The experimental facilities of IMT-MINAFAB

supporting the research in micro- and nanotechnologies

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General background

- IMT – Bucharest (National Institute for R&D in microtechnologies) is an institute organized as a *research company* and developing various activities in RTD, technology transfer, education etc.
  - About 100 people working in RTD
  - More than 10 million euro income in 2008
  - Participation to more than 20 European projects in FP6 and FP7
- IMT is facilitating access to its experimental facilities (clean room areas with fabrication and characterization tools, design and test areas), using the concept of an "*open centre*" for the so-called IMT-MINAFAB (IMT centre for MIcro- and NAnoFABrication).
- This *centre* is neither a separate institution, nor just a part of IMT. IMT-MINAFAB should be understood as an "interface" seen by the customer when looking at the possibilities to access the various experimental and computational resources of IMT.

A complex technological platform

- It is not only about fabrication!
  - The complete story also includes apart from micro- and nanostructuring facilities like mask fabrication, micro- and nanocharacterization (using various techniques based on laser, AFM, X-ray analysis etc.), testing (including reliability), computer simulation and design.
- Various scientific and technical services provided by IMT range in a broad spectrum, from direct access to equipments to cooperation in scientific research and technology development.
- IMT is not just an organization providing services. Behind the IMT-MINAFAB interface we have to imagine the fact that we shall find in many cases
  - It is not easy to organize such a system, however it has the chance – at least in principle – to be more consistent and attractive than a simple collection of equipments. Getting access to a sophisticated equipment means – in this case – finding a partner.

Customers?

- Research
  - Interdisciplinary research groups within IMT (open to external researchers)
    - MIMOMES centre itself;
    - Centre for Nanotechnologies
  - Researchers from other organizations
- Industry
  - Small companies
  - International companies
- Education
  - In cooperation with universities
    - Undergraduate
    - M. Sc. (disciplines provided entirely by IMT)
    - Ph. D. (experimental support)
  - Other
    - Postdoctoral studies (see MIMOMES, for example)
    - Training for industry in research

Contents

- Generalities about the new developments in the infrastructure;
- The most relevant examples of new equipments and other tools;
  - A few examples of results of cooperation are given;
  - European cooperation intensified within the new proposals
- Further details about how the equipments are used;
- Expected developments

Investing in infrastructure and making it operational

Sources of funding: To a great extent these are originating from various projects won by researchers, such as:

- *Three projects for technological networks* (2005-2008)
  - The investments from the projects have been concentrated to a great extent in the labs created by IMT, as coordinator.
  - These labs are "open" to the partners in the network
  - NanoBioLab and NanoScaleLab have been created: they nucleated the clusters of experimental labs to be seen today
- *Four infrastructure projects* (2006-2008);
  - Extending the capabilities of RTD laboratories
- *Eight infrastructure projects form the "Capacities" programme* (2007-2009)
  - Most of them (5 from 8) are consolidating the "Centre of nanotechnologies" (see next)
  - Reconstruction of the premises was also possible
- *MIMOMEMS project of centre of excellence*, funded by EU;
- Various *research projects* in national programmes
- *Individual themes* of research in the "core programme" of the institute (institutional funding).

As a result the "picture" is a very fragmented one or even "*the pieces of the puzzle*" seem to be from different pictures!

How to bring them together and compose a coherent and functional experimental centre?

Making the investments fully operational

- **Providing a support infrastructure (clean room area). Main facilities:**
  - **A class 1000 clean room (220 sqm) for the mask shop and the most demanding technological processes (in use since September 2008);**
  - A class 100,000 clean room, the so called "grey area" (200 sqm), mostly for the characterization equipments (in use since September 2008);
  - A class 10,000 clean room (105 sqm) for thin layer growth by CVD techniques, RTP etc. (to become operational in 2009).
- Implementing in the above area new "*experimental laboratories*" (EL) initiated and operated by various research groups. These EL are open for use by all researchers. Therefore, **a "common experimental facility" was created as a kind of "joint venture" of various RTD labs.** This valid for most of the characterization equipments, as well as for nonconventional structuring tools.
- In contrast with the above all equipments which can be used for production (mask shop, wafer processing etc.) are managed by execution personnel, in a separate department.

A technological platform

IMT-Bucharest acts as a technological platform, providing tools for design, fabrication (including a mask shop), characterization and reliability tests.

- Design, simulation of MEMS/Microsystems, nanostructures (using COVENTOR WARE, ANSYS, COMSOL OptoiFDTD, IE3D);
-Fabrication of micro- nano structures, microsensors, microsystems (MEMS, MOEMS, RF- MEMS, microfluidics, biochips: microarrays, biosensors) based on semiconductor technology, including also mask fabrication, electron beam lithography (EBL), dip-pen nanolithography and nanoprinting;
- A laboratory for rapid prototyping (with laser) is under development;
- Microphysical characterization (SPM, SEM, XRD, SNOM, WLI, Impedance spectroscopy, Raman, Spectrophotometer; Spectroscopic Ellipsometer, experimental set-up for optoelectric characterisation in UV-VIS-IR spectral range);
- Reliability tests (thermal, mechanical etc.);
- *Important*! Mounting and packaging is provided by small companies (from the science park), with equipments located in the same technological area

Main Tools - 1 -

- lithography – chrome, maskless, nano
- 4-6" processes – e-beam induced, physical/chemical depositions, thermal...
- characterization – electron/contact/X-ray/UV/Vis/NIR/chemical/ mechanical/electrical/thermal
- CAD and simulation – coupled analysis, M(O)EMS, RF-MEMS, microfluidics...

