L6: Microphysical characterization laboratory

- Mission
- Main areas of expertise
- Research Team
- Specific facilities
- International Projects

Mission: Research and development in the field of characterization methods for materials and processes at micro and nanometric scale. Application of high resolution surface investigation techniques to solve engineering problems at these scales, especially investigation of correlations between technological process parameters-structure and structure-properties order to obtain materials for specific applications etc. The lab is the first one in Romania developing research and providing services for nanolithography, using EBL technique.

Main areas of expertise: Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Electron Beam Lithography for nanoscale devices, Optical Microscopy, Electrical characterization of materials and devices.

Research Team: 3 senior researchers - background in Physics and Electronic Engineering an early stage researcher (Physics) and 2 MS students in Electronics.

Team from left to right: Adrian Dinescu, Cecilia Codreanu, Loredana Draghiciu, Marian Popescu, Laura Eftime, Mihaela Marinescu, Raluca Gavrila, Alexandru Herghelegiu

Specific facilities: • Scanning Probe Microscope (AFM, STM, EFM, KPM etc) - NTEGRA (NT-MDT).
Features: built-in capacitive sensors, active antivibrational table, could be operated under different environments: air, liquid, controlled gaseous atmosphere, low vacuum (10-2 torr).
Scan range: 100x100x10 μm, noise level, XY: 0,3 nm, Z: 0,06 nm, non-linearity in X, Y with closed-loop sensors < 0.15 %.
• SEM: TESCAN VEGA II LMU-General Purpose Scanning Electron Microscope (resolution: 3 nm @ 30 kV, accelerating voltage 200V-30 kV, electron gun source: tungsten filament, magnification: 13X - 1.000.000X, detectors: SE, BSE, LVSTD)
• FEI Nova NanoSEM 630- Ultra High resolution Field Emission Gun Scanning Electron Microscope - This SEM delivers high resolution surface information and can be widely used in many applications: nanotechnology, materials analysis, semiconductor technology, quality assurance, life sciences.
• EBL - Raith Elphy Plus - pattern generator for Electron Beam Lithography. Features: 6 MHz high-speed pattern generation hardware, 16 bit DAC vector scan beam deflection, 2 ns writing speed resolution.
• Raith e_Line - Electron beam lithography dedicated equipments. It is a versatile electron beam lithography system having complied with the specific requirements of interdisciplinary research. Selected options for nanomanipulation, EBID and EBIE expand this system to a versatile nano-engineering workstation. Basic hardware features: thermal assisted field emission gun, cross-over free column with highest beam current density at 2 nm spot size, laser interferometer stage with 100 mm by 100 mm travel range and 20 nm resolution achieved by closed-loop piezo-positioning, minimum line width < 20 nm, stitching accuracy 40 nm, overlay accuracy 40 nm.

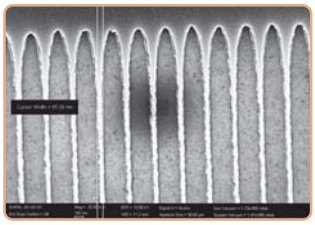
International projects: **FP7** ***CATHERINE*** "Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts"- STREP- FET proactive (2008-2010), ***Coordinator*** **Consorzio Sapienza Innovazione, Italy.** ***Partners:*** CNIS-Italy, TUD-Netherlands, CIRIMAT-France, USL-Italy, ULV- Lativia, IMT- Bucharest- Romania, FOI- Sweden, INFN-Italy, PHILIPS- Netherlands, Smoltech- Sweden.
IMT-Bucharest: contact person Phys. Adrian Dinescu- (adrian.dinescu@imt.ro)

CATHERINE project aims to provide a new unconventional concept for local and chip-level interconnects that will bridge ICT beyond the limits of CMOS technology.

The main goals of CATHERINE are:
- To develop an innovative cost-effective and reliable technological solution for high-performance next-generation nanointerconnects.
- To develop proof-of-concept nanointerconnects to assess and verify the new proposed solution.

