption shoulder.



Fluorescence spectra of PpPD-CD at the different excitation wavelengths (left), and fluorescence stability of the PpPD-CD under continuous illumination with 375 nm/6mW (right).

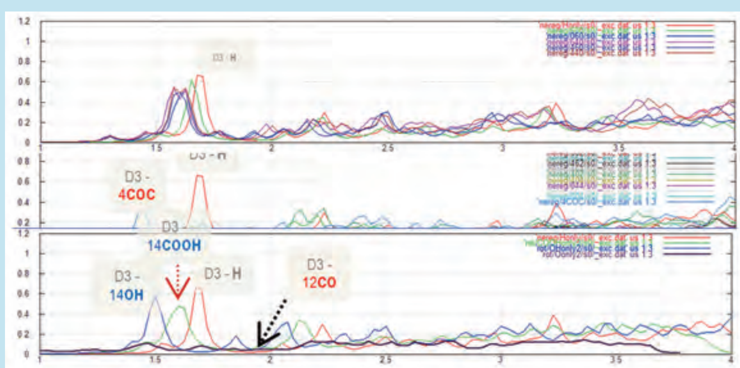
Optoelectronic effects of oxidic groups in CQDs - extensive theoretical analysis

Numerical modeling and simulation studies were performed in order to evaluate the chemical factors that affect the fluorescence quantum yield of CQDs via the enhancement or inhibition of the photoabsorption mechanism. While it has been observed experimentally that the radiative potential of graphitic nanostructures exhibits a steep enhancement following chemical (functionalization, chemical reduction), or physical (energy treatments-such as exposures to plasma or UV radiation-targeting chemical reduction) modifications, the mechanisms responsible for such efficiency benefits are still elusive and intensely debated. Our numerical studies aimed at understanding the effects of the presence in various configurations and concentrations of the oxidic groups inherent to graphene oxide - carboxyl, hydroxyl, carbonyl, epoxy - on the radiative potential of the material. The structures analyzed were 1-2nm sized graphenes, of regular (D6h) and irregular (Cs) shapes, with extensively various compositions of their oxidic content. After structural optimizations, the calculations led to: total and projected DOS, vertical absorption energies and the corresponding oscillator strengths, absorption spectra, relevant transitions and their orbitals.



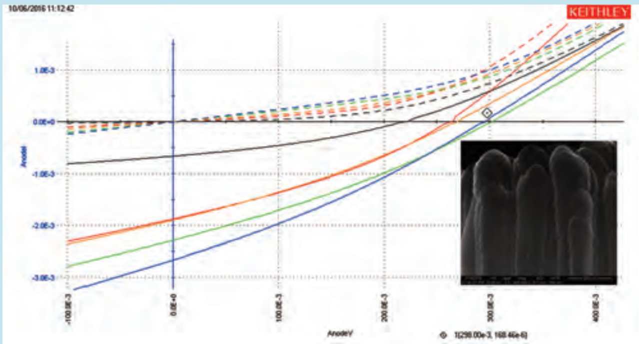
Examples of analyzed nanographenes 'doped' with oxidic groups (COOH, CO, OH, COC)

The main results revealed: (i) the detrimental role played by the unpassivated groups (carbonyl, epoxy) on the photoabsorption efficiency (progressive absorption decrease, correlated with the group concentration); (ii) the strong selectivity and monotony - reflecting the quantum confinement - of the absorption peaks generated by the $\pi \rightarrow \pi^*$ transitions (a possible explanation of the typically observed emission spectral heterogeneity phenomenon o nanographenes). One of the practical implications of these conclusions is that the fluorescence quantum yield depends strongly on the post-synthesis processes that could reduce the concentration of carbonyl and epoxy groups.



Simulated absorption spectra for a class ('D3') of Cs-symmetry nanographenes. Abscissa: [eV]; Ordinate: oscillator strength, Lorentzian broadening. For comparison, the same shape class, completely H-passivated ('D3-H').
- Top: superimposed absorption spectra for all the simulated configurations not containing carbonyl or epoxy groups.
- Middle: superimposed absorption spectra only for the simulated configurations containing carbonyl or epoxy groups.
- Bottom: superimposed absorption spectra for some selected configurations with large concentrations of oxidic groups.

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)



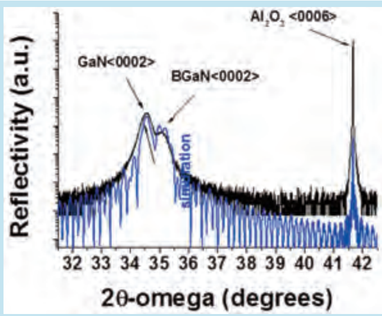
I-V curves of PV devices enhanced using GQD functionalization (red, orange, green and blue), compared with a non-GQD reference structure (black), at 1 sun (solid lines), or zero illumination (dashed lines). Inset: SEM micrograph illustrating the hybrid interface based on SiNWs and GQDs, covered with an ITO film.

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

Gbm/Si hybrid interface

The efficiency of PV devices depends on enhancing the absorption of incident photons, on reducing the optical reflection and on optimizing the collection of generated carriers. In these respects, nanostructured silicon represents a good candidate material. Silicon nanowires (SiNWs) are obtained by metal-assisted chemical etching (MACE), followed by functionalization with graphene quantum dots (GQDs) in order to provide a functional hybrid interface. Top and bottom contacts are realized using ITO and Au layers, respectively.

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)



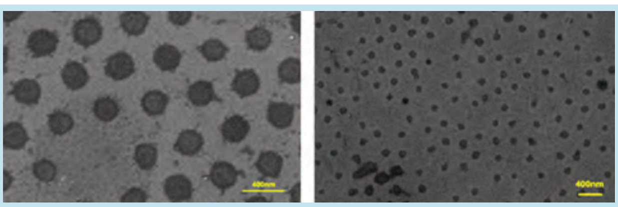
The X-ray diffraction curve of the BGaN/GaN/sapphire grown structure (black curve) and the simulated results of a structure of 21nm BGaN layer with 7.7% Boron and a 28nm GaN layer on sapphire (blue curve). The absence of reflection edges in case of the grown structure is probably due to the low growth temperature employed for the (B)GaN layers. The low temperature was necessary to favor a high absorption of Boron and to avoid the degradation of the interface/surface.

The project objective is the fabrication of 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. By introducing Boron in the solar cells crystalline structure, the mismatch and the thermal coefficients are ameliorated. With these advantages, BGaN structures may be superior to the InGaN or AlGaN structures on AlN and SiC substrates. Moreover, for a boron content up to 12%, the BGaN structure may offer a good crystalline lattice-match with AlGaN for the entire range GaN-AlN.

(B)GaN growth by MBE

Epitaxial growth of (B)GaN layers was performed on Sapphire substrates of <0.2o offcut, using the Compact 21DZ/Riber MBE system. The process is initiated by heating the substrate at 370°C and exposing it to nitrogen plasma, followed by growth of GaN (at 465°C) and of BGaN (500°C, solid source Boron). Crystal quality and Boron content were evaluated by XRD analysis (HR-XRD SmartLab/Rigaku), while the surface morphology was examined by AFM.

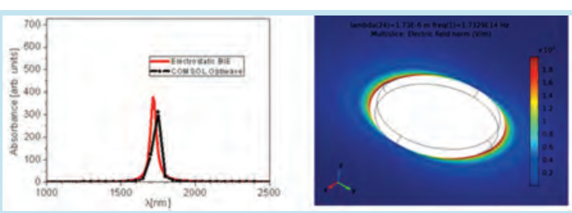
Synthesis of size-controlled graphene nanostructures (Project 15N/2016-PN16320201) - contact Dr. Monica Veca (monica.veca@imt.ro)



SEM images of the graphene nanoparticles obtained by colloidal nanolithography: using polystyrene spheres of 425 nm (left) and 287 nm (right) in diameter. The corresponding GQD's dimensions are 200 nm and 100 nm, respectively.

Graphene quantum dots of controlled dimensions ($^{24}_{12}$ 50 nm), uniformly distributed on the silicon substrate, have been synthesized using colloidal nanolithography. Subsequently, as-synthesized nanoparticles will give us the opportunity for the experimental and theoretical analysis of the photoluminescence mechanism in graphene quantum dots, as well as the possibility to test the development of optoelectronic devices using the structured GQDs as exciton recombination/dissociation centers.

Numerical analysis of light absorption due to intraband conductivity in graphene nanodisks (contact Dr. Titus Sandu (titus.sandu@imt.ro)



Numerical results of plasmonic effects in a graphene nanodisk with a 4nm diameter. Left: Absorption spectrum (BIE method versus COMSOL—Optiwave). Right: The near field configuration at resonance (COMSOL simulation).

In graphene nanodots the intraband conductivity generates localized plasmon resonances whose signature is strong light absorption at given wavelengths depending on nanodot geometry. Starting from Boundary Integral Equation (BIE) formulation the inherent 2D nature of nanodisks is treated by a 3D model (T Sandu et al., "A Heuristic Look at Plasmon Resonances in Graphene Nanodisks", CAS 2016 Proceedings, pp. 105-108.)

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, 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 microsystems/actuators and microsensors;
- **Design and microfabrication of microfluidic and micro-electro-fluidic systems, electrical and contact profilometry characterization**;
- **Characterization of physical phenomena** in wide band gap semiconductors;
- **Development of technology** for preparing and doping process for ZnO transparent films and nanostructures, with potential in different device applications, in transparent electronics, photovoltaic cells, functional sensors in UV domain including functioning in harsh environments and space;
- **Atomistic simulations** and analysis by ab initio calculations of the electronic structure in the presence of impurity doping and defects for semiconductor materials.

Team

PhD. Raluca Müller - senior researcher I, PhD in electronics, laboratory head

PhD. Rodica Plugaru - senior researcher I, PhD in physics

PhD. Gabriel Moagar-Poladian - senior researcher II, PhD in physics

PhD. Oana Tatiana Nedelcu - senior researcher I, MS in mathematics, PhD in electronics

PhD. Franti Eduard - senior researcher III, PhD in electronics

Phys. Constantin Tibeica - scientific researcher, physicist

Phys. Eng. Victor Moagar-Poladian - IDT III (Technological Development Engineer), physicist engineer (MS)

PhD. Rodica-Cristina Voicu - senior researcher III, mathematician, PhD in mathematics

PhD. Anca-Ionela Istrate - senior researcher III, PhD in materials engineering

Eng. George Boldeiu - IDT III (Technological Development Engineer), MS in electrical engineering

Eng. Angela-Mihaela Baracu - scientific researcher, PhD student in electronics

Eng. Ramona Corman - MS student 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

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

COMSOL 5.2.A - Software package for simulation of physical phenomena such as: mechanics of solids, heat transfer, fluidics, acoustics, RF-MEMS.

ANSYS Multiphysics 18.1 - 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 algorithm development, data acquisition, data visualization, data 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 reporting and for growing the productivity of CAD and PDMWorks. It includes management solutions for design data, suited to single or group management of SolidWorks projects.

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

■ **Technology**:

- **3D Printer Selective Laser Sintering EOS Formiga P100**
- **3D Printer based on Single Photon Photopolymerization MiniMultiLens system from EnvisionTEC**
- **Laser microengraving system**

Services:

• Computer aided Modelling and Simulation (using FEM, FVM, BEM) 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;

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

• Rapid prototyping using 3D Printer Selective Laser sintering for the following applications: manufacturing of models for design, architecture, educational purposes; 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;

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

International collaborations

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

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

National collaborations

• **IDEAS project**: “Prospective research regarding rapid prototyping processes for applications in the field of micro and nanosystems realization”, (2011–2016), Coord: IMT, Dr. Gabriel Moagar-Poladian;

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

• **PN II project**: “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, Coord: ICEMENERG, IMT Partner: Phys.Victor Moagar-Poladian;

• **STAR:** “Tribomechanical Characterization of MEMS Materials for Space Applications under harsh environments – MEMSMAT”, Project 97, 2013-2016, Coord: Technical University of Cluj-Napoca, IMT Partner: Dr. Raluca Müller

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

- **PN16320103** “Nanostructures and heterostructures for micro-nano-(opto)electronics components”

- **PN16320104** “MEMS based integrated microactuators and sensors”

- **PN16320202** “Technological processes for thin films advanced materials”

- **PN16320203** “Nanoelectronics technologies and devices for graphene and other single atomic layer materials”

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

► ECSEL-H2020: 3Ccar: „Integrated components for control in electrified cars”, (2015 – 2018).