❑ **Micro and nanolithography; Nanoprinting**
- Mask less lithography system - *DWL 66 fs*, Heidelberg Instruments Mikrotechnik
- Electron beam lithography and nanoengineering workstation - *e_Line*, Raith
- Pattern Generator - *Elphy Plus*, Raith
- Double Side Mask Aligner - *MA6/BA6*, Suss MicroTec
- Dip Pen Nanolithography Writer - NSCRIPTOR, NanoInk

❑ **Technological Processes**
- Electron Beam Evaporation an DC sputtering system - *AUTO 500*, BOC Edwards
- PECVD - *LPX-CVD, with LDS module*, STS
- LPCVD - *LC100*, AnnealSys
- RIE Plasma Etcher - *Etchlab*, SENTECH Instruments
- Rapid thermal processing/annealing - *AS-One*, AnnealSys
- Micro-Nano Plotter - *OmniGrid*, Genomic Solutions

Main Tools - 2 -

❑ **Characterization**
- X-ray Diffraction System - *SmartLab*, Rigaku
- Field Emission Gun Scanning Electron Microscope (FEG-SEM) - *Nova NanoSEM*, FEI Company
- Scanning Electron Microscope - *Vega II LMU*, Tescan
- Scanning Near-field Optical Microscope - *alpha 300S*, Witec
- Scanning Probe Microscope - *NTEGRA*, NT-MDT
- Scanning Electrochemical Microscope - *ElProScan*, HEKA
- Nanomechanical Characterization equipment - *Nano Indenter G200*, Agilent
- High Resolution Raman Spectrometer - *LabRAM*, HORIBA
- Spectroscopic ellipsometer - *800 XUV*, SENTECH
- Combined Time Resolved and Steady State Fluorescence Spectrometer - *FLS920P*, Edinburgh Instruments
- White Light Interferometer - *Photomap 3D*, FOGALE nanotech
- Microarray Scanner, *GeneTAC UC4*, Genomic Solutions
- Microwave network analyzer (0.04 - 65 GHz) with Manual Probing Station - *Lightning VNA*/Anritsu; *PM5*/Suss MicroTec; *to be extended soon to 110 GHz;*
- Semiconductor Characterization System, Wafer Probing Station - *4200-SCS*/Keithley; *Easyprobe EP6*/ Suss MicroTec

❑**CAD and Simulation**
- *CoventorWare 2008.010*, COVENTOR
- *Ansys Multiphysics 11.0*, ANSYS
- *Opti FDTD 8.1, Opti-HS, OptiBPM 9.0, OptiGrating*, Optiwave
- *IE3D, FIDELITY*, Zeland

Details ►Scientific Services for Modeling and Simulation

Expertise:
- **design, development and optimization** of **MEMS/MOEMS** components and devices (switches, cantilevers, bridges, membranes, microgrippers); mechanical, thermal, electrical and electrostatic, piezoelectric, fluidic, as well as coupled field (static and transient) analysis;
- modelling and simulations of microfluidic components and systems for biomedical applications and micro-electronic fluidic systems (valves, pumps - with various actuation principle as electrostatic, piezoelectric, pneumatic, electro osmotic- cell reservoirs, microchannels, filters, mixers, heaters, etc.)

– the **microfluidic analyzes** include: fluid dynamics in microstructures (general flow, fluid mixing, thermal analysis); electrokinetic flow (electrophoresis, electroosmosis); electrokinetic with field switching analysis; fluid diffusion; bubble and droplet simulation (transport, merging, splitting); interaction between fluids and mechanical parts; mechanical, electrostatic, piezoelectric analysis for microfluidic actuators-; modelling of optoelectronic devices, neural networks.

Tools available:
● COVENTOR 2006.2 (in 2007 new modules: Architect; FlowMM; MemHenry; MemPackage; Designer; Analyzer Std. ; MemOptics CW 2006 release)
● MATLAB 7:
● ANSYS Multiphysics 11.0- Structural, thermal, acoustic, electromagnetic and coupled field analyses, CFD
● COMSOL Multiphysics 3.3 and 3.4 (enabling parallel computation)
● Workstation with 4 quad-core Intel Xeon MP 2.93 GHz processors, 64 GByte RAM and 584 GByte HDD + 876 GByte external storage

Equipments for technological processes

Within “clean-room” spaces

➢ **Mask manufacturing using Pattern generator - DWL 66fs Laser Lithography System**

Applications: It can be used for mask manufacturing or direct exposure on basically any flat material coated with photoresist. Numerous optional features increase the flexibility and make the system suitable for more applications. If one of your applications requires a special technology, it can most likely be implemented in the DWL 66FS.

•**Critical Dimensions Specifications**: The current spec for the critical dimensions is 2 micron with a 0.2 micron tolerance. The CD can be pushed down to 2 micron, but results depend strongly on the layout and are not guaranteed.

•**Mask File Acceptable Formats**: Either CIF of GDSII formats are preferred. DXF is also acceptable, but please verify the pattern with the process engineer before submitting it as we have found incompatibility problems.

•**Available Plates**: We currently have Chrome Soda Lime Masks and the available sizes are 4inch, 5inch, and 6inch (maximum 6 inch, only on command). We DO NOT supply Iron Oxide masks and there is currently no plan to have that kind of masks available in the near future. If you need Iron Oxide, please contact other mask shops.