High resolution CNTs imaging

Electric contacts at nanoscale- 65 nm width lines



Laboratory Head — Phys. Adrian Dinescu (adrian.dinescu@imt.ro)

He received the M. Sc. (1993) degree in Physics from University of Bucharest. From 1993 -1997 he was Research Scientist at Research Institute for Electronic Components, ICCE Bucharest in the Optoelectronics Laboratory; From 1997 he is **Senior Researcher** at the National Institute for R&D in Microtechnologies (IMT Bucharest) in the ***Microphysical Characterization Laboratory***.

His main scientific interests include: Electron Beam Lithography, Scanning Electron Microscopy and Scanning Probe Microscopy (mainly AFM Surface morphology imaging and characterization), force sensors for Atomic Force Microscopy. A Dinescu was the leader of several national research projects (Matnantech, Ceres, CEEX) and partner in international projects (CATHERINE FP7, ASSEMIC- Marie Curie Training Network, FP6) and the author more than 15 scientific papers presented at conferences and published in journals.

NATIONAL PROJECTS

A- Projects for infrastructure development

Laboratory for morphological analysis at nanometric scale

The SPM equipment acquired within the NANOMORPH project

The project aims at establishing a laboratory for nanometric scale morphological characterization of material surfaces. The laboratory will be certified to ISO IEC 17025:2005 standard for testing and calibration laboratories and will provide high- quality AFM and SEM characterization services for research and/or production of materials whose surfaces have a nanometric scale structure. At present the laboratory is fully functional and under accreditation by the National accreditation Body- RENAR.

NANOMORPH (2006-2008). Project type: CEEX- Module IV/P-CONFORM, Infrastructure development for evaluation and certification of conformity;
Project no. 234/2006, Coordinator: IMT Bucharest;
Project manager: Phys. Raluca Gavrila (raluca.gavrila@imt.ro).

Functionality enhancement of NANOSCALE-LAB The Nanoscale structuring and characterization laboratory

EBL equipment (e-line Ultra High Resolution Electron Beam Lithography and Nanoengineering Workstation)

The main purpose of the project is to develop the material base of the "**NANOSCALE-LAB**" Laboratory of IMT-Bucharest for structuring and characterization at nanoscale and improve the capacity by offering scientific services. The laboratory facilities were completed by acquiring a state-of-the art equipment for nanomechanical characterization and several equipments that would allow the use at maximum performance of the existing EBL installation: Fixed Beam Moving Stage (FBMS), Gas injection system (GIS) for Electron Beam Induced Deposition (EBID) and a system of nanomanipulators.

NANOSERV (2007-2009); Project type: PN II /Capacities no. 9/2007
Coordinator: IMT- Bucharest;
Project manager: Acad. Dan Dascalu (dan.dascalu@imt.ro)

NANOSCAN-Developement of topographical and compositional analysis capabilities at nanoscale of Microphysical Characterization Laboratory

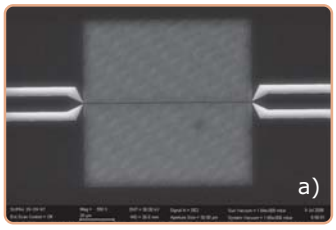
FEG-SEM

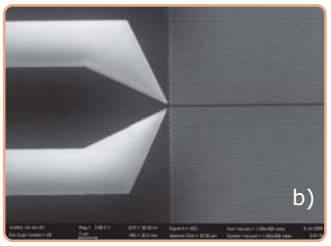
The main goal of this project is to complete the equipments of the lab with a state of the art Field Emission Gun Scanning Electron Microscope (FEG-SEM) able to work with low accelerating voltages for true surface imaging: resolution bellow 1.5 nm at 1kV accelerating voltage, in-lens detectors for SE and BSE, true eucentric sample stage, charge compensation system.

