National Institute for Research and Development in Microtechnologies -
IMT Bucharest

Scientific Report 2019

From micro- to nanotechnologies,
nano-biotechnologies and nanoelectronics

Ministry of Research and Innovation

National Institute for Research and Development in Microtechnologies

IMT Bucharest

SCIENTIFIC REPORT 2019

Research, Technological development and experimental infrastructure

Design: IMT Bucharest

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Introduction

The National Institute for Research and Development in Microtechnologies – IMT Bucharest was set up at the end of 1996. The institute is the successor of the Institute for Microtechnologies IMT, founded in 1993 which merged with Research Institute for Electronic Components, founded in 1969. IMT Bucharest is coordinated by the Ministry of Education and Research, acting basically as an autonomous, non-profit research company.

Our institute is an internationally competitive organization, involved in world class research with an attractive environment for interdisciplinary research. In 2019 IMT continued its activity in highly innovative research, developing novel technologies in the field of: micro and nanoelectronic components and systems, smart sensors, micro and nanotechnology, education, technology transfer and offering services for industry.
The research activity performed in national and international projects is published in ISI ranked papers, covering all range of activities from basic research to applied science and is mainly oriented to:

- micro and nanoelectronic devices
- micro and nanophotonics
- nanotechnologies
- advanced materials
- devices and circuits devoted ti quantum computing
- digital platform for health, societal security and environment

IMT- Bucharest is one of the most successful institute in Romania related to EU funding. In 2019, our institute was involved as partner in 5 H2020 projects: 3 H2020-FETOPEN projects: CHIRON, NANOPOLY, IQubits, 1 H2020-ICT: NANOSMART (coordinated by: IMEC, Belgium; Thales RTS, France; Arhus, University, Denmark; Thales RTS, France). IMT coordinated ENF2019- EURONANOFORUM 2019 – "NANOTECHNOLOGY AND ADVANCED MATERIALS PROGRESS UNDER HORIZON2020 AND BEYOND". IMT had implemented other types of European projects, as: BANDPASS - Carbon quantum dots/graphene hybrids with broad photoresponsivity– H2020-ATTRACT, M.ERANET, ESA, EUREKA.

As in previous years, the research collaborative activity of its 4 departments, grouping 11 laboratories, was focussed to the priorities of the Romanian National Strategy for Research and Innovation SNCDI (2014-2020) and of EU program Horizon 2020.

At national level, a Structural Funded project "TGE-PLAT" is a dedicated platform offering access to IMT's infrastructure and allowing knowledge transfer to Romanian small and medium-size entreprises, offering the opportunity of cooperation with 8 industrial companies in the fields like ICT and Security and Health.

In 2019, we continued the implementation of an important Romanian Project of Excellence in ICT, Space and Security (Contract 13PFE/16.10.2018), which support the development of the institute in micro and nanotechnoloies for smarts systems, allowing the upgrade of its infrastructure and the competences of the staff. One must mention 8 Complex Romanian projects, IMT being involved as coordinator or partner in the field of: ICT, Eco-Nanotechnoloies, Health, New and emergent Technologies, Bio-economy.

IMT's infrastructure comprises two main technological facilities: IMT-MINAFAB (Facility for Design, Simulation, Micro- nano-fabrication of electronic devices and systems) and CENASIC (Research Centre for Integrated Systems, Nanotechnologies and Carbon Based Nanomaterials). In 2019 IMT continues the investments in infrastructure.

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

CENASIC, in use since November 2015, is oriented to research in the field of graphene based devices and other carbon based nano materials, as nanocrystaline diamond and SiC.

IMT is the organizer of an annual international conference, CAS - International Semiconductor Conference - an IEEE event, in 2019 at its 42th edition.

IMT Bucharest was selected by the European Commission to organize in Bucharest a major event EURONANOFORUM 2019 – "Nanotechnology and Advanced Materials Progress under Horizon 2020 and beyond", 12-14 June 2019, during the Romanian Presidency of the Council of the European Union. The event was financed through a H2020 CSA project. The conference had a great impact for the field of nanotechnology and advanced materials, Many well known scientists and European policy makers gave interesting talks. It increased also the awareness of H2020 NMBP programme, particularly in Romania. The event was an important opportunity of network between European R&D performers and Romanian experts and entities.

EuroNanoForum 2019 in figures: - approx. 500 delegates, with 128 speakers and moderators
- 3 plenary sessions and 15 parallel sessions with 85 oral presentations, 8 Workshops
- 89 posters, 16 posters in the student sessions
- 30 projects applying for the Best H2020 project in NMBP Competition
- 180 meetings between 68 delegates from 19 countries in the Brokerage sessions
- 22 exhibitors in the Industrial and Research Exhibition
- 13 media partners

This year, IMT participated at World Micrommachine Summit, held in Xi'an, China, representing the only country from Eastern and South Europe, 13th consecutive participation- only by invitation.

Concerning human resources, current research activity involves multidisciplinary teams, composed of: physicists, electronic engineers, chemists, material engineers, mathematicians, biologists, young PhD students, technicians and administrative staff (in total 199), which areengaged in national and international research projects. The figures presented in the report show a relatively balanced distribution of human resources between young and senior researchers (also between male and female).

In 2019 the institute approved a New Research Plan for the next 5 years, targeting ambition scientific tasks and it was evaluated, obtaining the accrecitation for the next 5 years.

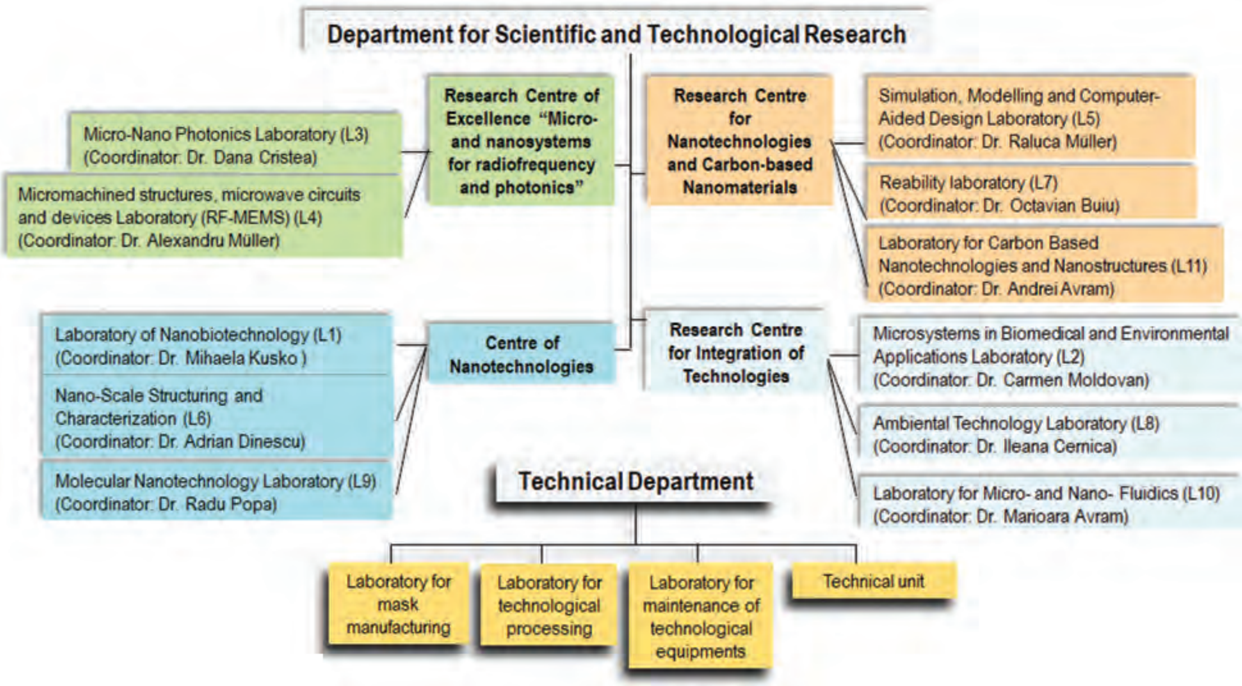
The turnover increased in 2019 compared with year 2018, due to the number and value of the national and international projects. IMT Bucharest is involved in partnerships with higher education institutions (University Politechnica Bucharest and others), providing access to Romanian and international students for internships, to advance their knowledge and gain new skills.

The Scientific Report 2019 presents the most important projects and the research highlights of the 11 research laboratories. A list of ISI scientific publications concludes the report.

I would like to thank my colleagues for their great work and support during the year of 2019.

Dr. Miron Adrian Dinescu
CEO and President of the Board

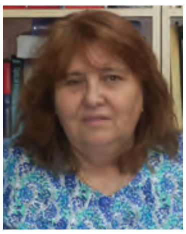
Organization: Scientific and Technical Departments



Dr. Adrian Dinescu

PhD in Physics, General Manager of IMT Bucharest.

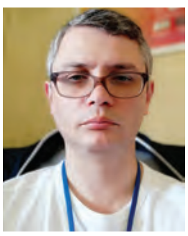
See the CV on page 22.



Dr. Raluca Müller

PhD in Electronics, Scientific Director of IMT Bucharest.

See the CV on page 29.



Dr. Dan Vasilache

PhD in Electronics, Technical Director of IMT Bucharest.

Dr. Dan Vasilache obtaine the Licence in Atomic Physics in 1995 from Bucharest Univ. and PhD degree in 2011 from Politechnica Univ. Bucharest. His career started with ICCE-Research Institute for Electronic Components, Romania (1995-1997), and starting from 1997 he is with IMT-Bucharest (1997-2009 and 2012-present), while between 2010 and 2012 he was employed at FBK-irst Trento. He was clean room head between 2006 and 2008 and 2016-2017, and starting from 2017 he is the Technical Manager of IMT-Bucharest. He is involved in technological design ang processes development for RF MEMS devices.

Dr. Alexandru Müller

PhD in Physics, Director 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, IMT Bucharest.

See the CV on page 10.

Dr. Radu Cristian Popa

PhD in Quantum Engineering and Systems Science, Director of Centre of Nanotechnologies CNT, IMT Bucharest.

See the CV on page 26.

Dr. Mircea Dragoman

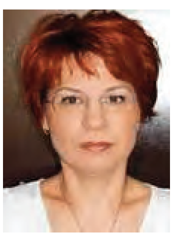
PhD in Electronics, Director Centre for Nanotechnologies and Carbon-based Nanomaterials CENASIC, President of the IMT Bucharest Scientific Council.

See the CV on page 5.

Dr. Carmen Moldovan

PhD in Electronics, Centre for Research and Technologies Integration, IMT Bucharest.

See the CV on page 39.



Ec. Constantina Simon

Financial Director

Constantina SIMON is an expert accountant, graduate of the Faculty of Economic Sciences – Licence degree (2002) in Finance and banking. C. Simon has 20 years experience in the position of Economic Director, 12 of them in research field. She has a high expertise in financial-accounting activity, having as responsibilities: organising, coordinating, financial and accountable analyses, income and spending budget, balance sheet, financial balance, cash flow, financial management, etc.;

Human resources, funding and investments

Human resources

IMT Bucharest is active in R&D and Innovation with a number of researchers, engineers, technicians and other support personnel. IMT has become an attraction for skilled and motivated people because of his high level infrastructures and the important number of national and European projects in the field of ICT, space and security, photonics, nanotechnologies, smart sensors a) and advanced materials.

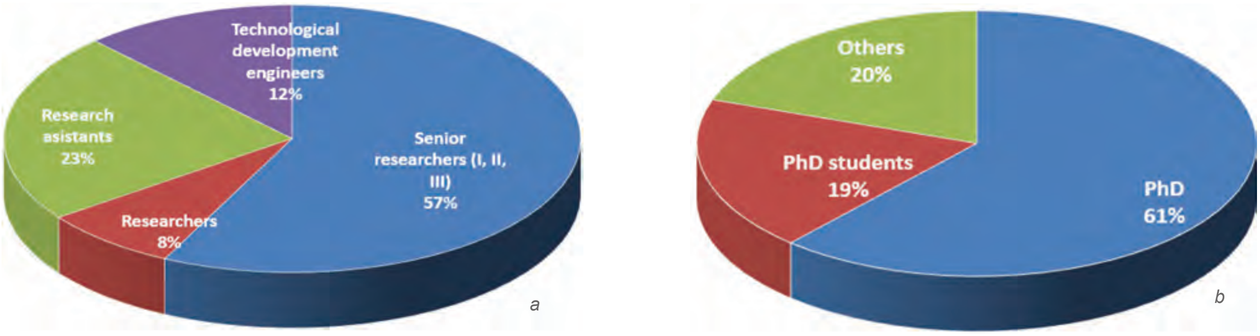


Figure 1 (a, b) provides information about the number and distribution of researchers and technological development engineers (IDT) active in IMT in 2019

Figure 1 (a, b) provides information about the number and distribution of researchers (88%), technological development engineers (IDT- 12%) and development and process engineers active in IMT in 2019 (117 persons). Considering the researchers 57% are senior researchers I, II and III, 8% researchers, 23% young assistant researchers. 20% of the employers are under 35 years. The average age of IMT researchers is around 46.

In 2019, in the frame of national projects, IMT hired a lot of young MS and PhD students.

Figure 2 presents information about the multidisciplinary background of researchers and IDT active in IMT in 2019.

The male (52 %) - female (48 %) ratio is relatively balanced.

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

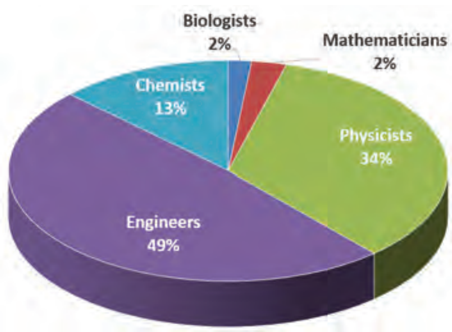
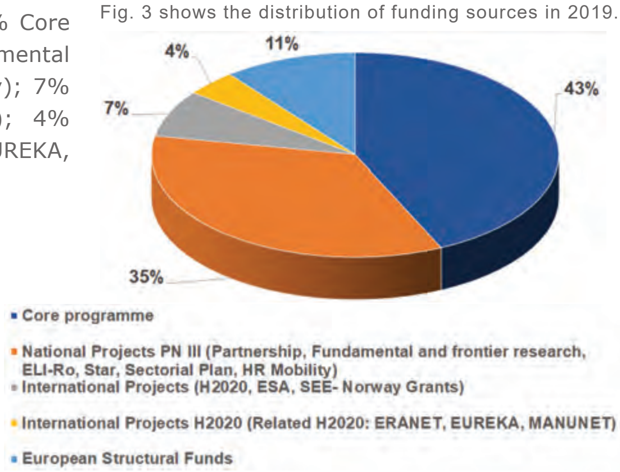


Fig. 2. presents information about the multidisciplinary background of researchers and IDT active in IMT in 2019.

Funding sources and investments

Fig. 3 shows the distribution of funding sources in 2019: 43% Core programme; 35% National Projects PN III (Partnership, Fundamental and frontier research, ELI-Ro, Star, Sectorial Plan, HR Mobility); 7% International Projects (H2020, ESA, SEE- Norway Grants); 4% International Projects H2020 (Related H2020: ERANET, EUREKA, MANUNET); 11% European Structural Funds.

Fig. 3 shows the distribution of funding sources in 2019.



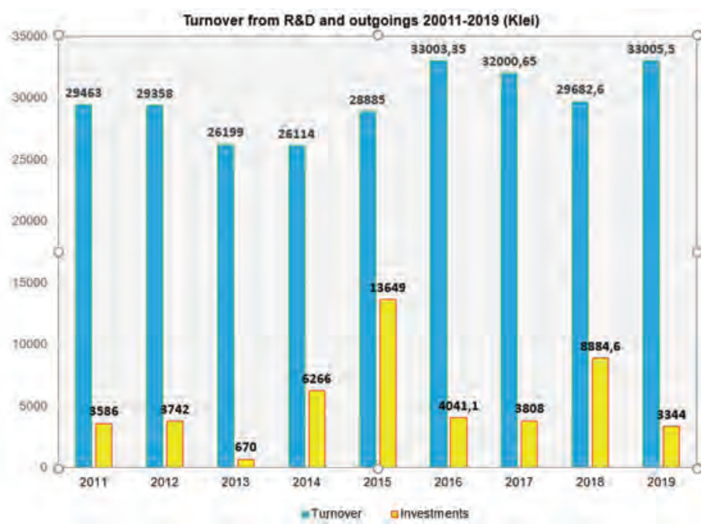


Fig. 4. Evolution of IMT turnover during the last period and information about investments

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 financial performance increased in 2019 compared to 2018.

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 micro-systems (www.imt.ro/MINAFAB), launched in April 2009.

The facility provides "open access" to modern, state of arts equipment 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 centres and benefits of the expertise of a multidisciplinary team.

IMT-MINAFAB has several clean-room areas with specialized technological and characterization laboratories-totalizing a surface of almost 700 m2 (including one clean room of class 1.000), and modern equipment worth more than 8 MEuro. The services and administrative activities of the center are SR EN ISO 9001:2008 certified by TÜV Thüringen e.V. This research infrastructure enabled IMT to extend its R&D capabilities.

IMT-MINAFAB infrastructure contains a key unit, the „Facility for micro-nanostructuring of devices and systems", unique in Romania. This facility is responsible for mask fabrication, photo-lithography 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: micro-nanoelectronics, photonics, nanotechnologies and advanced materials. Since 2017, the facility has been upgraded with an area of 280 m2 of clean room class 10,000.

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 (220 m2) for the mask shop and the most demanding technological processes (in use since 2008);
- A class 100,000 clean room, the so called "Grey Area"(200 m2), mostly for the characterization equipments (in use since 2008):
- A class 10,000 clean room (105 m2) 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, De.)

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, De.)

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, Fr.)

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

• 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, De)

• X-Ray diffractometry

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

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

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

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

• 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, De)

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 HR800 (HORIBA Jobin Yvon, Jp)

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

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

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

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;

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, De)

Frequency Synthesizer up to 110 GHz (Agilent, USA)

Spectrum Analyzer up to 110 GHz (Anritsu, Jp)

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 m2, 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 is developing the following research topics:

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

►Technologies for graphene and hybrid MEMS/NEMS

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

In 2019 the new research infrastructure CENASIC was an important support for new projects.
The centre offers services and equipment of high complexity, which allow the implementation of the most modern technologies for processes and analyses dedicated to the carbon class (films and structures 0D-3D), with an advanced degree of applicability and a strong interdisciplinary .
The investments in this research infrastructure provide an opportunity of new technological platforms able of supporting technologies as: synthesis and processing of nanomaterials with special properties, technologies for micro/nano processors and design of innovative systems and devices. 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. Mircea Dragoman (mircea.dragoman@imt.ro); Beneficiary: National Institute for R&D in Microtechnologies - IMT Bucharest; www.imt.ro, 126A, Erou Iancu Nicolae Street, 077190, Voluntari, Ilfov, Romania

Mircea Dragoman has graduated the Electronic Faculty, Polytechnical Institute in Bucharest, in 1980, and received the doctoral degree in electronics in 1991. In the period 1992-1994 he was the recipient of the Humboldt Fellowship award and has followed postdoctoral studies at Duisburg University, Germany.

He is Senior Researcher I with the National Research Institute in Microtechnologies. He co-authored more than 300 scientific papers and 7 monographies, such as M. Dragoman, D. Dragoman, Nanoelectronics: Principles and Devices, at Artech House, Boston, USA (2008) and M. Dragoman and D. Dragoman, 2D Nanoelectronics, Physics and Devices of Atomically Thin Materials, at Springer (2017), Electronics at atomic scale beyond CMOS, Springer (2021).

Dr. Dragoman was awarded the Gheorghe Cartianu prize of the Romanian Academy in 1999.

Director of CENASIC:
Dr. Mircea Dragoman,
mircea.dragoman@imt.ro

TECHNOLOGICAL TRANSFER INFRASTRUCTURES

CENTRE FOR TECHNOLOGY TRANSFER IN MICROENGINEERING
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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.

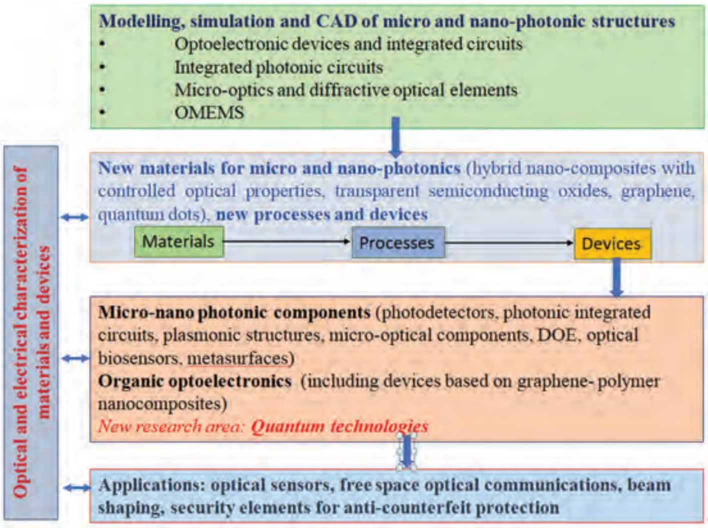
ROMANIAN-BULGARIAN SERVICES CENTRE FOR MICROSYSTEMS AND NANOTECHNOLOGY
Contact data: National Institute for Research and Development for Microtechnology IMT Bucharest, Science and Technology Park for Micro- and Nanotechnologies, MINATECH-RO
Address:126A, Erou Iancu Nicolae Street, 6th Floor, Room 607, 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

MIMOMEMS European Centre of Excellence

Laboratory of Micro/Nano Photonics

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, and participated in several FP6, FP7 and H2020 projects (WAPITI, 4M, ASSEMIC, FlexPAET, MIMOMEMS, ENF 2019). She is currently scientific manager in two projects aiming at knowledge transfer to SMEs and in R&I projects on opto-electronic devices based on QDs and nanoplasmonic structures.

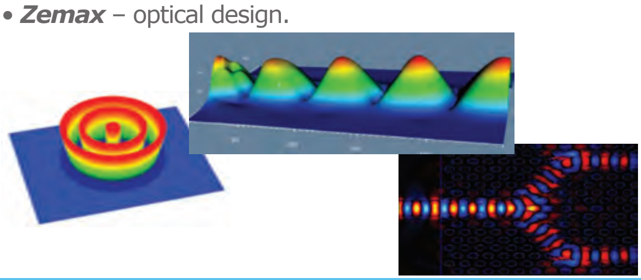
Team

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 in physics;
4. **Dr. Paula Obreja** senior researcher, M.Sc. and Ph.D. in physical chemistry;
5. **Dr. Mihai Kusko** senior researcher (M.Sc. in physics and photonics, Ph.D in optoelectronics);
6. **Dr. Florin Comanescu** – researcher, M.Sc. in electronics and PhD in optoelectronics at "Politechnica" University of Bucharest;
7. **Dr. Roxana Rebigan** researcher, M.Sc. in physics and Ph.D in optoelectronics;
8. **Dr. Roxana Tomescu** – researcher, M.Sc. in electronics and PhD in optoelectronics at "Politechnica" University of Bucharest;
9. **Dr. Rebeca Tudor** – junior researcher, M.Sc. in Electronics, PhD in Physics.
10. **Ing. Ramona Călinoiu** – AC, M.Sc student in Automatic Control and Computers
11. **Ing. Ştefan Cărămizoiu** – AC, PhD student in physiscs;
12. **Ing. Costel Păun** – AC, PhD student in chemistry
13. **Fiz. George Bulzan** – AC, M.Sc student in physics.

Specific facilities

Modelling and simulation:

• ***Opti FDTD 15.0*** – design and simulation of advanced passive and nonlinear photonic devices using FDTD (Finite-Difference Time-Domain) method.
• ***OptiBPM 13.1*** - 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 nano-composites and organic layers.

Characterization:

• ***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.*

Laboratory of Micro/Nano Photonics

National and international cooperation

National projects

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

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

• ***Partnership for using Key Enabling Technologies on aplatform for interaction with companies"*** TGE-PLAT POC-G – Operational Competitivity Program 2014-2021, Action 1.2.3, Contract No. 77/08.09.2016, a project financed by Structural Funding dedicated to knowledgetransfer from IMT to Romanian companies, in a high techfield of the Romanin Strategy (SNCDI 2016-2020): ICT, Space and Security), Coordinator: IMT. Laboratory for Micro and nano-photonics participates in 2 subprojects in partnership with SMEs:

- ***High quality forming image optical system with diffractive optical elements in LWIR spectral range for multisensory systems-SOFID***-Project manager Dr. Cristian Kusko- cooperation with ProOptica SA
- ***Technology for anti-counterfreiting metal microparticles***- Project Manager Dr. C. Parvulescu (catalin.parvulescu@imt.ro); cooperation with OPTOELECTRONICA 2001 SA.

EU projects

• **EURONANOFORUM 2019** – (ENF 2019), Nanotechnology and Advanced Materials progress Under H2020 and Beyond, *call H2020-IBA-LEIT-NMBP-Romanian-Presidency-2018,*

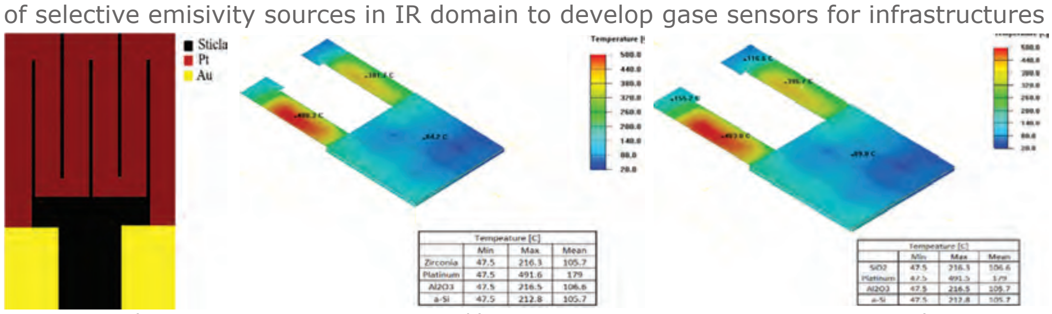
• **DNMF_net** - Network of nano research infrastructures in the Danube region (Project supported by the German Federal Ministry of Education and Research (BMBF) under the "ideas competition for the establishment and development of innovative R&D networks with partners in the Danube States", 2017-2019.

Scientific results

Project Infrared sensors with application in infrastructures security, part of the Complex Project ***"Sensors and Electronic and Photonic Integrated Systems for the Security of People and Infrastructures"*** PN-III-P1-1.2-PCCDI2017-0419. Project Coordinatorr Dr. Roxana Tomescu (roxana.tomescu@imt.ro).

We analized a variety of selective emisivity sources in IR domain to develop gase sensors for infrastructures security. These sources are composed of:

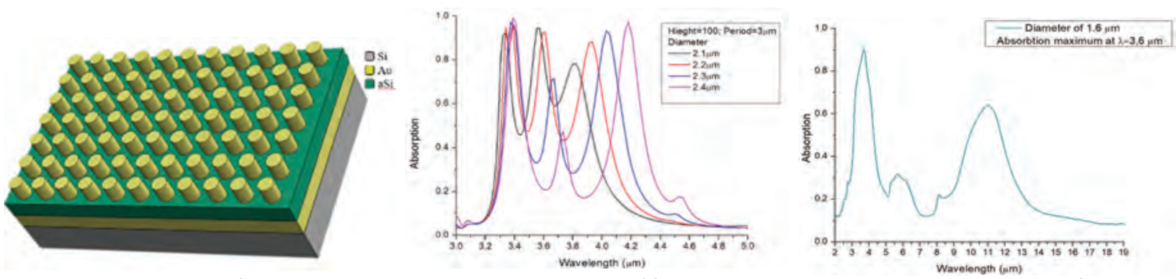
• A ***clasical thermal source*** with a configuration that offer a broad emisivity spectrum optimized for the desired application;



a) b) c)
Ansys Icepack numerical simulations of a thermic resistor in platinum meander configuration, with gold pads: a) Structure b) temperature distribution when it is employed a zirconia substrate; c) temperature distribution when it is employed a glass substrate.

• Metasupraface specifically taylored for improved apsorbtion on tight wavelength intervales in IR.

The metasurfaces the spectral characteristics can be tuned, by modifing its lay-out, to achieve absorption peaks at specific wavelengths coresponding to absorption wavelenghts of different gases. This property offers the posibillity to obtain gas sensors with high sensitivity.



a) b) c)
a) Metasurface configuration for perfect absorber; b) absorption spectre obtained simulation a metasurface configuration composed of gold pillars with 100 nm height; c) absorption spectre after FTIR measurements.

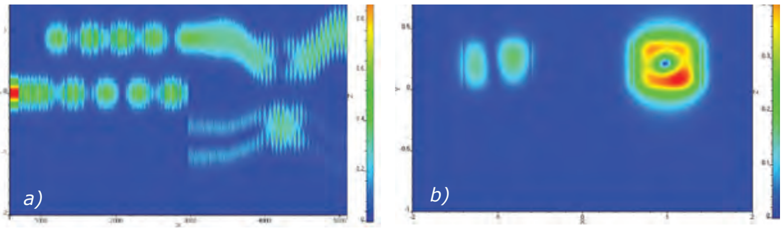
Laboratory of Micro/Nano Photonics

Scientific results

Project: Developing quantum information and quantum technologies in Romania

complex project (PCCDI) PN III-P1-1.2-PCCDI-2017-0338 2018-2021 (IFIN-HH coordinator, IMT partner, Cristian Kusko, cristian.kusko@imt.ro)

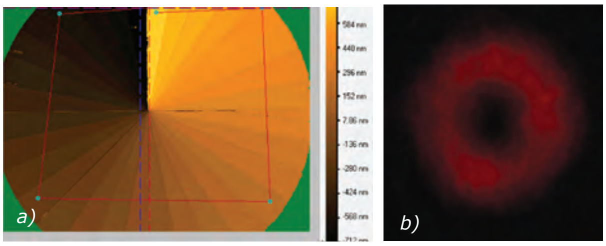
In the frame of the complex projects we designed, fabricated and characterized optical components, integrated circuits and optical systems with applications in quantum technologies.



Numerical modelling for the propagation of the optical radiation in a photonic integrated circuit which generates optical vortices with topological charge m=1; a) top view of the optical field in the circuit, b) cross section at the end of the output waveguide in the photonic circuit

✓ Subsidiary Project 2 Q-CHIP: Developing an integrated quantum photonics platform for quantum technologies using 3D lithography

We theoretically investigated, by simulations and modeling, and designed photonic circuits with different relevant functionalities for quantum technologies. The focus was on photonic circuits which generates optical vortices.

