L1: Laboratory of Nanotechnology

Affiliated to the Romanian Academy (of Sciences)

- Mission
- Main areas of expertise
- National and International networks
- International research grants
- Research Team
- Instruments and equipment
- Awards

• **MISSION:** Nanomaterials and nanostructures: design, modelling/simulation and technological experiments.

• **MAIN AREAS OF EXPERTISE:** The research activities carried on in Laboratory of Nanotechnology can be divided into three areas which are: Functional nanomaterials, Nanobiosystems, and icroelectromechanical Systems. The main research direction in Functional nanomaterials area is study of nano-structured silicon based or composite materials, from preparation to surface functionalisation and integration in complex systems. The Nanobiosystems area focuses on utilizing the various technologies developed in nano-fabrication and MEMS to study and solve biological issues. Biomolecular patterns in microarrays, integration of sensing elements onto biochips for study of bioreactions, and implantation of active device elements in cells to study cellular biochemistry are examples of research activities being carried out. The Bio-Microelectromechanical Systems (Bio-MEMS) area focuses on the design, modeling/ simulation and fabrication of new complex devices on silicon for applications in many interdisciplinary areas, and recently results in biochips, or microfluidic systems as laboratory-on-a-chip were obtained with applications in biomedicine and environmental monitoring.

• **NATIONAL AND INTERNATIONAL NETWORKS**

• *Partner in national networks:* RO-NANOMED, CEEX (2004-2006).

• *Partner in international networks* /projects: FP6-NoE: Nanostructured and Functional Polymer-Based Materials and Nanocomposites (NANOFUN-POLY) (2004-2008); FP6-ROManian inventory and NETworking for Integration in ERA (2004-2007); MIcro-NanOSystems European Network (2005-2008); S-E Europe Regional Network of Excellence Nanosciences and Multifunctional Materials (COSENT) (2002-2006);

• **INTERNATIONAL RESEARCH GRANTS**

• *Marie Curie Host Fellowships programme*: a young researcher from our group, Teodora Ignat, was involved in the project: Nanoelectrochemistry: from the synthesis of nanomaterials to functionality; job title: Functionalization of silicon surfaces for bioelectronics; Host Laboratory: PMC CNRS - Ecole Polytechnique France, 2005-2006.

• *NATO Collaborative Linkage Grant:* 'Novel optical nano-sensors on the basis of organic nanofibers', 2005 -2006, coordinated by Prof. .Dr. Horst-Günter Rubahn from Physics Institute, Syddansk Universitet, Odense, Denmark

• "Drug delivery system based on microreservoirs array with porous silicon resorbable membrane caps", Romanian-Greece International Cooperation, December 2005-2007.

• "Nanostructured silicon for optical biosensors", Romanian-Italian International Cooperation, 2005-2007.

• **RESEARCH TEAM** has multi-disciplinary expertize and is composed by 4 senior researchers (with background in physics, chemistry, electronics), 4 PhD students (with background in physics, chemistry, computers and specializations in pharmacy and biochemistry), 1 student (physics).

Team from left to right:
Florea Craciunoiu;
Adina Bragaru;
Mihaela Miu;
Monica Simion;
Irina Kleps;
Marioara Avram;
Teodora Ignat;
Mihai Danila;
Andrei Avram;

One Ph.D. student from our group working on microarray

Electrical measurement unit

• **INSTRUMENTS AND EQUIPMENT** Computers for simulation; instruments and software for electrical characterisation of nanostructures; Keithley model 6487-picoammeter/ voltage source- 2004; VOLTALAB10 and Trace Master 5; AMMT: Wet etching system with software for 4' silicon wafers, potentiostat MC, silicon etching power supply; Fluorescence set-up for LEICA DMLM with images acquisition and measurement system. We have full access to IMT technological and characterisation facilities.

• **AWARDS**

1. Diploma of Excellence for participation in FP6 competition (Irina Kleps) ;
2. The Wipo Award for Woman Inventor, INVENTIKA 2006, for invention: „Bipolar Magnetotransistor with Enhanced Emitter Injection Modulation and Carrier Deflection", Geneva and Bucharest, October 2006; (Marioara Avram).
3. Best Paper Awards "Microfluidic dynamic system for biological fluid viscosity measurements", M. Avram, A. Avram, C. Iliescu, E. Manea and C. Voitincu, Proc. of Int. Semiconductor Conf. – CAS 28th Edition, vol. 1, pp. 223-226, Sinaia, Romania.