•**Cost of Mask**: to estimate the cost of the mask, the extents of the pattern have to be specified. The extents are the X and Y dimensions of a rectangle that completely covers all the features of the pattern of the mask. Once you have these dimensions, you can contact the process engineer to obtain the cost of the mask.

•**Mask fabrication time**: depends on the masks design and the number of masks requested. An average time of about 2 day after the file is accepted, for dimensions bigger than 5 microns and for dimensions between 1-4 microns it strongly depends of the area to expose and it can be about 6 days.

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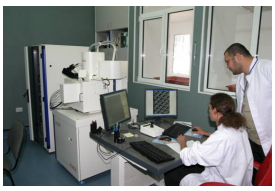
➢**Structuring at nanoscale range using Electron Beam Lithography and nanoengineering workstation- Raith e_Line from RAITH GmbH**

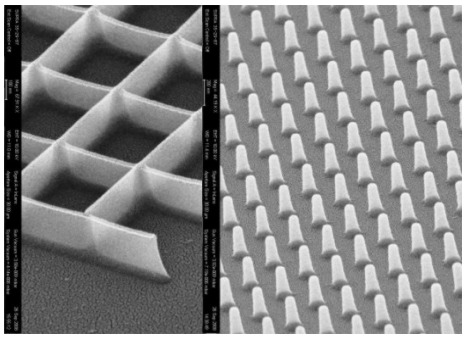
Ultra high resolution EBL (Electron Beam Lithography) and nano engineering workstation Raith e_Line is a versatile electron beam lithography system having complied with the specific requirements of interdisciplinary research, which allow nanoscale structuring. Selected options for nanomanipu-lation, **EBID and EBIE** expand this system to a nano-engineering workstation.

Basic hardware features:
•Thermal assisted field emission gun;
•Minimum line width < 20 nm; Stitching accuracy 40 nm; Overlay accuracy 40 nm;
•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 2 nm resolution achieved by closed-loop piezo-positioning;

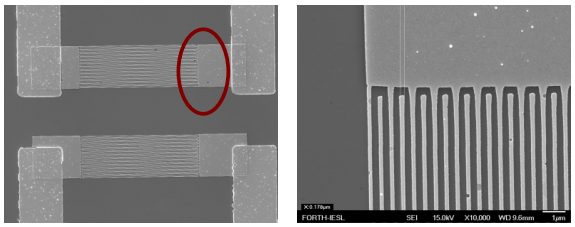
Applications: The state-of-the-art *e_LiNE* electron column matches perfectly with a number of **key applications in:** nanoelectroniccs, photonic crystals (PCs), Difractve Optic Elements (DOE), CNTs interconections, nanodevices and nanosystems for fundamental research and bio applications.
•Nano lithography with sub 20 nm resolution;
•High speed devices e.g. HEMT;
•CMOS process and device developments;
•Resist less lithography;
•E-beam induced deposition and etching;
•Imprint template fabrication;
•Nano probing and electrical measurements;
•Nano and pattern placement metrology;
•Gratings, DFB lasers, SAW devices;

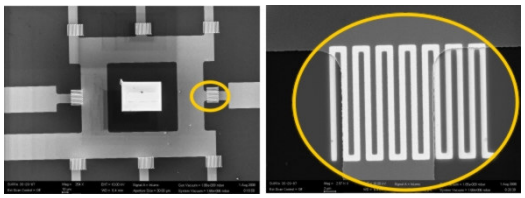


High aspect ratio (12:1) structures in PMMA applications in nanotechnology.
Left: crosslines; Rigth nanopilars.



SAW device for microwave applications obtained using EBL lithography (details of digits and interdigits 150 nm)





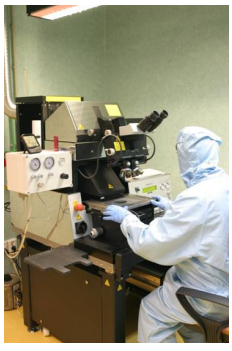
Mix-and-match lithography for biomedical applications:
optical lithography (left),
combined with EBL (right)

Partnership: CATHERINE- Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts, STREP, FP7-ICT, 2008-2011
Contact person: Phys. **Adrian Dinescu**, adrian.dinescu@imt.ro

➢ **Double Side Mask Aligner - MA6/BA 6 (Suss MicroTec);**

Description
4",5", fragments >5x5 cm;
Alignement range: X: ± 10 mm; Y: ± 5 mm ; Θ: ± 5°.
Mechanical increment resolution: 0.1 μm.
Top side alignment (TSA) – optical microscope "split field", 0.5 μm.
Bottom side alignment – high resolution LCD cameras, 0.1 μm.
Enhanced Image Storage System (EISS).
Exposure: contact, vacuum, proximity, flood.
UV 365 nm, 1000 W (Hg).
DEEP UV 249 nm 500 W (Hg / Xe).
UV- NIL

Applications:
•Equipment for alignment/exposure nanolithography and nanoimprint: Double face exposure alignment equipment, UV, nanoprint 4''-6".



Contact person: Eng. Adrian Albu, adrian.albu@imt.ro

➢ **Dry etching processes using Reactive Ion Etching (RIE) Plasma Etcher - Etchlab 200 (SENTECH Instruments, Germany);**

Reactive Ion Etching instrument, manual loading, capable of processing wafers up to 6", four process gases: CF_4, SF_6, O_2 and Ar, maximum RF power 600W, equipped with a fore pump and a turbo molecular pump capable of reaching pressures in the reaction chamber down to 10-6 mbar. Operational.