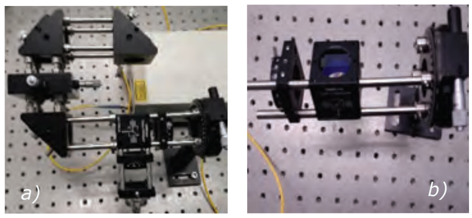


a) WLI Bidimensional profile for a spiral phase plate with 32 levels of order m=1, b) optical vortex with topological charge m=1 generated with SPP from a).

✓ Subsidiary Project 3 Q-VORTEX: Quantum information with optical vortices (IMT)

We fabricated optical components such as spiral phase plates (SPPs) with 32 levels operating in transmission for visible wavelength (λ=633nm) using photo-lithography, and chemical etching on fused silica substrate. This class of optical elements facilitates the conversion of a Gaussian beam into an optical vortex which carries orbital angular momentum.

We design, implemented and tested an optical system which generates rotational invariant photonic states for free space optical communication where the information is encoded using the polarization states of photons. This optical system has a transmitter module which uses the SPP operating in transmission, a receiver, and can be used for the implementation of quantum key distribution protocols in moving systems.

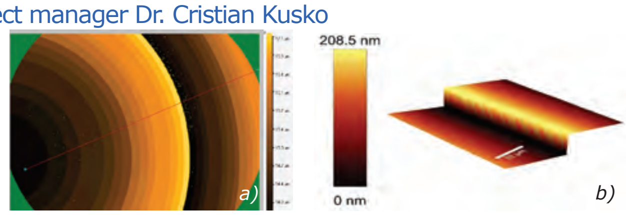


Optical system for rotational invariant photonic states a) Emission Module, b) Reception Module

Project POC-G Partnership for using Key Enabling Technologies on aplatform for interaction with companies" TGE-PLAT

✓ Subsidiary project "High quality forming image optical system with diffractive optical elements in LWIR spectral range for multisensory systems – SOFID – Project manager Dr. Cristian Kusko

Optical components have been fabricated for the general correction of the image generated by an optical system operating in the thermal IR range. The optical components illustrated in the figure bellow are Fresnel lens fabricated on silicon substrate by photolithography and plasma etching techniques.

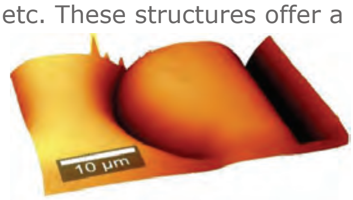


(a) WLI optical image for the correcting element consisting of the Fresnel lens with 16 levels (b) AFM image of one etched step between 2 levels

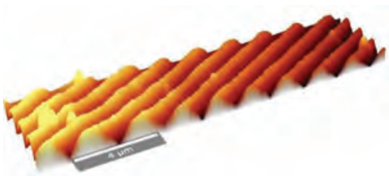
✓ Subsidiary project „Technology for anti-counterfreiting metal microparticles"- Project Manager Dr. C. Parvulescu (catalin.parvulescu@imt.ro); cooperation with OPTOELECTRONICA 2001 SA.

We optimised the technology for metallic microparticles structures fabrication and detachement. This type of structures are composed of a holographic background (arrays of diffraction of various dimenstions) and alphanumerical security elements.

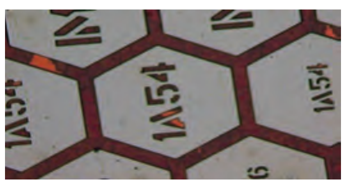
The metallic microparticles can be applied on various objects labels, valuable documents, paints, adhesives, etc. These structures offer a high security against product counterfeit.



AFM imagine - security alphanumeric element



AFM imagine – holographic background



Metallic microparticles before separation

Detached metallic microparticles

Laboratory of Micro/Nano Photonics

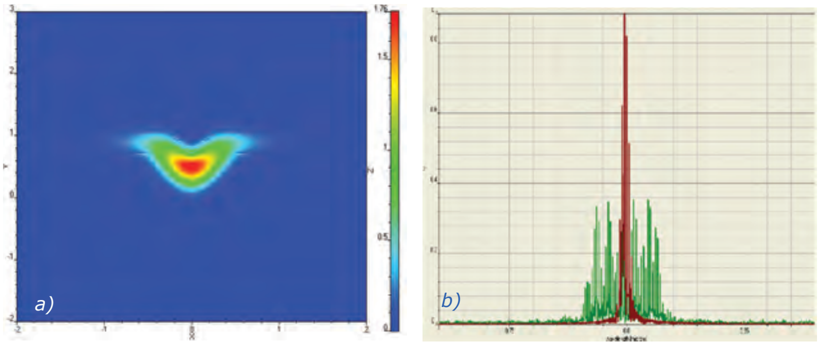
Scientific results

Project Technologies for photonic and optoelectronic components with applications in optical information processing at classic and quantum level

Project PN 19160103, part of the from IMT Core Programme - MICRO-NANO SIS PLUS Project coordinator Dr. Cristian Kusko (cristian.kusko@imt.ro).

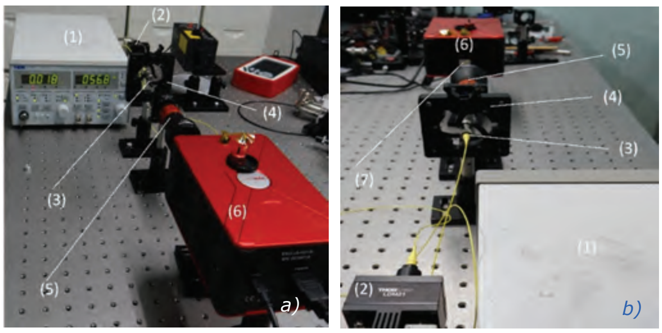
The objective of this project is to develop microtechnologies for the fabrication of photonic circuits, optical and optoelectronic components for quantum technologies.

✓ We investiogated at theoretical level, in simulations and then designed submicronic waveguides with high confinement in order to intensify nonlinear phenomena, such as of four-wave mixing that allows the generation of correlated photons needed for quantum applications.



a) Radiation distribution calculated numerically in a V-shaped groove Si3N4 waveguide with a triangular section, at a wavelength of 635 nm. The opening width of the V-groove is 1 μm and the thickness of the silicon nitride layer is 400 nm. b) The radiation spectrum from a waveguide in which the degenerate FWM phenomenon occurred. The red line represents the spectral characteristic for the propagation of the pumping optical signal on short-distance and the green line represents the long-distance spectral characteristic for the propagation of the pumping radiation.

✓ A photolithography system has been designed based on a spatial light modulator that generates holograms, light intensity configurations corresponding to those generated by photolithographic masks. The spatial light modulator operates in reflection and has a high definition liquid crystal array (1920 X 1080), the matrix pixels inducing a phase shift between 0 and 2π on 256 levels. The phase shift of each pixel is adjustable, so that the liquid crystal matrix is reconfigurable and thus an unlimited number of holograms can be obtained.



The experimental hologram generation system (a) image from the rear, respectively (b) simage from the front. The components of the system are: (1) the current and temperature controller for the laser diode, (2) the laser diode mount, (3) the laser diode, (4) the collimator which transforms the divergent beam emitted by the laser diodes into a parallel beam collimated beam, (5) beam expander, (6) Exulus HD1/M Thorlabs spatial light modulator (SLM).

Holograms were generated in the holographic system with SLM at different wavelengths. A hologram with a rectangular grid of squares (Fig a) was generated for λ=532 nm (Fig b), λ=633 nm (Fig.c) λ=405 nm.

✓Technological processes have been developed to allow both the deposition of thin layers of superconducting films and their micro-configuration in order to manufacture quantum detectors. Microstructures were fabricated by patterning a thin film of NbTiN superconducting material on silicon oxide substrate by chemical etching and argon ion etching.

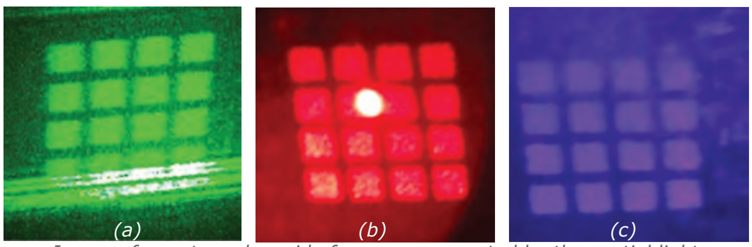
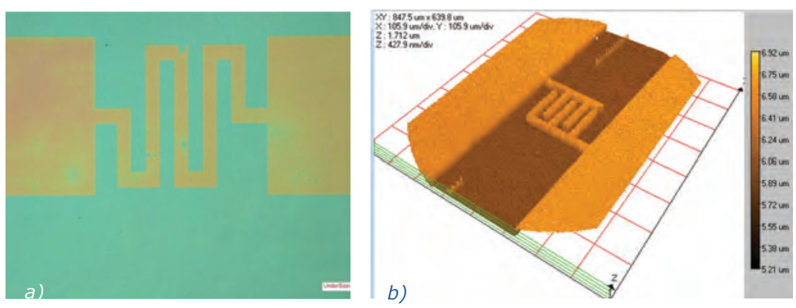


Image of a rectangular grid of squares generated by the spatial light modulator for the following wavelengths a) λ = 532 nm, b) λ = 633 nm c) λ = 405 nm



a) NbTiN structures on silicon oxide substrate obtained by chemical etching (optical image). b) NbTiN structures on silicon oxide substrate obtained by argon ion etching (image obtained by white light interferometry)

MIMOMEMS European Centre of Excellence

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 stared the research to develop acoustic devices using micromachining and nano-processing of wide band gap semiconductors (GaN/Si, AlN/Si) and experimental devices based on carbon nanotubes and graphene. L4 is one of the promoters of the RF – MEMS topics in Europe. It has coordinated the FP4 MEMSWAVE project (one of the first EU project in RF MEMS) nominated in 2002 for the Descatres prize and the FP 7 REGPOT MIMOMEMS (2008-20011). It has participated in the FP6 network of excellence "AMICOM" (2004-2007) with new and original results obtained in cooperation with key players in the European research in this topic (LAAS-CNRS Toulouse, VTT Helsinki, FORTH Heraklion). The laboratory was partners in IP/FP7 (NANOTEC, SMARTPOWER), STREP/FP7 (NANO RF, MEMS-4-MMIC), ENIAC JU (SE2A, MERCURE, NANOCOM), ESA and it has coordinted the H2020/Marie Curie project (SelectX)

The laboratory is now partner in three H2020-FETOPEN projects (CHIRON, IQubits, NANOPOLY), and one H2020 ICT RIA project (NANOSMART).

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;

Equipment

"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, Lake Shore Cryotronics tip CPX-VF equipment (up to 76 GHz, 2K criogenics temperature and up to 2.5 T magnetic field), Lake Shore Cryotronics tip EM-4V electromagnet up to 0,45 T / 100 mm, Measurement accessories, Computers and software for microwave electromagnetic simulations (IE3D, Fidelity, CST).

Team

The laboratory head is **Dr. Alexandru Muller**, PhD in Physics at Bucharest University in 1990. His competences includes Silicon, GaAs and GaN micromachining and nanomachining: manufacturing of RF MEMS components and circuits, technological process in GaAs MMICs, design, modelling and manufacturing of microwave passive membrane supported circuits, monolithically as well as hybrid integrated receiver front end modules, acoustic devices (FBARs and SAWs) based on micromachining and nano-processing of wide band gap semiconductors (AlN , GaN).
The research team has multidisciplinary expertise in physics and electronics of microsystems and is composed of 13 senior researchers (11 of them with PhD in physics and electronics) and two young researchers, PhD in electronics.

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

Ongoing projects

International Projects

CHIRON-H2020-FETOPEN-2016-2017 No: 801055 *"Spin Wave Computing for Ultimately-Scaled Hybrid Low-Power Electronics"* Coord. IMEC Belgium, 9 partners, 2018-2021, IMT partner;

Qubits-H2020 FETOPEN no. 829005 "*Integrated Qubits Towards Future High-Temperature Silicon Quantum Computing Hardware Technologies"*, Coord. Aarhus Univ. (DK), 6 parteners, 2019–2023, IMT partner;

NANOPOLY-H2020 FETOPEN no. 82906 *"Artificial permittivity and permeability engineering for future generation sub wavelength analogue integrated circuits and systems"* Coordonator: Thales TRT, Franta; 8 partners, 2019-2021, IMT partner;

NANOSMART - H2020 ICT RIA, no. 825430, *"NANO components for electronic SMART wireless systems"*, Coordonator: Thales TRT, Franta; 10 partners, 2019-2021, IMT partner.

National projects

PN III projects: one exploratory research project (2017-2019 www.imt.ro/supragan) coordinator Dr. A. Müller, **one complex research frontier project** (2018 – 2021 http://www.imt.ro/grapheneferro/) coordinator Dr. M. Dragoman and **one post doctoral research project** (2018 – 2020 http://www.imt.ro/M-TMA-ID) coordinator Dr. Martino Aldrigo.

Laboratory of micromachined structures, microwave circuits and devices

Most important scientific results

H2020, FETOPEN project, "Spin Wave Computing for Ultimately-Scaled Hybrid Low-Power Electron-ics", CHIRON, (2018 - 2021)

Coordinated by IMEC, Belgium; IMT partner, responsible: Dr Alexandru Muller

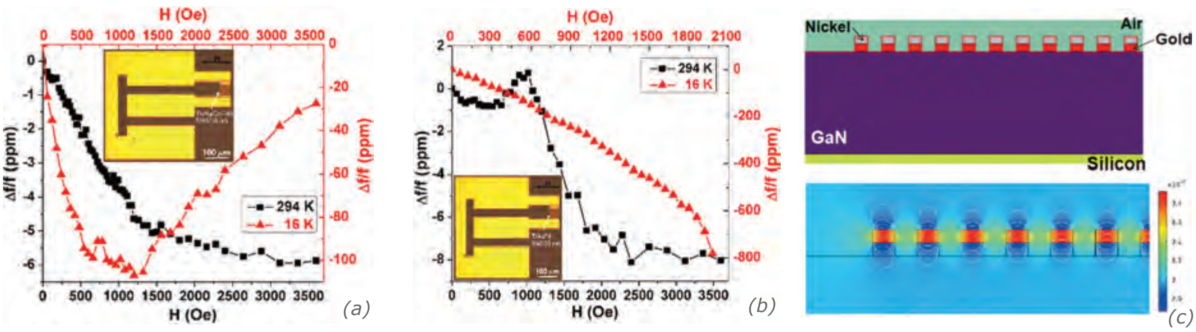
Other partners: TECHNISCHE UNIVERSITAET KAISERSLAUTERN Germany, Universite Paris-Sud France, Solmates BV Netherlands, CNRS France, FORTH-Heraklion Greece, THALES SA France, TECHNISCHE UNIVERSITEIT DELFT Netherlands

Within this project, the main objective of IMT is the manufacture of acoustic devices (SAWs and FBARs) on GaN piezoelectric layers, having resonant frequencies in the GHz range, capable of coupling the surface and bulk acoustic waves with the spin waves.

Magnetic sensors based on GaN/Si one port SAW resonators

cooperation between IMT, IMEC and Technische Universitaet Kaiserslautern

One port SAW resonators, having resonance frequencies >6 GHz, have been manufactured on GaN/Si. Two different magnetostrictive elements (Ni and CoFeB) have been directly deposited on the interdigital transducer (IDT) of the SAW structures. The variation of the resonance frequency with the applied magnetic field was analyzed for GaN/Si SAW resonators, having these types of magnetostrictive elements. The magnetic sensitivity of SAW structures was analyzed at room and cryogenic temperatures for a magnetic field, H, between 0 and 3600 Oe. A very high sensitivity (800 ppm) has been obtained at T = 16 K for the SAW structures having Ni as magnetostrictive element deposited on the IDT. The SAW structures having Ni in the composition of the IDTs were simulated in Comsol Multiphysics and the effect of the magnetic field on the stress of the structure has been analyzed at room temperature and also at the cryogenic temperature of 16 K. The obtained results aim emerging applications of SAW resonators in spin wave pumping, which is one of the main objectives of the CHIRON project.



The relative resonance frequency shift vs. H for SAW structures with (a) CoFeB layer and (b) Ni layer deposited on the IDTs; (c) FEM simulation of the magnetic field from the IDTs area for SAW structures having Ni deposited on IDTs at B = 3000 Oe and T = 16 K

Magneto-electric thin-film GaN bulk acoustic wave resonators

Magneto-electric thin-film GaN bulk acoustic wave resonators were developed together with FORTH Heraklion, in the frame of the CHIRON project. The piezoelectric resonance frequency is 2.98 GHz. Measurements were performed for in and out of plane external magnetic fields, in a controlled temperature and pressure environment. For a change in the external magnetic field of 2850 Oe, changes of 1521 ppm (in plane magnetic field) and 4123 ppm (out of plane magnetic field) of the S_{21} scattering parameter amplitude were recorded. Target applications are spin wave generation and low power magnetic sensors.

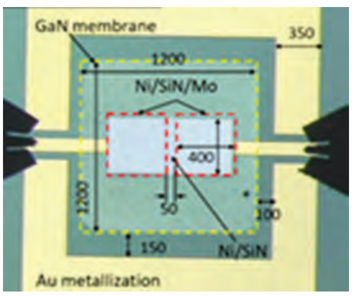
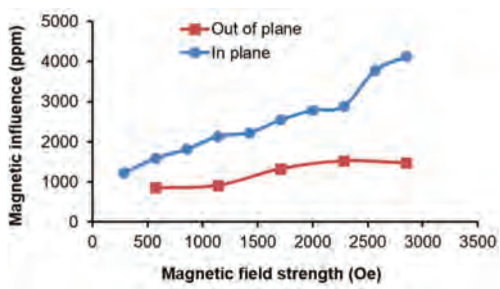
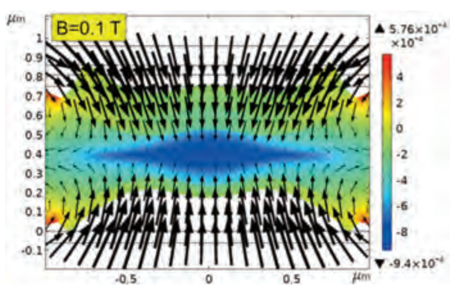


Photo of the device with dimensions in microns



Magnetic influence on the amplitude of the S_{21} parameter



Simulation of the effect of a 0.1 T external magnetic field at 2.98GHz

Most important scientific results

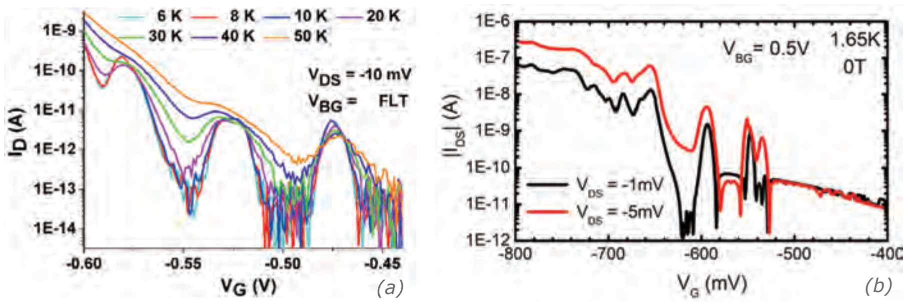
H2020, FETOPEN project „iQubits Integrated Qubits Towards Future High-Temperature Silicon Quantum Computing Hardware Technologies", iQubits (2019 - 2023)

Coordinator Aarhus University Denmark; IMT partner, responsible: Dr. Alexandru Muller
Other partners: CNR Istituto Nanoscienze Italy, Univ. of Toronto Canada, FORTH Heraklion Greece, MDLAB SRL Italy

The IMT objectives within this project are: -cryogenic measurements (down to 2K) for qubit type transistors;
-development of a set-up for cryogenic S-parameters measurements up to 110 GHz and T = 4K;
-development of a technological process (including nanolithographic processes with a resolution below 20 nm) in order to obtain transistor test structures;

Cryogenic measurements of the transfer characteristics for qubit pMOS type transistors (cooperation between IMT and University of Toronto)

In this stage, the transfer characteristics (source-drain current function of gate source-voltage) were analyzed for qubit SiGe pMOS type transistors, designed by the University of Toronto (UofT) and manufactured in 22 nm technology. The transfer characteristics of the pMOS type transistors have been performed by maintaining the value of the drain voltage at -10 mV and varying the temperature between 50 K and 6 K. The measurements were performed with a cryogenic equipment (able to cool down to 5 K) developed in the frame of the laboratory for microwave (on wafer) measurements up to 67 GHz. The quantum effects of pMOS type transistors are prsented in figure a. Figure b pesents the first measurements performed with a new equipment, available in laboratory, capable to measure both I-V and microwave characteristics up to 67 GHz, at temperatures below 2 K, in the presence of a magnetic field up to 2.5 T. A scientific researcher from University of Toronto participated at these measurements.



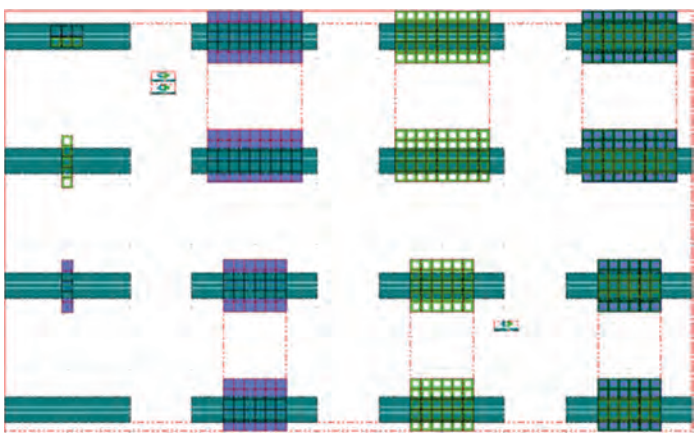
Transfer characteristics of pMOS transistor for (a) different temperature values at a constant drain voltage value and (b) different drain voltage values at a temperature of 1.65 K

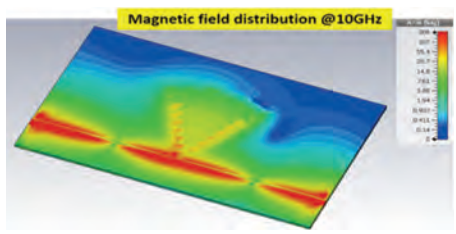
Project H2020 FETOPEN, "Artificial permittivity and permeability engineering for future generation sub wavelength analogue integrated circuits and systems", NANOPOLY (2019 - 2021)

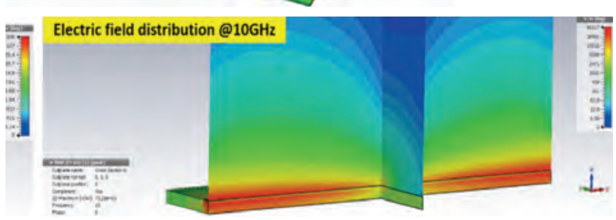
Coordinator: Thales TRT, France; IMT responsible: Dr. Mircea Dragoman; Other partners: FORTH-Heraklion (Greece), IHP GMBH (Germany), CEA-Grenoble (France), UnivPM-Ancona (Italy), RF Microtech SRL (Italy), ICN2 (Spain)

Design and electromagnetic simulation of patch antennas, spiral inductors, stub inductors and coplanar waveguide (CPW)-based lines, with operating frequencies at 10 GHz and 28 GHz, for their integration with meta-materials based on electric and magnetic resonators, with miniaturized dimensions with respect to the free-space wavelength.

We designed and simulated patch antennas, spiral inductors, stub inductors and coplanar waveguide (CPW)-based lines, with operating frequencies at 10 GHz and 28 GHz, for their integration with meta-materials based on electric and magnetic resonators, with miniaturized dimensions with respect to the free-space wavelength. We also analysed the distribution of the electric and magnetic fields to optimise the position of the meta-materials in the most favourable spots, in order to maximise the effects of the deployed meta-materials in terms of miniaturization/manipulation of the phase velocity in CPW-based structures. We fabricated the optical masks necessary for the fabrication of all the above-mentioned components.







Laboratory of micromachined structures, microwave circuits and devices

Most important scientific results

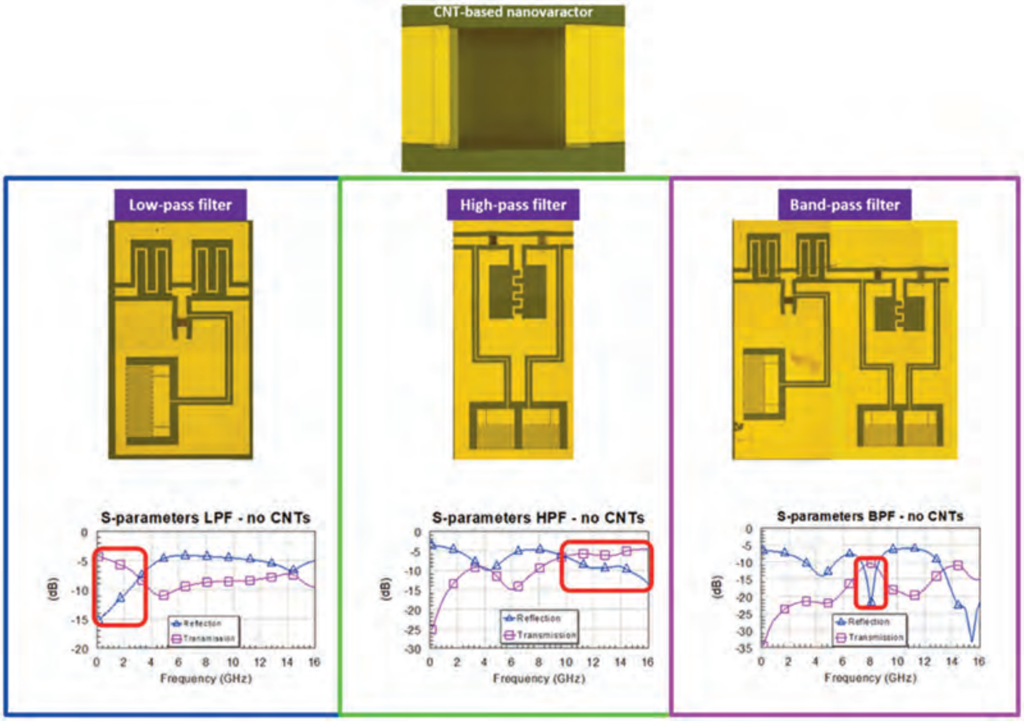
Project H2020 ICT RIA "NANO components for electronic SMART wireless systems", NANOSMART, (2019 - 2023)

Coordinator: Thales TRT, France; IMT responsible: Dr. Mircea Dragoman; Other partners: FORTH-Heraklion (Greece), Chalmers (Sweden), SHT (Sweden), UnivPM-Ancona (Italy), ESPCI (France), RF Microtech SRL (Italy), Tyndall (Ireland), ICN2 (Spain)

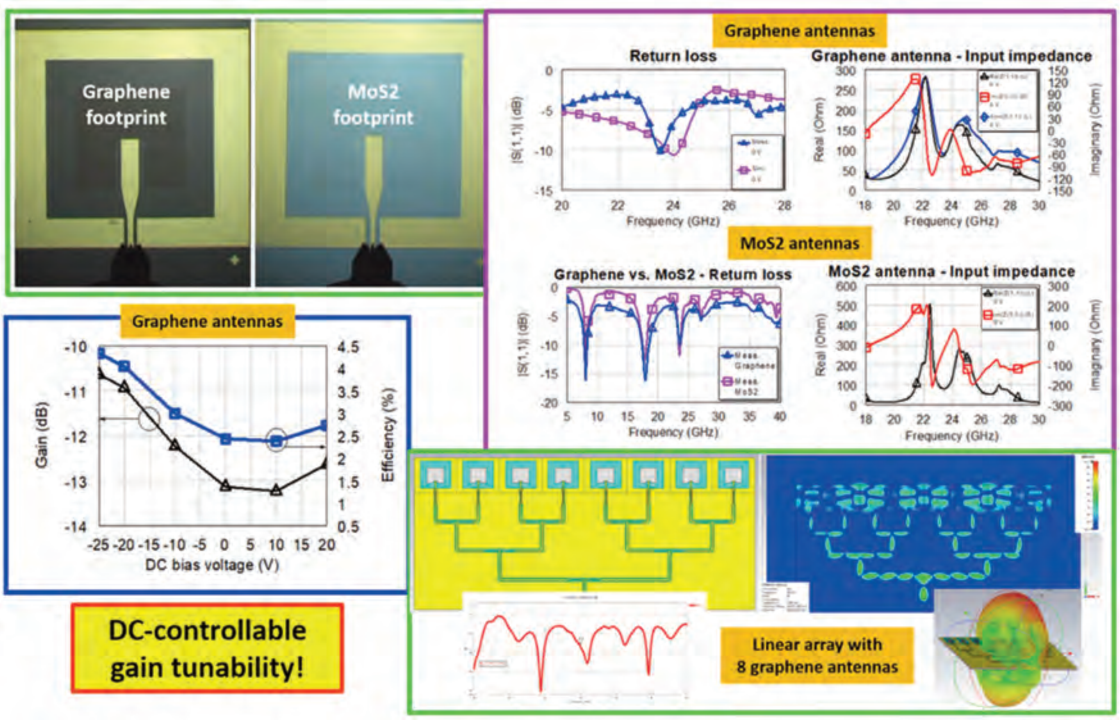
Design, fabrication and electrical characterization of:

1) CNT-based filters in the X band (8-12 GHz); 2) patch antennas based on monolayer graphene and monolayer molybdenum disulfide (MoS_2), with operating frequency between 10 GHz and 24 GHz.

1) We designed, fabricated and electrically characterized (in DC and at microwaves) reconfigurable X band (8-12 GHz) filters integrating varactors (i.e. variable capacitors) based on vertical carbon nanotubes (CNTs). These varactors provide a variable capacitance depending on the DC bias applied to the CNTs.



2) We designed, fabricated and electrically characterized (in DC and at microwaves) patch antennas based on monolayer graphene and monolayer molybdenum disulfide (MoS2), with operating frequency between 10 GHz and 24 GHz and reconfigurable gain, which depends on the DC bias voltage applied onto the graphene (MoS_2) monolayer.