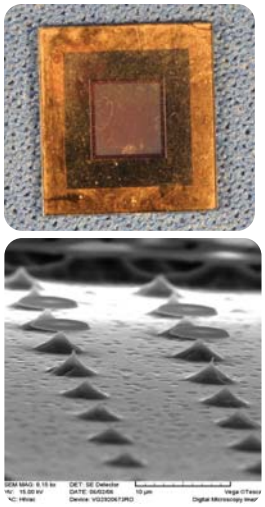
Laboratory Head - Dr. Irina Kleps (irinak@imt.ro)

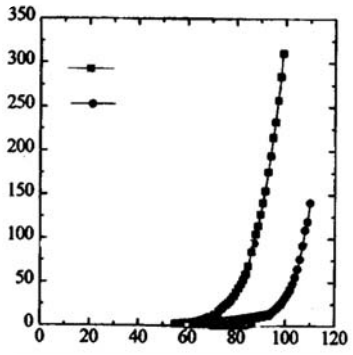
She obtained her MSc. in Chemistry Engineering, in 1973, and the PhD in chemistry in 1998 at Politehnica" University of Bucharest. *Her competence domains are*: nanomaterials, nanostructures, nanotechnology, new materials and technological development for bio-medical devices, microchemistry.

Dr. Kleps participated in several European projects: PATCOAT (hard coatings) (1994), NATO-CNR (LPCVD-TiO_2 and SNO_2 films) (1996), INCO-COPERNICUS SBLED (1998-2001), EMERGE (guest experiments at IMM, Germany) Metallics (2000-2003), PHANTOMS (Network of Excellence on Nanoelectronics) (2001-2004), NANOFUN-POLY (2004-2008). *She was expert* for project evaluation in the EC-FP5 (IST; Growth, Improving programmes), FP6 (NMP and Marie Curie) and MATNANTECH national program.

Other activities: Golden medal (2001), Salon International des Inventions-Geneve: Chapter „Electrochemical Nanoelectrodes", in „Encyclopedia of Nanoscience and Nanotechnology"; Co-editor of the „Nanoscience and Nanoengineering" (2002) and "Advances in Micro and NanoEngineering" (2004), (Romanian Academy); More than 100 papers published in international journals/conferences, 80 technical reports, and 4 Romanian patents.

INCREASE OF THE MICROPROCESSED SILICON TIPS FIELD EMISSION EFFICIENCY, BY LOCALIZED DEPOSITION OF THE NANO-STRUCTURED MATERIALS IN VACUUM THERMOIONIC ARC



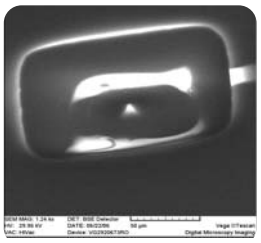


Field emission device and I-V characteristics

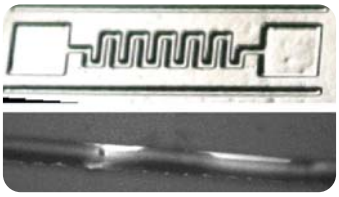
Achievements:
It was realized a demonstrator consisting in a silicon chip with an array of microprocessed tips (the square in the middle of the chip) as cathode, and a gold ring used for chip bonding with the cover conductive plate as anode of the device. Measurements were performed in a vacuum deposition tool, 10-6 torr level for vacuum.

MATNANTECH Project (2004-2006); Co-ordinator: IMT-Bucharest, Contact person Florea Craciunoiu:(floreac@imt.ro); Partners: National Institute of Materials Physics; ROMES SA.

DEVELOPMENT OF NEW COMPLEX TOOLS FOR PROTECTING HEALTH: LABORATORY-ON-A-CHIP SYSTEM (TOOPROLAB)



DNA- Lab-on-a-chip for genetic diagnosis



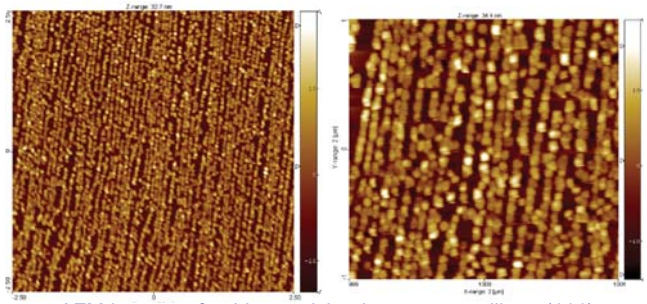
CELL-Lab-on-a-chip for in-vitro drug testing

The project scope is to design and fabricate two devices, tools for health applications, using microfluidics and microarray probes technologies: (i) CELL-Lab-on-a-chip for in-vitro drug testing and (ii) DNA - Lab-on-a-chip for genetic diagnosis.