NANOSCAN Project type: PN II/Capacities no. 12/2007, (2007-2009). Coordinator: IMT Bucharest; Project manager: Phys. Adrian Dinescu (adrian.dinescu@imt.ro).

B- . Research projects

Network of scientific services for nano-scale structuring and characterization, with applications in the development of convergent technologies





SEM photos of the experimental PC structures: b) the whole structure, including the taper sections c) detail of the taperd region

This Network for scientific research services and characterization tools at nano-scale bring together 11 well known research institutes and academia, which use in common characterization and manufacturing equipments and complementary skills, to successfully utilize in co-operation and partnerships the complete range of nano potential. The main results were disseminated in the frame of nantional events as National Semniar for Nanotechnologies (organized by IMT) and Functional Materials (organized by IMNR) and at an important number of international events, including MINAM Seminar on Micro- and Nanotechnologies for Industrial Applications, Portugal (March 2008).
Different demonstrators of nanodevices were developed as: nanostructured TiO_2 and ZnO thin films on Si/SiO_2substrates (IMNR), for photonics applications and solar energy convertion; nanodevices based on Carbon nanoparticles for field emission devises and gas sensors; photonic crystals (IMT) which can be used in optical communication circuits for complex optical processing. We the fabricated two-dimensional photonic crystals (PCs) obtained by direct patterning of positive PMMA electronoresist, using the Electron-Beam Lithography technique (EBL). The fabrication of the device was a challenge because we integrated the PC waveguide configuration with a taper optical waveguide on the same substrate. The finite difference time domain (FDTD) simulations were used to predict the optical behavior, and in particular the band gap. Although the refractive index contrast between the PMMA and the SiO_2 substrate is not very high, numerical simulations confirm that the structure acts as a waveguide in the visible spectral region.

NANOSCALE-CONV (2005-2008); Project type: PN II CEEX- CALIST; No. 6111/2005
Coordinator: IMT- Bucharest;
Project manager: Dr.Raluca Müller (raluca.muller@imt.ro)

B- . Research projects

RTN-NANOEL-Romanian Technological Network for integration in the European Platform for NANOELectronics (ENIAC)

Project type: CEEX – INFOSOC No 75 II/2006 (2006- 2008)

Modules for the existing nanolithography equipments were acquired.

Coordinator: IMT- Bucharest; Project manager: Prof. Dan Dascalu (dan.dascalu@imt.ro).

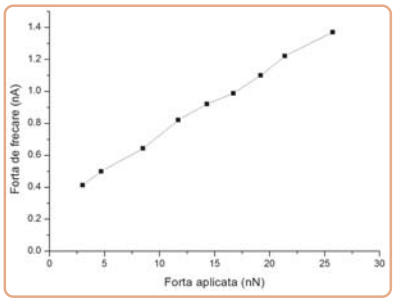
AFM applications to nanomechanical characterization of polymeric surface

Main goals: Design and performing AFM-based experiments on various polymeric materials for studying their elastic, viscoelastic and adhesive properties.

Results: For polymeric materials, which are prone to elastic and viscous deformations during AFM scanning, the interference of mechanical properties in AFM morphological images is generally more important than for than rigid materials. This research allowed us to identify of several types of effects of the mechanical properties of studied polymers on their AFM images (height artifacts due to compression or adhesion of surface features, resolution decrease, scanning rate artifacts due to viscoelastic properties) and to estimate their relative magnitude in practical applications and also provided keys to minimize these effects in AFM images of topography.

A second direction of our research was directed to the investigation of submicronic tribological properties of PMMA by LFM.

Project Type: National basic funding Project MINASIST +, PN 06240105: - (2006-2008); (Project manager: Raluca Gavrila - raluca.gavrila@imt.ro)



Friction force (a.u.) versus applied force for a thin PMMA film. In the peculiar conditions of our experiments the friction forces associated to PMMA and AFM tip follow a generalized form of Amonton-Coulomb macroscopic law, where the adhesive interface force must be considered too.