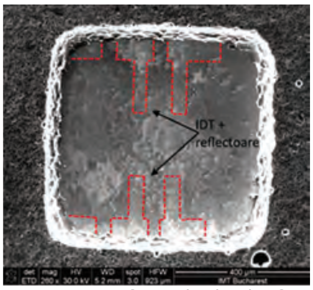
Laboratory of micromachined structures, microwave circuits and devices

Most important scientific results

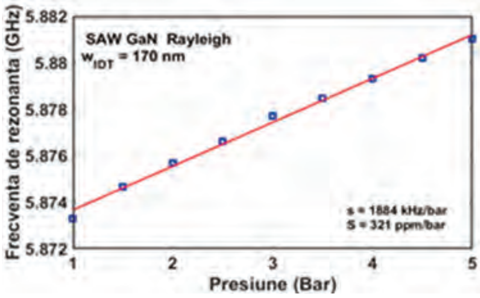
PN III IDEAS PCE, Ctr 147/2017, "Investigation of superior propagation modes in GHz operating GaN based SAW devices targeting high performance sensors and advanced communication system applications" Project coordinator Dr. Alexandru Müller

Pressure sensitivity of the SAW structure on GaN membrane

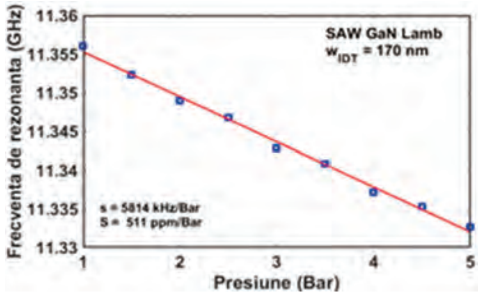
SAW "single resonator" and SAW "face to face" structures were manufactured on 1.2 μm thickness GaN membrane. The membrane is centered under the interdigitated transducer (IDT) having 500 μm x 500 μm area. The didit/interdigit width is 170 nm for the "single resonator" structures and 130 μm for the "face to face" structures. The structures have two resonance frequencies corresponding to the Rayleigh (5.8 GHz) and respectively Lamb (11.3 GHz) propagation modes appearing in the membrane supported SAW structures. Sensitivity versus pressure for Rayleigh and Lamb modes, at the room temperature, was determined for "single resonator" type SAW structure. The resonance frequency for Rayleigh mode is increasing with increasing of the pressure (321 ppm/Bar sensitivity) and is decreasing with the increasing of the pressure for the Lamb mode (511 ppm/Bar sensitivity).



SEM image from the back of a "face to face" type SAW structure with an area of 500 μm x 500 μm



Resonance frequency versus pressure for the Raleigh mode

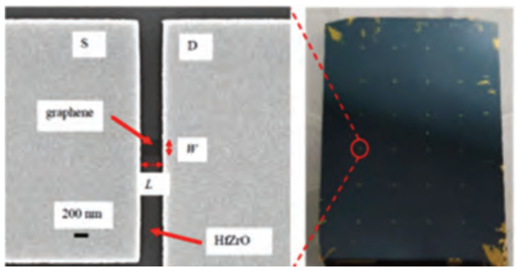


Resonance frequency versus pressure for the Lamb mode

PN-III-PCCF, "Advanced nanoelectronic devices based on graphene/ferroelectric heterostructures", GRAPHENEFERRO, Coordinator: Dr. Mircea Dragoman

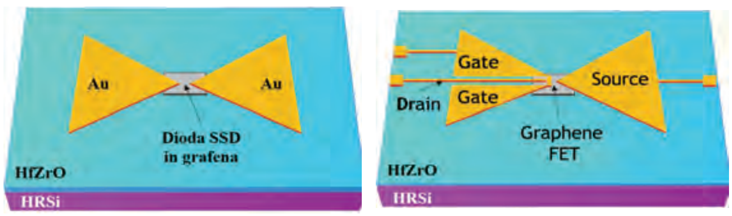
Advanced nanoelectronic devices based on graphene/ferroelectric heterostructures

We optimised the growth process of ferroelectrics based on hafnium dioxide (HfO_2) using Atomic Layer Deposition (ALD) method and Magnetron sputtering, doping HfO2 with Zr, Al, and Ge at the wafer level (4-inch). The results have been reported in papers published in high-impact factor journals.



Graphene/HfZrO FET (L=400 nm, W=300 nm)

Moreover, we succeeded to transfer graphene onto ferroelectric substrates and we fabricated FET transistors. We calculated the charge mobility as high as 8000 cm^2/Vs. We also validated experimentally the theory underneath such ferroelectric-based transistors, in the sense that the ferroelectric HfZrO layer opens a bandgap of 0.3 V in monolayer graphene. We published these results in two (2) papers in ISI journals with high impact factor.



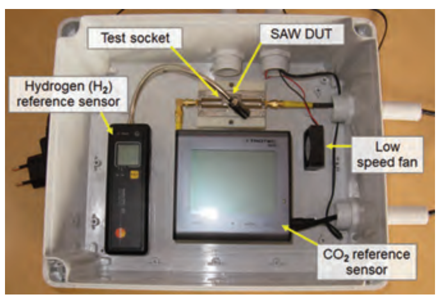
Design of demo 1 of the project – high-frequency FET detector based on graphene/HfZrO

TGE-PLAT Project – Contract subsidiar: Platforma senzitiva cu senzor SAW pentru detectia de gaze inflamabile, potential explozive (C77.3D)

Responsible from L4: Dr Valentin Buiculescu Parteneri: ROMQUARTZ S.A. (Romania)

Laboratory setup intended for the measurement and calibration of hydrogen and carbon dioxide SAW gas sensors.

A multi-sensor hermetically sealed enclosure was realized for the measurement of either CO2 or H2 gas concentration, and additional environmental parameters: temperature and relative humidity. The RF system covers MHz – 1000 MHz frequency range.



Inner view of the hermetically sealed enclosure for SAW sensors' characterization.

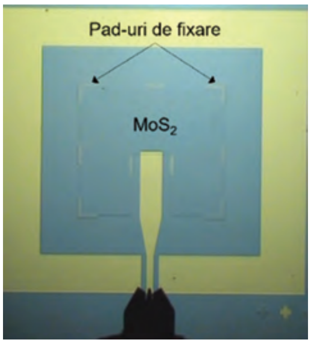
Laboratory of micromachined structures, microwave circuits and devices

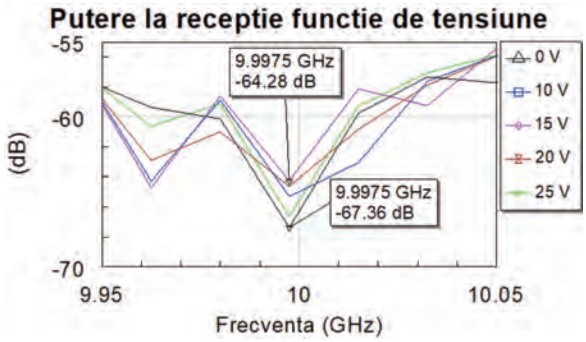
Most important scientific results

PN-III-P1-1.1-PD-2016-0535, „Smart Radio Frequency IDentification (RFID) Technology exploiting Two-Dimensional Material-based Time-Modulated Arrays", M-TMA-ID (2018-2020), Coordinator: Dr. Martino Aldrigo

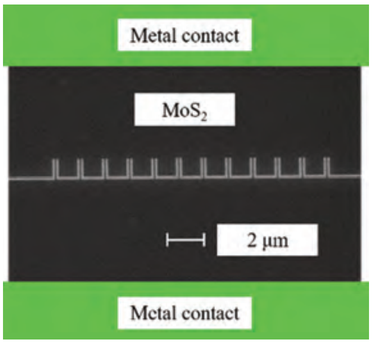
Design, simulation, fabrication and experimental characterization (in DC and at microwaves) of patch antennas based on molybdenum disulfide (MoS_2); design and fabrication of self-switching diodes (SSDs) based on MoS_2.

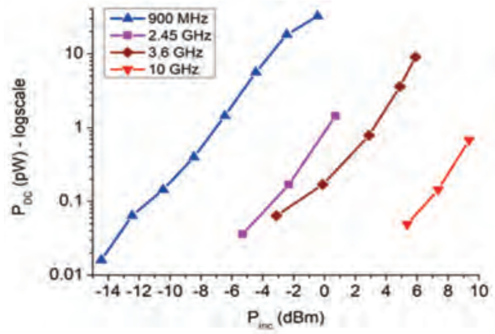
1) We designed a patch antenna controlled through a DC bias electric field, since molybdenum disulfide is able to switch its electric state (insulator-metal or vice versa) in a few picoseconds, which means that it behaves like an ultrafast switch. The fabricated antenna exhibits good radiation characteristics, especially with regard to the gain tunability by means of the applied DC bias voltage. This result, so far never reported in the literature, gives a proof of how one can select a desired value of antenna's gain as a function of the biasing voltage. In detail, at around 10 GHz the received power varies from -67.36 dB (0 V) up to -64.28 dB (15 V), which represents a gain tunability of more than 3 dB.





2) We fabricated self-switching diodes (SSDs) based on multilayer MoS_2, using an optical mask that comprises multiple typologies of diodes in CPW configurations with stubs of different lengths (300, 500, 700 and 900 µm) for the high-frequency matching of diode's impedance to the standard 50Ω impedance of the excitation ports. The detected power reaches values between 0.016 pW and 32.4 pW at 900 MHz, and between 49 fW and 676 fW at 10 GHz.





Centre of Nanotechnologies

Laboratory of Nanobiotechnologies

Mission

The mission of L1 is to propose and approach research directions in the field of nanostructures/nanomaterials/nano-composites, aiming to comprehend their properties and to find novel technological solutions for integration in devices with applications in sensing, medicine and energy. Furthermore, training programmes in collaboration with universities, as well as experimental and characterization services in the field of nano-bio-technologies are carried out. project (NANOSMART).

Research areas

The main areas of activity are:

(i) fabrication of functional nanomaterials / nanostructures, investigation, control and tuning their properties for specific applications;

(ii) supporting the development of some industrial safety nanoproducts for health and enviromental protection by assessing the toxicity/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, as well as hybrid systems for applications in multiple fields, from gas / temperature sensors to energy (e.g. micro-supercapacitors, solar cells or miniaturized fuel cells as clean energy sources).

Team

1. **Adrian Apostol,** Chemist, PhD. student, Research Assistant;
2. **Adina Boldeiu**, Chemist, PhD., Research Scientist II;
3. **Alexandra Purcarea**, Chemist, MSc student, Research Assistant
4. **Alexandru Bujor**, Chemist, MSc student, Research Assistant
5. **Alexandru Salceanu**, Physicist, Research Scientist;
6. **Cosmin Romanitan**, Physicist, PhD student, Research Scientist;
7. **Elena Constantin**, Engineer, MSc student, Research Scientist;
8. **Irina Bratosin**, Physicist, MSc student, Research Scientist;
9. **Iuliana Mihalache**, Physicist, PhD, Research Scientist III;
10. **Melania Popescu**, Biologist, PhD student, Research Scientist;
11. **Mihaela Kusko**, Physicist, PhD, Research Scientist I, head of L1 laboratory;
12. **Mihai Mihaila**, Physics Engineer, PhD, Research Scientist I, Associate Member of Romanian Academy;
13. **Monica Simion**, Physicist, PhD, Research Scientist I;
14. **Pericle Varasteanu**, Physicist, PhD student, Research Assistant;
15. **Razvan Pascu**, Electronics Engineer, PhD, Research Scientist III.

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

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

Equipment

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

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

● **Electrochemical Scanning Microscope** ElProScan (Heka, Germany), contact persons: *M St. Alexandru Bujor, 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 (Metrohm Autolab, NL)
contact persons: *M St. Irina Bratosin, Dr. Mihaela Kusko; Dr. Antonio Radoi*

● **Autolab TWINGLE/ SPRINGLE Surface Plasmon Resonance instrument** (Metrohm Autolab, NL)
contact persons: *M St. Elena Constantin, PhD St. Pericle Varasteanu*

● **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*

● **Programmable Dip Coater for layer-by-layer thin film deposition** (Automated Dip Coater PTL-OV5P MTI Group, USA), contact persons: *Dr. Adina Boldeiu, Dr. Monica Simion*

Laboratory of Nanobiotechnologies

National and international collaboration:

Ongoing projects

• **PN-III-P1-1.2-PCCDI-2017-0820 -** "New methods of pregnancy monitoring and prenatal diagnosis -*MiMoSa*" (2018-2020), Project director: Dr. Monica Simion

• **PN-III-P1-1.2-PCCDI-2017-0419 -** „Sensors and Integrated Electronic and Photonic Systems for people and Infrastructures Security – *SENSIS*", 2nd component project - "SiC-based hydrocarbons sensors for measuring the hydrogen and hydrocarbons in hostile industrial environments", IMT responsible - Dr. Razvan Pascu

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

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

• **PN-III-P2-2.1-PED-2016-0510** – „Dye-sensitised solar cells by molecular engineering of phenoxazine- or phenotiazine-based sensitizers - *EngDSSC*" (2017-2019) - coordinator: Institute of Macromolecular Chemistry "Petru Poni" Iasi; Resp. IMT – Dr. Mihai Mihaila

Most important scientific results

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

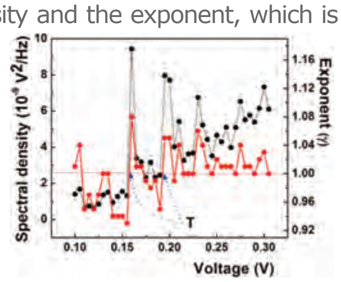
• Electron-phonon coupling as the source of 1/f noise in carbon soot

Two 1/f noise peaks were observed at Kohn anomalies of graphite in a carbon nanoparticle resistor. The ratio of electron-phonon matrix elements at anomalies calculated from the noise data was found to be the same as the one from Raman spectrum.


SCIENTIFIC REPORTS

OPEN Electron-Phonon Coupling as the Source of 1/f Noise in Carbon Soot

It resulted that electron-phonon interaction is the microscopic source of 1/f noise in carbon soot. A new, very general formula has been deduced for the frequency exponent. The interplay nonlinearity-dispersion in this formula predicts sublinear-supralinear transitions in the exponent at Kohn anomalies, which have been observed experimentally. A quadratic dependence of the 1/f noise parameter on the matrix element was proposed and used to explain the M shape of the noise intensity in graphene. The voltage dependence of the exponent tracks the noise intensity one, both featuring a similar structure, which has been correlated with the phonon energies of graphite. Hence, the electron-phonon coupling controls both the noise intensity and the exponent, which is possible only if 1/f noise spectrum extends into the thermal noise of the resistor till phonon frequencies. This extension implies a classic-quantum crossover, above which Planck blackbody radiation is valid (equipartition violation).



Dependence of the spectral density (black points) and frequency exponent (γ, red points) on voltage. Transitions (T) from γ<1 to γ>1 are visible at both Kohn anomalies. The two parameters feature a similar structure.

*"**Electron-phonon coupling as the source of 1/f noise in carbon soot**"*, Mihai Mihaila*, Doru Ursutiu, Ion Sandu, Scientific Reports 9, article number 947, 2019.

• Developement of a new non-destructive method for the strain investigation in highly dense nanowire arrays

A reliable and non-destructive X-ray laboratory formalism was developed to allow local examination along nanowires length that can be exploited to obtain finally the in-depth strain map and a quantitative description of the transfer energy processes between nanowires and dislocations.

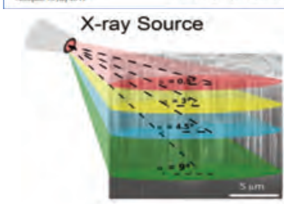

research papers

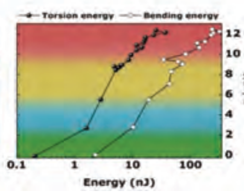
JOURNAL OF APPLIED CRYSTALLOGRAPHY

Unravelling the strain relaxation processes in silicon nanowire arrays by X-ray diffraction

Cosmin Romanitan, Mihaela Kusko, Marian Popescu, Pericle Varasteanu, Antonio Radoi and Cristina Pachiu

The method lies in changing the incidence angle, and thus investigation at different penetration depths. Thus, if in most cases, the X-rays diffraction studies concerning the strain in nanowires systems employ synchrotron X-ray sources, our formalism enables us to build unambiguously the bending and torsion profiles and to gain a quantitative description of the relaxation processes in connection with their morphological features using laboratory X-ray diffraction experiments.





Unlike the standard X-ray diffraction models, this novel approach allows us an individual study of the effects given by the bending, torsion and structural defects in the X-ray experimental profiles. The proposed method takes into account the finite penetration depth nature of the X-rays, as well as their ability to quantify the bending and torsion, in terms of tilt and twist. The obtained profiles show the occurrence of the coalescence processes for different array morphologies, and the experimental position for the coalescence has a small deviation than theoretical one. Moreover, the strain relaxation mechanisms were highlighted in the investigated systems, and finally the density of both edge and screw threading dislocations was estimated.

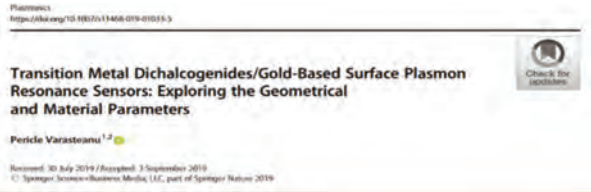
*"**Unravelling the strain relaxation processes in silicon nanowire arrays by X-ray diffraction**"*, Cosmin Romanitan*, Mihaela Kusko, Marian Popescu, Pericle Varasteanu, Antonio Radoi, Cristina Pachiu, **Journal of Applied Crystallography**, *52, 1077-1086, 2019.*

Laboratory of Nanobiotechnologies

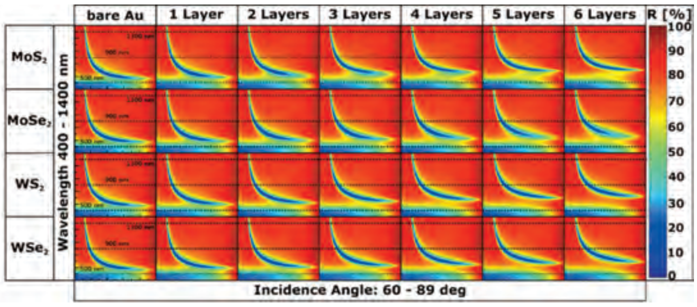
Most important scientific results

• Numerical studies of the influence of 2D Materials (MoS_2, WS_2, $MoSe_2$, WSe_2) on Surface Plasmon Resonance based sensors' response by exploring the geometry and material parameters

The sensors' response was correlated with the properties of surface plasmons from both gold-dielectric interface and gold-2D material-dielectric interface by analyzing dispersion relation and reflectivity maps.


Transition Metal Dichalcogenides/Gold-Based Surface Plasmon Resonance Sensors: Exploring the Geometrical and Material Parameters

Pericle Varasteanu[1,2]



Reflectivity maps for different sensors' configurations for visible and near-infrared wavelengths range (400-1400 nm)

To gain an insight about the mechanisms that improves sensitivity for the modified structures, dispersion relations were obtained using COMSOL Multiphysics (RF Module) and reflectivity maps were calculated employing the Transfer Matrix Method.

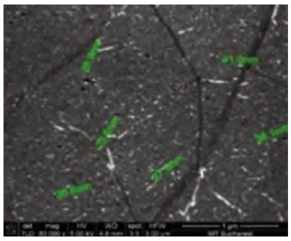
The sensors sensitivity was calculated in both reflectivity and phase for small variations of sensing mediums' refractive index (0.0001 to 0.02 RIU). The modified structures exhibiting a great improvement in sensitivity in comparison with the classic structure (Au-dielectric) due to the increased absorption in additional layers of 2D materials.

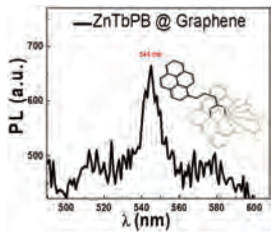
*"**Transition metal dichalcogenides/gold based surface plasmon resonance sensors: exploring the geometrical and material parameters**"*, Pericle Varasteanu*, **Plasmonics**, First Online: 12 September 2019

• New compounds / metal complexes with superior optoelectronic properties

The synthesis of pyrene 1,3,4-oxadiazole derivatives with high photoluminescence (PL) quantum yield ranging between 87-97% was successfully performed. Also, lanthanide metal–organic frameworks (LnMOFs) with very narrow PL bands located in the Vis-NIR do¬¬main were synthesized. The ligand in the form of a Schiff base allows the attachment of the two different metal ions (Zn-Ln) while pyrene allows binding of these complex combinations to a graphene support. The ZnTbValpn (hfac) PB @ graphene nanosystem resulted from the uniform decoration of graphene monolayer with derivatives of the Zn-Ln complexes.

Also, graphene quantum dots - molybdenum disulphide compound (MoS2-GQDs) was obtained using hydrothermal method assisted by MWs. The PL quantum yield increased from 20% (GQDs) to 53.46% (MoS2-GQDs) at 340 nm excitation. The results demonstrate the efficacity of the method which can be applied at large-scale with low costs. The compound could lead to better photoelectric performance in nano-optoelectronic applications compare to graphene or molybdenum disulfide (MoS2) used separately.





Project: New nanosistems for opto-electronic signal enhancement on Si or SiC nanostructurated substrate, MICRO-NANO-SIS PLUS Contract nr. 14N/2019 – Project Director Iuliana Mihalache

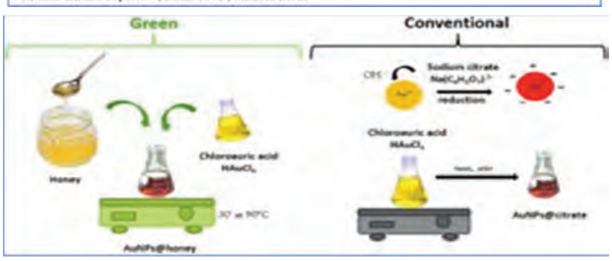
Project: ***New nanosistems for opto-electronic signal enhancement on Si or SiC nanostructurated substrate****,* MICRO-NANO-SIS PLUS Contract nr. 14N/2019 – Project Director **Iuliana Mihalache**

Direction II - Physico-chemical studies for toxicity and risk assessments of nanomaterials


Journal of Photochemistry & Photobiology, B: Biology

Comparative analysis of honey and citrate stabilized gold nanoparticles: In vitro interaction with proteins and toxicity studies

Adina Boldeiu, Monica Simion, Iuliana Mihalache, Antonio Radoi, Melania Banu, Pericle Varasteanu, Paul Nadejde, Eugeniu Vasile, Adriana Acasandrei, Roxana Cristina Popescu, Diana Savu, Mihaela Kusko



• Comparative study of honey and citrate stabilized gold nanoparticle behavior: in vitro interaction with proteins and toxicity studies.

Gold nanoparticles of comparable size were synthetized using honey mediated green method (AuNPs@honey) and citrate mediated Turkevich method (AuNPs@citrate). Their colloidal behavior in two cell media DMEM and RPMI, both supplemented with 10% FBS, was systematically investigated with different characterization techniques in order to evidence how the composition of the media influences their stability and the development of protein/NP complex. We revealed the formation of the protein corona which individually covers the nanoparticles in RPMI media, like a dielectric spacer according to UV-Vis spectroscopy, while DMEM promotes more abundant agglomerations, clustering together the nanoparticles.

*"**Comparative analysis of honey and citrate stabilized gold nanoparticles: In vitro interaction with proteins and toxicity studies**", Adina Boldeiu, Monica Simion, Iuliana Mihalache, Antonio Radoi, Melania Banu, Pericle Varasteanu, Paul Nadejde, Eugeniu Vasile, Adriana Acasandrei, Roxana Cristina Popescu, Diana Savu, Mihaela Kusko,* **Journal of Photochemistry and Photobiology B: Biology** *197, 111519 (2019)*

Laboratory of Nanobiotechnologies

Most important scientific results

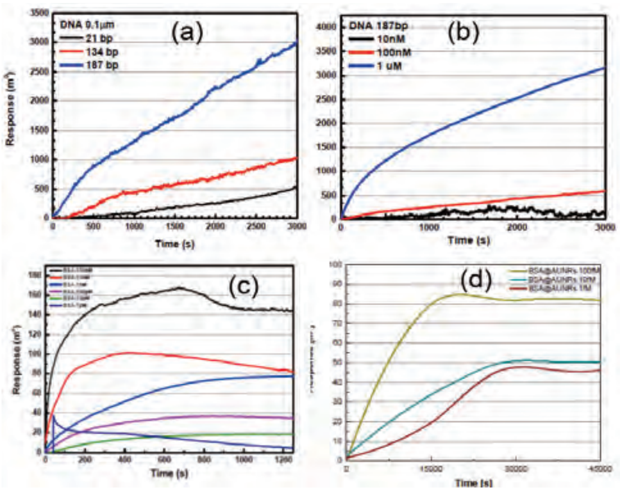
Direction III – Nanobiotechnologies / Biosensors

• Project: New methods of pregnancy monitoring and prenatal diagnosis – MiMoSa, COORDINATOR: Nanobiotechnologies Laboratory - INCD for Microtechnology, Contract no. 67PCCDI / 2018, project director: Dr. Monica Simion.

Project 1 - Non-invasive prenatal screening using free circulating fetal DNA extracted from maternal blood – SPR-DNA, Component project director IMT: Dr. Razvan Pascu (Dr. Melania Popescu).

Given the main objective of the project, which is detection of specific DNA sequences obtained by isolating fetal DNA in the mother's blood in the first months of pregnancy, which involves the analysis of picomolar concentrations, finding a method to amplify the SPR signal is necessary.

For this, the amplification of the signal can be obtained by using larger molecules that can be obtained in two ways: (i) the introduction of specific DNA sequences called helpings or (ii) the conjugation of gold nanorods of interest. In case of first method, ssDNA probes with different lengths and concentrations were immobilized on the Au surface. By attaching single-stranded DNA fragments to the surface of the gold film, we studied the changes in the SPR response for three DNA probes with different length 21, 134 and 187 bp. The lowest concentration determined was 10 nM for the 187 bp size DNA sequence. The second method of signal amplification by conjugation with AuNRs was tested for BSA to achieve a greater decrease in the detection limit. The interaction of gold nanorods (AuNRs) with bovine serum albumin protein (BSA) at physiological pH is investigated using as buffer MgCl2 to obtain dilutions of BSA @ AuNRs from a concentration of 1 µM to 1 fM. *It has proved a successful detection of low concentration (10 pM) using a larger molecule, BSA. A signal amplification can be obtained by binding gold nanorods to BSA molecules. The results confirmed that the detection limit of high molecular weight molecules can be reduced by modification with nanoparticles that are responsible for promoting further signal amplification.*



Sensograms corresponding to DNA immobilization on the surface of the Au sensor (a,b) and various concentrations of BSA (c) and BSA@AuNRs (d).

Dissemination: "***The influence of molecular weight of ssDNA-SRY and BSA on SPR signal amplification***", Elena Constantin, Melania Popescu, Monica Simion, EuroNanoForum 2019.

"Label free detection of protein using SPR signal", Elena Constantin, Melania Popescu, Monica Simion, NN 2019 - 16th International Conference on Nanosciences & Nanotechnologies, 2019.

"Enhancement of SPR signal using gold nanorods", Elena Constantin, Melania Popescu, Monica Simion, Adina Boldeiu, Iuliana Mihalache, International Semiconductor Conference (CAS), Sinaia, 9-11 Oct., 2019.

Project 3 - Assessment of the risk of premature birth due to HPV infection, Component project director IMT: Dr. Iuliana Mihalache.

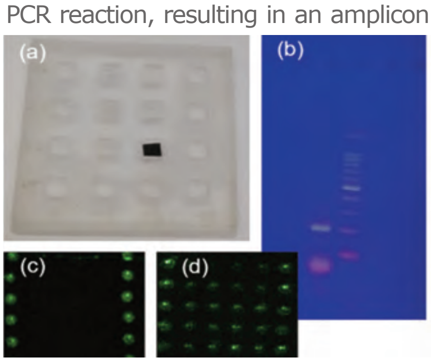
Two main directions were taken into account for the test structure design and fabrication: building blades as small as possible so that material consumption is as small as possible, with obvious impact on the production cost of the microarray blade, but also opting for a blade model that it can be introduced into a pre-designed well so that the whole subsequent hybridization process is as efficient as possible.

For the fluorescent labelling of the samples, a higher efficiency and a higher concentration was obtained using the Cy3 PCR Labelling Kit from Jena Bioscience, which uses the incorporation of fluorescently labelled Cy3-dUTP nucleotides during PCR reaction, resulting in an amplicon containing several fluorescently labelled nucleotides with CY3 fluorochrome. The PCR reaction was performed on the BioradiCycler equipment.

Targeted microchips for samples tested for HPV16 by microarray technology had built-in test leads for positive control and identical replicates of different concentrations with specific HPV16 probes.

The results obtained by microarray technology were validated by RT-PCR and Sanger sequencing.

The prenatal diagnostic devices will be tested for detection of the HPV infection in real samples obtained by IOMC from 140 patients with risk of premature birth. The inclusion of patients in the study was achieved in compliance with the national and international ethical norms in force. The samples were taken and processed in order to extract the DNA by the partners.



(a) Image of molding with wells in PDMS; (b) Electrophoresis for amplicon with length 217bp; (c) Images with fluorescent probes used as control probes; (d) Blade images with hybridized fluorescent DNA with complementary probe immobilized on the slide.

Dissemination: ***„Microarray flexible platform manufactured on cotton fabrics coated with ultrathin ZnO layer"***, Melania Popescu, Florin Nastase, Elena Constantin, Monica Simion, Cosmin Romanitan, Marian Popescu, Conference of the Romanian Electron Microscopy Society - C.R.E.M.S., 23-25.10.2019, Poiana Brasov

Laboratory of Nanobiotechnologies

Most important scientific results

Direction IV – Opto-electronic devices based on nanomaterials / thin films

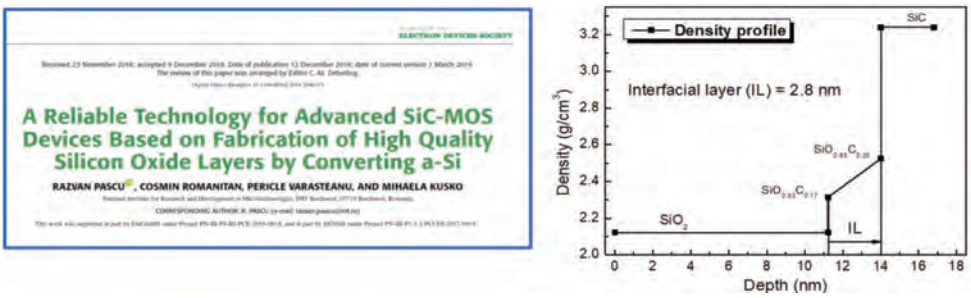
• SiC hydrocarbons sensors for security in hostile industrial environments

2nd constituent Project: „SiC-based hydrocarbons sensors for security in hostile industrial environments", IMT Team leader: Dr. Razvan Pascu, within the contract no. 71PCCDI / 2018, complex project realized in RDI consortia **"Sensors and Integrated Electronic and Photonic Systems for people and Infrastructures Security"- SENSIS"** - IMT coordinator, Project manager: C. Moldovan

The aim of the project is to design, manufacture and characterize gas sensors (hydrocarbons) based on new structures of unipolar devices on SiC - MOS capacitors (VARICAP), capable to operate up to 300°C with short response times (less than 5 s) and tolerance to hostile work environments.