Applications:

•the etching of dielectrics (SiO_2, Si_3N_4),
•semiconductors (Si),
•polymers and metals (Au, Pt, Ti, Ni).

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➢ **Chemical deposition processes**

•PECVD - LPX-CVD, with LDS module (STS, UK);

•LPCVD - LC100 (AnnealSys, France);

Description
Stress free silicon rich nitride deposition; silicon oxide; Annealing;
The LC100 is a four-inch tubular furnace. It can process up to 50 wafers per process. The process chamber is made of a quartz tube with stainless steel flanges. The quartz boats are held by two quartz rods attached to the loading door. The high quality, low thermal mass, heater elements provide fast thermal response and low contamination. A high quality digital temperature controller controls the temperature of each heating zone. The controller has auto-tuning capability and continuous parameter adaptation in case of process changes. This temperature control system provides

•APCVD - PYROX (Tempress, UK);

➢ **Physical deposition using Electron Beam Evaporation an DC sputtering system - AUTO 500 (BOC Edwards, UK);**

Front loading thin film system for R&D or pre-production services (500mm x 500mm chamber). Flexible substrate dimensions: 260mm-diameter workholder plate. Up to 6 coatings in a single vacuum process (4 E-Beam, and 2 DC-sputtering).
Coating materials: Al, Ni, Cr, Au, Pt. Up to 250ºC substrate heating.
Optional substrate plasma pre-cleaning. Ultimate vacuum: 7 x 10-7 mbar. PLC control and thickness monitoring with 0.1 nm resolution.

Applications: Vacuum depositions of thin films of Al, Ni, Cr, Au, Pt, etc. using plasma
sputtering and/or electron-beam evaporation.

Contact Person:
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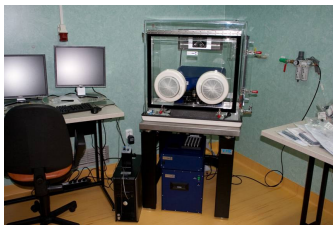
➢ **Rapid prototyping, nanoimprint using Dip Pen nanolithography System**

It allows the drawing of doth and lines with sizes as small as 20 nm under controlled conditions. Complex figures may also be realized. Is a nanolithography system that „prints" and „ink" directly on the substrate. The size of the geometrical features can vary from few tens of nanometers (in best conditions – 20 nm) up to several microns. It allows both a bottom-up approach and a top-down one when constructing the nanostructures. The working principle is that of wetting an AFM-type cantilever with an "ink" and writing down onto a substrate, similar with an ink pen that writes on a paper. The process is serial and is quite slow, but can be highly parallelized by using 2D arrays of cantilevers (55,000 such cantilevers on an array) and thus becomes efficient from the speed and through output points of view. Many materials can be used as "inks", as are solutions of polymers, small organic molecules, sol-gel precursors, macromolecules, nanoparticle colloids.

Applications:
•surface functionalization (with direct
• liaison to proteomics, DNA
•recognition, virus identification);
•photolithographic masks correction;
•molecular electronics;
•realization of master stamps for NIL (Nanoimprint lithography);
•novel devices (photonic and electronic);



Contact Person:
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Tools for characterization at the micro- and nanoscale

Also installed in clean-spaces
(class 100,000)

2. Microphysical characterization

- **Scanning Electron Microscopy characterization of materials and devices using Field Emission Gun Scanning Electron Microscope (FEG-SEM) - Nova NanoSEM 630 (FEI Company, USA)**

The equipment is a high-quality nanoscale research tools that offer a variety of applications that involve **sample characterization, analysis, prototyping, and S/TEM sample preparation.** It features a superior low voltage resolution and high surface sensitivity imaging in the range of Ultra high Resolution Field Emission Scanning Electron Microscopes (UhR FE-SEM).

The Nova NanoSEM 630 presents also low-vacuum imaging capabilities for spectacular nanoscale characterization on charging and/or contaminating nanotech materials. The Nova NanoSEM 630 also offers the most extensive set of tools for nanoprototyping, including an on-board digital pattern generator and dedicated patterning software, a high speed electrostatic beam blanker, gas injection systems for direct electron beam writing of nanostructures and its high stability 150 mm piezo stage.

Basic hardware features:

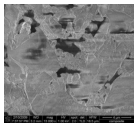
•Ultra-high resolution characterization at high and low voltage in high vacuum: 1.6 nm @ 1 kV;
•Beam deceleration mode with sub-100 V and high surface sensitivity imaging;
•Low and very low kV backscattered electron imaging for compositional characterization in high and low vacuum;
•Novel high stability Schottky field emission gun enabling a beam current up to 100 nA for analysis;
•150 x 150 mm high precision and stability piezo stage;
•True high resolution low vacuum FESEM, with a resolution of 1.8 nm @ 3 kV;
•The ultimate characterization solution for charging and/or contaminating nano-materials or –devices;
•Full prototyping solution with on-board 4 k x 4 k digital pattern generator, dedicated patterning software, fast beam blanker and gas chemistries;

Applications: microphysical characterization of a variety of challenging nanotechnology materials such as metals, magnetic materials, nano-particles and powders, nano-tubes and -wires, porous materials (e.g. silicon), plastic Electronics, glass substrates, organic materials, diamond films, cross-sections, microdevices etc.