The first type of device is dedicated to both optical and bio-electrochemical analyses of biological materials – different type of cells – subjected to external stimuli. The preliminary test structure contains an electrical circuit integrated in a microfluidic network, and fabrication of nano-electrodes on the reactor base determine the enhacement of sensitivity in electrochemical processes detection: The second type of device is designed to act as a micro-PCR (microreactor, resistor for thermal cycle, and temperature sensor) in connection with an microfluidic electrophoretic system for DNA separation (microchannel and microelectrodes).

CEEX Project (2005-2007), Co-ordinator : IMT-Bucharest, Contact Person: Irina Kleps (irinak@imt.ro)
Partners: InterNET SRL; DEXTER Com SRL ; Faculty of Medicine Faculty of Biology; METAV SA; Faculty of Chemistry, Faculty of Physics, INCDFLPR, LABOR&SOFT, ROMES SA

FUNCTIONALIZATION OF SILICON SURFACES FOR BIOELECTRONICS

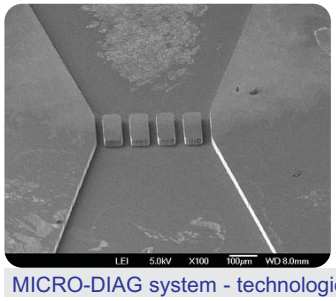


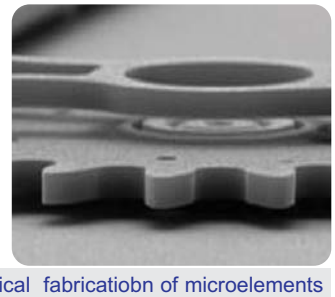
AFM images of gold-nano-islands on n-type silicon (111) substrates

Achievements:
Small metal islands were deposited on the surface of a semiconductor with the aim to obtain a particular arrangement which makes possible to increase the infra-red sensitivity by enhancement of the electromagnetic field on the surface. We have prepared by electrochemical deposition regular networks of gold nano-islands on silicon. Then we studied by IR spectroscopy the adsorption and the modification of thiol molecules on the surface of the nano-islands.

MARIE CURIE Host Fellowships programme (2005-2006), Contact person: Teodora Ignat (teodoran@imt.ro)

INTEGRATED MICROFLUIDIC SYSTEM FOR ADVANCED IN VITRO BIOCHEMICAL ANALYSIS FOR DIAGNOSTIC AND TREATMENT IN MEDICAL APPLICATIONS (MICRO-DIAG)





MICRO-DIAG system - technological fabricatiobn of microelements

The biodynamic analysis microsystem consists of two main modules. The first module is the microfluidic system consisting of the microgearing wheels system and microchannels system (for the determination of molecular transport coefficients in biological fluids), microchannels with high-doped walls and nanoelectrodes (for the detection, sorting and differentiating of suspended bioparticles) and heaters. The second module is the detection and measuring system.

CEEX Project (2005-2008), Co-ordinator : IMT-Bucharest, Contact Person: Marioara Avram (marioaraa@imt.ro)

MICROSTRUCTURES AND MICROGEARS WITH MAGNETIC DETECTION BASED ON GIANT MAGNETORESISTANCE NANOSTRUCTURES

A micromechanical system of gear-wheels was fabricated using silicon micromachining technology. The measurement principle is the detection of the rotation of a micromachining polysilicon gear wheels system combine the undercut and refill technique with pin-joint bearing permitting the fabrication of bushings that can be used to elevate the rotor away from the silicon surface.

Micromechanical system of gear-wheels microfabricated on polysilicon

MATNANTECH Project (2004-2006); Co-ordinator: IMT-Bucharest
Contact person: Marioara Avram (marioaram@imt.ro);
Partners: ICPE-CA, Universitatea Transilvania Brasov