Coordinator: Infineon Technologies AG Germany, Partner L5 from IMT: Dr. Gabriel Moagar-Poladian;

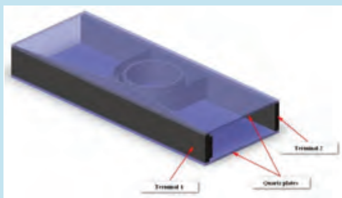
Domain fields for the activity of IMT:
- Structures for the thermal management of electric vehicles
- Advanced, multi-stimulus encapsulation systems
- IMT is coordinator of two tasks in the project (partners of tasks: Daimler, TNO, Infineon Technologies Romania)

Results:

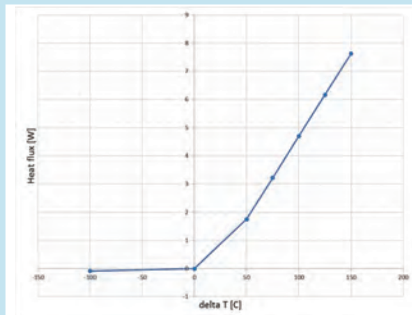
- Thermal diodes were conceived and simulated (Phys. Catalin Tibeica) – depicted in the next figures and, respectively,

- A thermal switch was devised and simulated, switch that has a very high ON / OFF ratio (Dr. Gabriel Moagar-Poladian) – see table. ON / OFF ratio: the ratio between the thermal conductance of the switch in the ON state and, respectively, in the OFF state.

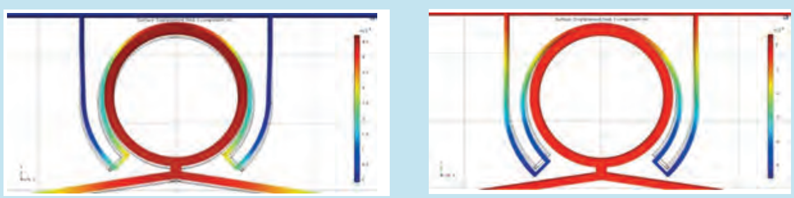
Table–The parameters of the thermal switch as resulting from simulations: Size: 1cm^3; Thermal impedance in the ON state (conduction): 0.5 K/W; ON/OFF ratio of thermal conductances (conduction state/insulation state): 1106; Maximum work temperature: 100°C; Switch time between states: 1s; Switching power: 1.5W.



Thermal diode 3D lay-out



The simulated response curve of the thermal diode (horizontal axis: temperature difference between parts; vertical axis: heat flux)

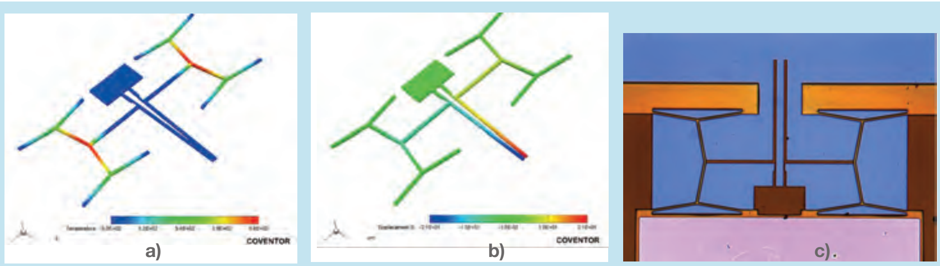


Displacements along the vertical axis for a temperature difference of 1000 C: left – “direct polarization”; right – „reverse polarization” (displacement magnified by 20 times for facilitating observation)

► MANUNET Project “Microgrippers as end-effectors with integrated sensors for microrobotic applications (ROBOGRIP)”, 2016-2017

Contract no. 22/2016, Coordinator: IMT, Dr. Rodica-Cristina Voicu.

- Design and simulation for MEMS microgrippers (a-b) in normally open operation mode and based on V-shaped electro-thermally actuators. Realization of coupled electro-thermo-mechanical FEM simulations with Coventorware 2014 program in order to analyze the temperature distribution in the structure and the displacements of the microgripper arms when the structure is actuated.

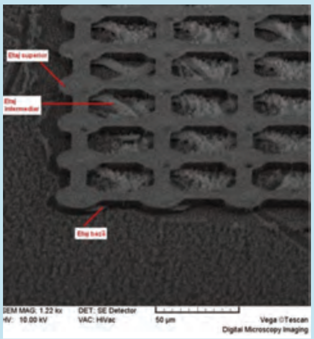


a) Temperature distribution in the structure at I=22 mA; b) In-plane displacements of the gripper arms for I=22 mA (simulations with Coventorware 2014) - FEM coupled electro-thermo-mechanical simulations c) Optical image of a microgripper structure fabricated using the SU-8 polymer and Cr/Au/Cr for the heaters

- Realization of a microgripper demonstrator electro-thermally actuated (c). Realization of technological process using the SU-8 biocompatible polymer as structural layer and thin films of Cr/Au/Cr for the metallic heaters configuration. Microphysical characterizations and electrical tests were performed in order to validate the microgripper functionality.

► IDEAS project "Prospective research regarding rapid prototyping processes for applications in the field of micro and nanosystems realization", 2011 – 2016

Contract no. 62/2011, Coordinator: IMT, Dr. Gabriel Moagăr-Poladian



SEM image of the 3D structure made of Au

- A 3D structure made of Au was fabricated (together with Dr. Dan Vasilache from L4), as presented in the attached figure.

- We have determined the specific limitations of the 3D Printing processes at micro-nanoscale.

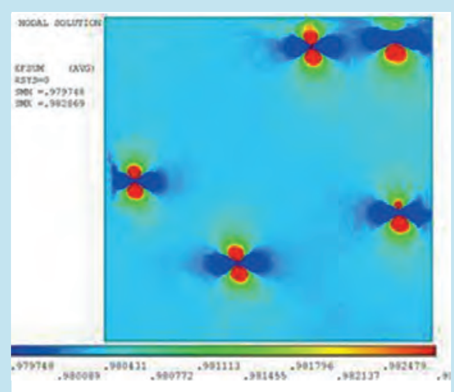
- We have formulated concepts for 3D Printing of integrated circuits (including active devices such as transistors and diodes)

- An European patent was granted for the 3D Printing at micro-nanoscale technology that uses 2D / 3D nanolithography of the fountain pen and, respectively, aperture pen type.

- We have published a paper in an ISI journal (M. Bulinski, G. Moagăr-Poladian – "Fourier-transform interference lithography", Romanian Reports in Physics, Volume 68, Number 2, p. 713 – 724, (2016)).

► PN II project: "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;



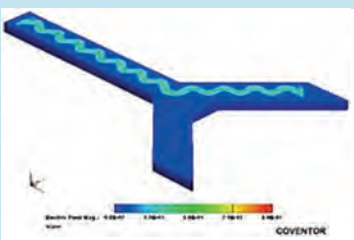
The electric field distribution in a section through a polymeric material containing 14 Si nanoparticles placed in a uniform electric field.

► PN II project: "Micro-electro-fluidic system for biological cells separation and electroporation - MEFSYS"

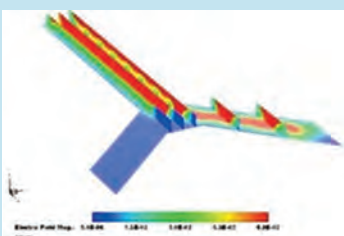
Contract no. 30/2014-2017, Coordinator: IMT, Dr. Oana Nedelcu.

Partners: • SC Spital LOTUS SRL Ploiesti; • DDS Diagnostic SRL Bucuresti; • University of Bucharest – Faculty of Chemistry; • University Politehnica of Bucharest – Faculty of Applied Sciences, Laboratory of Digital Holography.

Two new versions of Microsystems were designed: the geometry of electrodes is optimized in order to maximize the area of high electric field. Electrostatic and dielectrophoretic simulations were performed. We developed masks and microfabricated electrodes and channels on silicon. Nanoparticles – core and covered by gold – were synthetized and characterized, and the bioconjugation was performed: nanoparticles with two types of antibodies. Preliminary methods for electrical and optical detection were developed. The methodology for optical detection is based on 3D-phase imagistics using fractal descriptors for detection and quantification of specified types of cells.



a)



b)

Fig. 1 Simulation results for splitted channel (Coventorware) a) Electric field distribution at 10 V: b) Electric field distribution in cross sections

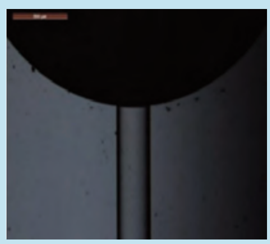


Fig. 2 Optic image: Microchannel and inlet chamber (DRIE in silicon)

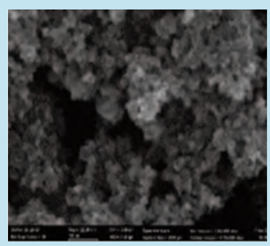


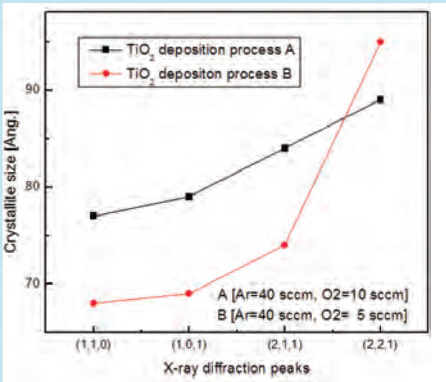
Fig. 3 SEM Image: Nanoparticles covered by gold for cells caption

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

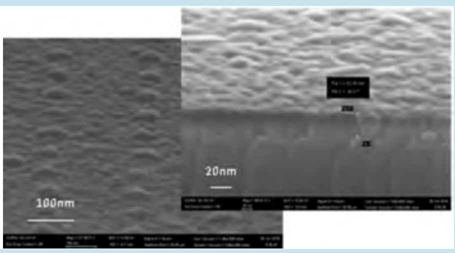
Collaboration on the following projects:

- *PN16320104 "MEMS based integrated microactuators and sensors"*
- *PN16320103 "Nanostructures and heterostructures for micro-nano-(opto)-electronics components"*
- *PN16320202 "Technological processes for thin films advanced materials"*
- *PN16320203 "Nanoelectronics technologies and devices for graphene and other single atomic layer materials"*
- *PN16320304: "Simulation and manufacturing of microstructures with controlled mechanical instability for obtaining 3D complex geometry devices with applications in biology and medicine"*

• PN16320103 “Nanostructures and heterostructures for micro-nano(opto)electronics components”, Coordinator: Dr. Rodica Plugaru.

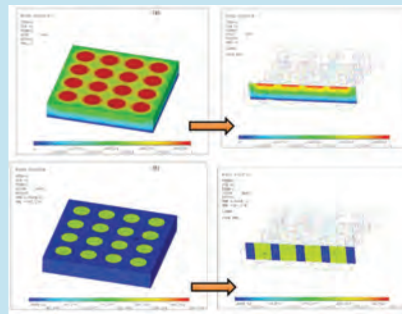


The crystallinity of TiO_2 films as function of the parameters of the plasma deposition process.



The surface and section of an array of core-shell nanodots: Ti (5 nm) / Au (25 nm) core / TiO_2 (25 nm) shell.

In the first stage of the project, nanostructure arrays of AxOy oxides have been prepared and characterized. Core-shell nanodot arrays, with the structure (Ti/Au) core/TiO_2 shell were obtained on EBL (electron beam lithography) patterned Si/SiO_2 substrates. The electric behavior (potential and current distributions) on the nanodot arrays has been analyzed by computational simulations, using the finite element method.