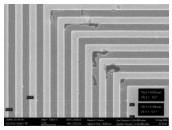
Targeting

- **RESEARCH:** Materials Qualification; Materials & Sample Preparation; Nanoprototyping; Nanometrology; Device Testing and Characterization
- **INDUSTRY:** Macro Sample to Nanometer Metrology; Particle Detection and Characterization; Sample preparation
- **SEMICONDUCTOR & DATA STORAGE:** Circuit Edit (lab); Defect analysis (near fab/lab); Failure analysis (near fab/lab)

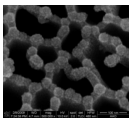
Materials Qualification
The structure of an composite material used in aeronautics- sample from INFN Italy



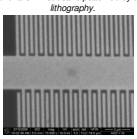
Nanometrology
Detail of MRS 4.1-calibration standard used in nanometrology.



Sample preparation *Porous silicon covered with gold nanoparticles by sputtering.*

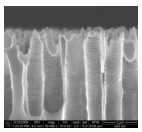


Nanoprototyping
Detail of a SAW structure patterned by e-beam lithography.



Particle Detection and Characterization
Micro and nanospheres produced in the process of CNTs growth.

Porous alumina membrane covered with Ni catalyst used as template for CNTs growth



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- **Scanning Electron Microscopy characterization of materials and devices using Scanning Electron Microscope - Vega II LMU @ Pattern Generator - PG Elphy Plus (TESCAN s.r.o , Czech Republic @ Raith, Germany)**

SEM - General purpose scanning electron microscope, tungsten heated filament. Maximum resolution 5nm@30kV, SE and BSE detectors, low vacuum working mode up to 250Pa, movements: X= 80 mm - motorized Y= 60 mm - motorized Z= 47 mm - motorized PG- 6 MHz high-speed pattern generation hardware, 16 bit DAC vector scan beam deflection, 2 ns writing speed resolution, TTL and 100 V blanking signal drivers.

Applications:
•general purpose SEM imaging using
•secondary
electrons (topography) and backscattered;
•electrons (composition);
•electron beam lithography with sub-50nm
•resolution;

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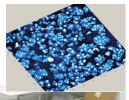
➢**Microphysical characterization using Scanning Probe Microscope NTEGRA Aura (NT-MDT Co., Russia)**

The equipment enables several related techniques for high resolution imaging and measuring of surfaces, the properties which could be characterized depending on the chosen technique.
Main applications - in the field of surface metrology, for quantitative measurements of the 3D surface topography for a large variety of samples.
Key advantages of the technique as compared with other microscopies as optical and SEM: ability of measuring the vertical dimensions of the samples together with lateral ones with little or no sample preparation required; samples could be measured in various environments (normal ambient, controlled gaseous, liquid, low vacuum);
The range of samples that could be imaged: very large, no matter of the sample conductivity, covering metallic, ceramic, polymeric and semiconducting materials. **The SPM microscope could in principle image and perform three dimensional measurements of any surface features from surface roughness to nanometer-sized features.** Scanning Probe Microscope (SPM) performs 3 dimensional imaging of the topography and studying other physical properties of sample surfaces on a scale from microns down to the nanometric level. Measurements could be done in ambient atmosphere or in controlled atmosphere.

•Scan range: 100x100x10μm.
•Non-linearity in X, Y with closed-loop sensors < 0.15 %.
•Positioning sensitivity: 2μm



AFM image of step patterned Si. Individual step height: 15 nm. Individual atomic planes could be noticed in the 3D rendered image.

Application fields:
•High-resolution surface profilometry;
•Evaluation and optimization of thin film coatings for various applications (optical, packaging, paintings, wear-resistant etc);
•Grain and particle size analysis;
•Surface cleaning and polishing studies (Characterization of optical surfaces roughness, electro-polished metal surface evaluation etc);
•Microstructural studies (Pharmaceutical, Polymers);
•Morphological studies of biological and biocompatible materials;
•Virtually any other field where nanometer-sized surfaces are concrened;

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➢ **Microphysical characterization using Nano Indenter G200 - Nanomechanical Characterization Equipment Agilent Technologies**

Description:

•nanomechanical characterization equipment operating by instrumented and scratch testing.
•maximum load : 500 mN.
•load resolution : 50 nN.
•maximum indention :500 μm.
•displacement resolution : 0.01 nm.

Applications:
•High resolution mechanical characterization of a wide variety of materials (metals, semiconductors, ceramics, biocompatible material, especially in the form of thin films, coatings and generally small volumes of material. The characterized properties include hardness, modulus, film adherence, wear behaviour.

Contact Person: phys. Raluca Gavrila , raluca.gavrila@imt.ro

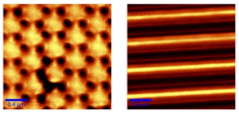
➢**Microphysical characterization using Scanning Near-field Optical Microscope -** *Witec alpha 300S* **(Witec, Germany)**

The Scanning Near-field Optical Microscope (SNOM) is combining the characterization methods of SNOM, Confocal Microscopy (CM) and Atomic Force Microscopy (AFM) in a single equipment. The Alpha300 S uses patented micro-fabricated SNOM cantilever sensors (aperture size typically 100 nm) for optical microscopy with spatial resolution below the diffraction limit (optical resolution of 50 – 100 nm).

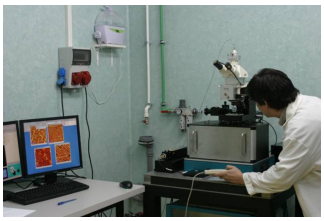
Operating modes:
- *Near field optical microscopy*: transmission, reflection, collection, fluorescence;
- *Confocal microscopy:* transmission, reflection, fluorescence, can be upgraded with a Raman spectrometer;
- *Atomic force microscopy*: contact and AC Mode.