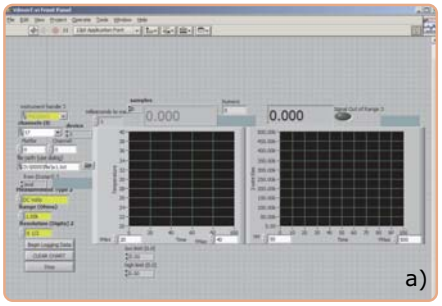
Virtual instrumentation for the characterization and experimentation of microfluidic devices

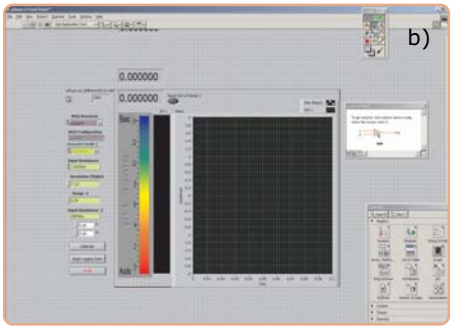
An integrated system for the measurement and characterization of microfluidic devices and sensors was implemented. The system was realized on the basis of PCI and PXI modules from National Instruments. It works under the control of the NI LabVIEW graphical programming software and provide the development of test, measurement, and control applications. It can rapidly and cost-effectively interface with measurement and control hardware, acquire, analyze, and graphical process data, and share results.

PC/LabView/PCI Modules:
- Oscilloscope
- DAQ
- Signal Generator

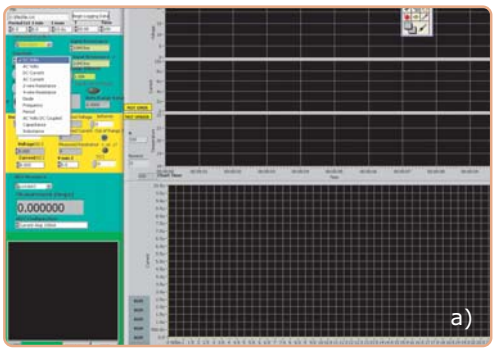
GPIB Interface

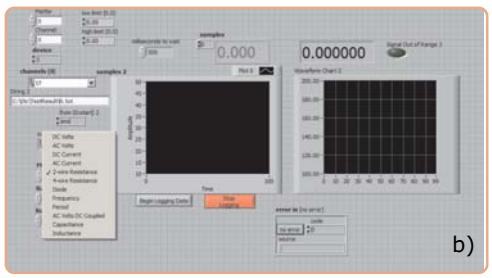
PXI Chassis/PXI Modules:
- Programmable Power Supply
- Digital Multimeter 71/2 digits
- Amplifier
- Controller
- Multiplexer





Virtual Instrument interfaces for the measurement of temperature sensors (a), and pH (b) sensors





Virtual Instrument interfaces for the measurement of small currents (a), and impedances (b)

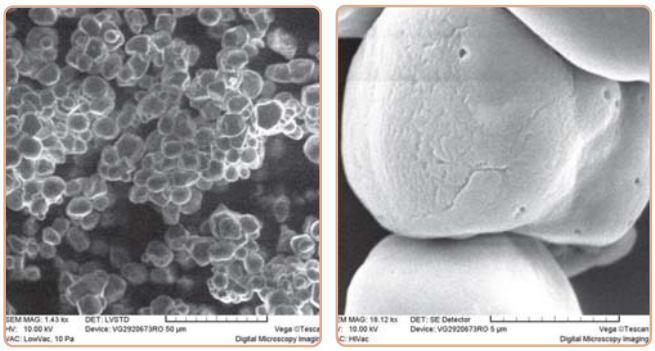
Project Type: National basic funding Project MINASIST+, PN06240203
Project manager: Cecilia Codreanu (cecilia.codreanu@imt.ro)

NATIONAL PROJECTS

Modified amidons, obtained by non-conventional technologies, with applications in alimentation industry

AMIR Project Type PNII; No51-007/2007(2007-2010)
Coordinator: INCDFLPR.