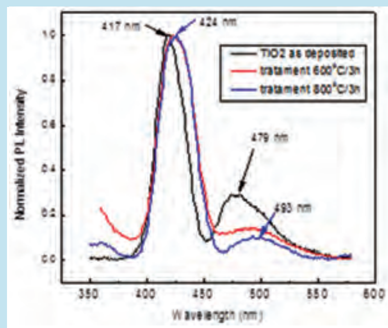


The surface and section of an array of core-shell nanodots: Ti (5 nm)/Au (25 nm) core/TiO_2 (25 nm) shell.

As well, the structural and optical properties of TiO_2 films used as shell structures were experimentally determined. Also, structural, optical, electrical and magnetic properties of doped binary oxide films (Zn1-xMxOy, where M = Mn, N or (Mn, N)) with potential to be used as shell structures were experimentally assessed. The effects of doping on the electronic structure of these binary oxides and the optimization of the doping processes for applications in electronic devices have been analyzed by ab initio calculations.

Technology: Technology for preparing core-shell nanodot arrays of binary oxides ((Ti / Au) / TiO_2) on paterned substrates

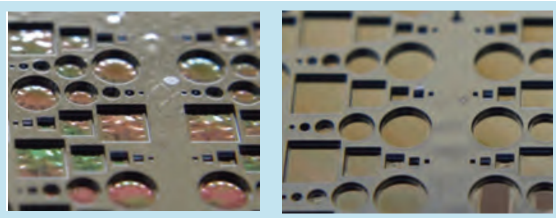
The developed technology enables preparation of core-shell nanodot arrays with geometrically controlled properties by patterning the substrates on which they are deposited. Technological steps: i) patterning the substrates by (electron beam lithography) EBL; ii) deposition of the core Ti / Au structure; iii) TiO_2 shell coating.



The crystallinity of TiO_2 films as function of the parameters of the plasma deposition process.

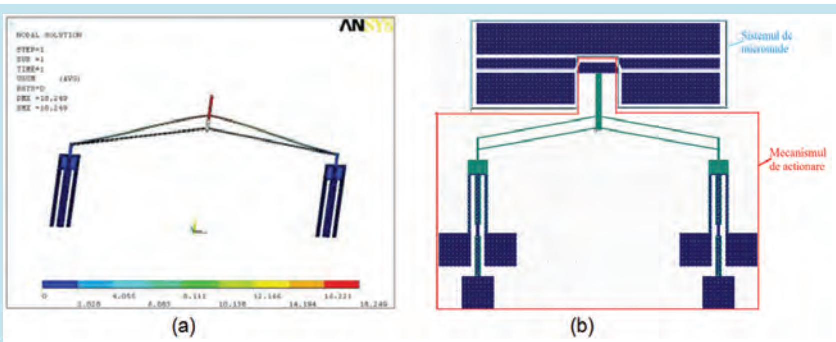
• Contributions to PN16320104 project “MEMS based integrated microactuators and sensors”

Manufacturing of mono-crystalline silicon membranes with sub-micrometer thickness (50-500 nm) and diameters up to 3 mm, to be used as components for various MEMS-based sensors.



Optical images of the manufactured membranes from SOI wafer: a) buckled membranes before silicon oxide etching; b) flattened membranes after silicon oxide etching Contact: Phys. Catalin Tibeica; Dr. Rodica Voicu.

• Contributions to PN16320104 project “MEMS based integrated microactuators and sensors”



a) Displacement distribution for 100 mV applied voltage
b) Proposed configuration of thermally actuated RF-MEMS switch

Design, simulation and layout solution for a RF- MEMS switch.

The proposed configuration consists in two main parts: a dual-actuator ***driving mechanism***, which contains the movable metallic contact, and ***the CPW RF signal line***. The driving mechanism provides a large in-plane displacement of the contact plate, therefore a very stable switching action. (Contact PhD Student Angela Baracu, Eng. George Boldeiu).

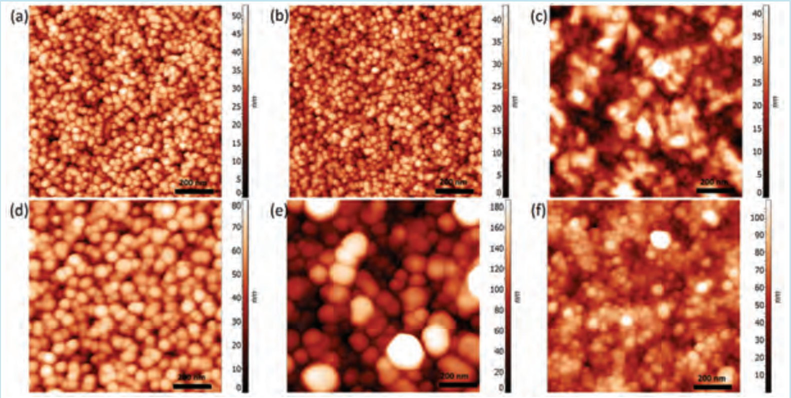


Fig. 4 Atomic force microscopy images of the surfaces of some films of ZnO (a), 1-Ca:ZnO (b) and 5-Ca:ZnO (c), 0.25 M and ZnO (d), 1-Ca:ZnO (e) and 5-Ca:ZnO (f), 0.5 M.

• Contributions to PN16320202 project "Technological processes for thin films advanced materials"

Contact Dr. Anca Istrate

- Synthesis of ZnO and Ca doped ZnO thin films by sol-gel method:

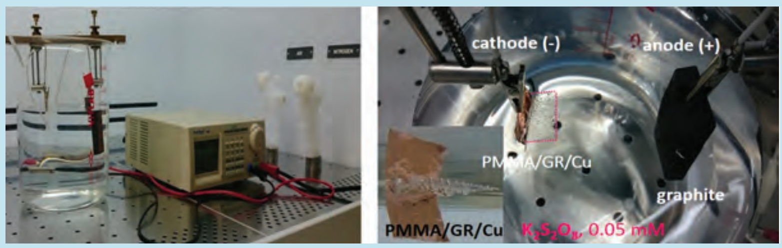
• the study of dopant influence of ZnO thin films on morphological, structural, optical and electrical properties;

• optimizing of controlled doping processes with n-type doping elements;

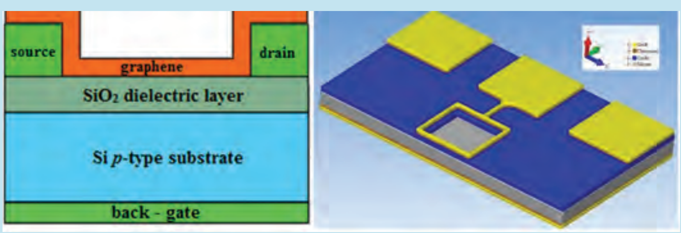
• characterization of obtained thin films.

• Contributions to PN16320203 project "Nanoelectronics technologies and devices for graphene and other single atomic layer materials"

Graphene transfer technologies: It has realized graphene transfer process on Si/SiO2 and Si substrates, the graphene transfer process has been optimized, graphene-FET and graphene-Si diode test structures were manufactured.



Electrochemical delamination home-made system of graphene transferred from Cu foil: overview (left) and enlarged view (right), in inset, image showing the peeling of the "whole film" PMMA/graphene from the Cu foil. (Contact Dr. Anca Istrate, Dr. Monica Veca, Dr. Florin Nastase)

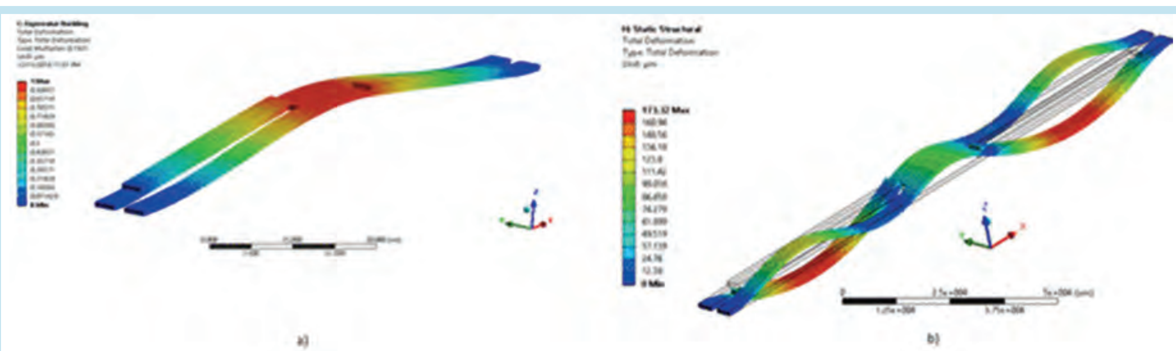


Schematic diagram of the device configuration before graphene transfer: (left) FET structure provided by Ossila and (right) the graphene-Si heterojunction geometry; active areas are square windows with pre-defined Au contacts; Contact Dr. Anca Istrate (L5), Dr. Monica Veca(L9), Dr. Florin Nastase (L6)

Graphene-FET and graphene-Si test structures: They were achieved grafena-FET structures on substrates configured from Ossila and were designed and manufactured graphene-Si test structures with square geometry.

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

Coordinator: Phys. Victor Moagar- Poladian



a)Total displacement for the first mode of buckling of a Si-SiO_2 structure due to compressive internal stress of SiO_2 layer in a linear buckling simulation. b) Total displacement for the first mode of buckling of the same Si-SiO_2 structure due to compressive internal stress of SiO_2 layer in a non - linear buckling simulation.

Mission

Creating and using tools to evaluate, improve and monitor the reliability of sensors, microsystems, nanostructures and electronic devices. These actions are in line with the Concurrent Engineering approach, which starts with the design phase and continues during the development phase, up to, and including real life use.

Activity areas / Expertise areas?

Reliability building: Design for Reliability (DfR); Design for Manufacturability (DfM); monitoring and selection of micro and nano structures and devices; Device Reliability in Harsh Environment, in fields such as nuclear, geological, automotive or aerospace; Robust Design, with application for biosensors for monitoring of environmental quality.

Reliability Assessment: Accelerated testing of micro- and nanostructures (using single or multiple stresses, that better emulate the real life conditions and allow for a higher degree of acceleration of tests); Failure Analysis and Physics of Failure; Reliability Assessment of virtual prototypes.

Standardization: Certification;
Qualification and periodic tests;
Drafting of standards.

Team

In 2016, the team was composed of 4 specialists, all coming from the Politehnica University of Bucharest, the first 3, from the Faculty of Electronics, Telecommunications and Information Technology, and the 4th from the Faculty of Engineering and Management of Technological Systems.

- Eng. Dragoş Vârşescu, IDT III
- Eng. Virgil Emil Ilian, CS II
- Eng. Niculae Dumbrăvescu, CS III
- Eng. Roxana Marinescu, IDT

National and International Collaboration

National Collaboration

- Participation in the project „PROBA-3 ASPIICS OPSE HARWARE” - Contract No. 4000111522 / 14 / NL / GLC, led by the L8 Laboratory, in partnership with the European Space Agency (ESA);
- “Atypical Reliability Testing” project – Contract No. 4000116436 / 16 / NL / Cbi, also in partnership with the European Space Agency.

International Collaboration

- Coordination from IMT and participation with the laboratory services to the virtual network **ROMNET-LAB.CER.IN (LABoratoare de CERcetare și de ÎNCercări)**, beside other 16 institutions (research institutions and companies) from Bucharest, which are: INCD - Mecatronics and Measurement Technique, INCD - Microtechnology, INCD - ECOIND, INCD – Textiles and Leather, INCD – Materials Physics, IFIN - HH, INCD – MRR, ICECHIM, ICPE-CA, ITC, INMA, GEOECOMAR, CEPROCIM, PRO-OPTICA, INTEC and UTTIS. On 9 of July 2015, the authorized representatives of 9 institutions (INCD - Mechatronics and Measurement Technique, INCD - Microtechnology, UTTIS srl, INCD for Machinery and Instalations for Agriculture and Food Industry - INMA, INCD for Industrial Ecology – ECOIND, INCD – Textiles and Leather - INCDTP, INCD for Metals and Radioactive Resources Bucharest, Research and Technology Design Institute for Machine Buildings - ICTCM S.A and Ligue Francophone Roumanie) have signed the networking collaboration protocol at the CCIB sedium.
- Collaboration with the Quality Centre, Reliability and Informatic Technologies – EUROQUALCOM (of Politehnica University from Bucharest), led by Prof. I. Bacivarov,
- Protocol signed at the institutions level (specifying the realiability domain) with the company Honeywell Romania - Sensors Laboratory Bucharest – SLB.