The flexibility of this equipment and its operation modes allows **a large variety of applications in nanotechnology and nanosciences**. It allows the optical characterization (in both transmission and reflection mode) of various samples (nanostructures, biological samples, polymers) with a resolution of 50-90 nm in visible spectral range with the possibility of extension in the infrared spectral range. Working in the collection or photon scanning tunneling microscope (PSTM) mode the alpha 300S SNOM allows the imaging of propagating optical field in various metalic and dielectric waveguides providing a powerful method to caracterize and investigate nanophotonics and nanoplasmonic structures and devices. Also the AFM module working in both contact and alternative contact modes (with posibility of extension to magnetic force measurements and pulsed force mode) allows the topografical and chemical characterization of various surfaces and nanostructures.

Applications:
•imaging the optical properties of a sample with resolution below the diffraction limit with applications in nanotechnology, nanophotonics, nanooptics and plasmonics;
•Materials research and polymers
•Single molecule detection;
•Life sciences;
•Fluorescence characterizations



Nanostructure characterization by near field scanning optical microscopy: a) transmission mode image of a hexagonal array of aluminum regions deposited on a glass substrate (Fisher pattern). b) reflection mode image of an array of polymer stripes realized by electron beam lithography.



Partnership:
• European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors, **MIMOMEMS** (FP7-Capacities) 2008-2010;
• Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology **FLEXPAET** (IP- FP7/NMP) 2008-2010;

Contact Person: Dr. Cristian Kusko (cristian.kusko@imt.ro)

➢**Spectroscopy services using High Resolution Raman Spectrometer - LabRAM HR 800 (HORIBA Jobin Yvon, Japan)**

LabRAM HR 800 Raman Spectrometer is a powerful optical technique for materials study and characterization based on inelastic scattering of light due to light-matter interaction during which the energy of the incident laser will be shifted. This energy loss is characteristic for a particular bond in the molecule. The Raman spectrum provide qualitative and quantitative information: peak position is determined by chemical species; line intensity is proportional to concentration; shift in position of the peak indicate the stress and temperature effect and the width the structural disorder. The microscope is coupled confocally to a 800 mm focal length spectrograph equipped with two switchable gratings.

Characteristics:

•High spectral resolution (0.3 cm^{-1}/pixelat 633 nm);
•Large spectral range of Raman shift from 30 to 4000 cm^{-1} ideal for organic and inorganic species;
•Unique adjustable angle notch filter technology;
•LabSpec Software for control the instrument, data acquisition, data manipulation and mapping option;

Applications (analysis of solids, liquids and solutions)**:**

•chemical identification, characterization of molecular structures;
•to determine the composition and phase (crystalline/ amorphous) of composites materials;
•environmental stress on a sample and crystal quality and composition of alloy semiconductors;
•nature of oxides on compound semiconductors;
•polymers characterizations and polimer nanocomposites;
•chemical and biological detection using SERS technique;
•micro/nano structures characterization (micro/nanorods, carbon nanotubes), self assembled molecule (SAM) on functionalized substrate and other.

Partnership:

•European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors - **MIMOMEMS** (FP7-Capacities) 2008-2010;
•Flexible Patterning of Complex Micro Optical Structures using Adaptive Embossing Technology **FLEXPAET** (IP- FP7/NMP) 2008-2010;

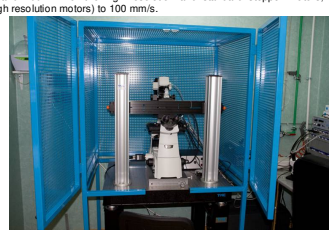
Contact person: Dr. phys. **Munizer Purica** , munizer.purica@imt.ro

➢**Investigations of *electrochemical* active surfaces using Scanning Electrochemical Microscope - ElProScan (HEKA, Germany)**

ElProScan features

• can perform measurements in an extremely wide ***current range up to 2 A***. It is operates as a standard (Bi-) potentiostat/Galvanostat, thus, making it usable for many other electrochemical applications also.
• low current preamplifiers allow high-resolution low-noise recordings in the low pA range.
• high precision real time controlled positioning system mounted on a stable holder made of granite, resolution in XY: 100 nm or 15 nm stepper motors, resolution in Z: 100 nm stepper motor + Fast real time controlled Z-piezo with 5 nm resolution and 100 mm scan range, closed loop regulated.
• the system comprises a large scan area (50 mm on each axis) with accurate position control and a fine piezo-driven z positioning.
• with electrodes in the sub micrometer range, the Faradaic current at the tip of the electrode becomes very small, making high demands on the amplifier.
• the smallest resolution for a scan step is 15 nm and 100 nm for the high resolution and standard stepper motors, respectively. The scan speed ranges from 15 nm/s (high resolution motors) to 100 mm/s.

Applications:



•*Imaging and positioning:* three-dimensional SECM image. SECM can be used to image the surfaces of different types of substrates, both conductors and insulators, immersed in solutions. The resolution attainable with SECM depends upon the tip radius. For example, local activity of an enzymatic reaction on a filtration membrane can be determined

•*Studies of heterogeneous electron transfer reactions:* heterogeneous kinetic studies on various metal, carbon and semiconductor substrates; measurements of kinetics of reactions at the interface between two immiscible solutions (for example, water/oil).
•*Studies of homogeneous chemical reactions:* studies of homogeneous chemical kineticsof different substrates
•*Characterization of thin films and membranes:* studying thin films on interfaces. For example, polyelectrolytes, electronically conductive polymers, passivation films on metals and dissolution processes.
• *Membrane transport*: the transport of chemicals through natural or artificial membranes, and biological tissues.
•*Liquid-liquid interfaces:* the study of charge transport at the interface between two immiscible electrolyte solution (ITIES). Charge transfer processes across the ITIES with or without membranes can be studied.