ISOLATED GATE BIPOLAR TRANSISTOR (IGBT) FABRICATION TECHNOLOGY FOR HIGH POWER AND HIGH TEMPERATURE APPLICATIONS

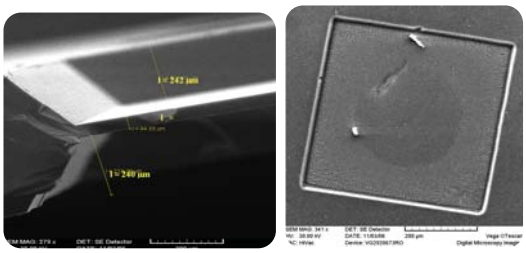
Achievements: The SiC-IGBT is used for applications that require a high breakdown voltage of 5 kV and more. The SiC devices reduce power loss and equipment size, and drastically reduce ON – resistance, too. A problem that is common to silicon carbide is that its manufacturing cost is higher than that of silicon. The proposed IGBT has one epilayer (cheaper), an buffer layer between substrate and epilayer to improving the dynamic characteristics and a guard ring / epilayer junction to increase the saturation current. The SiC – IGBT is used in applications that require: higher current conduction capability, power losses efficiently dissipated, operation at higher temperatures, up to 600^0C, and in very harsh environment.

RELANSIN project (2004-2006); Co-ordinator: IMT Bucharest, contact person: Marioara Avram (marioaraa@imt.ro);
Partners: Politehnica University of Bucharest; ROMES SA

FABRICATION TECHNOLOGY OF NANOSTRUC-TURED SILICON MEMBRANES WITH APPLICATIONS IN SENSORS AND BIOMEDICAL DEVICES

The project scope is to obtain a versatile fabrication technology for silicon nanostructured membranes that can be integrated in a complex process flow to realize devices with improved characteristics. Two wet etching processes were used for fabrication: chemical etching for crystalline Si membrane fabrication and electrochemical etching for membrane porosification. The experimental structures were characterised from morphological point of view using microscopic techniques:

The future work in this project will be dedicated development of devices based on proposed technology: humidity sensor, fuel cell and respectively biomedical system for controlled drug delivery.

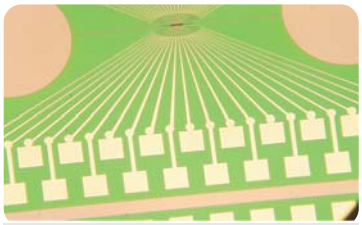


SEM images: (a) cross-section of membrane suspended at the middle of microreservoir;
(b) plan-view of membrane on the bottom of microreservoir.

MINASIST-program (2006-2007); Co-ordinator: IMT-Bucharest, Contact person: Mihaela Miu (mihaelam@imt.ro).

MICROSYSTEM FOR DNA MACROMOLECULE SEPARATION

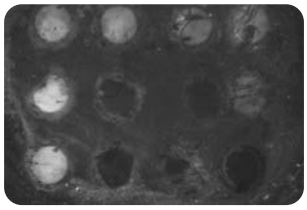
Achievements:
Microsystem realized on a silicon chip, which contains two reservoirs (for supply or collect DNA macromolecules) connected by microchanels and a line of 23 micro-electrodes. The microelectrodes are polarized in traveling wave, by a specific power supply containing 3 microcontrollers, special designed. Testing is performed using fluorescent markers, in order to control flow of the substance by the microchanels.



Silicon chip for DNA macromolecule separation

MATNANTECH Project (2004-2006) Co-ordinator: IMT-Bucharest,
Contact person Florea Craciunoiu: (floreac@imt.ro); Partners: Academy Biochemistry Institute; ROMES SA.

SILICON AND GLASS SURFACE FUNCTIONALIZATION IN ORDER TO OBTAIN BIOCHIPS FOR PRINTING MICROARRAY

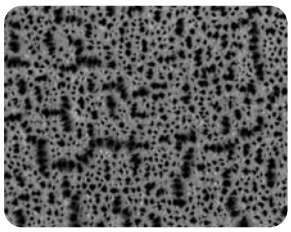


Fluorescence microscope image of the DNA/polipyrol spots

Glass functionalization with polipyrol: it was tested a structuring method with the aim to obtain conductive surfaces which are containing biological probes arrays (active bio-molecules as oligonucleotides). The process is about the immobilization of the biological probes after the electrochemical polymer film deposition on surface.

Silicon functionalization. For silicon substrate, the best results were obtained by using silanizated wafers, but it can be observed good adherence of the poly-L-lysine on silicon surface, also.

MINASIST-program (2006-2007); Co-ordinator: IMT-Bucharest, contact person: Monica Simion (monicas@imt.ro)



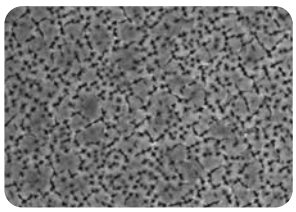
SERVICE OFFER:

MICRO- AND NANOSTRUCTURED SILICON FABRICATION

• Fabrication of porous silicon (PS) layers (2-500 mm thickness) on n+ or p+ Si, 4inch diameter.