Referents to european research programs and to publishers and magazines, members in national standardization and editorial colectives V. Ilian - President of National Standardization Committees 17 - Semiconductor Devices and 193 - electronic component assembly technology, member of the national standardization committee CT 375: audio-video equipments and multimedia systems.

Reliability Testing equipment:

The laboratory has a wide range of Reliability Testing equipment, but also high performance electronic equipment. The main equipment and their specifications are given bellow.

Test type Equipment / Manufacturer	**Main specifications**
Burn-in UFB 400 / MEMMERT	Temperature: up to 220oC ; Volume: 53 l
Combined temperature + low pressure VO 400 / MEMMERT	Temperature: +25°C…+200°C; Pressure: 10…1100 mbar; Volume: 49 l
Thermal Cycling / Damp Heat CH 160 / Angelantoni	Temperature: -40oC…+180°C; RH: 20…95%; Volume: 160 l
Highly Accelerated Stress Test (HAST) - Temperature + Humidity + Pressure EHS-211M / ESPEC EUROPE GmbH	Temperature: 105°C…142°C; RH : 75%...100%; Pressure: 0.02…0.196 Mpa; Volume: 18 l
Thermal Shocks TSE-11-A / ESPEC EUROPE GmbH	Chamber with separate hot and cold temperature zones. Low Temperature Zone: -65°C…0 / High Temperature zone: +60°C…+150°C; Volume: 11 l

Reliability Testing equipment:

Test type Equipment / Manufacturer	Main specifications
Vibrations + Environmental conditions TV 55240/LS / TIRA CH 250 / Angelantoni	Vibrations: DC…3000 Hz; Temperature: -40°C…+150°C; RH:10%...95%; Maximum specimen weight: 50 Kg; Volume: 250 l
Mechanical Shocks MRAD 0707-20 – Free Fall Sock Machine / Cambridge Vibration	Maximum acceleration: 4500 g; Maximum specimen weight: 9 kg
Thermal conditioning TP04300A-8C3-11 7 Thermo Stream / Temptronic	Temperature range: - 80°C to +250°C; Transition time: 7 sec up, 20 sec down
Infrared thermography IR Camera SC 5600 + G3 L0605 / FLIR Systems	Sensors: InSb; Resolution: 640 x 512

Electronic equipment:

Equipment	Specs
Keithley 4200-SCS Semiconductor Characterization System	• DC current-voltage (I-V) range: 10 aA - 1A; 0.2 μV - 210 V • Capacitance-voltage (C-V) range: 1 kHz - 10 MHz; ± 30V DC bias • Pulsed I-V range: ±40 V (80 V p-p), ±800 mA; 200 MSa/sec, 5 ns sampling rate
PXIe-1078 Chassis	• 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
HM8118 LCR Bridge/Meter - Rohde & Schwarz	• 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) • Fanless design
Teledyne LeCroy WaveSurfer 3024 Oscilloscopes	• 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
Lock-In Amplifier Stanford Research Systems SR865	• 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 timebase input and output • GPIB, RS-232, Ethernet and USB • HDMI video output

Results (examples)

• ***Partipants in the ESA project PROBA-3 ASPIICS OPSE - Contract No. 4000111522 / 14 / NL / GLC***.

In this project, the Reliability Laboratory aided in the design and construction of functional prototypes for OPSE ("Oculter Position Sensor Emitter" – a device for satellite alignment), that were sent for characterisation at INAF in Italy. Also, a series of tests for the OPSE system and subsystem were designed, in order to validate them by the requirements of the PROBA-3 programme. Some of these tests were already performed, others will be performed in the following year.

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

Mission

The main mission of laboratory is **research and development**, focused on 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 biomedical and environmental 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

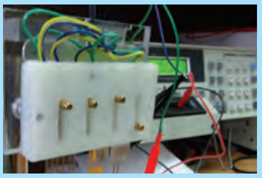
1. **Dr. Carmen Moldovan -** CS I, PhD in electronics, head of laboratory;
2. **Dr. Nicolae Marin** – CS I, PhD in electronics;
3. **Rodica Iosub** - CS III, chemist;
4. **Cecilia Codreanu** – CS III, engineer;
5. **Bogdan Firtat -** CS III, engineer;
6. **Dr. Marian Ion -** CS, PhD in Physics;
7. **Silviu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

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). (Figure 1)

VoltaLAB 10 – electrochemical laboratory, PGZ100 all-in-one potentiostat, Voltamaster 4 electrochemical software for cyclic voltammetry, chronoamperometry and impedance (Figure 2)

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. (Figure 3)



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.

Areas of activity

Micro-Nanosensors – Microsensors development (resonant, MOX and polymeric 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;

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.

International and national collaborations

1) *International cooperation* with research centers and renowned companies in the UK, Germany, France, the Netherlands, Switzerland, 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 si HIPOT RR – Slovenia, ITE and Medbryt - Polonia) - coordinated by the laboratory;

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 **IMUNOPLAT** *(Micro-Immunosensor Platform for Metabolic Syndrome Investigation)*: DDS Diagnostic SRL, "Carol Davila" University of Medicine and Pharmacy in Bucharest, Telemedica SRL, University of Bucharest;

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

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).

The concept of piezoelectric MEMS devices for efficient energy generation

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

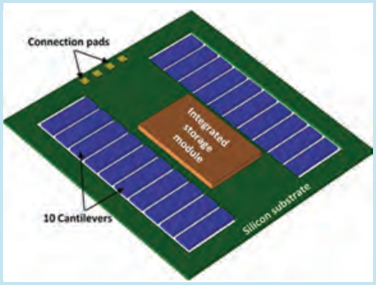


Fig 4. The concept of resonating microbar area for efficient energy generation

Fig 6. Optical Photography - Etching tests for the release of resonant bars

The modeling, simulation and optimization of resonance micro-bars structures for piezoelectric micro-generators has been performed and the design of the inertial mass resonance bar has been optimized. The set of masks and an initial technological process necessary to achieve the energy harvesting facility were developed.

Also, the electronic circuit for signal processing and application was designed.

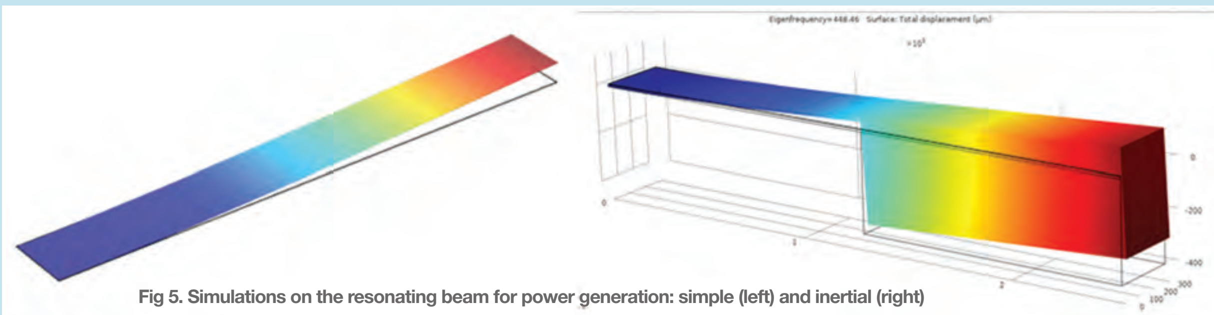


Fig 5. Simulations on the resonating beam for power generation: simple (left) and inertial (right)

Micro-Array Immunosensors for Detection of Acute Myocardial Infarction

The DDS partner, together with the coordinator (IMT), made the final design of microbiosensors by obtaining the prototype box for the future microbiosensor.

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. The 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.

Microbiosensors were developed, which allowed two biomarkers to be identified 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.

Fig 7. Capsule cover: 1. Slot area sample, 2-point measuring area, 3 guide pin

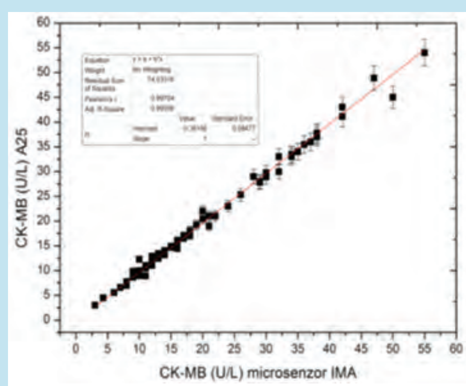


Fig 8. Correlation Chart Between Reference Method, Immunoinhibition and AMI-DETECT Method for the 100 Test Patients, r^2=0.997

Micro-Nanotechnology for portable biomedical devices

Four studies have been conducted on: a) measurement methods in intelligent systems; b) using the mobile phone to generate and capture useful signals in electrochemical characterizations; c) efficiency and optimization degree for designing interdigital electrodes; d) Ink-Jet technology adapted for portable biomedical devices. Sensor design for the detection of physiological parameters; Project for printed microelectrods for biodetection on flexible substrate and on Si substrate; Project for microelectrode technology printed on flexible substrate and on silicon substrate; Project for fabrication technology of a device based on mini supercapacitors; Design for technology regarding the fabrication of a body core temperature sensor; Design for pH sensor made by Inkjet and Sputtering techniques.

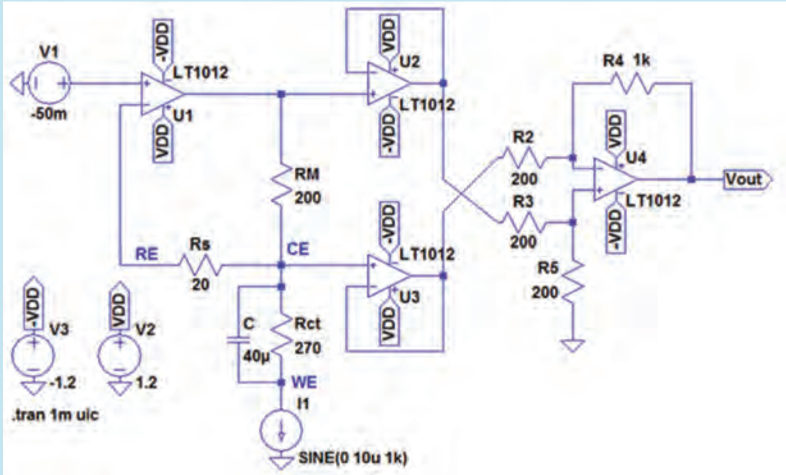


Fig 9. Design of the measurement-amplification circuit

Gas sensors - development and characterization

We have optimized the layout of a test sensor for detecting pollutants and explosive gases at very low concentrations. With the help of the mask set and based on the technological processes, the final gas sensor was obtained on the ceramic substrate.

The electrical characterization of the metal layers deposited on the alumina substrate was performed by electrical measurements (conductivity and resistivity). The functional testing of the measuring equipment was carried out through preliminary tests in order to demonstrate the functionality of the "electronic nose". As a result of the functional tests, a variation of the resistance value was observed when it was introduced into the environment containing different types of gases, about 30% of the measured value in open air.

A study was conducted on the influence of substrate composition from which the miniaturized ceramic transducer is built. Transducers based on porous (alumina) material have presented a reproducible response and a total recovery when compared to transducers based on non-porous materials (silicon).