•*Probing patterned biological systems:* to probe artificially or naturally patterned biological systems. Both amperometric and potentiometric techniques with ion-selective tips can be used.
•*Fabrication*: The SECM can be used to fabricate microstructures on surfaces by deposition of metal or other solids or by etching of the substrate. Two different approaches could be used, the direct mode and the feedback mode. Typically, in the direct mode, the tip, held in close proximity to the substrate, acts as a working electrode (in deposition reactions) or as the counterelectrode (in etching processes). The feedback mode of fabrication utilizes the same arrangement as in SECM imaging. The tip reaction is selected to generate a species that reacts at the substrate to promote the desired reaction, i.e., deposition or etching.

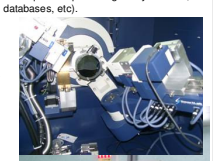
Contact Person: Dr. Mihaela Miu

➢ **X-ray diffraction crystallographic measurement using X-ray Diffraction System - *SmartLab* - (Rigaku Corporation, Japan)**

SmartLab makes thin films analysis more flexibile. SmartLab approach is to aid users in choosing the specific measurement conditions, experimental geometries and application methods best suited to their particular sample. The system is multimodular (quick alignement computer aided, small measurement time), modern techniques for producing X-ray sources, real time ultraspeed detectors and difraction data processing (especialized software, databases, etc).

The system offers multiple measurement techniques:

•X-ray Powder diffraction (XRPD);
•High resolution X-ray diffraction (HRXRD) (including multiple reflection HR-MRXRD Ge(220) 2 and 4 bounce monochromator, Ge(220) 2 bounce analyzer, focussing/ flat diffracted beam monchromator);
•X-ray reflectometry (XRR, including HRMR XRR);
•Grazing incidence diffraction (GIXRD);
•In-plane grazing incidence diffraction (IPGID);
•Small angle X-ray scattering (SAXS);
•Single crystal diffraction (SCD);
Some of the characterized structure parameters are:
•multilayer structure- thickness (1~ 103 nm), density (H_2O ~ Heavy metals), roughness (0.2 ~ several nm);
•phase identification- interface, transition layer;
•crystal structure- crystal quality, lattice parameter (several nm);
•crystal orientation - single: orientation relation of the substrate and film;
•poly: preferred orientation;
•particle/pore size analysis- 1~ 102 nm;



Applications:

•crystal structure (HR RSM, HR RC);
•film thickness, density, roughness;
•characterization of the ultra thin film (in plane XRD);
•particle/ pore size analysis (reflection SAXS, transmission SAXS);
•phase identification, crystal structure (powder/thin film/poly/ mono/ crystal, trace, small area/quantity);

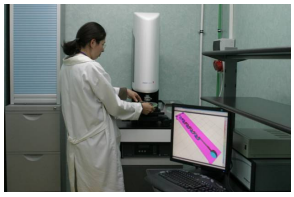
Persoana de contact: Phys. Mihai Danila, mihai.danila@imt.ro;

➢**Non-contact profiling surface measurements by interferometry using White Light Interferometer - Photomap 3D (FOGALE Nanotech, France)**

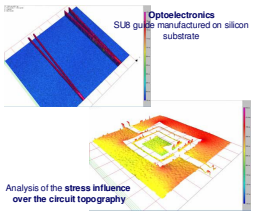
The white light interferometer perform optical, non-contact profiling of rough surfaces, that uses interferometric techniques as well as digital signal processing algorithms to produce fast, accurate, repeatable two and three-dimensional surface profile measurements. The method of determining surface height is based on white light as the source in an interferometer, and measurements of the fringe modulation degree, or coherence, instead of the phase of interference fringes. The WLI profilometer uses the measurement of surface height through vertical scanning of the reference arm of the interferometer, and calculate the relative modulation of the intensity signal as a function of vertical position. WLI present sub-nanometer vertical resolution (down to 0.1 nm), non-contact measurements allowing accurate and repeatable results, all axes motorization enabling automatic stitching of multiples fields of view, sub-nanometric roughness measurements, reflectivity 1%-100%, ability to measure transparent films and require no sample preparation.

***Caracteristics*:**
• manual translation stage 100x100 mm range, 20µm resolution; optical head vertical range 150 mm; nanometric objective translation unit; capacitive sensor closed loop control, 500 µm range; white light and Monochromatic light source; automatic switching, software control; antivibration feet; field of view 126 x 96 µm up to 2.5 x 1.9 mm depending on objective (without zoom);
•**white light profilometry, 3 nm rms z resolution; monochromatic light profilometry, 0.1 nm rms z resolution;**
•automatic step height and roughness measurement; semi-automatic focus detection;
•results exploitation (heights, roughness, dimensions, field stitching, filtering, 3D view, bump size, height, roughness measurements); motorized x0.35 to 1.6 zoom;
•out of plane measurements (by stroboscopic interferometry within range 100Hz - 2MHz and by time averaged operation without frequency limitations);
•synthesized function generator: 2 channels controlled by software (one channel for stroboscopic illumination, the other one for MEMS AC voltage supply);
•high voltage module (amplitude up to 200V; offset up to 200V; 1% resolution;
•sinusoidal and square signal; power 20W; current output max 100 mA);
•multi-reflectivity (5%,25%,50%,85%) objectives (x2.5, x5, x20);
•motorised XY stage; active vibration isolation stage.