1. Fabrication of the VARICAP devices based on 4H-SiC. Microphysical investigations.

The microphysical characterization of MOS sensor structures on SiC (by X-ray diffraction techniques) aimed to determine the properties of MOS oxide. The oxide / SiC interface was also investigated, with a thickness of approximately 2.8 nm of the interfacial layer.



MOS oxide profile on SiC and highlighting the oxide / SiC interface

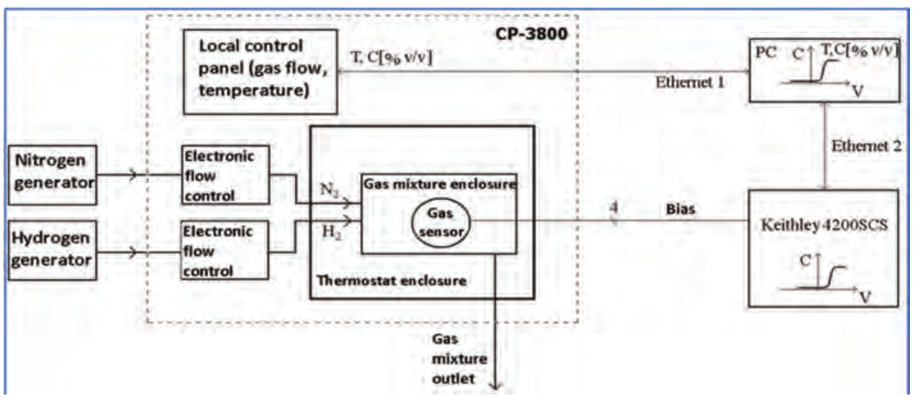
As it can be observed, a density of MOS oxide grown on SiC with a value of about 2.12 g/cm^3 was obtained. The C concentration at the SiO_2 / SiC interface was also determined. It is found that the interfacial layer is richer in C in the vicinity of the SiC.

2. Packaging of the SiC sensors

The packages were subjected to 1000 thermal cycles, in which the temperature varied between 50 and 400°C. Following the tests, the TO39 capsule was selected. The anode is contacted, by means of a gold wire with a thickness of 25 µm. The cathode of the diode is connected directly to the base. For this contacting, several gluing processes were tested using: an electrically and thermally conductive paste (Au or Ag); an Au-In alloy preform; a solid-solid diffusion.

3. Design and implementation of an electrical characterization system at different temperatures of gas sensors

The C-V characteristic of the VARICAP structure changes both with the variation of the gas concentration and with the temperature. As a result, the characterization of the gas sensor involves the creation of an environment with controlled gas concentration and temperature. A dedicated testing system has been designed and developed.



Electrical temperature measurement and characterization system for gas sensors. Block diagram.

Both equipment can be controlled either locally, from the device panel, or with a computer via Ethernet interfaces. In this way, the system has a great deal of flexibility and a degree of automation.

Dissemination:

» „A reliable technology for advanced SiC-MOS devices based on fabrication of high quality silicon oxide layers by converting a-Si", Razvan Pascu, Cosmin Romanitan, Pericle Varasteanu, Mihaela Kusko, IEEE Journal of the Electron Devices Society 7, 158-167 (2019).

» „400°C Sensor Based on Ni/4H-SiC Schottky Diode for Reliable Temperature Monitoring in Industrial Environments". Florin Draghici, Gheorghe Brezeanu, Gheorghe Pristavu, Razvan Pascu, Marian Badila, A. Pribeanu, E. Ceuca Sensors, 19(10), 2384 (2019).

» „Characterization of non-uniform Ni/4H-SiC Schottky diodes for improved responsivity in high-temperature sensing", G. Pristavu, G. Brezeanu, R. Pascu, F. Drăghici, M. Bădilă, Materials Science in Semiconductor Processing, 94, 64-69 (2019).

» „Nickel silicide compounds investigation obtained at low and high temperatures", R. Pascu, C. Romanitan , O. Tutunaru, F. Comanescu, M. Kusko, Gh. Pristavu, Gh. Brezeanu, International Semiconductor Conference (CAS 2019) Proceedings, pp. 319-322.

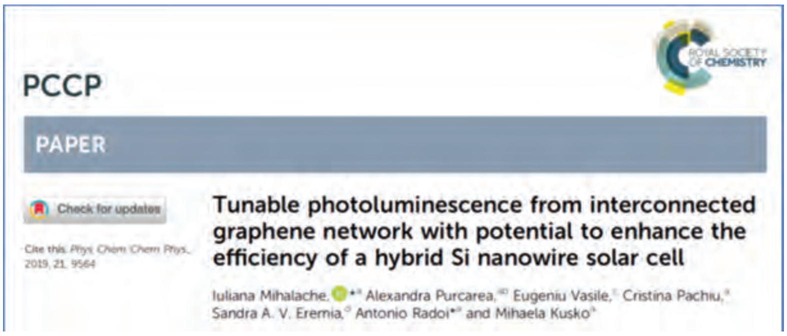
Laboratory of Nanobiotechnologies

Most important scientific results

• Photovoltaic devices on silicon based on interconnected graphene networks

Interconnected graphene networks (IGNs) synthesized using the MWs-assisted hydrothermal method showed excitation dependent PL emission located in the 300 - 500 nm range. Thus, IGNs could be considered the new member of the recently emerging class of PL tunable carbon nanomaterials.

Moreover, the optically active material had been successfully incorporated into a solar cell device based on the radial heterojunction of IGNs/silicon nanowires (p-SiNWs) fabricated with controlled electrochemical deposition at -2V for 300s.


PCCP

PAPER

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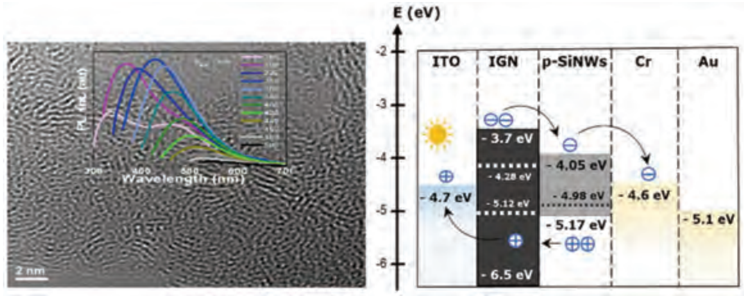
Cite this: Phys. Chem. Chem. Phys., 2019, 21, 9564

Tunable photoluminescence from interconnected graphene network with potential to enhance the efficiency of a hybrid Si nanowire solar cell

Iuliana Mihalache, Alexandra Purcarea, Eugeniu Vasile, Cristina Pachiu, Sandra A. V. Eremia, Antonio Radoi and Mihaela Kusko

The hybrid solar cell showed a conversion power 7.5 times higher than the reference cell. The short-circuit current density (Isc) incresed three times and the open-circuit voltage (Voc) increased by 9% realative to the reference cell. The effects induced by electrochemical deposition along and the propertise of IGNs contributed to the observed improvement of the cell. IMPS / IMVS spectroscopy demonstrated that IGNs successfully passivated the surface of p-SiNWs.



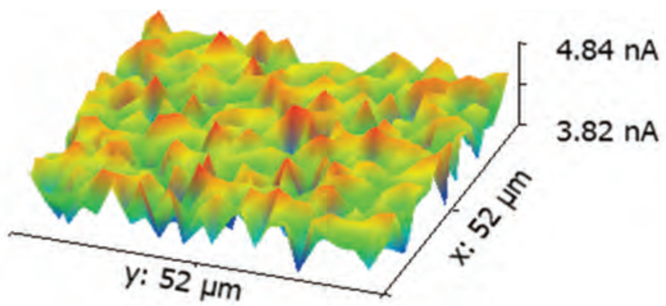
SEM image and PL spectra associated with IGNs (a) Diagram of energy levels in the solar cell (b).

Dissemination: *"Tunable photoluminescence from interconnected graphene network with potential to enhance the efficiency of a hybrid Si nanowire solar cell",* Iuliana Mihalache*, Alexandra Purcarea, Eugeniu Vasile, Cristina Pachiu, Sandra A. V. Eremia, Antonio Radoi*, Mihaela Kusko, **Physical Chemistry Chemical Physics***, 21, 9564-9573*

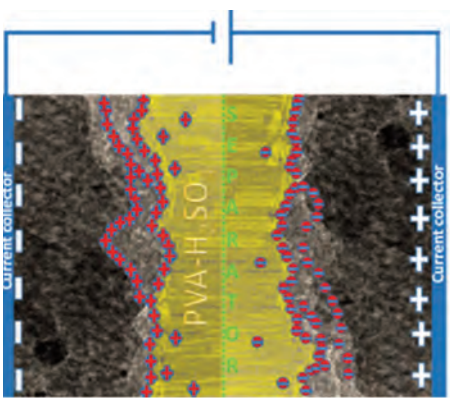
• Silicon based supercapacitors using graphene based nanocomposite as active material.

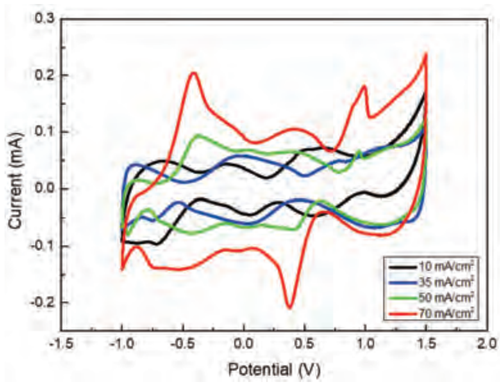
Quasi-solid symmetric microsupercapacitors were fabricated assembling two silicon based electrodes and PVA-H2SO4 gel electrolyte. The conformal modification of the ultra-high internal surface of nanoporous silicon was tackled by electrochemical polymerisation of quinone based polymers that can promotes faradaic charge storage. The additional thermal treatment determines a graphenic structure with local order, increasing the charge transfer.

The hybrid solar cell showed a conversion power 7.5 times higher than the reference cell. The short-circuit current density (Isc) incresed three times and the open-circuit voltage (Voc) increased by 9% realative to the reference cell. The effects induced by electrochemical deposition along and the propertise of IGNs contributed to the observed improvement of the cell. IMPS / IMVS spectroscopy demonstrated that IGNs successfully passivated the surface of p-SiNWs.



SEM image and PL spectra associated with IGNs (a) Diagram of energy levels in the solar cell (b).





Contract PN-III-P4-ID-PCE-2016-0618, *"Challenges and issues in engineering nano-systems based on graphene-like materials for supercapacitors – EnGraMS"* – Project Director Dr. Mihaela Kusko.

Centre of Nanotechnologies

Nano-Scale Structuring and Characterization Laboratory

Mission

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

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

Areas of expertise

Characterization:

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

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

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

Structuring:

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

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

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

Team

• **Dr. Adrian Dinescu**, Physicist, Senior Researcher I, Head of the laboratory
• **Phys. Raluca Gavrila**, Physicist, Senior Researcher III
• **Dr. Octavian Ligor**, Physicist, Senior Researcher III
• **Dr. Gabriel Crăciun**, Physicist, Senior Researcher III
• **Dr. Oana Tutunaru**, Junior Researcher
• **Ing. Stefan Iulian Enache**, Technological Development Engineer
• **Mihaela Marinescu**, Principal economist

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 equipment

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

• ***Dip Pen Nanolitography System - NSCRIPTOR*** (NanoInk, Inc., USA). It is employed for ink-and-pen nanolithography, with 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*** (KLA - former Agilent Technologies, USA). It is used for high resolution characterization of the mechanical properties of small-volume samples.

L6 comprises four experimental laboratories clustered in the IMT-MINAFAB support centre for micro- and nano-fabrication 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

• ***Running national projects:***

- **"Laser targets for ultraintense laser experiments"**/TARGET, PN-III- /ELI-RO (IMT – Partener) (2016-2019)
- **"Technologic paradigms in synthesis and characterization of variable dimensionality systems (VARDIMTECH)"**, PNCDI III/PCCDI (PN-III-P1-1.2-PCCDI-2017) (IMT – Partener) (2018-2020)

• ***Running international projects:***

- **„Elastomeric tuneable metasurfaces for efficient spectroscopic sensors for plastic detection (ELASTOMETA)"**, EEA Grants, EEA-RO-NO-2018-0438 (IMT – Partener) (2019-2023)
- **"Reliable roadmap for certification of bonded primary structures"**, COST Action CA18120 (2019-2023)

Nano-Scale Structuring and Characterization Laboratory

Education and training:

Master courses and laboratory activities in collaboration with the **University "Politehnica" of Bucharest**:

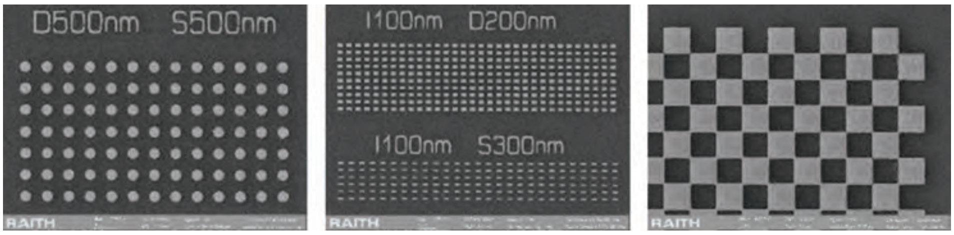
- "Microphysical Characterization of Micro- and Nanosystems" - *Master course, <<Microsystems>> MSc program, Faculty of Electronics, Telecommunications and Information Technology -ETTI*
- "Electronic Technologies for Optoelectronic Applications"- *Master course, <<Optoelectronics>> MSc program*
- "Object-Oriented Programming" - *Laboratory, Year II, ETTI*
- "Databases in Oracle environment" - *Laboratory, Year III, <<Economical engineering in the electrical, electronic and energy fields>>, specialization, The Faculty of Entrepreneurship, Business Engineering and Management - FAIMA*

Publications

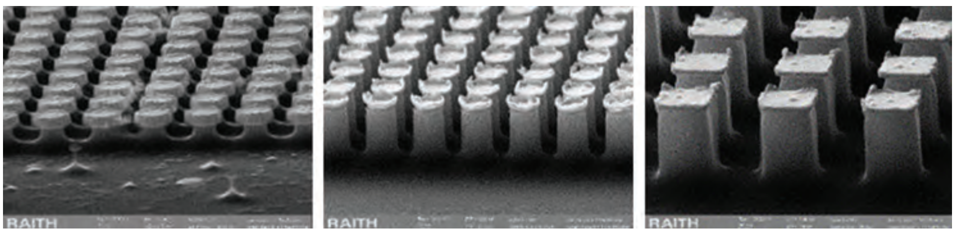
In 2019, L6 team has co-authored 20 scientific papers in ISI ranked journals (5 as a first author from IMT)

MAIN RESULTS - RESEARCH HIGHLIGHTS

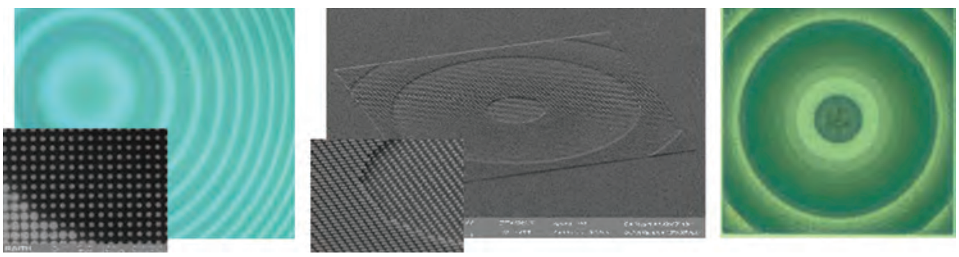
• Nano-engineering functional surfaces (metasurfaces) for photonic sensors intended to selective detection of plastics in industry



Array of metallic nanostructures manufactured by EBL and lift-off for fabrication of test structures (SEM images)



Test structures obtained by reactive ion etching through metallic pattern mask into the underneath SiO_2 film (SEM images)

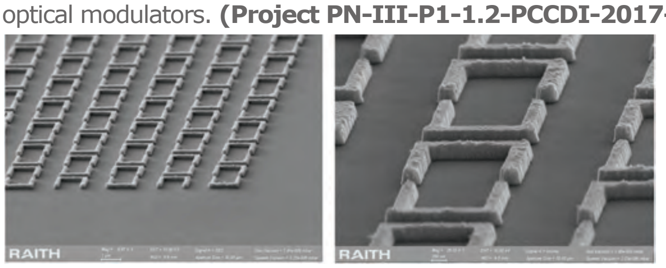


Metasurface-based lenses pictured in evolving technological stages (optical and SEM images); left: after PMMA configuration, before lift-off; center: after SiO_2 patterning; right: in the final stage, after etching into Si

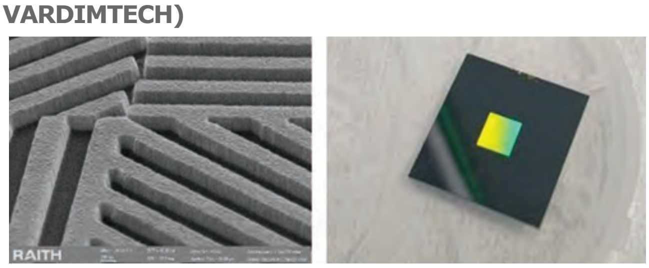
Several types of metalenses were manufactured starting from monocrystalline Si surfaces, by combining different nm-sized periodic nanostructures. To this end, silicon dioxide (SiO_2) was thermally grown on Si surface, then selectively etched using RIE (Reactive Ion Etching) through metallic mask structures patterned by EBL (Electron Beam Lithography) techniques. The intended metasurface-based lenses (metalenses) were manufactured by DRIE (Deep Reactive Ion Etching) of the Si substrate, using the SiO2 structures as an etch mask. **(Project EEA-RO-NO-2018-0438 - ELASTOMETA).**

• Plasmonic-based metasurfaces enabling compact optical components with significantly improved functional characteristics for optoelectronic applications

The devised metasurfaces consist of planar arrays of nanopatterns, intended to modulate reflectivity and polarization of light waves, enabling planar ultrathin optical components with tunable characteristics. To this purpose, an axisymmetric polarizer (ASP) was fabricated and characterized morpho-structurally. It consists of a Si chip with two types of nanostructures (plasmonic antennas and linear micropolarizers) manufactured on each of the two faces. The fabrication techniques included EBL lithography, selective deposition and etching of thin layers and also lift-off procedures. The characteristics of the resulted metasurfaces can be exploited in fabrication of polarization state analyzers and electro-optical modulators. **(Project PN-III-P1-1.2-PCCDI-2017- VARDIMTECH)**



Overview and close-up SEM images of a two-dimensional array of plasmonic antennas manufactured on the front side of the ASP polarizer

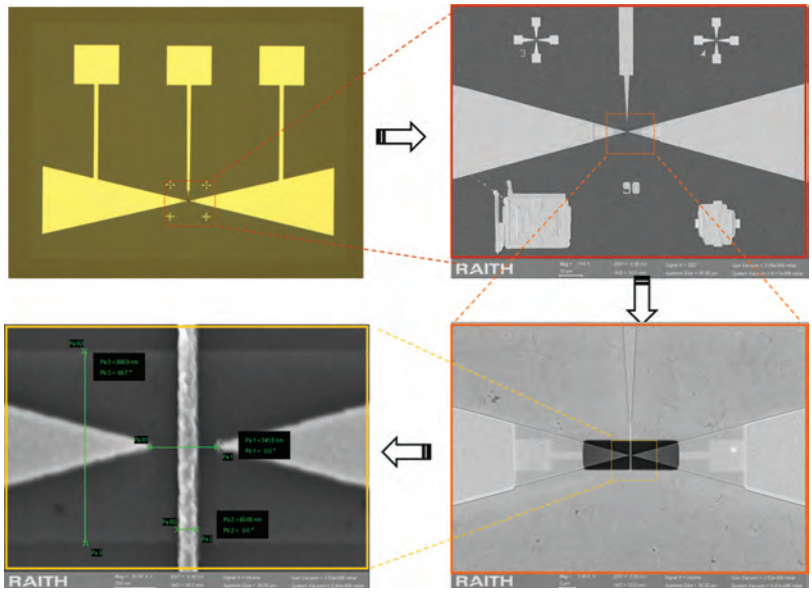


Linear micropolarizer arrays fabricated on the back side of the ASP polarizer;left: close-up SEM image; right: whole chip photo

Nano-Scale Structuring and Characterization Laboratory

MAIN RESULTS - RESEARCH HIGHLIGHTS

• Graphene FET transistors manufactured on ferroelectric substrates



SEM images at successively increased magnifications (in the direction of the arrows) of a graphene FET transistor (G-FET) on ferroelectric substrate (HfZrO)

HfO_2-based ferroelectric thin films doped with ZrO_2 were produced on Si(100) surfaces by Atomic Layer Deposition (ALD) and Magnetron Sputtering. Next, CVD Graphene was transferred onto these ferroelectric layers. Starting from substrates prepared this way, FET transistors were manufactured in order to study their physical properties, measure the mobility of charge carriers and experimentally validate theoretical predictions over graphene-HfZrO heterostructures. ***(Collaboration with L4 Laboratory of IMT Bucharest within the project PN-III-PCCF „Advanced nanoelectronic devices based on graphene/ ferroelectric heterostructures" - GRAPHENEFERRO)***

• Suspended ultrathin metal foils for super-intense laser-matter interaction experiments

In applications for ultra-high energy particle acceleration by super-intense laser-matter interaction at the future high-power laser infrastructure ELI (Extreme Light Infrastructure), the configuration and thickness of the targets are critical features in terms of minimizing losses, maximizing laser absorption and controlling the acceleration mechanism. We have designed and implemented a new technology for fabrication of ultrathin suspended metal foils, complying with the most demanding requirements in these respects and compatible with the alignment layout for the targets, which was developed by the project partner.

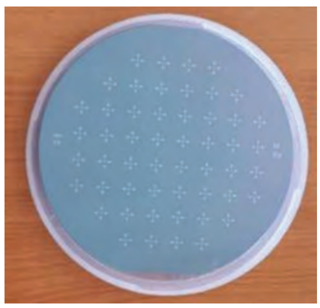
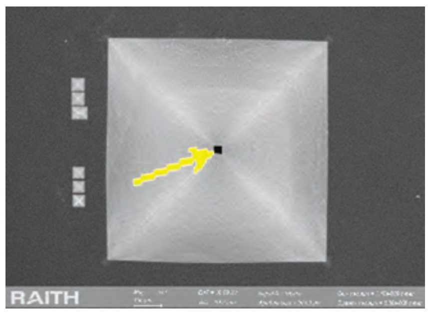
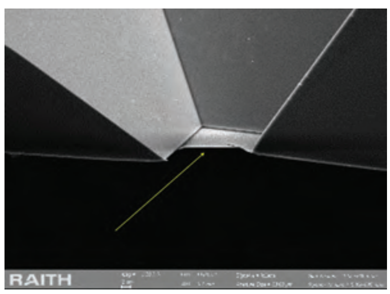


Photo of a processed Si wafer (back side). Opened windows in oxide for anisotropic etching are noticeable

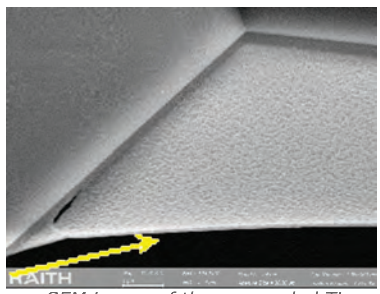


SEM image of an etch window with a suspended foil located at the bottom

A system for individual identification of each target from both sides of the wafer was designed and put in practice. The system is useful both in target manufacturing workflow and in subsequent "laser shot" experiments. Using thermal processes, isotropic and anisotropic wet corrosion and electron beam evaporation, we have obtained 50 nm thick Ti and Al foils with nominal suspended lateral size of 15 µm x 15 µm and a total lateral extension of 100 µm x 100 µm. ***(Project PNCDI III//ELI-RO - TARGET)***



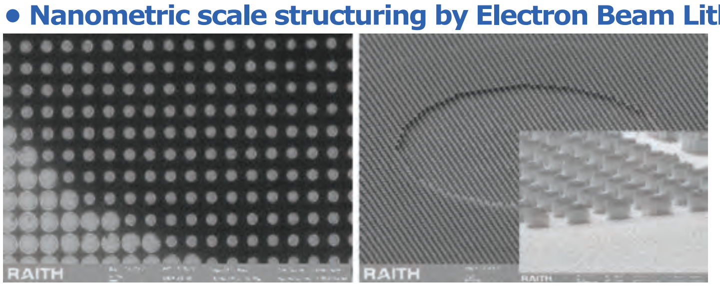
SEM image of a purposely cross-sectioned structure in order to reveal the suspended metal target



SEM image of the suspended Ti membrane (50 nm thick)

Services

• Nanometric scale structuring by Electron Beam Lithography



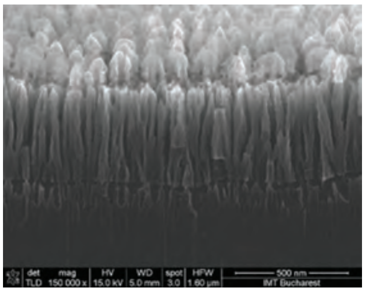
a) Nanodots (200 and 400 nm diameter) produced by direct Electron beam lithography (SEM image)
b) Structure obtained by etching with reactive ions using metal dots configured by EBL as a mask; The low-right inset is a close-up view of the same area. The structure is part of the process of making a metasurface lens for planar optics (SEM images)

Nano-Scale Structuring and Characterization Laboratory

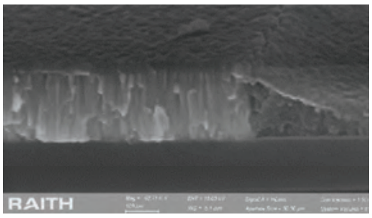
Services

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

Scanning Electron Microscope (SEM) (both conventional and field emission gun)

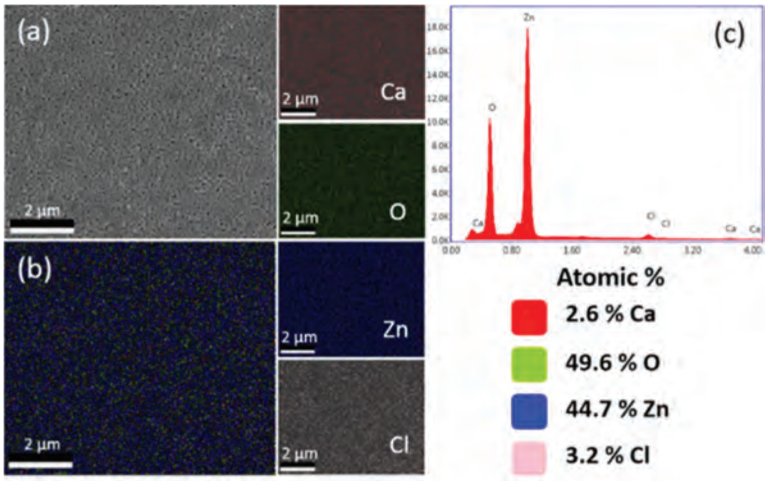


Porous Si carbide (SiC). SEM image in cross-section. Scale: 500 nm (Sample prepared by the team of L1 Laboratory of IMT Bucharest)



This high-resolution SEM image (scale: 100 nm) enabled the diagnosis of a technological problem. The Mo layer underlying the Ti film was overetched, changing explicitly its structure (the area to the right of the image).

• Energy Dispersive X-Ray Spectroscopy (EDX)

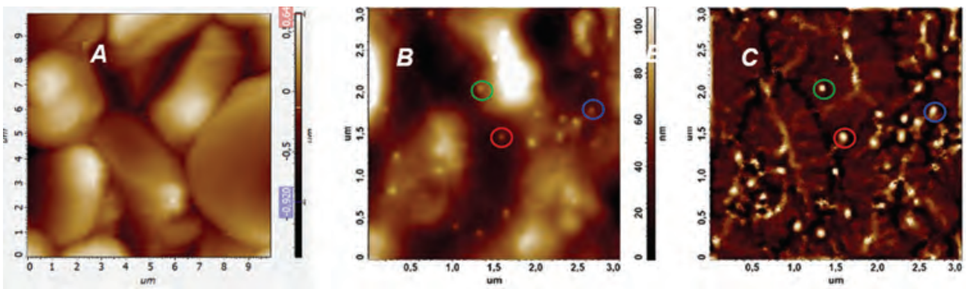


Thin ZnO films doped with Ca
(a) Morphological characterization by SEM
(b) Elemental distribution mapping using the EDX technique
(c) Quantitative analysis performed on the secondary electron image
In the central part of the figure: Map of the same sample,acquired on each element

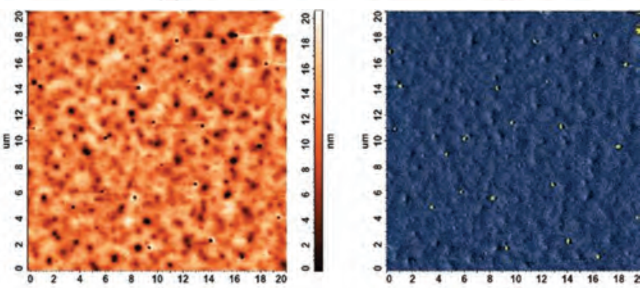
• Atomic Force Microscopy and related techniques (SPM)

Absorption studies of GOx enzyme immobilization on the surface of an amperometric biosensor.

AFM images can provide information on the coverage, organization and spatial distribution of the enzyme on the sensor surface.