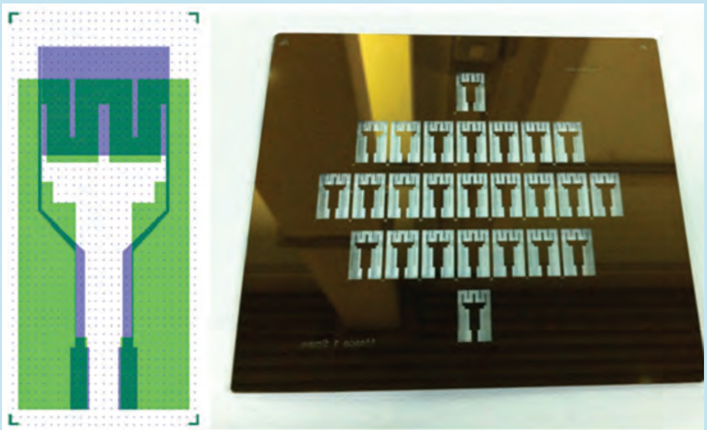


Fig 10. Optimized sensor layout (left) and photo of a worktop (right)

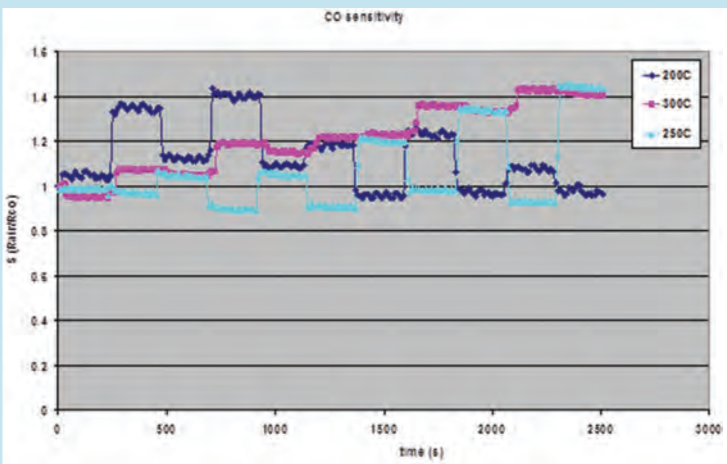


Fig 11. 4 Response / Recovery TiO_2 -NT /Al_2O_3– 5S at 200-300 °C for CO concentration between 5-2000 ppm

Education and training services

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

L8 Centre for Research and Technologies Integration Ambiental Technologies Laboratory

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

• Electrical device characterization

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

Education, dissemination

• Associate teacher at University Polytechnic Bucharest, Faculty of Electronics and Telecomunication

• Organization of workshops, presentations on the laboratory profile (link with industry) sintering, calcinations at the high temperature

All activities of the Environmental Technologies Laboratory are being carried out with the aim of improving the environmental conditions and increasing the individual and social security (including health applications) and upgrading the traditional industries in order to make them more efficient

Domain activity

Research-Development-Innovation Competencies

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

• Microprocessing technologies on surface and volume- elena.manea@imt.ro; ileana.cernica@imt.ro

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

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

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

• Technologies for obtaining optical elements (areas of microlens, thin lenses, thin mirrors)-elena.manea@imt.ro

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

• Technologies for the development of advanced nanocomposite materials with antibacterial properties, self-cleaning with applications in civil constructions - alina.matei@imt.ro; ileana.cernica@imt.ro

Characterization Services and Technological Processes

• New directions for the future: FTIR, UV-Vis characterization alina.matei@imt.ro

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

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

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

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

Team

1. **Dr. Ileana CERNICA**-CS I, dr.eng. in microelectronics;
2. **Dr. Elena Manea**-CSI, dr.in phisics;
3. **Dr. Alina MATEI**-CS III, dr.ing. in chemical enginering;
4. **Eng. Florian PISTRITU**–principal electronist engineer;
5. **Eng.-Ec. Andrei GHIU**–engineer;

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.

Directions for the future

✣ Nanostructured materials and micro/nanosensors for building applications for environmental 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

Focus TGE-PLAT:

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

• Microsensors and microsystems for cross-border protection (eg explosion detection, aflatoxin detection, anti-explosive secure devices)

• Devices for the space industry (eg: Fields of optical alignment devices for correlated flights and for detection and capture of waste in space, incubators for plant growth for long-term missions or space stations)

• Applications of nanostructured materials and M / N sensors in aerospace research and in both directions: aeronautics and space (eg nanocomposite 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 Compound Semiconductors annealing

- **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.

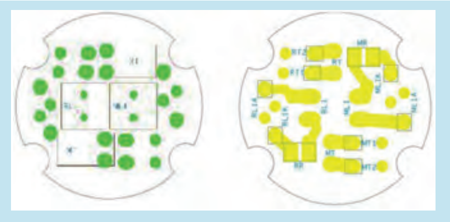
Characterization:

- 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 term in space)



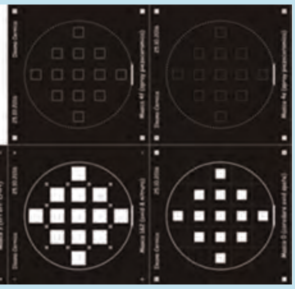
OPSE modal simulation made in cooperation with L5 Computer Assisted Modeling, Simulation and Design Laboratory, researcher Victor Moagar-Poladian

PCB OPSE Design, 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 the environment.

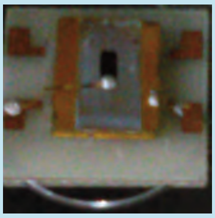


Set of masks

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

Project: Development of a sensor for multiple and selective detection of representative explosives (SENZOREX)

Partners: INCD for Electrochemistry and Condensed Matter INCEMC Timisoara; Military Technical Academy; INCD for Chemistry and Petrochemistry ICECHIM Bucharest; MIRA TELECOM; INCD for Microtechnology IMT Bucharest



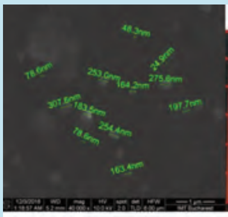
Integrated microsensor assembled

Purpose : The stage of realization of the sensible platform will be a proven and calibrated demonstrator model with low response time, high sensitivity and specificity, easy to use and interpreted by an unspecialized user and last but not least with a low cost . The progress made by the project through the obtained results are: innovative methodologies for obtaining titanium dioxide films and molecular impregnated polymers; creating scientific premises for serial production of a high-sensitivity device; the end product of the demonstrator model-model project through its subsequent implementation in the private company's production strategy will cover a gap on the domestic and foreign product market.

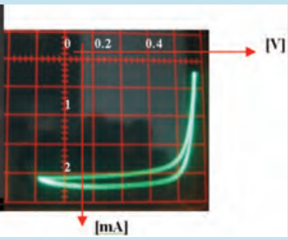
IMT Project Manager: Ileana Cernica (ileana.cernica@imt.ro)

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

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



SEM image of TiO_2 doped with P/$POCl_3$



I-V characteristic for TiO_2 structure doped with P/Si; scale: 0,1 V/div and 0,5 mA/div;

TiO_2 obtained by anodizing the Ti film deposited on Si type p by DG sputtering.
– Porous layers of TiO_2 have been obtained, which have a uniform pore size. The dimensions of the dopants trapped in the TiO_2 frame are higher than the pore dimensions.
– The doped TiO_2 layer with P is the type N layer; deposited on a Si wafer of type p forms a Schottky photodiode. The traced characteristic is in accordance with the low resistivity values
– For the determination of the electrical properties of the obtained films, the current-voltage characteristic was drawn.

From the slope of the straight we determined the resistance of the obtained films
Phase manager : Elena Manea(elena.manea@imt.ro)

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

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, chemistry, molecular biology, and had the fundamental objective the realization of a prototype of an integrated microfluidic system able to dose and encapsulate different chemicals for targeted drug delivery

Mission

Research, development and continued education in the micro and nano-fluidics domain. The primary focus of our research is the modelling, simulating and designing Lab-on-a-chip microfluidic devices with applications in clinical diagnostics and regenerative medicine.

Domains of activity

CFD (Computational Fluid Dynamics) modelling of the Newtonian and Non-Newtonian fluid flow, such as: mono and multiphase flow, mixing, turbulence, heat transfer, implementing user defined additional flow parameters, magnetohydrodynamics, etc.

Microfluidic device designing for applications in clinical diagnostics and regenerative medicine.

Rheological characterisation of micrometric scale fluid flows and applications for Lab-on-a-chip devices optimization.

Experimental nano- and micro-technology: clean room technological processes (polymer, glass and silicon micro-structuring), design, simulation, fabrication and characterisation of Lab-on-a-chip microfluidic devices with integrated electrochemical, impedimetric, magnetic, spintronic or plasmonic biosensors.

Development of micron-resolution particle image velocimetry by using the µ-PIV system, the development of devices and protocols for micro-mixing, manipulating particles by using dielectrophoresis and magnetophoresis and the analysis of interface conditions at a microscale level.

Bioengineering: cellular uptake of nanoparticles; studies of the cellular activity and apoptosis induced by magnetic hyperthermia; investigation of the morphology and architecture of tumor cells by using UV fluorescence, microscopy techniques (SEM, SNOM) and spectroscopy (FTIR, Raman, impedance).

Fluid dynamics in microchannels: liposome preparation by hydrodynamic focusing (experimental determinations and numerical predictions by using a microfluidic device with 3 intakes and an outlet).

Molecular transport in microfluidic devices: Magnetophoretic system for the detection of magnetic tagged biomolecules; active magnetophoretic systems for cell separation by using magnetic fields; filters for the separation of microparticles with different morphologic, electric and magnetic properties; microfluidic devices for nanoparticle separation.

Flow visualization and characterisation: Our experimental methods used for studying microscopic flows are based on: (i) the contrast of the substances used for the distribution of the flow lines; (ii) µ-PIV measurements for the determination of the local hydrodynamic behaviour of stationary flows, quantitative measurements of the speed profiles and vortex identification.

International and national cooperation

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

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

Team

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 Țîncu** – 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.

Electric and magnetophoretic characterization of the magnetophoretic platform

Lab-on-a-chip (LOC) devices are small diagnostics microfluidic platforms, compared to a smartphone or even smaller – handlet. These devices will allow not only a reduction in size of the biodetection device but also a reduction of the quantity of biologic material, reagents, etc., compared to conventional devices. Not least, these devices have the advantage of portability and low price. The structure of one of this devices can be quite complex despite of their reduced size; it may have one or more microchannels through witch fluids are dosed, microvalves, micropumps, flow sensors and biofilters or biochips where selectiv detection takes place. There are two main used methods for the selective biodetection process: (i) electrochemical method and (ii) magnetic method, both of which use magnetic nanoparticles linked to the antibodies used in the biodetection process.

Flow characterization in a microfluidic system – CELLIMMUNOCHIP

One of the main application of microfluidics is the hydrodynamic control in microchannel in order to analyze the transported cells/particles.

The main problem is capturing the cells (especially tumor cells at the microchannel side to analyze it and to collect it separately). In this moment, there are more solutions being tested, by using structured surfaces of the acoustic/magnetic fields, or by changing the local hydrodynamics. In this project several types of micro-structured surfaces have been numerically investigated, mainly by using crossflow channels and microcylinders.

Designing the microfluidic device for the quantification of the number of lymphocytes – BIOLIMF

The general objective of the project is to increase the competitiveness of the economic environment by assimilating the CDI result of the research organizations and their transfer on to the market.

In this project we are proposing the development of an integrated microfluidic prototype for the separation of leukocytes in the blood, separation of T helper lymphocytes (CD4+) and T cytotoxic lymphocytes (CD8+) of white blood cells, and to determine the number of leukocytes that enter in the capture chamber and the ones that exit, respectively. The counting is done by two electrochemical sensors with interdigitated nano-electrodes, positioned at the entrance of the capture chamber and at the exit, respectively.

T helper, CD4+ lymphocytes, represent ~60-65 % of the T lymphocytes in the body. These are specialized in secreting the lymphokines, in order to recruit or activate different cells of the immune system. Depending on the synthesized lymphokines, T helper cells divide in two categories: Th-1 and Th-2. Th-1 lymphocytes synthesize type 1 cytokines that activate the cell mediated immunity. Th-2 lymphocytes synthesize type 2 cytokines, which stimulate the activation of B lymphocytes.

Cytotoxic T lymphocytes, CD8+, represent 25-35 % out of T lymphocytes. These are cells specialized in the destruction of virus infected cells and tumor cells.