• Fabrication of meso- and macroporous silicon membrane (thickness 500 mm) on n+ or p+ Si, 4inch diameter.

Contact person: Mihaela Miu (mihaelam@imt.ro)



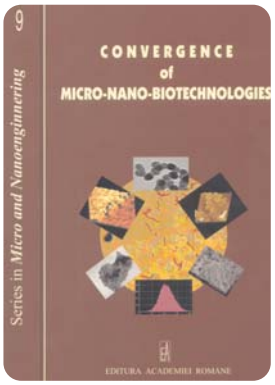
MICROARRAY BIOCHIPS:

Microarray technology includes applications for functional genomics, pharmacogenomics, SNP genotyping, proteomics and cell signaling. We have expertise for microarray manufacturing, processing, surface chemistry, detection reagents, scanning and analysis. Specific preparation protocols and probe design workflow can be developed in function of requested application. We are working using the new facilities, nano-plotter and micro-array scanner from NanoBioLab.

Contact person: Monica Simion (monicas@imt.ro)

CONSULTANCE ACTIVITIES: • nanostructures/ nanomaterials integration into the microsystems structures; • technological processes on silicon; • luminescent properties of the porous silicon; • nanostructured bioactive silicon for biomedical applications; porous silicon biocompatibility; • functionalization of silicon surface; • micro-systems for drug delivery; • magnetic sensors and magnetic nanostructurated nanomaterials; • CVD processes using liquid precursors; • project evaluation for national/international competitions.

Editing activities: "Convergence of MICRO-NANO-BIOTEHNOLOGIES" Volume 9 from the "Micro and Nanoengineering" series (edited by the Publishing House of the Romanian Academy) and includes a selection of extended and up-dated papers presented at the 5th Seminar of Nanoengineering and Nanotechnologies organized in 2 March 2006 by the Romanian Academy, Council for ERA (coordinator IMT-Bucharest). Among the editors are Irina Kleps PhD, senior research and head of the Center of Nanotechnology from IMT-Bucharest and Professor Dan Dascalu, member of the Romanian Academy, General Manager of the IMT-Bucharest.



Due to the breakthrough of nanoscience and nanotechnology in all science, the topics of the papers in this volume are various. The papers present novel results in different inter- and multidisciplinary fields, obtained in the frame of the Romanian Research Programs MATNANTECH and CEEX. Some of the papers presents results obtained in large consortiums, involving also partners from Porto University, Tor Vergata University – Rome, Glasgow University or Royal Institute of Technology – Stockholm.

The papers refers to fabrication, physical and chemical properties of nanoscale materials, atomic and nanoscale characterization including theory, modelling, simulation and experimental methods, application of functional nano-structures and nanoprocesses.

A group of seven papers from bio/nanotechnology field contributes to join the latest news related to topics such as controlled drugs delivery, nanostructure formation of seed storage protein, artificial chaperones, template nano-materials in obtaining bioconjugated for medical applications, etc .

This publication is addressed to all interested people from research institutes, universities and companies and will be distributed to the university libraries.

L1: Participation to NoE's in FP6

NANOSTRUCTURED AND FUNCTIONAL POLYMER-BASED MATERIALS AND NANOCOMPOSITES

Acronym: NANOFUN-POLY

Coordinator: Prof. José M. Kenny; Italian Consortium for Science and Technology of Materials (INSTM);
E-mail: kenny@unipg.it; Fax: 39 0744 492925, Tel: 39 0744 492939 / 39 3292332268

IMT collaboration proposals for nanobiomaterials internal projects in the frame of NANOFUNPOLY

1. Complex nanostructured matrix based on meso/ macro porous membranes or microparticles for drug delivery or tissue engineering applications

2. Investigation of hybrid (biohybrid) interfaces for biosensors.

3. Microarray technology.

4. Surface engineering techniques to investigate inorganic-biomolecular interfaces

Information on mobility

• PhD Adina Bragaru: Third Short Course on ADVANCES IN POLYMER CHEMISTRY AND PROCESSING OF NANOSTRUCTURED POLYMER MATERIALS Modelling and Simulation in Nanopolymer Processing Nanostructure by Polymer Chemistry, Florence, Italy, February 9th and 10th, 2006;

• Dr. Irina Kleps: Fourth Workshop on "NANOFUN Research Internal Projects"
Donostia-San Sebastian, Spain, September 15th and 16th, 2006;

• Dr. Florin Craciunoiu to "2nd Annual NANOFUN-POLY Meeting", Florence, Italy, June 26th and 27th 2006;