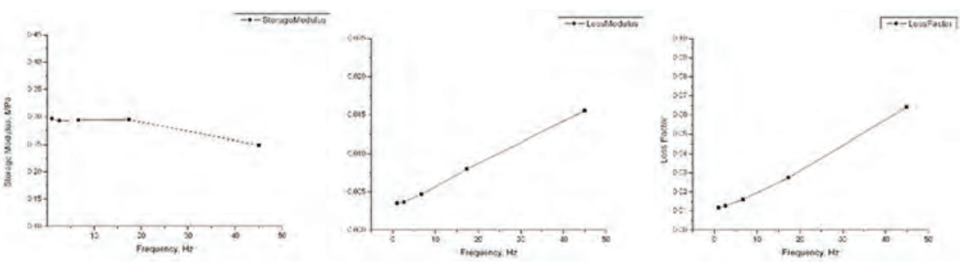


A: Overview image of metal electrode morphology before processing (10 μm x 10 μm)
B: AFM image of a 3 μm x 3 μm area after immobilization of the GOx enzyme on the surface of the metal electrode, modified using conductive polymers.
C: Amplification by software techniques of the details in fig. B allows a more accurate visualization of the distribution of immobilized enzyme molecules on the sensor surface.



Complementary AFM investigations of a functional coating layer for aerospace industry applications. The analyzed material is a composite based on transition metal oxides (PMMA-YAG). AFM measurements reveal the morphology (left) and distribution of oxide nanoparticles (right) at the surface of the composite.

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



Measurements of the storage modulus, the loss modulus and the loss factor for a viscoelastic material consisting of nanofibers of animal collagen. The measurements were performed dynamically using the Nanoindenter® G200 (KLA -Tencor) equipped with the CSM (Continuous Stiffness Measurement) module (Data published in M. Rapa et. Al, New Nanofibers Based on Protein By-Products with Bioactive Potential for Tissue Engineering. Materials (Basel) 2020 Jul 15;13(14). Epub 2020 Jul 15).

Centre of Nanotechnologies

Molecular Nanotechnology Laboratory

Mission

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

The main areas of interest are fundamental research and development of technologies for the fabrication of functional materials and micro/nano systems and devices based on synthesis and physico-chemical modifications, structural optimization, epitaxial MBE growth etc.

The studies are directed towards understanding, and making use of, the mechanisms that provide new functions by combining the techniques of preparation and synthesis of 3D...0D structures, controlled molecular attachments, theoretical modeling and numerical analysis by ab- initio and (semi)-empirical methods.

Research areas

• Synthesis, development, characterization and mechanism studies of nanomaterials that exhibit 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, mechanical sensors, solar cells, LED devices, transparent functional electrodes, MEMS. Development of dip-pen nanolithography (DPN) processing.

• Development of new materials based on MBE technology: III-N materials, epitaxial graphene etc. and related heterostructures with various applications, such as solar cells.

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

Team

• Dr. Lucia Monica Veca - CS I, PhD in Chemistry, Clemson Univ, USA, 2009.
• Dr. Antonio Marian Radoi - CS I, PhD in Chemistry, Tor Vergata Univ., Italy, 2007.
• Dr. Titus Sandu - CS I, PhD in Physics, Texas A&M Univ., USA, 2002.
• Dr. Emil-Mihai Pavelescu - CS I, PhD in Technology, Tampere University of Technology, Finland, 2004.
• Dr. Cristina Pachiu - CS III, PhD in Physics, Univ. Le Havre, France, 2007.
• Dr. Mihaela Carp – IDT III, PhD in Engineering, Nanyang Technological Univ., Singapore, 2008.
• Dr. Steluța Carmen Ciobanu - CS III, PhD in Chemical Eng., Politehnica University of Bucharest, 2011.
• Marius Constantin Stoian - ACS, Chemistry MSc student, Faculty of Chemistry, University of Bucharest.
• Dr. Radu Cristian Popa - IDT I, PhD in Quantum Eng. and Systems Science, Univ. of Tokyo, 1998; Laboratory head.

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

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

He was assistant professor in Electrical Engineering at the Polytechnic University of Bucharest (1991—1995), and senior researcher at the Science Solutions Intn. Lab., Inc., Tokyo (1998—2003), where he managed industrial research projects with leading Japanese companies and institutions, mainly in numerical modeling and analysis of complex phenomena and devices.

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

Radu Popa joined IMT Bucharest in 2007. Main scientific activities include theoretical and experimental studies of micro-nano materials and structures, experiment planning.

National and international cooperation

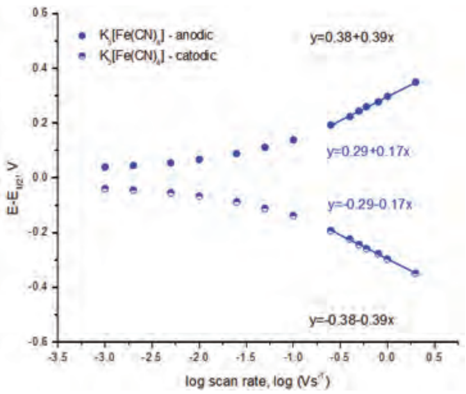
• Clemson University, USA - Prof. Ya-Ping Sun
• Natl. Institute for R&D in Electrical Engineering ICPE-CA, Dept. of Advanced Materials, Bucharest - Dr. Cristina Banciu
• Natl. Institute for R&D in Biological Sciences, Bucharest - Dr. Sandra Eremia, Dr. Simona Litescu
• Natl. Institute for R&D in Lasers, Plasma and Radiation Physics, Bucharest-Magurele - Dr. Catalin Ticos
• Natl. Institute for R&D in Material Physics, Bucharest-Magurele - Dr. Cristian Mihail Teodorescu
• "Babeș-Bolyai" University, Cluj, Romania - prof. Anamaria Elena Terec, prof. Simion Aștilean
• Institute of Physical Chemistry "Ilie Murgulescu", Bucharest - Dr. Viorel Chihaia
• Universitatea Wisconsin at Milwaukee, SUA - prof. Valerica Raicu
• Norvegian University of Science and Technology -NTNU - prof. Turid Reenaas
• Optoelectronics Research Centre, Tampere University of Technology, Finlanda – Prof. M. Guina
• Wroclaw University of Science and Technology, Polonia - prof. Robert Kudrawiec
• Universitatea Kassel - Prof. J-P Reithmaier, Dr. Cyril Popov
• Université Catholique de Louvain, Belgia - prof. Sorin Melinte

Molecular Nanotechnology Laboratory

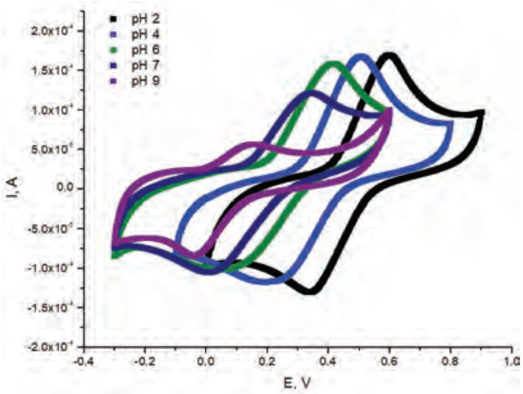
RESULTS

Project: „Carbon based nanostructured materials for environmental gas and PAHs sensors" - Project no. 3 of PN-III-P1-1.2-PCCDI-2017-0619 - contact Dr. Antonio Radoi (antonio.radoi@imt.ro)

The project investigates the application of graphene based materials for the development of electrochemical sensors able to detect polycyclic aromatic hydrocarbons (PAHs) such as anthracene. In this context we have fabricated associated electrodes using nanocrystalline graphite/graphene (NCG) layers in the presence of potassium ferricyanide (Figure 1), or of a polyphenol such as the caffeic acid (Figure 2). The NCG material characterizations were presented in: a) C. Albu, S.A.V. Eremia, M.L. Veca, A. Avram, R.C. Popa, C. Pachiu, C. Romanitan, M. Kusko, R. Gavrila and A. Radoi, Electrochim. Acta, 2019, 303, 284. Nano-crystalline graphite film on SiO2: Electrochemistry and electro-analytical application; b) C. Albu, S.A.V. Eremia, M.L. Veca, A. Avram, R.C. Popa, C. Pachiu, C. Romanitan, M. Kusko, R. Gavrila and A. Radoi, Data Brief, 2019, 24, 103923. Dataset on large area nano-crystalline graphite film (NCG) grown on SiO_2 using plasma-enhanced chemical vapor deposition.



Anodic and cathodic currents vs. the (square-root of) scan rate, in the presence of 2 mM K3[Fe(CN)6].

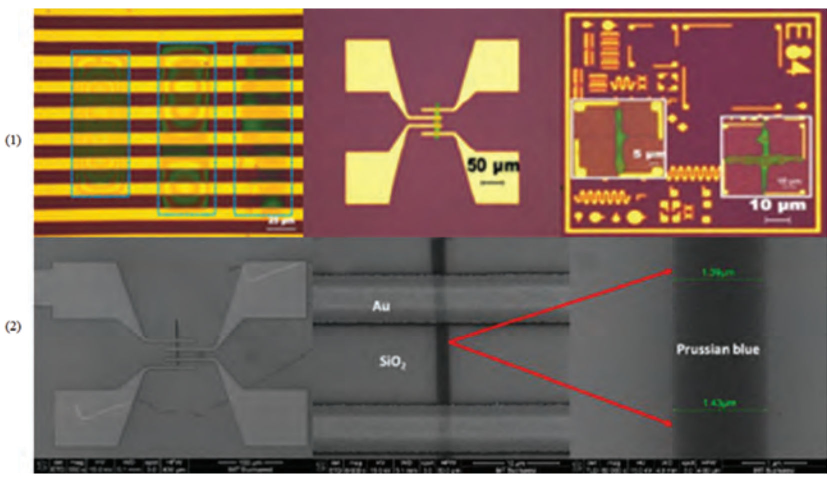


pH-mediated variation of NCG electrode response, in the presence of 0.1 mM caffeic acid.

Project: „Nanocarbon materials - unconventional processes and technologies, test applications" - in the framework of the IMT Core program MICRO-NANO-SIS PLUS/IMT PN 19-16 - contact Dr. Cristina Pachiu (cristina.pachiu@imt.ro)

Direct writing of functional materials by DPN technique

Controlled deposition of functional inks by micron/sub-micron direct writing using Dip-Pen Nanolithography (DPN). C. Pachiu , M. Carp, V. Dediu, „Direct Writing Patterns of Metallic Thin Film by DPN Technique", E-MRS 2019 Spring Meeting Nice; C. Pachiu, et al., "Direct writing of Prussian blue patterns down to micrometer scale: Preliminary tests results", Proceedings of the International Semiconductor Conference, CAS, 2019, 41-44. Selective writing of $FeCl_3$ based inks was performed on Si wafers with Au interdigitated electrodes, in order to develop Prussian blue patterns.

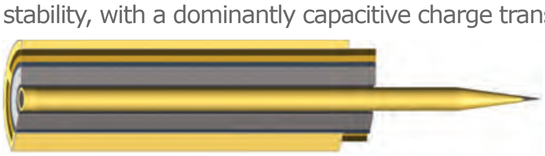


(1) Linear DPN writing across electrodes and metallic patterns for 4-point electrical measurements.
(2) SEM micrographs detailing the written functional traces.

Innovative developments using functional materials - contact Dr. Radu Popa (radu.popa@imt.ro)

Concept, patent application and PED 2019 project proposal, regarding: development of a probe with circumferentially segmented carbon film multielectrodes with application in multichannel neurophysiological exploration

The essential feature of the patented multielectrode probe is that its contact electrodes are fabricated as patterned carbon films and are segmented circumferentially. The main functional advantages obtained thereby are: superior electrochemical stability, with a dominantly capacitive charge transfer within a wide electrochemical window, superior recording quality of action potential firing by reducing the signal-to-noise ratio, geometric selectivity in stimulating and recording the neural activity. Collaboration with the company Termobit Prod, within a Collaboration Agreement in R&D activities, Sept. 2019.



RESULTS

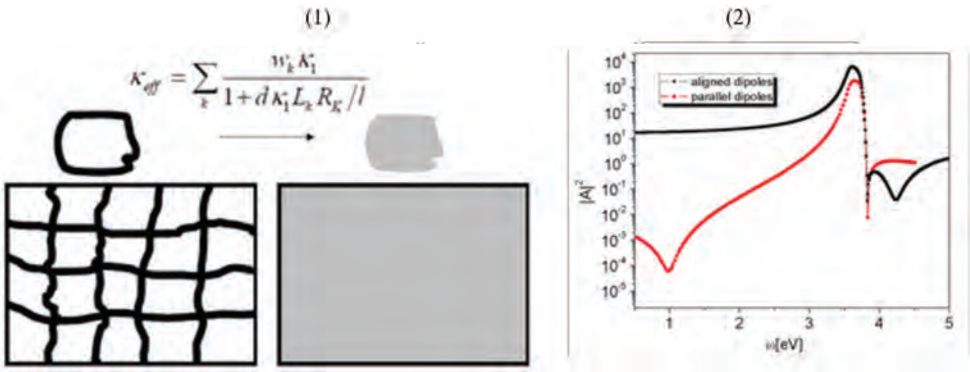
Analytical/numerical methods for material and process modeling
Contact Dr. Titus Sandu (titus.sandu@imt.ro)

Development of a numerical model for estimation of thermal conductivity in composite and polycrystalline materials, with applications to thin films of nanocrystalline and ultrananocrystalline diamond

Polycrystalline materials can be modeled also as composite materials (i.e., the crystallites are assimilated as the filler), in view of the fact that the intra-crystallite thermal conductivity differs substantially from the inter-crystallite one, as well as from that of the overall polycrystal. The various modeling approaches are using a shape approximation of the crystallites, usually, as perfect spheres. This spherical approximation has its own inconsistencies, related to the spatial coverage by sphere packing. Theoretically, the packing ratio can reach a maximum of only 72%, which is indeed incompatible with usual polycrystals. We have studied these aspects in depth and proved, however, that the spherical crystallite model is able to provide relevant results in thermal conductivity modeling. Moreover, we developed a direct calculation formula for the thermal conductivity in polycrystalline materials, with possible application in NCD and UNCD thin films; the derivation was based on the coherent potential approximation (CPA), which is usually employed in the thermal conductivity theory of composite materials.

Description of the multipolar electromagnetic response of dielectric or metallic nano-objects in the electrostatic approximation

The response to electromagnetic excitation of nano-objects is usually described based on the dipole approximation (we have in view here, e.g., the plasmonic response of metal nanoparticles). We study the response given in all the modes that a nanoparticle can sustain, depending on both its shape, and size. For the electrostatic mode we calculated the Green function of a nanosphere at an arbitrary excitation, the study having application in the non-radiative energy transfer between molecules (FRET), mediated by metallic nanoparticles.



(1) Homogenization methodology and formula for modeling the thermal conductivity of a polycrystalline film in the coherent potential approximation (T. Sandu, C. Tibeica, "A perspective on effective medium models of thermal conductivity in (ultra)nanocrystalline diamond films", Appl Surf Sci., 492, 309-313, (2019)

(2) The FRET enhancement coefficient calculated for two alignments types of the dipoles of the donor and receptor molecule mediated by a nanosphere. Sandu, et al., "Modal Approach to the Theory of Energy Transfer Mediated by a Metallic Nanosphere", Rom. J. of Information Sci. & Tech. (ROMJIST) 22, 3-13, (2019)

Centre for Nanotechnologies and Carbon-based Nanomaterials

Simulation, Modelling and Computer Aided Design Laboratory

Mission

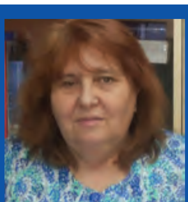
Research, development and applications of simulation, modelling and design techniques of micro-electro-mechanical and microfluidic systems focused to collaborative research projects, **education** (courses, labs, thesis coordination), services (specific design solution, models, enabling access to hardware and software tools) and consultancy (design/optimization) in the field of micro-nanobio/ info technologies. T**he 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 nano-devices (thin films and nano-structures of oxide semiconductor materials).

Team

1. **Dr. Raluca Müller**, senior researcher I, PhD in electronics, laboratory head
2. **Dr. Rodica Plugaru**, senior researcher I, PhD in physics
3. **Dr. Oana Tatiana Nedelcu**, senior researcher I, MS in mathematics, PhD in electronics
4. **Dr. Gabriel Moagar-Poladian**, senior researcher II, PhD in physics
5. **Dr. Franti Eduard**, senior researcher III, PhD in electronics
6. **Phys. Constantin Tibeica**, scientific researcher, physicist
7. **Phys. Eng. Victor Moagar-Poladian**, IDT III, physicist engineer
8. **Dr. Rodica-Cristina Voicu**, senior researcher III, mathematician, PhD in mathematics
9. **Dr. Angela-Mihaela Baracu**, scientific researcher, PhD in Electronics
10. **Dr. Mihai Gologanu**, senior researcher III, mathematician, PhD in mathematics-mechanics

Expertise

- **Design, simulation and development/ optimization of MEMS/MOEMS** devices and components (cantilevers, membranes, micro-grippers) and **microfluidics** (micro-channels, mixers, filters, handling and monitoring systems) for biologic, microelectronics, environmental, security and biomedical applications;
- **Modelling and simulation for multiphysics phenomena;** mechanical, thermal, electrical, electro-magnetic, piezo-electric, **coupled field analysis** (static and transient); **microfluidic analyses: CFD, diffusion, mixing, electro-kinetics, fluid-structure interaction, particle dynamics.**
- **Rapid prototyping**: 3D Printer (SLS, respectively, a single-photon-absorbed photopolymerization);
- **Rapid manufacturing**: 3D Printing (SLS, single-photon-photopolymerization), development of novel additive manufacturing technologies;
- **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;**
- **Realization of heterostructures** with (ultra)thin layers by advanced technological processes for devices with controlled functionality.
- **Complex characterization of response functions of junctions** with ultra-thin films and nano-object arrays by electrical measurements.
- **Analysis of the physical phenomena at surfaces and interfaces** in metal-oxide-semiconductor heterostructures. **Modeling** their properties for multifunctional devices.



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

Dr. Raluca Müller received the M.Sc and PhD in Electronics and Telecommunications from "Polytehnica" University of Bucharest. From 1978-1994 she was researcher scientist with ICCE Bucharest, since 1994 she is with IMT Bucharest. 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 120 scientific papers presented at conferencesand published in journals (Sensor&Actuators, J. of Micromechanics and Microengineering, Appl.Optics., Journal of Luminescence, Thin Solid Films, etc).

National and international colaborations

National collaborations

POC-G - Operational Competitivity Program 2014-2021, Axa1: Action 1.2.3, Contract No. 77/08.09.2016, TGE-PLAT *"Partnership for using Key Enabling Technologies on a platform for interaction with companies"* is a project financed by Structural Funding dedicated to knowledge transfer from IMT to Romanian companies, in a high tech field of the Romanin Strategy (SNCDI 2016-2020): ICT, Space and Security, Coord: R. Müller, IMT. In the frame of this POC-G two collaborative projects with SME were conducted by the lab:

Sub-project C77.3D: ***Sensitive Platform with SAW sensor for inflammable and potentially explosive gases detection***; coord: Dr. A. Baracu, in collaboration with S.C. ROM-QUARTZ S.A.

Sub-project C77.5D: ***Image forming optical system by using „free-form" (FF) components and technology forthe fabrication of these;*** coord: G. Moagăr-Poladian, in collaboration with S.C. ROVSOL S.R.L.

Project PN-III-P1-1.2-PCCDI-2017-0871, contract 47PCCDI/2018: ***„New directions of technological development and use of advanced nanocomposite materials"***, Coord. INCD-FM; IMT Partner, Coord Dr. Raluca Müller.

„Core" funding: MICRO-NANO-SIS PLUS, Project ***"Development of components and microsystems for sensors and smart control with applications in IoT and bio-engineering"***, 2019-2022 Coord: Dr. Oana Tatiana Nedelcu.

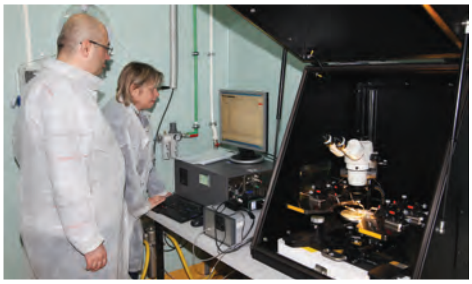
International collaborations - Scientific services contracts:

- ***Design, microfabrication and testing of microfluidic chips for lensless microscopy***, Beneficiary: CEA Saclay, France, March-August 2019, Contact Dr. Oana Tatiana Nedelcu
- ***Development of methods for compensation of electrochemical gas sensors***, Beneficiary: City Technology, Portsmouth, United Kingdom, Contact Dr. Mihai Gologanu

Simulation, Modelling and Computer Aided Design Laboratory

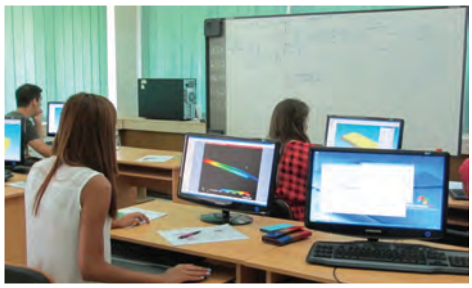
Equipment

Hardware: - Dual IBM 3750 Server, 8 quad-core Intel Xeon MP 2.93 GHz, 196 Gbyte RAM, 1 TByte HDD.
Software for modelling and simulation:
COVENTORWARE 2014-software package dedicated to design, modelling and simulation for MEMS and microfluidics. It contains modules for design (2D layout, 3D models generator) and simulation modules for main physical phenomena in microsystems functionalities and development.
SEMulator3D, 2011-Software for complex 3D models for structures and devices obtained by silicon technology.
COMSOL 5.5-Software package for simulation of physical phenomena such as: mechanics of solids, heat transfer, fluidics, electromagnetics, electrokinetics, acoustics, RF-MEMS.
ANSYS Multiphysics 2020 R1 Software package for FEM simulations taking into account several physical phenomena (mechanical, thermal, electromagnetic and fluidic or coupled). Complex simulation methods: ***Sequential method*** and, respectively, ***Direct coupling***.
MATLAB R2015b – Mathematical software: numerical computation, visualisation and programming. It can be used for mathematical calculus, algorithm development, data acquisition, visualization and analysis, scientific and engineering graphs.
SOLIDWORKS – Design software for 2D and 3D complex geometry, able to export CAD files to other simulation software tools; it has additional modules for projects correlation and for growing the productivity of CAD and PDMWorks.
MATHEMATICA 7 – Software for numeric and symbolic calculus; suitable for solving linear and non-linear equations, integral and differential equations, statistics, optimisation, 2D and 3D graphics.
ORIGINPRO 8 – Software for data processing: graphic, interpretation/ interpolation by statistical processing.



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

Tehnology:
- 3D Printer Selective Laser Sintering EOS Formiga P100
- 3D Printerbased on Single Photon Photopolymerization from Envision TEC



• Investigation of emergent physical phenomena at oxide-semiconductor and oxide-oxide interfaces by electrical characterization.
• Rapid prototyping using 3D Printer Selective Laser sintering for fabrication of mouldings, robotic components, encapsulation systems, functional mechanical and fluidic components.
• Training for design and simulation, student laboratory work, master courses, practical stages for students.
• Classroom equipped with computer network for training.

Results

Project PN-III: „ New directions of technological development and use of advanced nanocomposite materials",

Fabrication and encapsulation of Cr / Au interdigitated structures on HfO_2 / $GeSiHfO_2$ / HfO_2 / Si substrate, for Ge-based NC photodetectors.

Contact Dr. Raluca Müller.

Optical images of fabricated interdigitated structures: digit / interdigit width -10 µm

Encapsulated structures

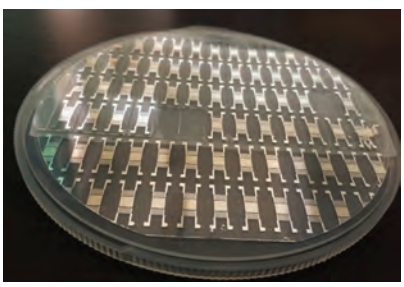


Image of SAW structures at wafer level

POC-G, Sub-project C77.3D: Sensitive Platform with SAW sensor for inflammable and potentially explosive gases detection:

Manufacture of surface acoustic wave sensor on quartz substrate, for hydrogen gas detection (different concentrations: 2%, 3%) for environmental applications.

Contact: Dr. Angela Baracu

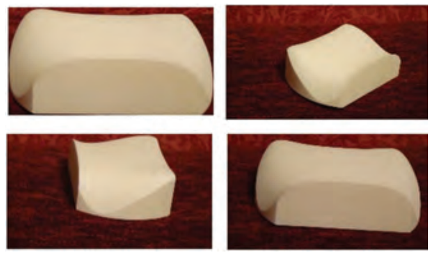
Simulation, Modelling and Computer Aided Design Laboratory

Results

POC-G, Sub-project C77.5D: Image forming optical system by using „free-form" (FF) components and technology for the fabrication of these

Optic free-form elements have been realized in positive and negative version.

Contact Dr. Gabriel Moagăr-Poladian



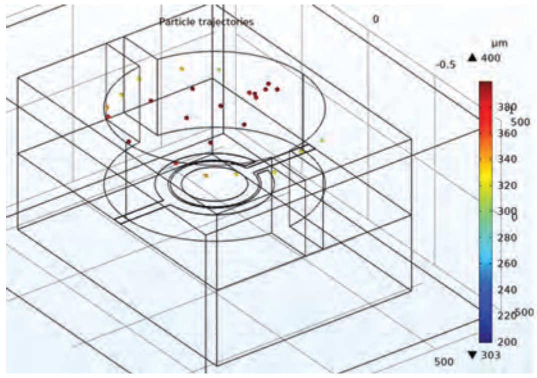
Multi-angle photographic image of the free form optical element no. 2, the "positive" variant. Ready to use for sub-THz and THz optics; use as a mold for visible optics.

„Core" funding Development of components and microsystems for sensors and smart control with applications in IoT and bio-engineering

Objective 1: Modeling, simulation and realization of microsystems for detection applications in microfluidics

Design and simulation of a electro-fluidic microsystem for the transport of samples in liquids and separation in the visualization region by dielectrophoresis (DEP). The microsystem includes microchannels and microelectrodes for sample separation in field ov view at single cell level. A version of the microsystem was designed and several configuration of electrodes and input data were analyzed by simulation in order to handle the cells by positive and negative DEP.

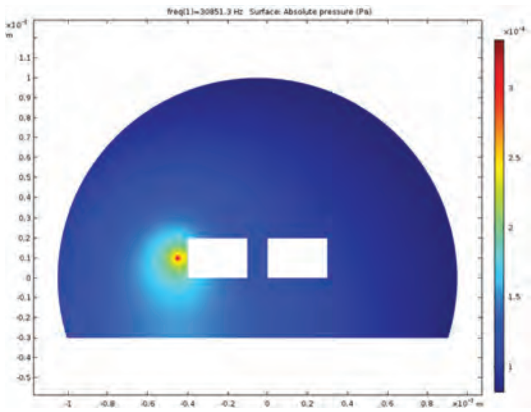
Contact Dr. Oana Tatiana Nedelcu, Phys. Catalin Tibeica



Cells moving by negative dielectrophoresis (COMSOL)

Design and development of SOI and Si resonators with piezoelectric layer of AlN and ZnO, for photoacoustic gas sensors: Finite element models in COMSOL were performed for the evaluation of the resonant frequency and the quality factor and for the evaluation of the acoustic pressure wave created by photoacoustic effect and of the pressures acting on the resonator.

Contact Dr. Mihai Gologanu



Pressure wave created by photoacoustic effect from an optical source with parallel focus with the tuning fork arms and eccentric to them (COMSOL)

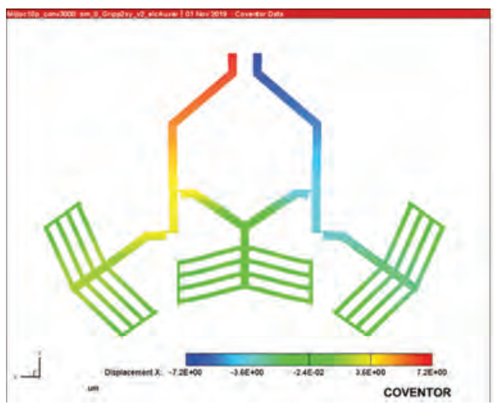
Objective 2

Design, simulation and fabrication of MEMS structures with multidirectional actuation and displacements (in and out of the working plane) and with integrated sensors

Design and simulation of MEMS structures that integrate electro-thermal actuators in order to obtain multidirectional (2D) displacements in the structure plan.

Coupled electro-thermo-mechanical simulations were performed to analyze the behavior of the MEMS structure when the actuator pairs are actuated.

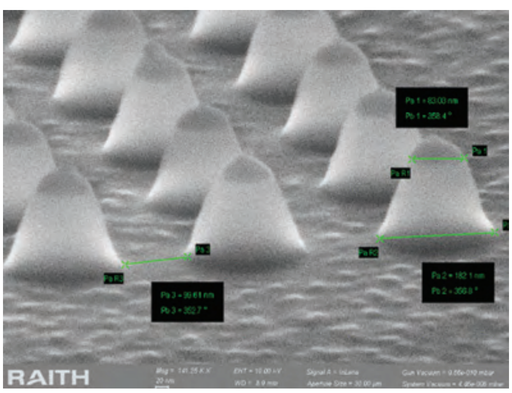
Contact Dr. Rodica Voicu



Simulation of displacements (opening of the arms) in the plane of the structure when the middle actuator is actuated (Coventorware)

Preliminary experiments on technologies for MEMS actuators. Technological tests of dry etching (RIE) of a thermal SiO2 layer (100 nm), used as a sacrificial layer in the structures development.