Designing the final device which integrates the electrochemical device in the microfluidic device

The integrated microfluidic device has an area of 4×4 cm2 and is composed of five main modules:

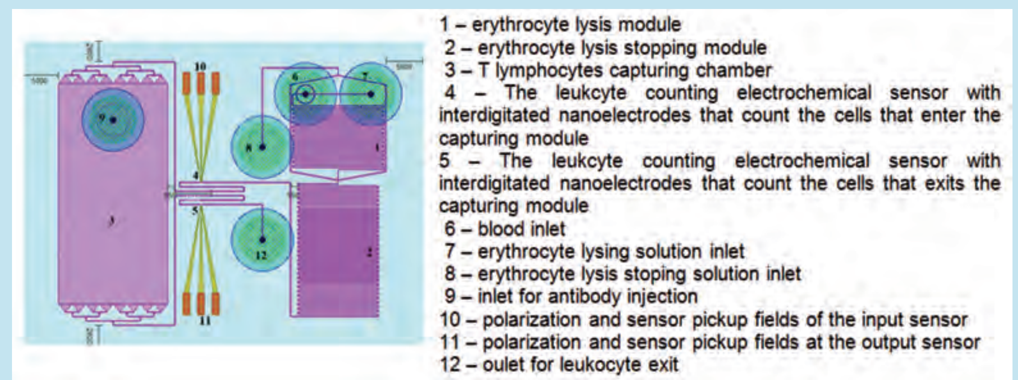
1.The module for erythrocyte lysis, with a surface of 8×12 mm2, composed of a winding microchannel with a width of 100 µm and the distance between the microchannels of 200 µm, that provides two inlets, one for the blood and one for the erythrocyte lysing solution. This module is surrounded by a microchannel of 100 µm width that links to the erythrocyte lysis stopping module and through which the erythrocyte lysis stopping solution flows.

2. The erythrocyte lysis stopping module, with a surface of 8^{3}_{2}18,5 mm2, composed of a winding microchannel with a width of 100 µm and the space between microchannels of 200 µm, with an inlet for the erythrocyte lysis stopping solution and the lysed sample and an outlet for leukocyte exit.

3. T lymphocytes capturing chamber with a length of 3 cm, 15 mm width and a height of 50 µm, in which there are micro-fabricated ~13000 posts with a diameter of 30 µm, with a gap between posts of 15 µm and a height of 50 µm, used for immobilizing antibodies that will bind immunochemically with T lymphocytes. This chamber is designed with a set of 12 microchannels, that represent the inlets, for the access of leukocytes and another set of 12 microchannels for leukocyte output.

4. The set of microchannels that links the module for erythrocyte lysis, the lysis stopping module, T lymphocytes capturing chamber and the electrochemical sensors for leukocyte counting. The microchannels onto which the sensors are placed are narrowed to 15 µm on a length of 300 µm.

5. The electrochemical sensor with interdigitated nanoelectrodes are positioned on the microchannel that enters and exits the capturing chamber, in the place where the microchannels are narrowed to 15 µm on a length of 300 µm, in order to force the leukocytes to pass through the sensors in a single row, so that they may be counted. The sensors have two working interdigitated nanoelectrodes with a width of 100 nm and an interspace of 100 nm, a reference nanoelectrode and an auxiliary nanoelectrode for counting.



Optimization, fabrication and preliminary characterization of the biosensors and the microfluidic system – CANCELLAB

Modeling the electrochemical biosensor

The evaluation and selection of the technologic solutions for developing the electrochemical biosensor and the plasmonic biosensor, were made by modelling the used technologic processes with the help of SEMulator3D™ software, that we also used to generate 3D models of the thin layers deposited or grown on the monocrystalline silicone or glass substrate, structures and developed devices. The SEMulator3D™ software allows the evaluation, selection and optimization of the technologic process design, and also the design of the micro-devices. Thus the production costs are optimized and the span of time necessary for launching the product on the market is shortened. By using the 3D physic modeling technique that the SEMulator3D™ software offers, a wide variety of processing steps can be modelled. Every process step needs only a few geometric and physic parameters, which are easy to understand and calibrate. The process parameters like the deposition conformity, anisotropy and the selectivity of the etching process, interacts with other parameters, and with the design data, in a complex mechanism, with consequences on the structure of the final device.

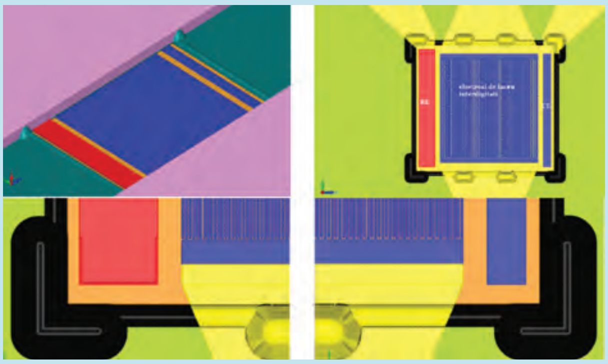


Figure 1: Electrochemical biosensor modelling

Modelling the plasmonic biosensor

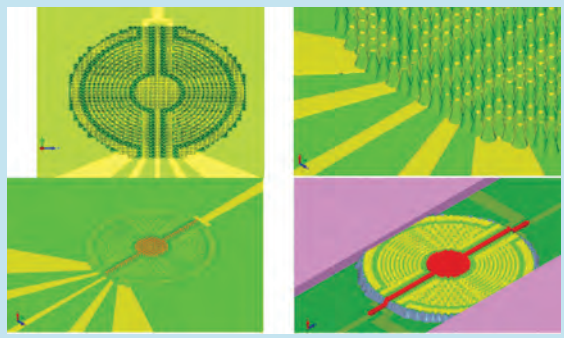


Figure 2: Modelling the plasmonic biosensor

Optimization, fabrication and characterization of the microfluidic system

After the numerical analysis done in the previous activities, the following improvements of the microfluidic system arise: increasing the length of the microchannel and/or finding a method for passive mixing, necessary to the diffusion process and decreasing the size of the biosensors (especially the plasmonic biosensor), in order to reduce or even eliminate their influence on to the flow spectrum. To this end we optimized the microfluidic system by making the following changes in the system design:

a) The considerable reduction of the biosensor size, especially the plasmonic biosensor. From a diameter of ~500 µm, with pyramidal structures with a height of 5 µm, we will obtain a maximum diameter of 30 µm and structures that don't exceed 300 nm. This will remove the influence of the structures on the flow. Thus, the microchannel in which the two sensor are going to be integrated will be reduced in width, and a much better length/width ratio will be obtained, with a cross section of 30 x 30 µm .

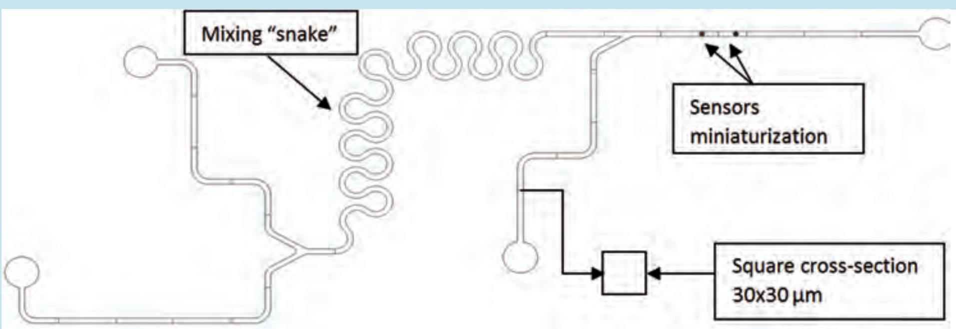


Figure 3: The schematic of the optimized microfluidic system – overview of the modified elements

b) Introducing a passive mixer after the symmetric bifurcation in order to optimize the diffusion process. Because in microfluidic it is very hard, maybe even impossible to obtain a turbulent regime, this is achieved by using passive or active mixing methods of the fluids. One of this methods is represented by a "snake" type passive mixer that has 16 linked loops, which lead to the formation of "Dean" vortices that greatly improve the fluid mixture, obtaining a highly efficient mixing of the working fluids.

After optimizing the microfluidic system, we continued with the fabrication of the fluidic microchannels. By using the same principles of the numerical modelling, the system was divided in several subparts, for a more efficient usage: {1'} the symmetric bifurcation with a square cross-section, {2'} coupling the symmetric bifurcation with the "snake" type mixer and with {3'} the biosensor area.

The microchannels related to the microfluidic system have been fabricated on silicon wafers (4 inches in diameter, with a thickness of 525-550 µm, Semiconductors Wafer Inc., Hsinchu, Taiwan) by using a deep reactive ion etching system (ICP-RIE - Oxford Plasmalab System 100), through Bosch process.

The experimental characterization of the flow was done with the help of the Micro-PIV (Particle Image Velocimetry). For the quantification and comparison of the experimental and numerical results, we used two dimensionless parameters: the Reynolds number (Re) and the Dean number (De).

The numerical results were compared to the experimental investigation, composed of direct views and quantitative observations. The result are in good agreement, given the approximations of the numerical model for reducing total convergence time. Also, the direct views using the micro-PIV system, aren't achieved in a single median plane, but in a series of very close planes on a stretch of a few microns. This led to small differences compared to the numerical predictions.

International Semiconductor Conference - CAS 2016

The 39th edition of International Semiconductor Conference (CAS) (www.imt.ro/cas) was organized by the National Institute for Research and Development in Microtechnologies - IMT Bucharest in Sinaia, Romania, in the period 10-12 October 2016. Since 1995, CAS is also an IEEE event, with Proceedings published in the IEEE system.

CAS 2016 participants

The main topics of CAS 2016 were: nanoscience and nanoengineering; micro- and nanophotonics and optoelectronics; microwave and millimeter wave circuits and systems; microsensors and Microsystems; modelling; semiconductor devices; Integrated Circuits; physics of materials.

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

The 12 invited speakers originated from Belgium, Canada, France, Italy, Poland, Romania, Spain, Sweden, Switzerland.

National Seminar for Nanoscience and Nanotechnology 2016

The 15th 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 15, 2016.

Ana-Maria Grigore, Policy Officer, European Commission, DG Research and Innovation, D1, Industrial technologies. Strategy Unit

While the previous editions of the Seminar consisted of scientific sessions, the event in 2016 was entitled "Smart specialization in nanotechnologies and advanced materials" and included two categories of presentations. The first part of the seminar was dedicated to the national strategy and European strategy for smart specialization. The second part of the event included presentations of Romanian projects funded by Horizon 2020, related to nanotechnologies and advanced materials and "Spreading Excellence and Widening Participation".

All details about the event (programme, presentations, photo gallery) are available at the address: http://www.romnet.net/nano/SNN2016/ (information in Romanian only).

17th edition of the International Symposium on RF-MEMS and RF-MICROSYSTEMS - MEMSWAVE 2016

MEMSWAVE 2016 participants

In 1997, the team of the **Micromachined structures, microwave circuits and devices Laboratory (RF-MEMS)**- of IMT- Bucharest, have proposed as coordinator (A. Müller), the ***FP4/INCO Copernicus Project "Micromachined Circuits for Microwave and Millimeter Wave Applications " "MEMSWAVE"*** with 9 partners from 6 countries: IMT Bucharest-Coordinator, FORTH Heraklion, Uppsala University, IRST Trento, Tor Vergata University, Rome, CNR Rome, HAS Budapest, ISP Kiev, Microsensor Ltd. Kiev. The proposal was accepted and the results obtained in the period 1998 – 2001 have contributed to the actual state of art in RF MEMS. **It was the first project coordinated by Romania in IST and also by a Easten European country**. Also, due to the project achievements, **MEMSWAVE** was nominated between the first 10 European research projects, out of 108 projects from various fields, at the **2002 call for the DESCARTES Prize**, for **IST** (actual **ICT**).

The project has generated **the International Symposium on RF-MEMS and RF-MICROSYSTEMS – MEMSWAVE**. The first edition was held in 2000, in Sinaia, Romania, after became an itinerant European event. Now the symposium take place every year with the support of the RF-MEMS Topical Group of the European Microwave Association (EuMA). **In 2016, the 17th edition, was organized again by IMT, in Bucharest between 4 and 6 July.**

The symposium consisted of two events: MEMSWAVE Conference (July 5th-6th, 2016) and RF-MST Cluster Meeting (July 4th, 2016) co-organized with the European Commission, where the achievements of MEMS-related EU projects were presented and discussed.