IMT-Bucharest: partner; Contact person for IMT: Phys. Adrian Dinescu (adrian.dinescu@imt.ro)



SEM micrographs of amylum grains exposed to high energy electron beams.

Development of a food tracing system dedicated to regional producers

TRASALIM - Project Type: PNII- Innovation, No 121/2007 (2007-2010),
Coordinator: S.C. ZOOM-Soft SRL;

IMT-Bucharest partner; Contact person for IMT: Phys. Adrian Dinescu, (adrian.dinescu@imt.ro)

SEM micrographs of authentication stamps used in food industry.

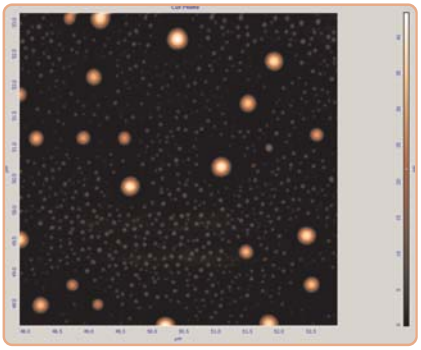
Trainning activities:

Alexandru Herghelegiu: Spring School "Technology for Photonics Integration" , 11 to 17 may 2008, Portoferraio, Elba Island, Italy

Services offered by the LAB: AFM, SEM, EBL

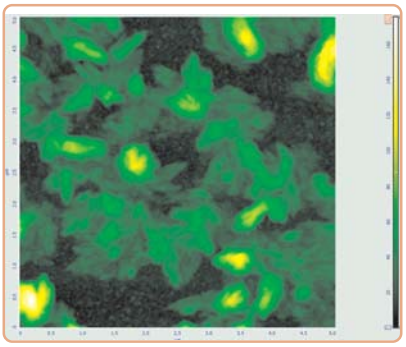
High resolution surface morphology investigations by Atomic Force Microscopy (AFM): 3D surface topography recording and measurement (waviness, roughness, step heights, grains, particles etc);:

SPM SURFACE MORPHOLOGY STUDIES

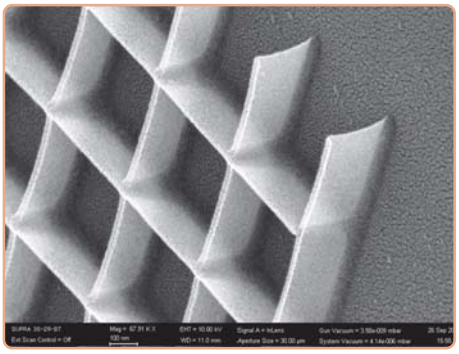


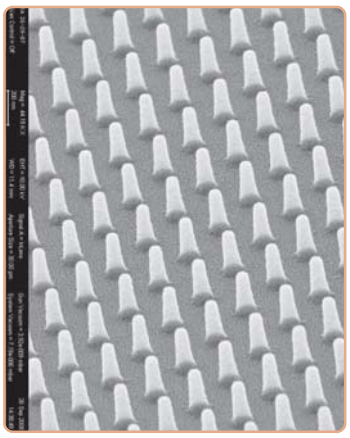
Study regarding the efficiency of a cleaning process for a quartz substrate (AFM image of cleaned quartz surface;) AFM images reveal the persistence of contamination spots with diameters of tens to hundreds of nm and heights down to a few nm.

NANOLITOGRAPHY



AFM image revealing the growth pattern of a sol-gel ZnO thin film on Si for applications in optolectronic devices and gas sensors (scan size: 5x5 μm).





High aspect ratio (12:1) structures in PMMA applications in nanotechnology. Left: crosslines; Rigth nanopilars