Contact: Dr. Angela Baracu



SEM image of test structures profile in SiO_2, realized by optimization of RIE process

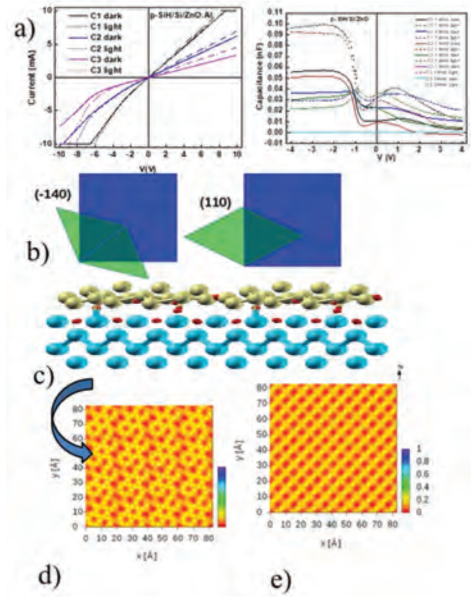
Results

Objectiv 3: Characterization of the response functions to applied electrical field and light of multilevel structures with ultrathin films

The interface states effects on charge photogeneration, accumulation and transfer in heterostructures with ultrathin layers of intrinsic silicon and ZnO deposited on hydrogenated p- and n-type silicon substrates have been analysed by (pulsed) I-V and C-V measurements performed in dark and under light excitation conditions. First principles calculations on systems consisting of 2D Si layers on a hydrogenated Si (100) substrate have been performed in order to determine the energetically favorable atomic arrangements and to look at the charge density distribution in the depth of the interface region. A significant gradient of electronic density is present in the structures, with a maximum situated in the plane of 2D Si layers. The p-Si:H/i-Si and p-Si:H/i-Si/Al:ZnO structures demonstrate higher photoresponsivity. The carriers density is higher in the n-Si:H/i-Si structures than in the n-SiH/i-Si/Al:ZnO in dark and under light excitation. The results suggest that the Si:H/i-Si system could exhibit topological properties. Contact Dr. Rodica Plugaru

Right: I-V and C-V characteristics of p-Si:H/iSi/ZnO:Al heterostructures (a). Models of 2D Si layer on hydrogenated (100) Si substrate (b). 2D Si layer on H passivated (100) Si substrate, relaxed structure (c). Charge distribution in the 2D Si layer (d) and at Si:H interface (e). DFT calculations. E-MRS Fall Meeting, Warsaw, September 2019.

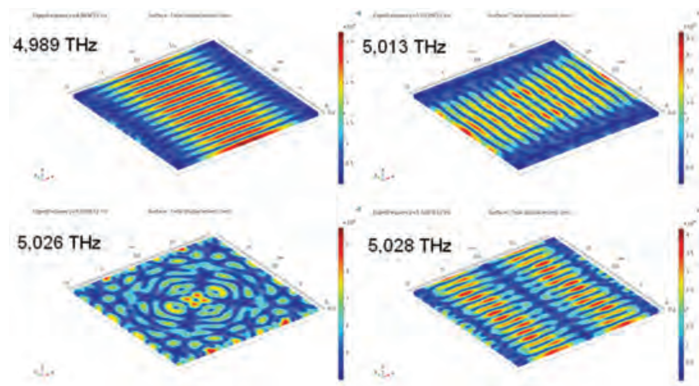
Contact Dr. Rodica Plugaru



I-V and C-V characteristics of p-Si:H/iSi/ZnO:Al heterostructures (a). Models of 2D Si layer on hydrogenated (100) Si substrate (b). 2D Si layer on H passivated (100) Si substrate, relaxed structure (c). Charge distribution in the 2D Si layer (d) and at Si:H interface (e). DFT calculations. E-MRS Fall Meeting, Warsaw, September 2019.

Obiectiv 4: Advanced research on the development of electronic components and circuits using rapid prototyping techniques (3D Printing) on carbon materials

A study on realization of ready-made graphene films and how they can be detached from the copper catalyst substrate and attached on the desired substrate. The concept includes the growth of ready-configured graphene and its transfer, by electrostatic methods, to the plate of interest. The ready-configured growth can be achieved if the copper substrate is configured by local oxidation. The oxidation was performed in two variants: e-DPN, which allows the precision configuration but on a small area and, respectively, the chemical oxidation through photoresist mask.



Contact Dr. Gabriel Moagar-Poladian

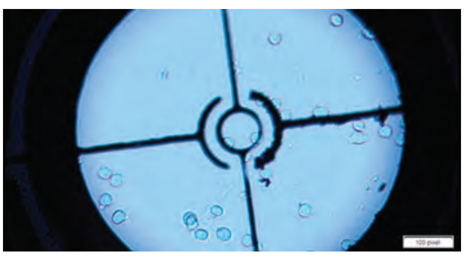
The first 4 modes of graphene film oscillation on copper substrate (ANSYS).

International collaborations: Scientific services

Design, microfabrication and testing of microfluidic chips for lensless microscopy

Beneficiary: Laboratory of Interactions, Dynamics and Lasers, CEA Saclay, France.

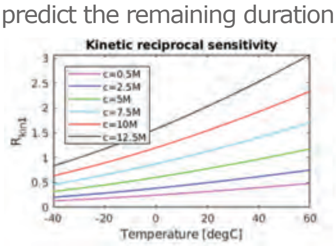
Development of a system on chip and integration into a bio-imaging platform for electro-optic cell morphology analysis by fluidic manipulation and nanoscale microscopy.

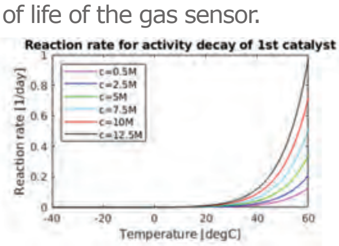


Contact Dr. Oana Tatiana Nedelcu

Development of methods for compensation of electrochemical gas sensors, Beneficiary: City Technology, Portsmouth, United Kingdom:

Using periodically measured temperature and electrolyte concentration to compensate gas readings for gas diffusion, liquid diffusion, kinetic effects and for long term effects that reduce catalytic activity. The developed model has been implemented in an embedded chip. The model is also able to predict the remaining duration of life of the gas sensor.





Contact Dr. Mihai Gologanu

Centre for Nanotechnologies and Carbon-based Nanomaterials

Reliability Laboratory

Mission

The design, development and implementation of innovative solutions for the testing and monitoring of the functionality and reliability of sensors, actuators, microsystems, nanostructures, intelligent systems, microelectronic and optomechanical components. These actions, with a strong interdisciplinary character, take place in the spirit of Concurrent Engineering, starting with the design and definition phase of the project and then throughout the entire development of the device, including real-life use.

Activity areas

Research-development-innovation

Development of innovative solutions for sensors and intelligent sensor systems using nanocarbonic sensitive layers and metal oxides, with applicability in environmental monitoring.

Reliability building: Design for Reliability (DfR), Design for Manufacture (DfM), Monitoring and selection of micro and nanostructures and devices, Reliability of components in Harsh Environment (extreme temperatures, aerospace, radiation field, etc.).; Customized Robust Design (environmental quality monitoring biosensors for example).

Testing and trials services for internal and external partners

- Accelerated testing of micro and nanostructures (using single or combined tests);
- Accelerated testing of electro-optomechanical components used in pieces of equipment that work in hostile environments and/or special requirements (space, automotive, security).

Team

In 2019, the L7 team was made out of 6 specialists, who graduated University POLITEHNICA of Bucharest (Faculty of Electronics, Telecommunications and Information Technology, Faculty of Industrial Chemistry, Faculty of Engineering and Management of Technological Systems), University of Bucharest (Faculty of Physics, Physical Technological Specialization) and the University of Oil and Gas, Faculty of Automatics, Computers and Electronics - Ploieşti.

• Dr. Fiz. Octavian Buiu, CSIII, head of laboratory – since March 2017.
• Dr. Ing. Cornel Cobianu, CSI – since February 2017
• Dr. Ing. Bogdan – Cătălin Şerban, CSIII – since February 2017
• Dr. Ing. Octavian Ionescu, CS III, since February 2017.
• Ing. Niculae Dumbrăvescu, CS III.
• Ing. Roxana Marinescu, IDT.

Laboratory head:
Dr. Octavian Buiu,
octavian.buiu@imt.ro

Dr. Octavian Buiu is a graduate of the Faculty of Physics, University of Bucharest, with a PhD in Atomic and Molecular Physics ("Babes-Bolyai" University of Cluj). He has more than 30 years' experience in R&D, in private and public institutions: R&D Institute for Nuclear Power Reactors, R&D Institute for Electronic Components, Institute of Microtechnology Romania, and Honeywell Romania. Between 1997 and 2007, he worked in United Kingdom as research associate, fellow, and senior fellow at De Montfort University and University of Liverpool. In 2002 he has appointed as Lecturer in Electrical Eng. Dpt., University of Liverpool. Throughout his career, Octavian served as deputy scientific director at IMT Bucharest (1994-1997), Portfolio Manager and Senior Technology Manager at Honeywell Romania – Advanced Technology (2007-2014 and 2014-2017, respectively). Currently he is a scientific researcher in IMT Bucharest and head of the reliability and testing laboratory; he has more than 70 papers in ISI journals and more than 100 papers and presentations at National and International Conferences. He is author and co-author in 20 book chapters, co-author of 26 US and EU patents, and 30 patent application submitted to the Romanian Patent Office.

International and national collaborations

International collaborations

• Participants in the project coordinated by the Laboratory L8, project with the European Space Agency (ESA) the project entitled PROBA-3 ASPIICS OPSE HARDWARE - Contract No. 4000111522/14 / NL / GLC;
• Collaboration with CSEM (Switzerland) and ESA for the development of gyro sensor testing methodology.

National collaborations

• Participation to project „Partnership in the exploitation of Essential Generic Technologies (TGE), using an interaction PLATform with the competitive enterprises (TGE-PLAT)" - code SMIS2014 + 105623. Laboratory L7 prepared and presented - to the interested companies (Pro Optica) - the offer of testing services and reliability tests.
• Collaboration with national institutes (INOE 2000, INFLPR - Bucharest; INECMC - Timişoara) and research groups from Universities (UPB, "Transilvania" University of Braşov) for the execution of activities within the Nanocarbon + complex project. Within the activity of exploiting the results, a collaboration agreement was concluded with SC Termobit SRL, regarding the development, in common, of some industrial applications that would use the results obtained within Nanocarbon +.
• Performing testing/reliability services: ADT TU Testing (AGS–WBDL) for Elettra Communications, Romania; RF antenna testing for INFLPR Bucharest.
• Services for the development and characterization of sensors and materials developed within IMT Bucharest (graphene-based aerogels, electronics for accelerometer testing) and used by the Romanian automotive industry.

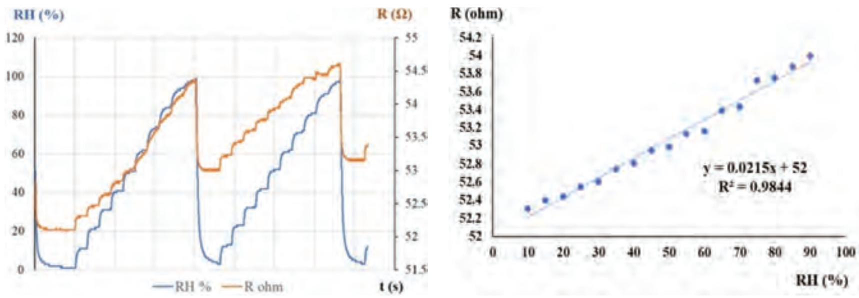
Reliability Laboratory

Results

1. Contract no.: 14N/2019 "New advanced research in micro/nanoelectronics, photonics and micro/nano-bio systems for the development of applications in the intelligent specialization field - MICRO-NANO-SIS PLUS**". Code: PN 19 16; Project nr 5: Nanocarbon materials – unconventional processes and technologies, test-applications;**

Phase 5.2a: Composite sensitive layers, on a rigid substrate, using carbon nanohorns for chemiresistive detection of relative humidity

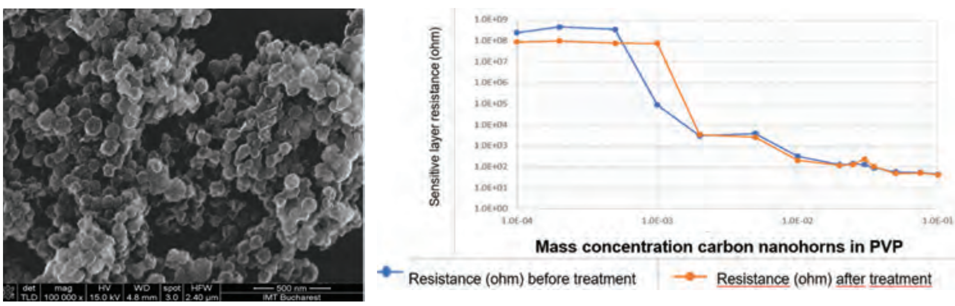
Part I. Three types of sensitive layers for monitoring relative humidity using a chemiresistive sensor structure were synthesized and investigated (an absolute novelty, according to the current state of the art in the field) : oxidized carbon nanohorns, nanocomposite matrix oxidized carbon nanohorns-PEG-PPG-PEG and nanocomposite matrix oxidized carbon nanohorns- PVP. The moisture response of the three composite materials was investigated and different RH monitoring mechanisms were highlighted. Thus, the increase of resistance is quasi-linear over the entire RH domain for the oxidized carbon nanohorns and the nanocomposite matrix with PVP. For using the oxidized carbon nanohorn-PEG-PPG-PEG matrix, due to the "swelling" effect generated by the swelling of the copolymer triblock at RH values higher than 75%, a "switch" type characteristic is registered, with important applications in relative humidity monitoring in the electronic industry. The obtained humidity sensors show promising characteristics, close to those of the commercial Sensirion sensor, representing a viable alternative for RH monitoring. Optimizing the mass report of "oxidized carbon nanohorns / hydrophilic polymer", as well as the deposition conditions on the rigid substrate represent two future strategies for reducing the hysteresis and for improving the sensitivity of the sensor. The results were disseminated as it follows: 4 presentations at international conferences and 1 presentation at a national conference; 5 patent applications; 2 manuscripts sent for review to ISI journals.



Response - in humid air – of the humidity sensor using oxidized carbon nanohorns: (1): response in time (orange curve); (2) transfer function

2. Within the same contract and project - Phase 5.2a: Sensitive composite layers, on a rigid substrate, using carbon nanohorns for chemiresistive detection of relative humidity

Part II – Evaluation of the percolation step for sensitive nanocomposite materials; optimized sensitive layers, on IDT structures (rigid and flexible substrate) were synthesized and investigated four types of sensitive layers for monitoring relative humidity using a chemiresistive sensor structure: nanocomposite matrix oxidized carbon nanohorns- PVP (mass ratio 1:1) and three types of ternary nanocomposite matrix graphene oxide/oxidized carbon nanohorns/polyvinylpyrrolidone (mass ratios 1:1:1, 1:2:1 and 1:3:1, respectively). These represent absolute novelties in terms of sensing materials and are covered by Romanian patent applications. The moisture response of the four composite materials was investigated, the resistance increase being quasi-linear over the entire RH field. The obtained humidity sensors show promising sensitivities, close to those of the commercial Sensirion sensor, representing a viable alternative for RH monitoring. Also, the percolation steps of carbon nanohorns in polyvinylpyrrolidone (PVP) were determined on both rigid Si/SiO2 and flexible (polyimide) substrate. While the first percolation step was achieved at a concentration of 0,2% oxidized carbon nanohorns in nanocomposite matrix, the second percolation step has a value of 3,5%. Although surprising, the difference of about one order of size is justified by the fact that the rigid substrate has a distance between electrodes of 10 μm, while the flexible substrate has a distance between electrodes of 100 μm.



(1) SEM image of the GO ternary nanocomposite matrix/oxidized carbon nanohorns/polyvinylpyrrolidone in a 1:2:1 ratio;
(2) Determination of the percolation step for the binary matrix of carbon nanohorns in polyvinylpyrrolidone (PVP), on Si/SiO2 substrate

Contact: Dr. Bogdan Catalin Serban (bogdan.serban@imt.ro),
Dr. Cornel Cobianu (cornel.cobianu@imt.ro), **Ing. Niculae Dumbravescu** (niculae.dumbravescu@imt.ro)

3. The chemoresistive structures used for monitoring the relative humidity were mechano-thermally tested to identify any functionality changes (i.e., abnormal variations of resistance) generated by the tests. A correlation between the value of the applied mechanical stress and the electrical resistance was established, for different sensitive layer thicknesses; the results will be published during the year 2020.

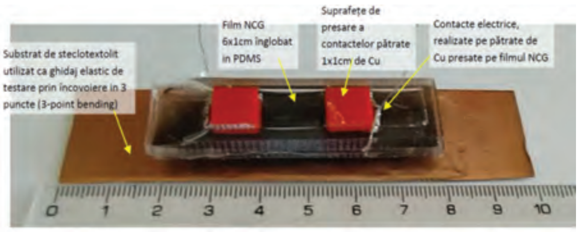
Contact: Dr. Octavian – Narcis Ionescu (octavian.ionescu@imt.ro), **Ing. Roxana Marinescu** (roxana.marinescu@imt.ro)

Reliability Laboratory

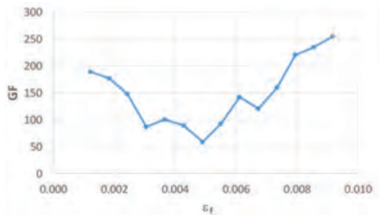
Results

4. Within the component project 1 ("Piezoresistive effects in nanocrystalline carbonic films and applications in mechanical stress sensors (PIEZOCARB)", from project PCCDI-2017-0619 (Nanocarbon+)- https://www.imt.ro/nanocarbon+/index.php, the laboratory team was involved in: a. preparation of the test structures including thin GNC layers (nanocrystalline graphene) and AGC (carbonic aerogel) and b. the development of an experimental setup and a working methodology for the preliminary functional laboratory verification (resistive tensometric sensitivity). The controlled mechanical deformation was performed using the MultiTest 2.5-i (Mecmesin, UK) equipment, in the 3-point bending assembly. Electrical measurements were performed with an 8846A precision multimeter (Fluke, USA).

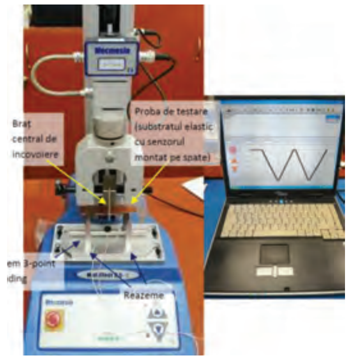
Contact: Dr. Octavian-Narcis Ionescu (octavian.ionescu@imt.ro),
Ing. Niculae Dumbravescu (niculae.dumbravescu@imt.ro),
Dr. Octavian Buiu (octavian.buiu@imt.ro)



Test run for the piezoresistive sensitivity of the NCG films. The carbonic film (6x1 cm) is collected, electrically contacted and embedded in PDMS polymer (polydimethylsiloxane).



Evolution of GF (Gauge Factor) piezoresistive sensitivity with relative deformation (elongation) (taking into account temporal hysteresis).



Set up for extension-controlled mechanical deformation in the 3-point bending version

Equipment

The laboratory has a wide range of pieces of equipment for reliability testing, and also high-performance electronic equipment. The main ones (including their main characteristics)are listed below. ***Equipment for reliability testing:***

Test type/ measurement	Manufacturer and model ID	Test parameters
High temperature	UFB 400 / MEMMERT	Temperature: +5°C...+220°C ; Volume: 53 l
Temperature + Low pressure	VO 400 / Memmert	Temperature: +25°C...+200°C; Pressure: 10...1100 mbar; Volume: 49 l
Temperature + Humidity	CH 160 / Angelantoni	Temperature: -40°C...+180°C ; Humidity: 20...95% RH: Volume: 160 l
Temperature + Humidity + High pressure (HAST)	EHS-211M/ESPEC EUROPE GmbH	Temperature: 105°C...142°C; Humidity: 75%...100%: Pressure : 0.02...0.196 Mpa; Volume: 18 l
Thermal cycles	TSE-11-A / ESPEC EUROPE GmbH	Method with 2 cameras, variable travel speed: Low temperature: -65°C...0 / High temperature: +60°C...+150°C; Volume: 11 l
Vibrations + Temperature + Humidity	TV 55240/LS / TIRA	Size of the transport table: 7inx7in; Maximum specimen height: 10 in; Maximum drop height of the transport table: 60 in; Maximum acceleration: 4500 g
Mechanical shocks (Freefall)	MRAD 0707-20 – Free Fall Sock Machine / Cambridge Vibration	Size of the transport table: 7inx7in; Maximum specimen height: 10in; Maximum drop height of the transport table: 60 in; Maximum acceleration: 4500 g
Thermal conditioning on measurement	TP04300A-8C3-11 7 Thermo Stream/Temptronic	Temperature variations: -80°C to +250°C, with transition time: 7sec up, 20sec down; Temperature control +/- 0.1°C
Thermal analysis	Microscope IR SC 5600 + G3 L0605/FLIR Systems	Sensor: InSb, Resolution (pixels): 640 x 512: Calibrated temperature range: -20°C ... 3000°C

Electronic equipment:

Equipment	Specifications
Keithley 4200 SCS electrical characterization system	• Stimuli: Voltage CC < 100V, Current CC < 1A; • Pulses: analog signal 30V, <40MHz • Measurementsi: voltage 0.5 μV, current 1 fA
NI PXIe-1078 data acquisition system with the following boards:	• NI PXIe-6341 - X Series Multifunction DAQ • NI PXI-2501 - Low-Voltage Multiplexer/Matrix FET Switch • NI PXI-5114 - 250 MS/s, 8-Bit Oscilloscope/Digitizer • NI PXI-4065 - 6½-Digit PXI DMM • NI PXI-5402 - 20 MHz Arbitrary Function Generator
LCR Rohde & Schwarz HM8118	• Measuring range: 20 Hz to 200 kHz (69 steps); error: 0.05 % • Automatic or manual selection of the circuit type (serial, parallel) • Types of measurements: L, C, R, |Z|, X, |Y|, G, B, D, Q, Φ, Δ, M, N • Dual RS-232/USB interface; optional IEEE-488 (GPIB)
Teledyne LeCroy WaveSurfer 3024 Oscilloscope	• Bandwidth: 200 MHz, 350 MHz, 500 MHz, 750 MHz • 16 digital channels, with 500 MS/s Sample Rate • Wave functions generator and digital voltmeter
Lock-In Stanford Research Systems SR865 Amplifier	• Frequency range: 1 mHz to 2 MHz; time constant between 1 μs to 30 ks • Interfaces: GPIB, RS-232, Ethernet si USB; output video HDMI

Laboratory for Carbon Based Nanotechnologies and Nanostructures

Mission

The L11 Laboratory was founded in the **Research Centre for Nanotechnologies Dedicated to Integrated Systems and Carbon Based Advanced Materials (CENASIC)** with the main goal to assemble a team of young researchers capable to manage the newly commissioned research infrastructure in order to advance the research objectives proposed in the initial project proposal, as well as to initiate new research directions related to the mission of the centre.

Domains of activity

•Development, implementation, optimization of synthesis methods for carbon based advanced materials;
•Development of dedicated technologies and integration of carbon based materials in classical systems;
•Development of deposition processes for ultra-thin atomic layers with a wide range of applications, especially for nanoelectronics;
•Identification and exploitation of the special properties of integrated systems.

Team

- **Dr. Andrei Avram,** Physicist, Senior Researcher, Head of laboratory
- **Dr. Florin Năstase,** Physicist, Senior Researcher
- **Dr. Cosmin Obreja,** Chemist, Senior Researcher
- **Dr. Silviu Vulpe,** Physicist, Senior Researcher
- **Drd. Octavian Simionescu**, Physicist
- **Drd. Damir Mladenovic,** Physicist
- **Drd. Elena Anghel,** Engineer, Research assistant
- **Felicia Negreci,** Engineer, Research assistant

Equipment

- PlasmalabSystem100, ICP-RIE dedicated to high aspect ratio etching of silicon.
- NANOFAB 1000, PECVD dedicated to plasma enhanced and thermal growth of carbon-based materials.
- PlasmaLab System 400, Rf Magnetron Sputtering for various thin films.
- OpAl, ALD for ultra-thin film deposition
- Nanocalc XR, optical reflectometer for thin film thickness measurement
- Thermal UV-Ozone Cleaner, for cleaning and surface activation

Dr. Marius Andrei Avram is a full time Senior Researcher at the National Institute for R&D in Microtechnologies – IMT Bucharest, and is the head of the Laboratory for Carbon Based Nanotechnologies and Nanostructures. Dr. Avram holds a BSc in Physics (2009) and a MSc in Plasma Physics (2010) from University of Bucharest, and a PhD in Electrical Engineering (2014) from "Politehnica" University Bucharest.
He has an experience of over 10 years in developing and implementing plasma assisted process for etching and deposition of materials and process integration for the fabrication of micro- and nano- electronic devices and MEMS. Since started working as a researcher, he has been actively involved in the implementation of 15 national funded research projects, one of which he coordinated as project manager). Currently he is working on developing and integration of carbon based materials, like graphene derivatives, into different types of sensor for industrial and research applications.
His main research interests are in developing carbon-based materials, and implementation of fabrication processes for MEMS, microfluidics, micro-nano-electronics and dedicated microstructures.

Laboratory head: :
Dr. Marius Andrei Avram,
andrei.avram@imt.ro

National and International collaborations

- Plasma & Materials Processing Group- Dept. of Applied Physics-Eindhoven Univ. of Technology - Prof.dr.ir. Erwin Kessels; Hybrid Solar Energy Conversion Group- Department of Physics and Astronomy- Vrije Universiteit Amsterdam- Prof. dr. Elizabeth von Hauff.
- *Collaborations with companies, research centres and groups from national universities and institutes:*

Accent Pro 2000 SRL; DOSITRACKER SRL; Department for General Chemistry–Faculty of Applied Chemistry and Material Science– "Politehnica" University of Bucharest; Department for Metallic Materials Science, Physical Metallurgy–Faculty of Science and Materials Engineering –"Politehnica" University of Bucharest; Department of Electricity, Solid-State Physics and Biophysics–Faculty of Physics–University of Bucharest; Department of Microbiology and Immunology–Faculty of Veterinary Medicine–University of Agricultural Science and Veterinary Medicine-Bucharest; research group for "Surface and Interface Science" – National Institute for Research and Development in Material Physics; research group for „Photon Processing of Advanced Materials"–National Institute for Research and Development in Laser, Plasma and Radiation Physics; Department for "Opto-spintronics" – National Institute for Research and Development for Optoelectronics INOE 2000; Department for "Carbon-Ceramic Materials" – National Institute for Research and Development in Electrical Engineering ICPE-CA; Department for Advanced Materials – "Transilvania" University of Brașov; Laboratory for Analytical Process Technology – National Institute of Research and Development in Electrochemistry and Condensed Matter.

Laboratory for Carbon Based Nanotechnologies and Nanostructures

Collaborations in National and International Projects in 2019

◆ Carbon quantum dots/graphene hybrids with broad photoresponsivity - BANDPASS, ATTRACT 2019-2020 (project manager: Monica Veca)

◆ Artificial permittivity and permeability engineering for future generation sub wavelength analogue integrated circuits and systems -NANOPOLY, H2020-FETOPEN (project manager: Mircea Dragoman)

◆ NANO components for electronic SMART wireless systems -NANOSMART, H2020-ICT (project manager: Mircea Dragoman)

◆ Elastomeric tuneable metasurfaces for efficient spectroscopic sensors for plastic detection -ElastoMeta, EEA-RO-NO-2018-0438 (project manager: Adrian Dinescu)

o Nanostructured carbon based materials for advanced industrial applications -NANOCARBON+, PN-III-P1-1.2-PCCDI-2017-0619, (project manager: Octavian Buiu)

• Piezorezistive effects in nanocrystalline carbon films and applications in tensile stress sensors -PIEZOCARB; (project manager: Andrei Avram)

• Oxides-nanocarbonic materials nanocomposites for photonics (photovoltaic systems and lasers)– NANOCOMPOZITCARB; (project manager: Cosmin Obreja)

• Composit photocatalytic coatings: metalic oxide–nanocarbonic materials for environmental applications: self cleaning properties and advanced purging of organic pollutants - FOTOCAT-CARBONCOMP; (project manager: Cosmin Obreja)

◆ Advanced nanoelectronic devices based on graphene/ferroelectric heterostructures- GRAPHENEFERRO, PN-III, PCCF (project manager: Mircea Dragoman)

o Partnership in exploitation of Key Essential Technologies (KET), using an interaction platform with competitive companies (TGE-PLAT):

• Micro-sensors based on carbon nanotubes for the detection of pathogens in liquid environments - CNT-SENSE (project manager: Andrei Avram)

• Passive millimetre wave imaging system for fast scanning of persons with applications in security - BODYSCAN (project manager: Alina Bunea)

• High quality image forming optical system, with optical diffractive elements, in the LWIR spectral band, for multisensory systems – SOFID; (project manager: Cristian Kusko)

◆ Core Program: Advanced research in micro/nano-electronics, photonics and micro/nano-bio systems for the development of applications in intelligent specialization domains PLUS (MICRO-NANO-SIS- PLUS):

• PN 19160202 - Atom thick materials (2D) and their applications at the limit of Moore's law;

• PN 19160301 - Nanosystems for signal amplification for sensors based on optic, electronic, and electrochemic active markers on Si and SiC substrates;

• PN 19160201 – Nanocarbon materials– nonconventional processes and technologies, test-applications.

Results

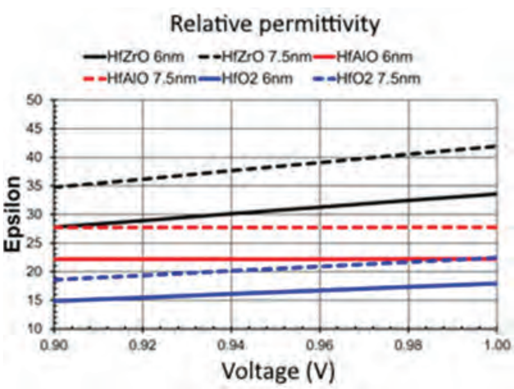
Increasing dielectric permittivity of oxide materials deposited by ALD

Increased dielectric permittivity of ultra-thin oxide films allows the fabrication of miniaturized electronic circuits based on 2D materials, especially in the high frequency range.

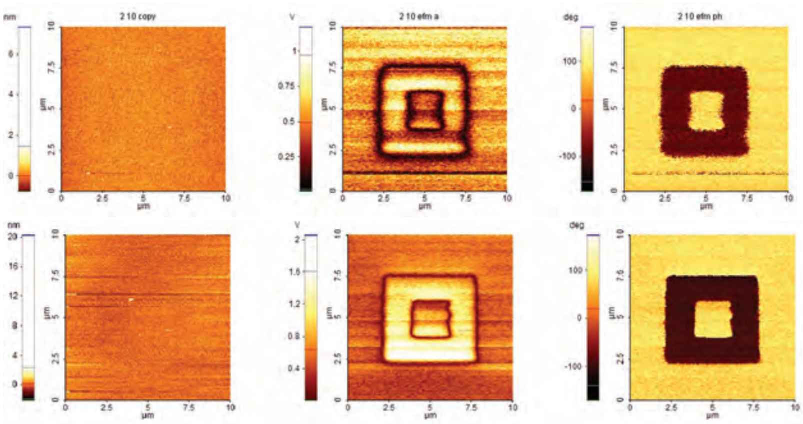
Ultra-thin films of HfO_2 have been doped with Zr or Al, by using an atomic layer deposition equipment (OpAl/ Oxford Instruments Plasma Technology).