Researchers from 11 countries attended the MEMSWAVE symposium (Belgium, Canada, France, Germany, Greece, Hungary, Italy, Romania, Spain, Sweden, Switzerland). The event represented an international forum for European scientists and industry for the exchange of information on the most recent advances in the area of RF-MEMS, MSTs and RF-NEMS.

IMT participation to World Micromachine Summit (MMS)

IMT was invited since 2007 to present activities in micro- and nanotechnologies domain from Romania at the World Micromachine Summit.

The 22nd edition of MMS took place in Tokyo, Japan, during 24-27 May, 2016 (http://2016.micromachinesummit.net/). Special interest topics for MMS2016 were "Aging Society and Health (Medical Applications of MEMS)". The Romanian delegation was formed by Dr. Adrian Dinescu, who delivered the country report and Dr. Carmen Moldovan, who delivered a presentation in the technical session dedicated to “Medical Application of MEMS”.

Conference for launching TGE-PLAT project

Information and publicity event. Thematic event. November 7, 2016, Romanian Academy Library, 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).

The invitation for attending this event was transmitted to companies that have already expressed their interest for collaboration, as well as other identified companies, potentially interested to interact in the project frame, representatives from mass media (press, Radio, TV), representatives from national research institutes, universities and public institutions.

The thematic event included presentations related to: general objectives of the project; results obtained by IMT researchers in national and international projects, on the three R&D areas of the project; the scientific and technological services that can be provided by the institute using a state-of-the-art infrastructure and unique expertise in some cases; type A activities for companies benefit; the use of Communication Platform.

A small exhibition was organized on this occasion, in order to promote main research results of IMT on the project topic and to exchange information with companies, on the three research directions promoted by the project: **microsensors, photonic components, millimeter wave devices and systems**.

93 persons from 50 organisations attended the event, with the following distribution: 6 mass media representatives (from the Press Office of the Ministry of National Defence, Press Office of the Romanian Academy, Radio Romania Cultural, “Tribuna economica” periodical) ; participants from 27 companies; 39 participants from 10 national research institutes (21 participants from IMT; participants from 6 public institutions; one participant from a university; 4 participants from an institute of the Romanian Academy;

All details about the event are available at the address: *http://www.imt.ro/TGE-PLAT/eveniment_7.11.2016.php*

Visits at IMT Bucharest: “Open door day”, December 19, 2016

Traditionally, IMT organizes each December the “Open door day”, with a distinct topic. In 2016, the topic was dedicated to CENASIC project (“Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials”), that has fully reached its objectives, becoming a new research centre, a part of IMT Bucharest and its experimental infrastructure.

The “Open door day” coincided with the 20th anniversary since IMT was set up.

On this occasion, it was remembered that the organigram of the new institute included a nanotechnology laboratory, for the first time at national level. This lab became in 2002 the Centre for Nanotechnologies, under the aegis of the Romanian Academy and since 2008 the centre includes three R&D laboratories from IMT.

The IMT recent evolutions in nanotechnologies related activities (which have expanded at the whole institute level and benefit from the facilities of the new CENASIC Centre), as well as the way IMT aims to address the challenges of the last part of “Horizon 2020” programme, were successively evoked by Dr. Mircea Dragoman, the Scientific director of the institute, Dr. Adrian Dinescu, CENASIC director and Prof. Dan Dascalu, Coordinator of the Centre for Nanotechnologies. IMT partners from institutes, private companies and universities attended the event.

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. A new 4H-SiC hydrogen sensor with oxide ramp termination, R Pascu, M Kusko, F Craciunoiu, G Pristavu, G Brezeanu, M Badila, V Avramescu, MATERIALS SCIENCE IN SEMICONDUCTOR PROCESSING, FEB 2016, Vol. 42, p. 268-272, E-MRS Spring Meeting 2015 Z entitled NanoMaterials and Processes for Advanced Semiconductor CMOS devices, MAY 11-14, 2015, IF 2.264

2. Assessment of structural, optical and conduction properties of ZnO thin films in the presence of acceptor impurities, Plugaru, R.; Plugaru, N. JOURNAL OF PHYSICS-CONDENSED MATTER Volume: 28 Issue: 22 Special Issue: SI Article Number: 189601 Published: JUN 8 2016 IF 2.209

3. Backscattering Modulators for UWB Antenna Measurement, V Buiculescu, I Giangu, Romanian Journal of Information Science and Technology, vol. 19 (2016), No. 3, pp. 215-226 IF: 0.304

4. Ballistic electron propagation through periodic few-layer graphene nanostructures, D Dragoman, I Mihalache, PHYSICA E-LOW-DIMENSIONAL SYSTEMS & NANOSTRUCTURES, Volume: 84 Pages: 60-70 Published: OCT 2016. IF 1.904

5. Carbon nanotube-based electromagnetic band gap resonator for CH4 gas detection; A Cismaru, M Aldrigo, AM Radoi, M Dragoman, JOURNAL OF APPLIED PHYSICS Volume: 119 Issue: 12 Published: MAR 28 2016 IF: 2.101

6. CdSe (quantum dots)-graphene oxide system for thiophene polymerization: a new strategy, a new material, E Rusen, A Diacon, A Mocanu, R Gavrila, LC Nistor, A Dinescu, RSC ADVANCES 2016, Vol. 6, Issue 30, p. 25577-25583, IF 3.289

7. COMPARATIVE DISCUSSION ON GLOBAL MODELS FOR OPTICAL PROPERTIES OF Bi2O3, Murariu, G.; Dinescu, A.; Murariu, A. G.; et al. ROMANIAN JOURNAL OF PHYSICS Volume: 61 Issue: 3-4 Pages: 626-637, 2016, IF 1.398

8. Computational prediction of capillary number impact on droplets formation in microchannels, Marculescu, C., Tincu, B., Avram, A., Burinaru, T., Avram, M. Energy Procedia, 85 (2016), pp 339 - 349, IF 1.07

9. Cymatics of selenium and tellurium films deposited in vacuum on vibrating substrates, Hristova-Vasileva, T.; Bineva, I.; Dinescu, A.; Arsova, D.; Nesheva, D.; SURFACE & COATINGS TECHNOLOGY, DEC 15 2016, Vol. 307, p. 542-546, IF 2.139

10. Determinari imunocromatografice ale proteinei de legare a acizilor grasi fractia cardiac (H-FABP) folosind nanoparticule fluorescente, Mihaela Savin, Dana Stan, Matei Iulia, Rodica Iosub, George Muscalu, Carmen Moldovan, Carmen-Marinela Mihăilescu, Asociatia Romana de laborator medical, Abstract publicat in Revista Romana de Medicina de Laborator, supliment la vol. 24, vol.1, Martie 2016 IF 0.143

11. Dielectric properties of composites containing silicone rubber and multiwall carbon nanotubes decorated with gold, Pantazi, A.; Palade, S.; Berbecaru, C.; Veca, M.; Dinescu, A.; Schiopu, V.; Oprea, O.; Dragoman, D. ROMANIAN REPORTS IN PHYSICS Volume: 68 Issue: 2 Pages: 648-657 2016 IF 1.367

12. Effect of doping concentration and temperature on the morphology, crystallinity and electrical conductivity of Al:ZnO nanostructured films grown from aqueous solution, Musat, V.; Mazilu, M.; Tigau, N.; Alexandru, P.; Dinescu, A.; Purica, M.; THIN SOLID FILMS, OCT 30 2016, Vol. 617, p. 120-125, DOI 10.1016/j.tsf.2016.07.004, Symposium M on Multifunctional Binary and Complex Oxide Films and Nanostructures for Nanoelectronics and Energy Applications - II / E-MRS Conference, MAY 11-15, 2015 IF 1.761

13. Effects of insertion of strain-engineering Ga(In)NAs layers on optical properties of InAs/GaAs quantum dots for high-efficiency solar cells, Pavelescu, Emil-Mihai; Polojarvi, Ville; Schramm, Andreas; Tukiainen, Antti; Aho, Arto; Zhang, Wenxin; Puustinen, Janne; Salmi, Joel; Guina, Mircea, OPTICAL MATERIALS Volume: 52 Pages: 177-180 FEB 2016 IF 2.183

14. Enhancing antimicrobial activity of TiO2/Ti by torularhodin bioinspired surface modification, C. Ungureanu, C. Dumitriu, S. Popescu, M. Enculescu, V. Tofan, M. Popescu, C. Pîrvu, BIOELECTROCHEMISTRY Volume: 107 Pages: 14-24 FEB 2016 IF: 3.556

15. Expeirmental Study of the Behaviour of Materials Used in Creating Polymer Dentures Mobilized by Irradiation Microwave, Dumitrescu, Raluca Anca Giurescu; Popescu, Anca Iuliana; Dumitrescu, Catalin Sorin; Popescu, Marian; Ion, Marian; Burcea, Alexandru, MATERIALE PLASTICE Volume: 53 Issue: 2 Pages: 189-193 Published: JUN 2016 IF: 0.903

16. Experimental investigation by atomic force microscopy on mechanical and tribological properties of thin films, Birleanu, Corina; Pustan, Marius; Muller, Raluca; C. Dudescu, V. Merie, R. Voicu, A. Baracu, INTERNATIONAL JOURNAL OF MATERIALS RESEARCH Volume: 107 Issue: 5 Pages: 429-438 Published: MAY 2016 IF: 0.687

17. Fabrication of periodical surface structures by picosecond laser irradiation of carbon thin films: transformation of amorphous carbon in nanographite, Popescu, C.; Dorcioman, G.; Bita, B.; Besleaga, C.; Zgura, I.; Himcinschi, C.; Popescu, A. C., APPLIED SURFACE SCIENCE Volume: 390 Pages: 236-243 Published: DEC 30 2016 IF 3.15

18. Fabrication, characterization, and modelling of polysulfone composite membranes with enhanced adsorbent capabilities, Pascu, Daniela-E.; Miron, Alexandra R.; Pascu-Neagu, Mihaela; Nechifor, Aurelia C.; Bita, Bogdan I.; Popescu, Marian C.; Trisca-Rusu, Corneliu; Totu, Eugenia Eftimie. SEPARATION SCIENCE AND TECHNOLOGY Volume: 51 Issue: 15-16 Pages: 2628-2638, 2016 IF 1.083

19. Fourier-transform interference lithography, Bulinski, M.; Moagar-Poladian, G., ROMANIAN REPORTS IN PHYSICS Volume: 68 Issue: 2 Pages: 713-724 2016 IF 1.367

20. FTIR Spectroscopy for Carbon Family Study,Tucureanu, Vasilica; Matei, Alina; Avram, Andrei Marius; CRITICAL REVIEWS IN ANALYTICAL CHEMISTRY 2016, Vol. 46, Issue 6, p. 502-520, IF 2.667

21. Ginger Essential Oil Encapsulation in PMMA Microcapsules., A Racoti, E Rusen, A Diacon, A Dinescu, M Buleandra, I Calinescu, MATERIALE PLASTICE, SEP 2016, Vol. 53, Issue 3, p. 357-360 IF 0.903

22. Graphene rectenna for efficient energy harvesting at terahertz frequencies, Dragoman, Mircea; Aldrigo, Martino, APPLIED PHYSICS LETTERS Volume: 109 Issue: 11 Article Number: 113105 Published: SEP 12 2016 IF 3.142

23. Influence of Au-Based Metallization on the Phase Velocity of GaN on Si Surface Acoustic Wave Resonators, A Stefanescu, A Muller, I Giangu, A Dinescu, G Konstantinidis, IEEE ELECTRON DEVICE LETTERS, MAR 2016, Vol. 37, Issue 3, p. 321-324, IF 2.528

24. Memristive GaN ultrathin suspended membrane array, M Dragoman, I Tiginyanu, D Dragoman, NANOTECHNOLOGY Volume: 27 Issue: 29 Article Number: 295204 Published: JUL 22 2016 IF 3.573

25. Molybdenum disulphide and graphene quantum dots as electrode modifiers for laccase biosensor, I Vasilescu, S Eremia, M Kusko, A Radoi, E Vasile, GL Radu, BIOSENSORS & BIOELECTRONICS, JAN 15 2016, Vol. 75, p. 232-237, IF 7.476

26. Morpho ierarhic TiO2 with plasmonic gold decoration for highly active photocatalysis properties, Mihai, S.; Cursaru, D. L.; Ghita, D.; Dinescu, A.. MATERIALS LETTERS Volume: 162 Pages: 222-225 JAN 1 2016 IF 2.437