The following aspects can be observed: (i) relative permittivity is increased by the nature of dopant; (ii) relative permittivity increases with the thickness of the ultra-thin film. A consequence of these observations is the dimension of electronic circuits can be decreased by a factor of $\sqrt{\varepsilon}$.

Alongside the increase of dielectric permittivity by doping with Zr or Al, we can also observe ferroelectric properties in thin films of about 6 nm.



Relative dielectric permittivity of HfO_2; HfZrO and HfAlO



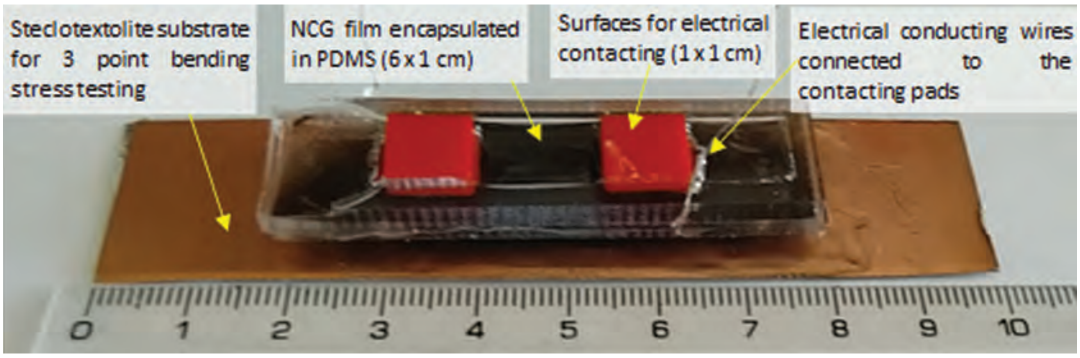
PFM for (a) Zr doped HfO_2 and (b) Al doped HfO_2 PFM writing on a 5 μm × 5 μm area at 10V and on a 2 μm × 2 μm at -10V; reading on a 10 μm × 10 μm area at 3V AC (PFM by dr. Raluca Gavrilă)

PFM figures represent topographical images along with the corresponding phase and amplitude signals. The last two images present the intensity of local mechanical response and, respectively, the phase shift between response and excitation. The local response is different between the initial areas and written areas. PFM images shows the polarity shift along the polling direction takes place in ultra-thin doped HfO_2 films. Phase shift is approximately 180° between successive written areas.

Results

Fabrication of a proof of concept electro-mechanical sensor, using nanocrystalline graphite as piezoresistive film

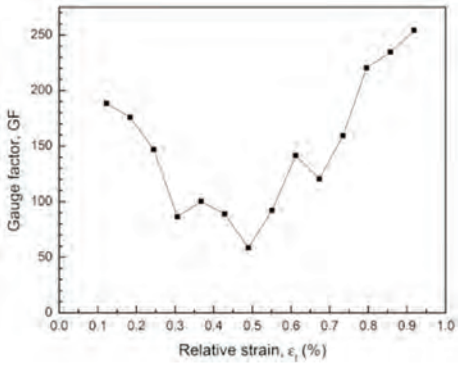
A thin film of nanocrystalline graphite (NCG) was deposited by PECVD on a silicon substrate and transferred on PDMS. The NCG thin film was mechanically contacted with a 1 × 1 cm Cu foil at each end of the strip. After conductive wires were attached to the Cu foils, they were mechanically pressed onto the NCG film in a 3D printed PLA mould. The entirety of the contacted NCG film was then encapsulated with PDMS.



PDMS/NCG/PDMS proof of concept used for electromechanical testing

A first piezoresistive response test was made through successive 3-point bending deformations and returns to zero deflection, such that in each cycle the targeted maximum deflection at the center of the beam is deeper with 0.1 mm than in the previous cycle, until a final d of 1.5 mm was attained. At the beginning and end of each cycle a resistance measurement was performed. The initial measured value of the sample resistance was 49 k and the up and down displacement rate was 1 mm/min. The figure presents the values measured in this experiment.

Preliminary measurements showed a high gauge factor GF ~ 50-250. The measurements were performed in collaboration with L7



Gauge factor with respect to the relative strain

Centre for Research and Technologies Integration

Laboratory for Microsystems in biomedical and environmental applications

Mission

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

Areas of activity

•**Micro-Nanosensors–Microsensors development** (chemo-rezistent, resonant gas sensors, accelerometers, micro- arrays, ISFET sensors, nanowire based sensors, implantable electrodes for peripheral nerves stimulation and detection, CNT and graphene based devices)

•**Microfluidic modules and chips** – Simulation, modelling and development of microfluidic platforms for organ on chip development.

•**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 modelling-simulation/modelling** using MEMS specific CAD tools (CoventorWare, COMSOL, CADENCE).

Team

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

Dr. Carmen Moldovan graduated on Electronics and Telecommunications and she owns a PhD in Microsensors. Her current research activity is focused on development of chemo-sensors 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 partner or coordinator of 17 EU Projects (FP6, FP7, ERA-NET) and 23 National Projects. She is currently coordinating 2 ERA-NET and 3 National projects. Her scientific activity was published in more than 120 papers in journals, books and Proceedings.

Laboratory head:
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carmen.moldovan@imt.ro

Equipment

• **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) Poli-Aniline (PANI).

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

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

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

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.

SIOS Vibrometer-Laser interferometer for vibration measurements (amplitude, frequencies or velocity) of mechanical systems / components like cantilevers or membranes. It is capable to measure amplitudes as low as tens of nm with a few pm resolution and frequencies as high as 5MHz.

International and National collaborations

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

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

• **iBracelet** - Inteligent bracelet for blood pressure monitoring and detection of preeclampsia–EUROSTARS (InfoWorld and "Politehnica" Univ. Bucharest, Romania, Cherry Biotech and Elvesys, France);

• **RoboCom++** - Rethinking Robotics for the Robot Companion of the future, FLAG-Era.net;

• **ARMIN-Arm** neuroprosthesis equipped with artificial skin and sensorial feedback–SEE Norway Grants („Politehnica" Univ. Bucharest, Univ. of South-Eastern Norway, Areus Technology, Romanian Academy of Medical Sciences, Emergency Hospital Bcharest)

• **CONVERGENCE**-Frictionless Energy Efficient Convergent Wearables for Healthcare and Lifestyle Applications – FLAG Era.net.

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:

• **SENSIS** (Sensors and Integrated Electronic and Photonic Systems for people and Infrastructures Security): INFLPR, „Politehnica" University Bucharest, Pitești University, Institute of Physical Chemistry I. Murgulescu, Centre of Scientific Research for Defence, CBRN and Ecology, Ministry of Defence;

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

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

• **MiMoSA** (New methods of pregnancy monitoring and prenatal diagnosis): "Carol Davila" University of Medicine and Pharmacy, Fundeni Hospital, „Politehnica" University Bucharest, INSMC "Alessandrescu-Rusescu".

Laboratory for Microsystems in biomedical and environmental applications

Results - MICROSENSORS AND MICROTRANSDUCERS

TF BAR sensors array - based portable microsystem for multiple detection of explosive substances

The project, a component of the SENSIS Complex Project, proposes to develop a portable microsystem based on TF BAR sensors for multiple detection of explosive substances. The system is designated to technical anti-terrorist control, critical infrastructures security (airport, subway, governmental buildings, command centres etc.) and persons / officials participating in major public events (political, sports, cultural or social events).

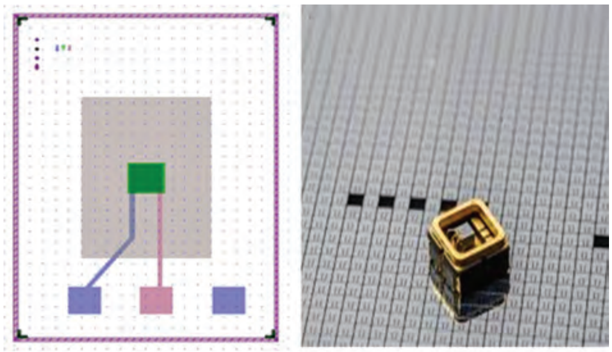


Fig. 1 Left: The TF BAR sensor for explosive substances detection – optimized layout; Right: TF Bar sensor with ZnO as sensitive piezoelectric layer

The risks associated with terrorist attacks in Europe are continuously rising, therefore the necessity of a portable, fully automated detection system is very present and urgent. The system will have selective and sensitive sensors, capable of detecting traces or particles of the main explosives on various objects (parcels, vehicles, clothes) or on the skin.

During 2019, the microsensors layout has been optimized in order to reduce the material stress in the membrane. In parallel to this optimization, another version of a TF BAR sensor with ZnO (zinc oxide) as sensitive piezoelectric layer was tested.

Electrochemical microsensors for rapid and selective detection of pesticides-ORGANOPEST

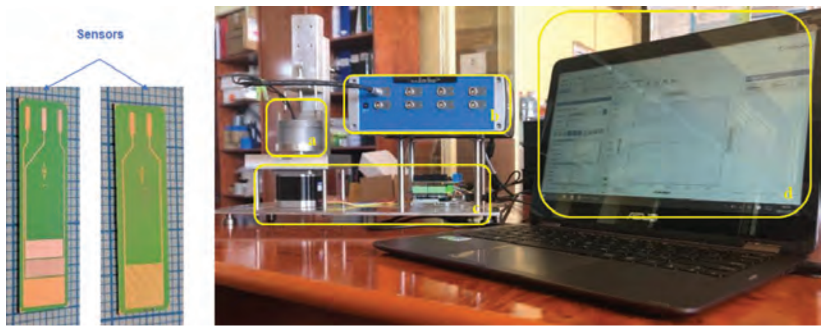


Fig. 2 Left: Two types of electrochemical microsensors for pesticides detection; Right: Testing platform for pesticides detection – (a) Solution recipient and microsensor support; (b) Electrochemical measurement module; (c) electronic module for motor control; (d) User-interface program for data acquisition and visualization

ORGANOPEST is an integrated system for the detection of pesticides. The electrochemical microsensors were designed and fabricated at IMT-Bucharest, as well as the mechanical and electrical components for the detecting platform. During 2019, a testing platform was developed. It has an easy-to-use user interface and is capable to detect organophosphorus and organochlorine pesticides.

Non-invasive microsensors for continuous glucose monitoring during pregnancy (MiMoSA)

The project proposes to study, build and test the technology for a non-invasive sensor for the measurement of glucose in the saliva. A new technology, based on micro fabrication and plastic electronics will lead to a new, sensitive, selective and completely non-invasive sensor for the continuous monitoring of glucose in pregnant women diagnosed with diabetes, in high risk of diabetes or other complication with high risk of premature delivery. This sensor does not exist on the medical market so a big challenge is going to be the fabrication of the device and testing it on biological probes from patients (saliva) versus blood tests ("golden standard") so all information will be harvested: medical requirements alongside patient's feedback so the monitoring system is built after users requirements to prove its full efficiency.

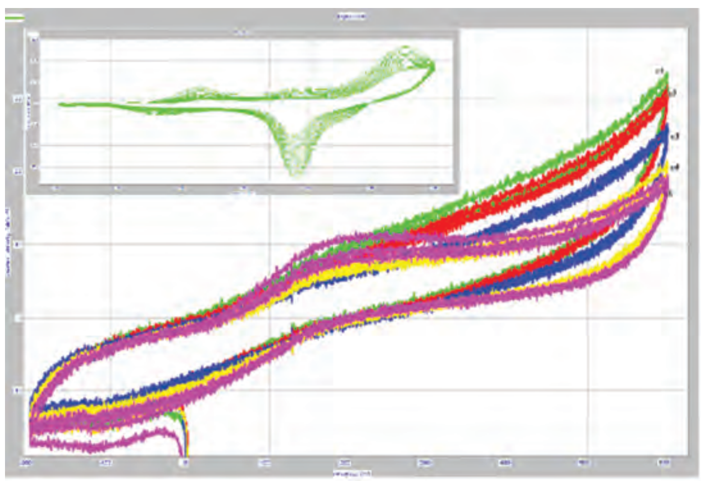


Fig. 3 – IV curves for the Pt/PANI sensor

During 2019, the technological processing of the sensors was performed, optimization tests and characterization of the bioactive films deposited on the electrode were performed, an in vitro measurement cell was made, and following the electrical tests, the software for reading and data acquisition was designed. The interference compounds in the sample were minimized by depositing a cationic membrane to prevent their electrochemical activity. Preliminary characterization tests of the bioactive layer showed by the structural mapping technique FTIR that it was deposited in a homogeneous way on the surface of the electrodes. The electrochemical activity was demonstrated by the linearity of the current signal, presented by the sensors when they were put in contact with the glucose concentrations.

Laboratory for Microsystems in biomedical and environmental applications

Results - MICROSENSORS AND MICROTRANSDUCERS

Smart Portable System for VOCs detection (VOC- DETECT)

Volatile Organic Compounds (VOC) have a large presence in most indoor areas (both households and working environments). According to a European Union study, they are one of the chemicals that cause the most concern related to the public health. Numerous studies revealed the toxic effect of these VOCs and most of them were able to connect the human diseases to the presence of VOC in indoor air. For example, some studies have suggested an influence of VOC exposure on the immune status of the new-born child after maternal exposure, such as the enhancement of sensitization and the risk of asthma or respiratory symptoms. Other studies referred to the carcinogenic effect of some VOCs (e.g. formaldehyde). Despite years of research, the tools for the detection of VOCs are still not very precise and are too expensive. For these reasons the project proposes to develop new sensors based on nano MOX (Metal Oxide) and CNT (Carbon Nanotubes) materials for VOC detection, integrated into a smart portable system providing quantitative information about the concentration of Formaldehyde and Benzene as VOCs in indoor air.

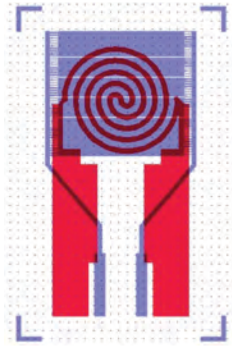


Fig. 4 - VOC-DETECT sensor layout

The focus of the project will be on the development of New sensors, highly sensitive, and selective, for detection of the most dangerous VOCs affecting the human health at low concentration exposure and with a high probability to be found in houses and working environments: Formaldehyde and Benzene. Within VOC-DETECT Project, IMT will design and prototype new sensors for VOCs (Volatile Organic Compounds) detection together with associated electronics for signal reading, processing, acquisition, analysis and diagnosis, providing at the end a Smart portable system to be used in houses or working environment.

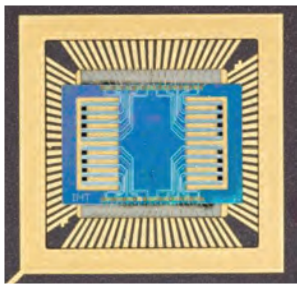
During 2019, the design of a sensor structure necessary to perform preliminary tests for the detection of volatile organic compounds (VOC) has been performed. The substrate chosen for this type of sensor was a ceramic type wafer.

Results - ENERGY HARVESTING DEVICES

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

Energy micro-harvesters for powering up sensors and portable microsystems

The project, a component of the SENSIS Complex Project, aims at developing piezoelectric micro-harvester (a MEMS structure covered with a thin piezoelectric film with the purpose to convert the mechanical energy into electrical energy – the direct piezoelectric effect). It will contain doped PZT (with high piezoelectric coefficients) as thin films on Si substrate. The project will also provide the design and fabrication of the energy storage device and the associated circuitry. The desired targeted field is the low frequencies area (hundreds of Hertz). The best results were on the rectangular piezoelectric-silicon cantilever with silicon proof mass as the energy harvester. Several cantilevers were grouped and clamped together in order to increase the power density and to make sure that the grouped cantilevers oscillate with the same phase.



Rectangular cantilevers grouped and clamped together

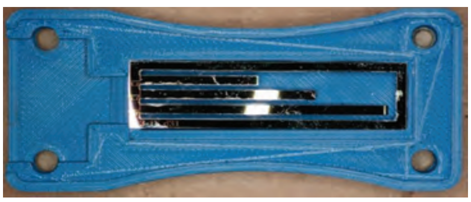


Fig. 5 Spiralled structure with 4 spires, designed for resonant frequencies in the 90 Hz range

Results - Micro-nanotechnology-based devices / IoT applications

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

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

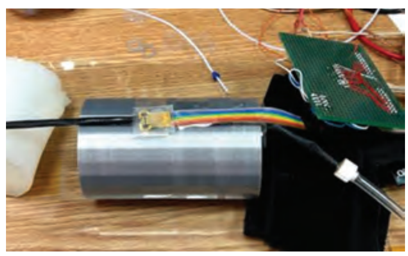


Fig. 6 - Evaluation of the pressure sensor (DC-2). A flexible tube was placed on one of the channels of the artificial arm 2, with thin walls through which the blood flow is simulated. Above it is the sensor which is connected to the measuring instruments

The second prototype was developed. It contains a flexible pressure micro-sensor, a data transmission module and a data processing module. The pressure sensor contains a thin Au film, deposited on a flexible substrate (PET).

With great flexibility, the device will be a solution for non-invasive, low-cost hemodynamic monitoring, which can be worn comfortably for long periods of time, without the need for specialized operation.

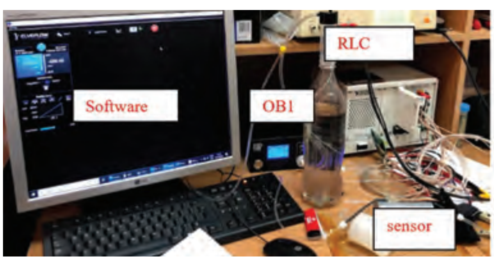


Fig. 7 - The AC-2 measurement setup used to validate the pressure sensor

Results - Micro-nanotechnology-based devices / IoT applications

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

RoboCom++ is meant to lay the foundation for a future global interdisciplinary research programme. It is going to pursue a radically new design paradigm, grounded in the scientific studies of intelligence in nature. The project with 26 partners from 17 EU countries (https://robocomplusplus.eu) continues to develop Research on emerging disruptive ideas to the level of proof-of-concept by means of a few pilots addressing key topics such as: Computational Foundations of Actions; Morphological Computation and Soft Robotics; Soft Technologies for Wearable and Mobile Robots; Bio-Inspired Self-Healing Materials; Biomimetic Cognitive Architecture for Human-Robot interaction.

In 2019 IMT's activity focuses on implementation and development of algorithms for detection of subliminal messages from audio discussion. The detection was realised with the help of specific neural convolutional neural networks. A Convolutional Neural Network (CNN) for detection and binary classification of audio messages coming from musical instruments superposed with a male voice containing subliminal messages.

Audio signals from musical files together with voice signals at 11025 Hz sampling rate have been used.

1900 images of spectrograms have been grouped in 1520 trainig images / spectrograms for training and 380 testing images/ spectrograms. This way, with 4 convolutive layers have been designed. Convolutional Neural Network. The result of the development was the demonstration of the capability of a CNN network to detect/ discriminate the messages with subliminal character from audio messages and this capability can be also implemented in companion robots.

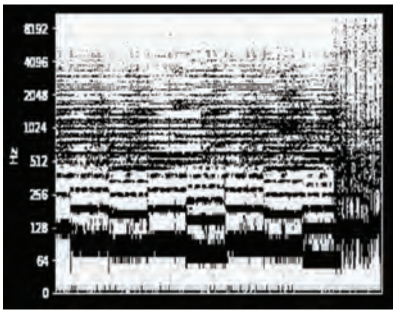


Fig. 8 - Audio signal spectrogram in the range 0 – 11025 Hz

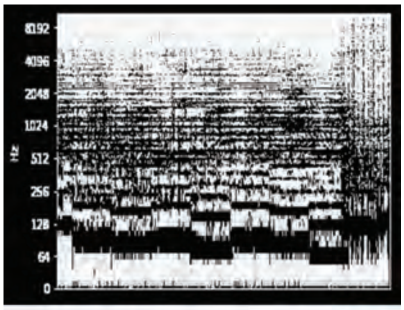


Fig. 9 - Signal spectrogram with the superposed subliminal voice

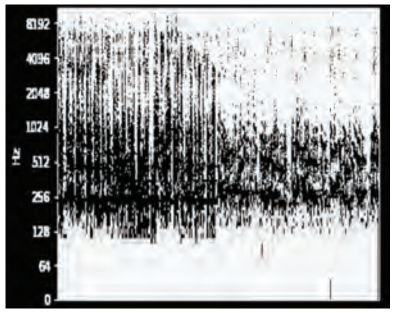


Fig. 10 - Spectrogram as a difference between the two signals

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

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

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

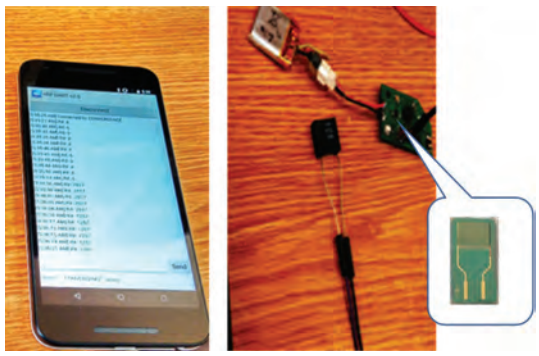


Fig 11 – Resistive measurements using the sensor device

One major outcome resulted from IMT's contribution to the project is the newly developed CO sensor, working at room temperature and with sensitivity as low as 2 ppm. The sensing material is an InkJet Printer composite. The whole platform (sensors and electronics) has a few centimetres and can be used as a bracelet.

Arm neuroprosthesis equipped with artificial skin and sensorial feedback (ARMIN)

The overall aim of the project is to develop a new, functional and performing neuroprosthesis, providing the amputee with the possibility to recover the lost arm functions. The results obtained so far in the project include a prototype of the mechanical structure, the design of the implantable electrodes and several experiments regarding the functionality and biocompatibility of electrodes.

The implantable electrodes were made of gold and were fabricated on Kapton substrate (50 microns thick) using metal deposition by sputtering, gold patterning by lift-off and clean room facilities and equipment. They have been designed to be wrapped around specific branches of the median /ulnar nerves from the patient's stump.

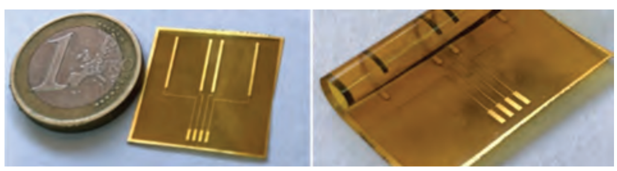


Fig.2. Picture of the implantable electrodes

Education and training

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

Centre for Research and Technologies Integration

Ambiental Technologies Laboratory

Mission

● Research, Development, Innovation of new technologies for micro/nano sensors for environmental and ambient applications. Technological design, technological development, technological development up to prototype stage.

● Research, Development, Innovation for satellite alignment optic systems with special design for harsh environment and space applications. Technological design, technological development, technological development up to prototype stage.

● Research, Development, Innovation for new nanostructured materials with applications in industry and agriculture. Sinthesis of new materials; development of devices/structures based on new materials.

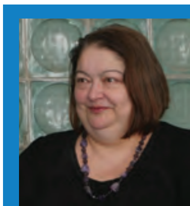
● Technological services including:

- Materials study and characterization
- Technological assistance and consulting (design of technological pipelines, control stations etc.).
- Analysis of technological compatibility and technological defects on technological pipeline.
- Technical assistance (technologic transfer) for passing from prototype phase to mass production.
- Development of individual customised technological processes such as oxides deposition/growth, metallic/dielectric depositions, photo-gravure chemical cleaning – surface preparation etc.
- Upgrading technological processes and technologies.
- Consulting/assistance in nanocomposite/nanostructured materials
- Electrical characterization of electronic devices.

All the activities of Ambient Laboratory is undergoing with the goal of upgrading environmental and ambient condition and to upgrade the society and individual security (including health applications) as well as upgrading classic industrial processes for improving efficiency. During the last decade activity of laboratory was diversified with applications in the area of space and security (ESA, STAR, ROSA programmes).

Team

Dr. Ileana CERNICA - CS I, dr.ing. in microelectronics , Team manager
Dr. Elena MANEA, CSI, dr.in physical science
Dr. Ciprian ILIESCU, CSI (IBN Singapore), dr.ing. in mechanical engineering
Dr. Octavian Narcis IONESCU (associate) , CSIII, dr.ing. In Systems theory
Dr. Violeta DEDIU, CS , dr.ing. in materials engineering;
Drd. Ing. Florian PISTRITU – electrical engineer; drd in electronics
Drd. Edwin Alexandru LASZLO, ACS, physician, drd in physical science



Laboratory head:
Dr. Ileana Cernica,
ileana.cernica@imt.ro

Dr. Ieana 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.

Areas of activity

Research Development Innovation:

• Advanced solar cell technologies (including for space applications)
- Surface and volume microprocessing technologies
• Technologies for integrating signal electronics with sensors
• Micro / nanosensor technologies (including sensor areas)
• Optoelectronic technologies (eg photodiodes, suppressor diodes, optical alignment systems)
• Technologies for making optical elements (microlens, thin lenses, thin mirrors)
• Technologies for the realization of advanced nanocomposite materials with antibacterial, antifungal properties with applications in civil construction, agriculture, health.
• M / N systems technologies for cell analysis and health (diagnosis, prevention)
• Technologies for the realization of optical alignment systems with operation in a wide range of temperatures for space applications
• Characterization Services and Technological Processes: Electrical characterization of the microsystem and Realization of test benches and signal electronics IoT compatibility technologies




Equipment

• **Tehnologies:** - RTP Rapid Thermal Processing system for silicon, compound semiconductors, Photonics and MEMS process (ANNEALSYS, France), Manufactured in 2010.
Aplications: Rapid Thermal Oxidation (RTO); Rapid Thermal Nitridation (RTN); Crystallizationd and/or annealing; Anneling of Semiconductor Compound;
- High temperature furnace, Carbolite. Manufactured in 2011.
Aplications in the field of: 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, Manufactured in 2007.
- CCS-100/204 Optical cryostat system with sample in vacuum, JANIS Research Comp. Inc. Manufactured in 2017

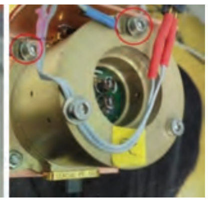
Laboratory for Microsystems in biomedical and environmental applications

Results

PROBA-3 CoronagraphSystem Mission-OPSE (ESA)

Prime Contractor: Liège Space Center
Subcontractor for OPSE: IMT Bucharest
IMT project director Ileana Cernica (ileana.cernica@imt.ro)
Purpose: development of 3 Occulter Position Sensor Emitter (OPSE) systems for aligning the coronograph in the PROBA 3 space mission (space launch deadline 2020)
Initial TRL 2, Final TRL 9 (flight model)

OPSE thermal balance tests



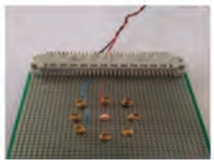
OPSE STM

Optical alignment systems for space flights in formation and deorbitation of space residues- OASYS (STAR)

FSO system schematics

Partners: ISS Bucharest and the Military Technical Academy; IMT project director: Ileana Cernica (ileana.cernica@imt.ro)

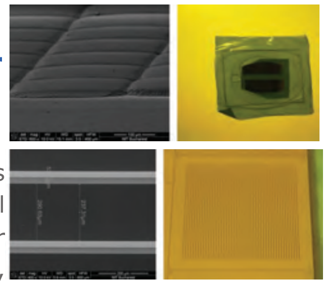
In the research project we focused on presenting the methods and techniques of optical alignment that we want to implement for the two proposed applications: the alignment of the flight of spacecraft/satellites in formation and the realization of an alignment system for removing (deorbing) the surrounding waste. earth. The evolution of the human species has also led to the accelerated evolution of space technologies that have the obvious disadvantage of increasing the population of uncontrolled and functional residues (satellite satellites or rocket stages), which present a serious risk for future missions. Controlling the amount of space debris to maintain long-term access to space in the next decade leads to the development of technologies for autonomous interception, appropriation and orbiting missions.



MD de OASYS pe test-board

TRL initial 2, TRL final 5

Technologies for the realization of the areas of micro-optical elements for space applications - MICRO-OPTEH (STAR)



IMT project director: Elena Manea (elena.manea@imt.ro), Initial TRL 2, Final TRL 4

The aim of the project is to develop versatile, cheap and short-cycle manufacturing technologies for the realization of micro-optical element arrays with applications in both space and terrestrial applications-optical devices for imaging, detection elements and various types of solar concentrators. The technological problem we address through this project is the design, optimization and evaluation in laboratory conditions of a new technology for capturing and concentrating light on photovoltaic areas as small as possible. This technology will make an important contribution to reducing the mass of the solar panel, which is a very important factor for the use of dedicated space applications (e.g. satellites), while reducing the costs associated with making solar panels. The technological concept of the planar optical concentrator, based on the concentration of light on photovoltaic areas as small as possible, developed in the project is based on the use of three optical elements consisting of two two-dimensional arrays of micro-optical elements, one with micro-lenses and two with integrated micro-mirrors with an optical guide and a photovoltaic cell. The networks of micro-optical elements were obtained by replication in polymer using silicon mold.

Realization of demonstrator in planar transistor technology with tunneling of ultra-thin insulators - as a promoter of a series of nano-devices and highlighting the utility in industry - DEMOTUN (PED)

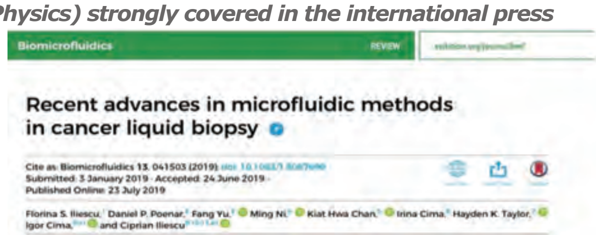
IMT project manager: Elena Manea (elena.manea@imt.ro); Coord. Polytechnic University of Bucharest; IMT - Bucharest - P1, Initial TRL 2, Final TRL 4

The aim of the project is to manufacture a prototype electronic device based on the tunneling of ultra-thin insulators, as the first exponent of the so-called Nothing on Insulator (NOI) transistor. For the NOI device, the insulator can be vacuum or oxide, but it is important to be ultra-thin, 2-10nm thick. Within this project, a p-NOI planar architecture was proposed, in silicon, using oxide as insulator.

The IMT team involved in the implementation of this project developed two technological variants for making thin oxides in steps for planarNOI: Variant 1 through which the thickest oxide was first grown, and then through successive corrosion the thinnest oxides were obtained; In the process of making the p-NOI structures through this variant, different corrosion solutions were used to obtain oxide thicknesses from 80nm to 40nm, 20nm, 10nm, 5nm and 2nm respectively. And Variant 2 in which the thinnest oxide was initially increased and then successively by thermal oxidations, the other thicker oxides were increased.

Article coordinated by IMT (with international participation), published in "Biomicrofluidics" (American Institute of Physics) strongly covered in the international press

" If you isolate some cells and expose them to drug candidates, you can predict the response of the patient in advanced", said Iliescu, a researcher at IMT-Bucharest in Romania, „Then you can track how the tumor is evolving in response to treatment."



Biomicrofluidics REVIEW

Recent advances in microfluidic methods in cancer liquid biopsy

Cite as: Biomicrofluidics 13, 041503 (2019)
Submitted: 3 January 2019 · Accepted: 24 June 2019 ·
Published Online: 23 July 2019

Florina S. Iliescu, Daniel P. Poenar, Fang Yu, Ming Ni, Kiat Hwa Chan, Irina Cima, Hayden K. Taylor, Igor Cima, and Ciprian Iliescu

Centre for Research and Technologies Integration

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Laboratory for Micro- and Nano- Fluidics

Mission

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

Domains of activity

❖ *Computational Fluid Dynamics (CFD)* modelling of Newtonian and non-Newtonian flow, e.g. single- and multiphase flows, mixing, turbulence, heat transfer, user defined function implementation for additional flow parameters setting, magnetohydrodynamics, etc.
❖ *Design of microfluidic devices for applications* in clinical diagnostics and regenerative medicine.
❖ *Investigation of fluid flow and rheology at the microscale*, and its application to optimize lab-on-a-chip devices.
❖ *Experimental nano- and microtechnology*: cleanroom processes (glass silicon and polymer micromachining, plasma-based processes), synthesis of nanocomposites, design, simulation, fabrication and characterization.
❖ *Bioengineering*: Cellular uptake of nanoparticles; studies of cells activity; tumour cells investigation spectroscopy (FTIR, Raman, Electrochemical Impedance).
❖ *Molecular transport in microfluidic devices*: Dielectrophoretic and Magnetophoretic systems for separation of biomolecules.
❖ *Visualization and flow characterization:* our experimental methods used for microscopic flow investigations are based on (i) contrast substances for the path lines distributions (ii) µ-PIV measurements for local hydrodynamic behaviour of a steady fluid flow and quantitative measurements of the velocity profiles and vortex identification.

Team

1. **Dr. Marioara Avram** - CS I, modelling, simulation, design, micro-processing and characterization of lab-on-a-chip microfluidic devices with integrated biosensors;
2. **Dr. Cătălin Valentin Marculescu** - CS III, modelling and simulation of Newtonian and Non-Newtonian fluid flow, mono and multiphase flows, mixing, turbulence, heat transfer, implementation of user defined functions for setting additional flow parameters;
3. **Dr. Vasilica Tucureanu** - CS III, chemist, synthesis of nanostructured inorganic materials, study of hybrid nanocomposites, thermal processes, optoelectronics, electrochemistry, analytical chemistry, substrate configuration;
4. **Dr. Alina Matei** - CSIII, chemical engineer, synthesis of nanostructured materials and hybrid nanocomposites, thermal processes and characterization of nanomaterials;
5. **PhD Student Tiberiu Alecu Burinaru** - Research assistant, nanofluidics modelling on biomolecular interactions.
6. **PhD Student Cătălina Bianca Ţîncu** - Research assistant, experimental set-up for the characterization and testing of biosensors integrated on microfluidic platforms; synthesis and characterization of carbon nanomaterials.
7. **Dr. Petruţa Preda** - CS, graduate in Biochemistry and PhD in Biology; synthesis of polymeric biomaterials, physico-chemical analysis and their biological characterization; determination of antimicrobial activity, biocompatibility.
8. **PhD Student Eugen Chiriac** – Research assistant, modelling and numerical simulation of fluid flow in microfluidic and dielectrophoretic systems; microfluidic systems design; soft lithography; transparent micro-fabrication.

Laboratory head:
Dr. Marioara Avram,
marioara.avram@imt.ro

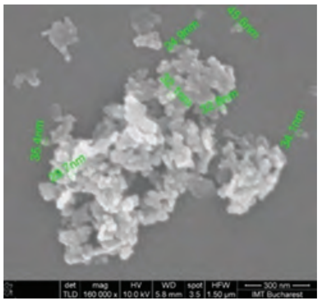
Dr. Marioara Avram is Senior Scientific Researcher at National Institute for Research and Development in Microtechnologies, Micro- and Nano- Fluidics Laboratory. She received her PhD in 2004 from the University „Politehnica" of Bucharest. Her areas of expertise include fundamental and applied research with defined innovation objectives: bionanoengineering, micro&nanofluidics, micro-biosensors and bioinspired carbon nanomaterials.
She was initiator, principal investigator and manager in multiple national and international research projects.
She is the author and co-author of more than 150 scientific papers with over 800 citations (between them 53 ISI indexed) and 18 patents.
Awards: The WIPO Award for the Best Women Inventor in 2006; 14 Gold Medals and 14 Special Awards for her inventions to International Exhibitions of Inventions: Inventika – 2006, 2007 and 2014, Geneva- 2002, 2007, 2014, 2015, 2016, 2017 and 2019, EUREKA and Brussels 2008, ARCA in Croatia 2015, INNOVA, Barcelona 2017, Timișoara 2019.

Laboratory for Micro- and Nano- Fluidics

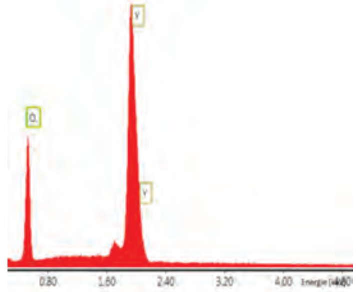
Results

Innovative technological approaches for the development of multifunctional nanosystems for integration in "theranostics" platforms
(Core 14N/2019-Project 9)

Preliminary studies for Y_2O_3 synthesis by sol-gel method using $Y(NO_3)_3$ and acetyl acetone, in the presence of DMSO, EG and CTAB, and a heat treated precursor at a maximum of 900ºC. The physicochemical properties and applicability of Y_2O_3 nanoparticles in the field of biotechnology are strongly influenced by the morphology and structure of the particles. Morphological studies have shown the formation of spherical particles, without surface defects. An average particle size of 30-40 nm was estimated. From a structural point of view, we obtained a compound with the formula $Y_{1.97}O_{3.03}$ and high purity.

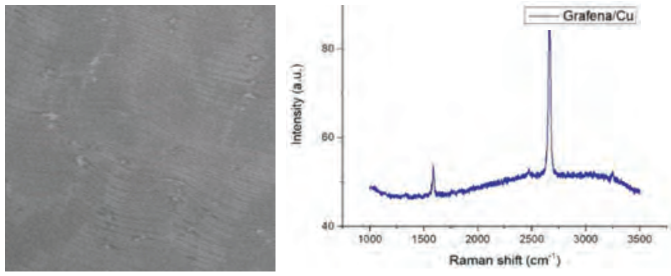


SEM image for a representative sample of Y_2O_3 obtained by the sol-gel method



EDX spectrum for a representative sample of Y_2O_3 obtained by the sol-gel method

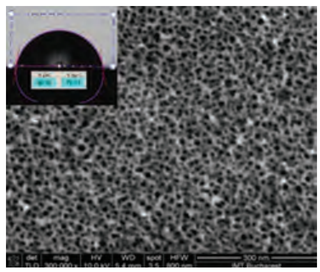
Experiments for the synthesis of monolayer graphene by chemical vapor deposition for its integration in theranostics platforms for diagnosis and treatment (biodetection, early diagnosis and targeted drug release).



Characteristics of CVD grown graphene on Cu substrate a) SEM micrograph and b) Raman spectrum

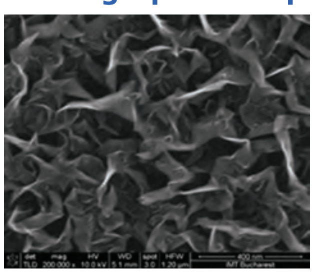
Multifunctional nanocomposites based on transition metal oxides with applicability in the aerospace field (OXITRANS)

Optimized technologies for: (i) Synthesis of oxides based on transition metals - the coprecipitation method and the solid phase process were used for the synthesis of oxides based on yttrium (type YAG and M2Ox, undoped or doped with rare earths); (ii) Obtaining nanocomposites by ex-situ incorporation in epoxy resin; (iii) Deposition of nanocomposite materials (RE-YAG and RE-M2Ox) on the aluminium alloy substrate (type A2014). Preparation of the surface of aluminium alloy substrates (type A2014) by degreasing and chemical roughing (using solutions based on NaOH and HNO3) to ensure a good adhesion of the deposited thin films. The developed devices were tested by exposure to UV radiation, thermal cycles and vibration tests, and the influence of the test media was analysed by light microscopy, SEM microscopy and contact angle measurement. Also, the devices were mechanically tested by determining the tensile strength and nanoindentation (measurements of storage mode, mode and loss factor)

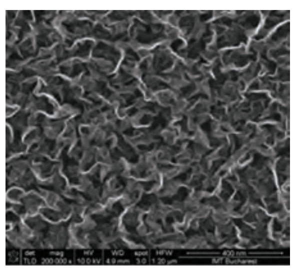


SEM nanocomposite image and contact angle for a representative sample of processed substrate RE-YAG: Ce deposited on aluminum alloy substrate

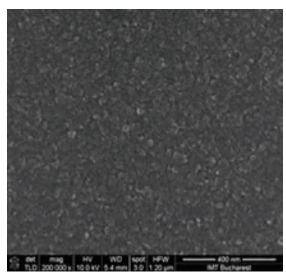
Improved CVD processes for the growth of carbon nanomaterials (monolayer graphene, vertical graphene, nanocrystalline graphite - EquiMS, TGE-PLAT C77.1C



Vertical graphene grown at 700ºC



Vertical graphene grown at 750ºC



Nanocrystalline graphite

The standard monolayer graphene growth process takes place in 5 steps: 1) the catalyst metal is placed on a special molybdenum support in Load-Lock and loaded into the reaction chamber where the vacuum takes place - at a pressure of 6 mTorr and a target temperature of 200°C; 2) the sample is subjected to a gradual heating, in atmosphere of Ar and H2, until the optimum growth temperature is reached: 1080˚C; 3) heat treatment in the atmosphere of H_2 for the formation of binding sites; 4) during the growth process the surface migration of the precursors to the nucleation centres and the increase of the atomic layer takes place; 5) cooling: the system is brought to the temperature of 200˚C, then the sample is taken out in Load-Lock.

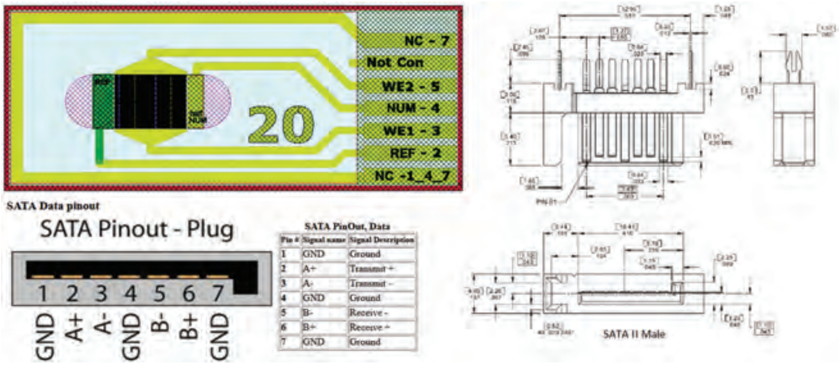
To increase the vertical graphene (GNW) films at process temperatures of 700°C and 750°C and the nanocrystalline graphene film (NCG) with a height of approximately 200 nm, the following work steps were performed: (i) chemically cleaned 3 Si wafers, then the carbon nanomaterials were grown using the Nanofab 1000, Plasma Pro 100 equipment. (ii) Carbon growth processes: (a) GNW-700°C. (b) GNW - 750°C. (c) NCG increase~200 nm.

Laboratory for Micro- and Nano- Fluidics

Results

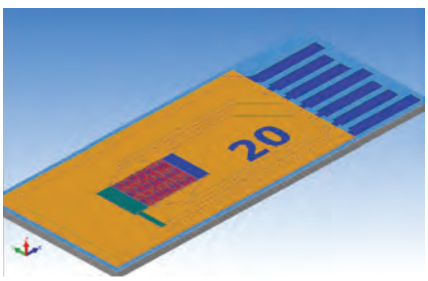
Technological design and modelling of individual technological processes for the realization of the microfluidic system with integrated impedimetric sensors (PCCDI - uCellDetect).

Designing photolithographic masks. Photolithographic masks were designed using CleWin software. In this program the impedimetric sensor is designed for which we need 4 masks and 6 overlapping transparent layers. To ensure the transfer of electrical signals from the device to the measurement and control interface using V-C (cyclic voltammetry), a connection area to a SATA II Male USB was implemented on the side. A short circuit is made between the 1-4-7 terminals to adapt to the USB.

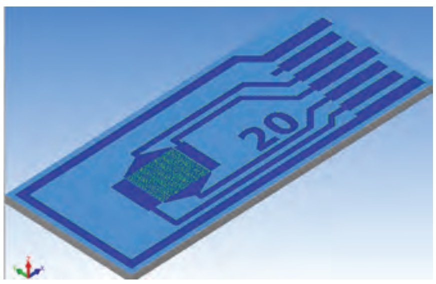


The design of the sensor with the 4 overlapping masks, the corresponding USB SATA II male pinout as well as its technical sketch

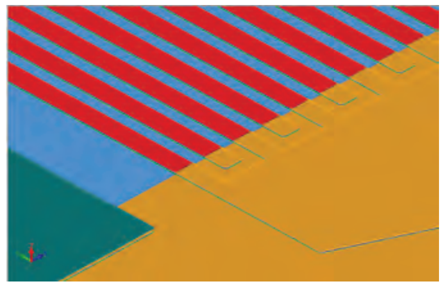
Modelling of the technological processes. Impedimetric sensor modelling was performed using Coventor's SEMulator3D software. The evaluation and selection of technological options for the biosensor were made by computer modelling of technological processes using the SEMulator3D™, program, which generated 3D models for thin films deposited or grown on monocrystalline silicon substrate. Through the SEMulator3D™ program a wide variety of process steps can be modelled. Each process step requires a number of geometric and physical input parameters. Process parameters such as deposit conformity, anisotropy and corrosion selectivity, interact with other parameters, but also with design data, on the structure of the final device. An important aspect of modelling is that it saves time, avoiding the problems related to the incompatibility between materials and the thickness of the layers.



Overview of the impedimetric sensor after all process steps have been modelled

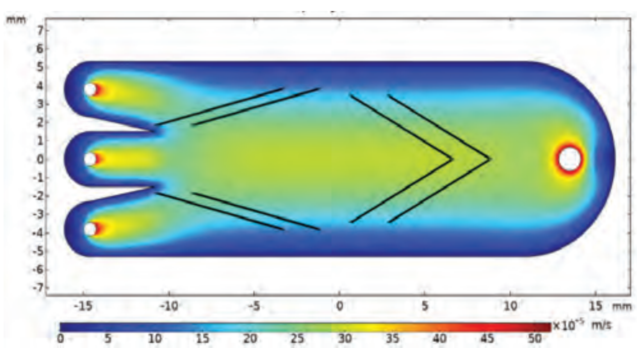


Modelling after deposition of the 200 nm CrAu layer, lift-off and TiN etching.

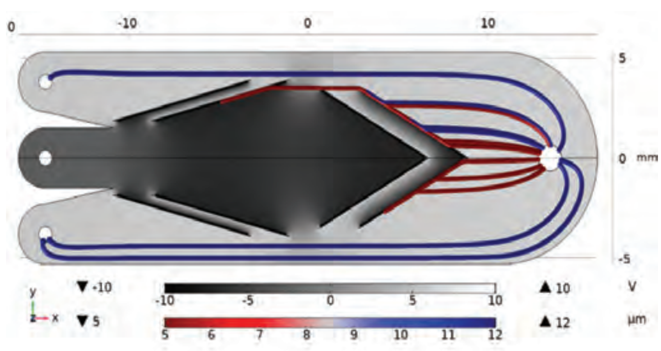


Functional area detail with interdigitated electrodes

Numerical simulation of a dielectrophoretic system for separation of circulating tumor cells. The 3D numerical simulations were performed in COMSOL 5.5. The two types of cells that were separated using dielectrophoresis are Reb Blood Cells and Circulating Tumor Cells from breast cancer. In order to do the numerical simulation, three modules have to be used. In the Creeping Flow module, we have the following initial and boundary conditions: at the inlet the initial flow velocity is 500 μm/s, at the outlet the relative pressure is set to zero and for the walls we have no slip. For the Electric Currents module, the electric potential is set to ±10V for the interdigitated electrodes and the frequency of the AC to 100kHz. In the Particle Tracing for Fluid Flow module, it is necessary to add further boundary conditions for the wall and the particles.



Velocity Magnitude



Particle trajectories t=250

Scientific events and Education activities

EURONANOFORUM 2019

The main aim of EuroNanoForum 2019 (ENF2019) conference organised in Bucharest, Romania, within the framework of the Romanian EU-Presidency was to facilitate and stimulate debates between researchers and stakeholders acting in Nanotechnologies and advanced Materials areas (NM) in Horizon 2020 NMBP Programme. The national, regional and European policy makers were engaged in discussions on future challenges and research priorities, especially in the perspectives of post-Horizon2020 scenarios. For that reason, the motto of the ENF2019 was "Almost there - what's next?". The event was structured in three days, with the conference sessions organized during the first two days and the workshops, brokerage events and visits took place in the third day. The industrial and research exhibition was organized on the entire event duration, with the aim to promote organic discussions between stakeholders and strengthen research – industrial partnerships.

PETER DROELL
Director, Industrial Technologies, Innovation at European Commission

Overview of EuroNanoForum 2019

• 3 Plenary sessions – 1 scheduled in the first conference day and 2 plenaries in the second day. The plenary sessions included 12 presentations and panel discussions delivered by top-level specialists from research and innovation, industry and policy makers, with the aim to initiate stimulating discussions and exchange ideas on key policy, scientific, industrial and societal issues in advanced materials and nanotechnology.

- 1st PLENARY: Almost there – what's next?
- 2nd PLENARY: Boosting innovation for EU Industry: the role of nanotechnologies
- 3rd PLENARY: The Challenges for a Better Europe

• 15 parallel sessions with 73 presentations structured in 6 THEMATIC PILLARS: NANO for ENERGY, NANO for PEOPLE, POLICY for NANO, NANO for EU RE-INDUSTRIALISATION, Instruments for nanomaterials know-how, and Instruments for nanomaterials application. The conference speakers' cover the full value chain, thus key players from various disciplines including researchers, representatives of industry, large companies and SMEs, as well as policy makers were invited, paying attention to the gender balance and nationalities.

• A posters exhibition with selected posters was available during the first two days of the conference. Besides the 103 posters displayed in the posters' exhibition, 29 Horizon 2020 projects in NMBP presented their results, concepts and demos at EuroNanoForum 2019, by posters or at exhibition stands. The best posters/project were awarded.

• The Industrial and Research EXHIBITION was organized for the entire duration of ENF2019, in order to deliver a comprehensive image of the nanotechnology and advanced materials potential for various European industrial sectors. The exhibition offered the participants possibilities to interact and consolidate partnerships between research/academia and industry. Horizon 2020 projects in NMBP showcased their results, concepts and demos at EuroNanoForum 2019.

• 22 exhibitors attended EuroNanoForum 2019 Industrial and Research Exhibition: funding agencies, organizations, centres of cooperation, companies, EU-funded projects, research institutes and universities in Romania. The exhibitor profiles are described on the conference website.

• 7 Interactive WORKSHOPS were selected and scheduled in the third day of the conference: 53 speakers and moderators delivered presentations aligned to the conference's goals and objectives.

• The brokerage event offered attendees opportunities to establish synergistic connections and find potential future collaborations. The brokerage was scheduled during the third day of the conference, in parallel with the workshop sessions. 68 delegates from 19 countries participated in 180 meetings.

To raise awareness of the General Public on the relevance of nanotechologies and advanced materials for developing new technologies and products that can contribute to a better standard of life an intense press campaign and social media posts targeting the general public was implemented.

Scientific events and Education activities

International Semiconductor Conference - CAS 2019

The 42nd edition of International Semiconductor Conference (CAS) (www.imt.ro/cas) took place between 9 and 11 October 2019, in Sinaia, Romania. The conference is an annual event organized by IMT Bucharest, sponsored by the Ministry of Research and Innovation and IEEE-Electron Devices Society.
The conference has become a recognized forum at international level, bringing together experts from the industry, academia, research institutes and students, who share their ideas and expertise, presenting the latest research results and technological advances in the micro- and nanotechnologies field to the interested scientific community and to potential beneficiaries.
CAS 2019 was focused on the following main topics: Nanoscience and Nanoengineering; Micro- and Nanophotonics and Optoelectronics; Microwave and Millimeter Wave Circuits and Systems; Microsensors and Microsystems; Modelling; Semiconductor Devices; Integrated Circuits.

CAS 2019 gathered 173 attendees from 46 institutions in 19 countries.
The conference programme comprised 105 presented papers: 11 invited papers in the plenary sessions, 63 papers presented in 11 sessions for oral presentations, including 3 sessions for Student papers and 31 papers in the poster sessions.
The papers presented at 2019 edition were peer-reviewed by the conference Paper Review Board and published in the Conference Proceedings, further available in the IEEE Xplore® digital library at ieeexplore.ieee.org/xpl/conhome/8915785/proceeding.

Authors of selected papers presented at CAS 2019 were invited to submit extended versions of the papers in special issues of indexed journals, such as Solid State Electronics Letters (SSEL) CAS 2019 Special Issue, Reviews on Advanced Materials Science and Romanian Journal of Information Science and Technology (ROMJIST).
Following the conference tradition, the 2019 edition included an awards ceremony, giving 13 Best Paper Awards and 5 Best Student Papers Awards.
The International Semiconductor Conference - CAS 2019 offered participants the opportunity to be up to date with the latest scientific achievements and top technological developments in the field of semiconductor technologies and micro- and nanosystems, in the same time providing perspectives for advance of new research directions.
CAS ensured a proper environment for debates and networking as well, allowing attendees to lay the foundations for new partnerships at national or European level in the scientific domains approached by the conference.
Details about CAS 2019, including the conference programme, invited papers abstracts and speakers CVs, Best papers awards, Papers Review Board & Editors, Photo Gallery, are available on the conference website at https://www.imt.ro/cas/history.php.

Conference General Chairman: **Dr. Adrian Dinescu** (IMT Bucharest).
Technical Programme Committee Chairs: **Dr. Mircea Dragoman** (IMT Bucharest), **Prof. Gheorghe Brezeanu** (University "Politehnica" of Bucharest).

Educational activities developed inside IMT Bucharest

Master Courses held in IMT Bucharest (teaching and laboratory classes)
M. Sc. Courses of the Faculty for Electronics, Communications and Information Technology, University "Politehnica" of Bucharest since 2009, (with access to experimental facilities) were held at IMT, by our researchers.
Specialization fields and courses are listed below:

☐ **Microsystems**
- Intelligent sensors and microsystems;
- Microphysical characterization of structures;

☐ **Micro- and Nanoelectronics**
- Advanced Technological Processes;

Laboratory classes for undergraduate and M.Sc. courses:
☐ **"Microsensors"**, Applications lab using MINAFAB Facility. For year IV students at Faculty of Electronics, Tele-communications and Information Technology, "Politehnica" University of Bucharest.
☐ **Applications lab for RF-MEMS** - M. Sc. Course.

IMT Bucharest **hosted internship** in micro and nano-technologies for Romanian and foreign students.

ISI Papers

1. Terahertz shielding properties of aero-GaN, Braniste, T; Zhukov, S; **Dragoman, M;** Alyabyeva, L; Ciobanu, V; **Aldrigo, M;** Dragoman, D; **Iordanescu, S**; Shree, S; Raevschi, S; Adelung, R; Gorshunov, B; Tiginyanu, I; SEMICONDUCTOR SCIENCE AND TECHNOLOGY Vol: 34 Issue: 12 Pub: DEC 2019; IF: 2.654, Q2
2. Tuning electrical properties of polythiophene/nickel nanocomposites via fabrication, Pascariu, P; Vernardou, D; **Suchea, MP**; Airinei, A; Ursu, L; Bucur, S; Tudose, IV; **Ionescu, ON**; Koudoumas, E. MATERIALS & DESIGN Vol: 182 Pub: NOV 15 2019 IF: 5.77, Q1
3. New carbon/ZnO/Li_2O nanocomposites with enhanced photocatalytic activity, Diacon, A; Mocanu, A; Raducanu, CE; Busuioc, C; Somoghi, R; Trica, B; **Dinescu, A**; Rusen, E; SCIENTIFIC REPORTS Vol: 9 Pub: NOV 14 2019, IF: 4.011, Q1
4. A perspective on effective medium models of thermal conductivity in (ultra) nanocrystalline diamond films, **Sandu, T; Tibeica, C**; APPLIED SURFACE SCIENCE Vol: 492 Pg: 309-313 Pub: OCT 30 2019 IF: 5.155, Q1
5. Synthesis and characterization of Ca doped ZnO thin films by sol-gel method, **Istrate, AI; Nastase, F; Mihalache, I; Comanescu, F; Gavrila, R; Tutunaru, O; Romanitan, C; Tucureanu, V;** Nedelcu, M; **Muller, R**; JOURNAL OF SOL-GEL SCIENCE AND TECHNOLOGY Vol: 92 Issue: 3 Pg: 585-597 Pub: DEC 2019 IF: 1.986, Q1
6. Unravelling the strain relaxation processes in silicon nanowire arrays by X-ray diffraction, **Romanitan, C; Kusko, M; Popescu, M; Varasteanu, P; Radoi, A; Pachiu, C;** JOURNAL OF APPLIED CRYSTALLOGRAPHY Vol: 52 Pg: 1077-1086 Part: 5 Pub: OCT 1 2019 IF: 2.867, Q2
7. Performance of single layer graphene obtain by chemical vapor deposition on gold electrodes, **Tincu, B;** Demetrescu, I; **Avram, A; Tucureanu, V; Matei, A; Tutunaru, O; Burinaru, T; Comanescu, F; Voitincu, C; Avram, M**; DIAMOND AND RELATED MATERIALS Vol: 98 Pub: OCT 2019 IF: 2.29, Q2
8. Nb-TiO_2/ZnO nanostructures for chemoresistive alcohol sensing, **Dediu, V**; Musat, V; **Cernica, I**, Applied Surface Science Vol: 488 Pg: 70-76 Pub: SEP 15 2019 IF: 5.155, Q1
9. Electromagnetic interference shielding in X-band with aero-GaN, **Dragoman, M**; Braniste, T; **Iordanescu, S**; **Aldrigo, M**; Raevschi, S; Shree, S; Adelung, R; Tiginyanu, I; NANOTECHNOLOGY Volume: 30 Issue: 34 Art No: 34LT01 Pub: AUG 23 2019 IF: 3.399, Q1
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11. Comparative analysis of honey and citrate stabilized gold nanoparticles: In vitro interaction with proteins and toxicity studies, **Boldeiu, A; Simion, M; Mihalache, I; Radoi, A; Banu, M; Varasteanu, P**; Nadejde, P; Vasile, E; Acasandrei, A; Popescu, RC; Savu, D; **Kusko, M**. JOURNAL OF PHOTOCHEMISTRY AND PHOTOBIOLOGY B-BIOLOGY Vol: 197 Pub: AUG 2019 IF: 4.067, Q1
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14. Spectroscopic techniques for the characterization of the YAG:Ce, Gd phosphors and PDMS-YAG:Ce,Gd composites, **Tucureanu, V; Matei, A**; Popescu, MC; **Mihalache, I; Avram, A; Tincu, BC; Avram, M; Munteanu, D**. JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS Vol: 21 Issue: 7-8 Pg: 518-523 Pub: JUL-AUG 2019 IF: 0.588, Q4
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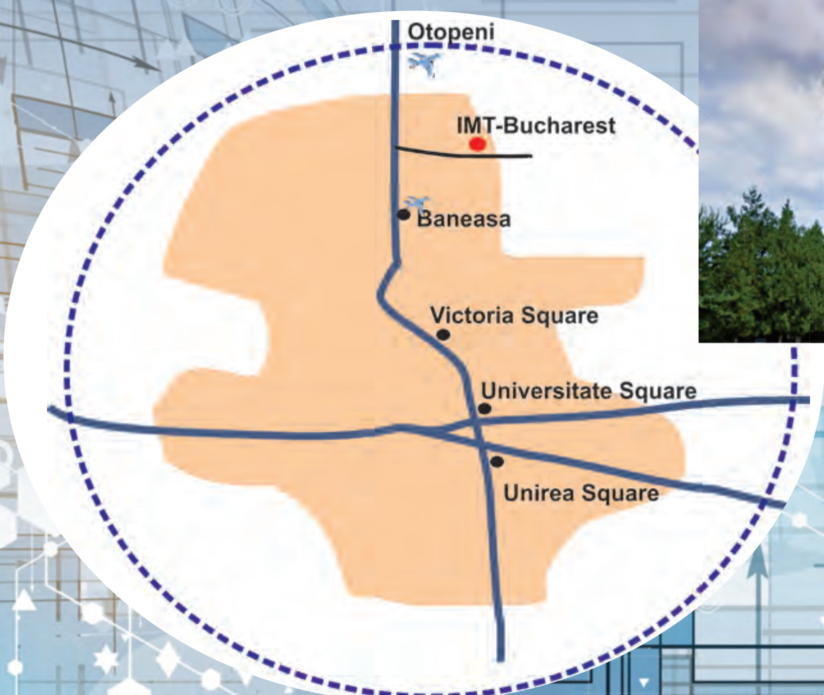

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