26. Morpho ierarhic TiO2 with plasmonic gold decoration for highly active photocatalysis properties, Mihai, S.; Cursaru, D. L.; Ghita, D.; Dinescu, A.. MATERIALS LETTERS Volume: 162 Pages: 222-225 Published: JAN 1 2016 IF 2.437

27. Nanostructured SnO2-ZnO composite gas sensors for selective detection of carbon monoxide P.Chesler, C. Hornoiu, S. Mihaiu, C. Vladut, J.M. Calderon Moreno, M. Anastasescu, C. Moldovan, B. Firtat, C.Brasoveanu, G. Muscalu, I. Stan and M. Gartner,. BEILSTEIN JOURNAL OF NANOTECHNOLOGY Volume: 7 Pages: 2045-2056 Published: DEC 22 2016 IF: 2.778

28. Non-volatile memory devices based on Ge nanocrystals, D Vasilache, A Cismaru, M Dragoman, I Stavarache, C Palade, AM Lepadatu, ML Ciurea, PHYSICA STATUS SOLIDI A-APPLICATIONS AND MATERIALS SCIENCE V: 213 I: 2 Pages: 255-259 FEB 2016 IF1.648

29. On the 1/f Noise and Energy Partition in Solid, M. Mihaila, Romanian Journal of Information Science and Technology 19 (1-2), 175-187, 2016 IF 0.304

30. Optimized stateful material implication logic for three-dimensional data manipulation, Adam, Gina C.; Hoskins, Brian D.; Prezioso, Mirko; D.B. Strukov; NANO RESEARCH Volume: 9 Issue: 12 Pages: 3914-3923 Published: DEC 2016 IF 8.893

31. Pan-European inter-laboratory studies on a panel of in vitro cytotoxicity and pro-inflammation assays for nanoparticles, Jean-Pascal Piret, Olesja M. Bondarenko, Matthew S. P. Boyles, Martin Himly, Ana R. Ribeiro, Federico Benetti, Caroline Smal, Braulio Lima, Annegret Potthoff, Monica Simion, Elise Dumortier, Paulo Emilio C. Leite, Luciene Bottentuit Balottin, José Mauro Granjeiro, Angela Ivask, Anne Kahru, Isabella Radauer-Preiml, Ulrike Tischler, Albert Duschl, Christelle Saout, Sergio Anguissola, Andrea Haase, An JacobsInge Nelissen, Superb K. Misra, Olivier Toussaint, Archives of Toxicology, 2016 IF 6.637

32. Photonic Crystals Band Gap Modulation Using the Pattern of a Written DVD, E Rusen, A Diacon, A Mocanu, A Gavrila, AM Dumitrescu, A Dinescu, MATERIALE PLASTICE, JUN 2016, Vol. 53, Issue 2, p. 185-188 IF 0.903

33. Quantum logic gates based on ballistic transport in graphene, D Dragoman, M Dragoman, JOURNAL OF APPLIED PHYSICS Volume: 119 Issue: 9 Article Number: 094902 MAR 7 2016. IF: 2.101

34. Raman Study of Compositional Variations in ZnxCd1-xSe Films Prepared by Thermal Vacuum Evaporation; Nesheva, D.; Comanescu, F.; Bineva, I.; Purica, M.; Levi, Z.; Aneva, Z.; Muller, R. JOURNAL OF NANOSCIENCE AND NANOTECHNOLOGY Volume: 16 Issue: 8 Pages: 8513-8518, AUG 2016 IF 1.338

35. Reliability design of thermally actuated MEMS switches based on V-shape beams, M Pustan, R Chiorean, C Birleanu, C Dudescu, R Muller, A Baracu, R Voicu, Microsystem Technologies, January 2016, IF: 0.974

36. Response to comments on GaN/Si based single SAW resonator temperature sensor operating in the GHz frequency range, A Mueller; A. Stefanescu; G Konstantinidis; SENSORS AND ACTUATORS A-PHYSICAL, AUG 15 2016, Vol. 247, p. 162-163, IF 2.201

37. Room temperature nanostructured graphene transistor with high on/off ratio, M Dragoman, A Dinescu, D Dragoman, Published 28 November 2016, Nanotechnology, Volume 28, Number 1, IF: 3.573

38. Room temperature on-wafer ballistic graphene field-effect-transistor with oblique double-gate, M Dragoman, A Dinescu, D Dragoman, JOURNAL OF APPLIED PHYSICS Volume: 119 Issue: 24 Article Number: 244305, JUN 28 2016 IF 2.101

39. Scaling the graphene-silicon heterojunctions: fabrication and characterization, AI Istrate, LM Veca, F Nastase, A Baracu, R Gavrila, F Comanescu, V Tucureanu, A Dinescu, T Sandu, Romanian Journal of Information Science and Technology, 19 (2016), No. 3, pp. 282-294 IF: 0.304

40. SU-8 Microgrippers based on V-shaped Electrothermal Actuators with Implanted, Heaters, R Voicu, C Tibeica, R Müller, A Dinescu, M Pustan, C Birleanu, Romanian Journal of Information Science and Technology, vol. 19 (2016), No. 3, pp. 269-281 IF: 0.304

41. Surface passivation of carbon nanoparticles with p-phenylenediamine towards photoluminescent carbon dots, Craciun, A. M.; Diac, A.; Focsan, M.; Socaci, C.; Magyari, K.; Maniu, D.; Mihalache, I.; Veca, L. M.; Astilean, S.; Terec, A.; RSC ADVANCES, 2016, Vol. 6, Issue 62, p. S6944-S6951, IF 3.289

42. Two Compact Smith Charts: The 3D Smith Chart and a Hyperbolic Disc Model of the Generalized Infinite Smith Chart, Muller, Andrei; Esther Sanabria-Codesal, Esther; Moldoveanu, Alin; Asavei, Victor, Dascalu, Dan, Romanian Journal of Information Science and Technology, vol. 19 (2016), No.1-2, pp. 166– 174 IF: 0.304

43. Ultra-lightweight pressure sensor based on graphene aerogel decorated with piezoelectric nanocrystalline films, M Dragoman, L Ghimpu, C Obreja, et al. NANOTECHNOLOGY, Volume: 27 Issue: 47 Article Number: 475203, NOV 25 2016 IF 3.573

44. Using pressure sensors for motion detection of remote manipulation devices, L Milea, M Dascălu,, C Opriș, F Eduard, Romanian Journal of Information Science and Technology, 19 (2016), No.4, pp. 327-332 IF: 0.304

45. W-Band receiver with Zero Bias Diode operated in the 23K - 295 K temperature range, AC Bunea, D Neculoiu, A Avram, A Muller, Romanian Journal of Information Science and Technology, (2016), No. 3, pp. 227-239 IF: 0.304

ISI indexed Papers

46. Adaptive Visual Feedback for Remote Control of a Robotic Arm, M Dascalu, E Franti, L Milea, F Lazo, E Zoltan, A Plavitu, International Journal of Scientific Engineering and Applied Science (IJSEAS) V-2, Issue-12, pag 1-6 November 2016, ISSN: 2395-3470

47. Design and analysis of a membrane supported folded slot antenna for w-band applications, AC Bunea, D Neculoiu, A Avram,, UNIVERSITY POLITEHNICA OF BUCHAREST SCIENTIFIC BULLETIN SERIES C-ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, 2016, Vol 78, Issue 2, p. 109-120

48. Fabrication of micro-lens array obtained by anisotropic wet etching of silicon, C. Parvulescu, E. Manea, P. Schiopu, R. Gavrila, Defect and Diffusion Forum Vol. 369, pp. 71-76, 2016

49. Gold nanostructures sputtered on zinc oxide thin film and corning glass substrates, O Szabo, S Flickyngerova, T Ignat, I Novotny, V Tvarozek, FACTA UNIVERSITATIS-SERIES ELECTRONICS AND ENERGETICS, MAR 2016, Vol. 29, Issue 1, p. 77-88, DOI 10.2298/FUEE1601077S

50. Haptic Feedback Experiments with a Tele-Operated Robotic Arm, M Dascalu, L Milea, E Franti, F Lazo, E Zoltan, I Ispas. American Journal of Aerospace Engineering. Vol. x, No. x, 2016, pp. 25-31. doi: 10.11648/j.ajae.20150311.16

51. Influence of the thickness on the morphology and sensing ability of thermally-deposited tellurium films, Hristova-Vasileva, T., Bineva, I., Dinescu, A., (...), Arsova, D., Pejova, B. 19th International Summer School on Vacuum, Electron and Ion Technologies (VEIT2015) IOP Publishing - Journal of Physics: Conference Series 700 (2016) 012037

52. Online training module for patients with forearm amputations for efficient use of a myoelectric prosthesis, M Dascalu, E Franti, A Plavitu, International Journal of Scientific Engineering and Applied Science (IJSEAS) – V 2, Issue-12, November 2016 ISSN: 2395-3470

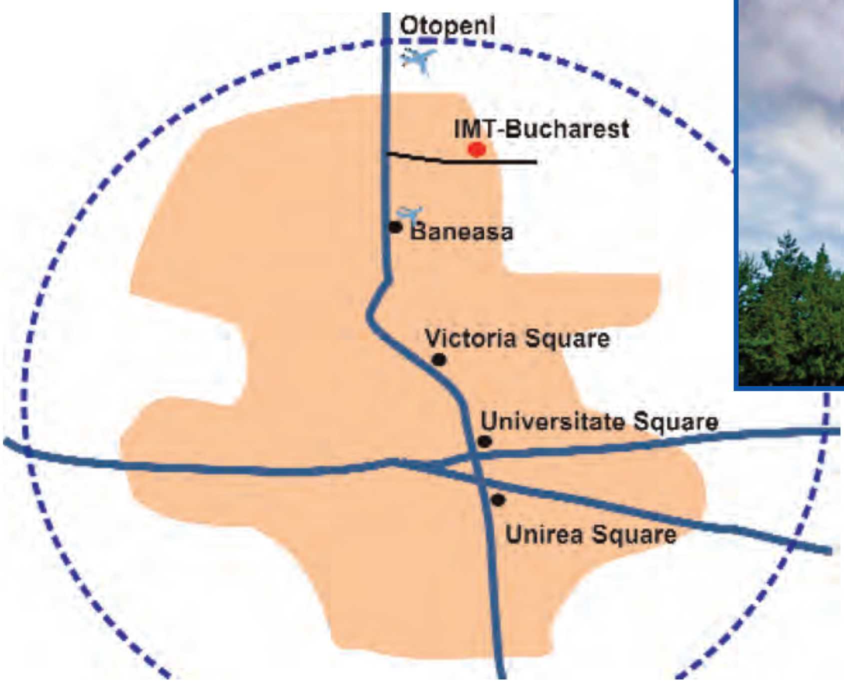
53. Polysulfone membranes doped with polymer colloids for water decontamination, Rusen, E., Mocanu, A., Dinescu, A., Mustea, G., Diacon, A. UPB Scientific Bulletin, Series B: Chemistry and Materials Science 2016 U.P.B. Sci. Bull., Series B, Vol. 78, Iss. 2, 2016

54. Robust Method for Deforestation Analysis of Satellite Images, I Ispas, E Franti, F Lazo, E Zoltan. International Journal of Environmental Monitoring and Analysis. Vol. 3, No. 6, 2015, pp. 420-424.

55. Scalar network analyzer-type approach for a temperature measurement system based on microwave saw resonators, I Giangu, V Buiculescu, M Nisulescu, G Lojewski, UNIV POLITEHNICA OF BUCHAREST SCIENTIFIC BULLETIN SERIES C-ELECTRICAL ENGINEERING AND COMPUTER SCIENCE, 2016, Vol. 78, Issue 3, p. 137-148

56. TiO2 thin films used in fabrication and functionalization of microfluidic channels, C. Parvulescu, M. Popescu, E. Manea, R. Tomescu, P. Schiopu, UPB Scientific Bulletin - Series B, Chemistry and Materials Science, 78(2), 111-120, 2016.

IMT-Bucharest is publishing annually the Scientific Report since 2005.
See: www.imt.ro



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;