Applications:
•Optical profilometer allow to measure the surface topography of very diverse materials (such as metals, plastics, semiconductors, biological materials etc);
•Ca be used for residual stress measurement for different thin film deposition layers;
•Conceived not only for statistical surface roughness measurements but also for high precision measurement of mechanical or chemical micromachining;
•Useful for thickness measurements of transparent layers (plastics, glasses or varnish) with known refraction indices;
•Can be used for MEMS dynamic measurements



Partnership:
•**MIMOMEMS** - European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors, FP7-Capacities, 2008-2010;
•**MEMS-4-MMIC**- Enabling MEMS-MMIC technology for cost-effective multifunctional RF system integration; STREP, FP7-ICT-2007-2, Contract no. 204101, 2008-2011
•**GIGASAB AR- SAW** and FBAR type resonators dedicated to applications in communications for 2-6 GHz, based on micro&nanomachining of wide band semiconductors (GaN and AlN); PN II Partnership, 2008-2011
•**MIMFOMEMS** - Advanced circuits for microwave, millimeter wave and photonics based on MEMS technologies, PN II Partnership, 2007-2010,



Contact Person: Dr. phys. **Alina Cismaru**, alina.cismaru@imt.ro

Reliability testing

3 Reliability and Testing

Scientific services about Materials, Microelectronic devices and Microsystems, containing:
•Environmental & reliability testing;
•Failure & reliability analyses;
•Assessment of reliability parameters;
•Reliability screening for selecting high reliability components
•Consultance / technical assistance on: Reliability analysis for all families of semiconductor devices; Elaborating standards and other documents for various types of electronic components; Qualification of semiconductor devices.

➢**Electrical characterization** (electrical characterization of micro and nano technologies products according approved standards and special specifications),

➢**Mechanical and climatical tests** (application specific tests development for micro and nano technologies products),

➢**Long time tests** (storage and endurance tests in various environmental and electrical conditions).

Testing at combined stresses: Damp heat, Thermal cycling, Pressure + Temperature, Thermal stress + Electrical stress, Electrical stress + Thermal stress + Humidity + Vibrations, Electrical stress + Thermal stress + Pressure, Mechanical ("Tilting") + Thermal stress;

Chambers for: -Thermal cycling – TSE-11-A (Espec): High temp. (-65...0ºC) and Low temp.(+60…200ºC); -Highly accelerated stress test (HAST) - EHS 211M (Espec): Temperature range: +105 ... +142ºC, Humidity range: 75%...100% RH, Pressure range: 0.02...0.196 Mpa; -Damp heat - CH 160 (Angelantoni): Temperature range: -70...+180ºC; Speed: 5oC / min, Humidity range: 20…95%RH, between +100 C…+80º C

Chamber for testing at temperature + low pressure - VC0400 (MEMMERT): 49 l; +20 ... +200 ºC; 10 ... 1100 mbar

Electrical characterization system and measurement equipments

Keithley 4200SCS: modules C-V 3532-50, DMM 2700-7700 and 2002; low level measurement units 6211-2182; Stimulus: voltage DC < 100V, current DC < 1A; Pulse: analogic signal 30V, <40MHz; Measurements: voltage 0,5 μV, current 1 fA

Temperature conditioning equipment for electrical measurement

Temptronic TP04300A-8C3-11 – ThermoStream: Temperature range: -80 ..+225ºC; Transition time: up 7 sec, down 20 sec; Temperature control +/- 0.1ºC

***Electrical characterization**: 4200SCS system (Keithley, UK): Voltage CC<100V, Current CC<1A; Impulses: analogical signal 30V, <40MHz; Measurements: Voltage 0,5 μV, Current 1 fA.*

Damp heat Climatic chamber

Angelantoni, Italia: Temperature range -70 ...+180ºC; speed 5ºC / min; Relative humidity range: 20...95 %, between +10ºC...+80º C

Temperature chamber with Forced air circulation

Memmert (Germany) / UFB 400:: Capacity 53 l; Temperature range 20...220 ºC

Vacuum oven

MEMMERT (Germany) – VO 400: Capacity: 49 l; Temperature range: 20 ... 200°C; Pressure range: 10 ... 1100 mbar;

Computer-aided simulation and testing

SERVICES OFFER IN SIMULATION, MODELLING AND COMPUTER AIDED DESIGN

We offer simulation, consulting and training services in micro and nano domains

Application areas: microsensors and actuators, integrated microsystems, MEMS/NEMS, MOEMS, RF MEMS, microfluidics, lab-on-chip, micro and nano-systems for diagnosis and drug delivery

→ **Computer Aided Design** using dedicated software tools: **COVENTOR WARE 2008 and ANSYS, COMSOL**

►**Mask Design, Process Editor, 3D building and mesh**

►**Modeling for technological processes/ optimizations**

►**Special features:** particularized use (macro or subroutine) creation; special geometrical modeling (AFM images reconstruction in CAD format, surfaces generated in accordance with mathematical expression, etc)

► **Modelling and simulation of MEMS, MOEMS:** switches, cantilevers, membranes, resistors etc). Analysis include simulation for mechanical, thermal, electrical, electrostatic, piezoelectric, optical, electromagnetic and coupled field.

→**Computer Aided Engineering and Analysis** (using FEM, FVM, BEM tools)

►**Modelling and simulation of microfluidic components and systems:** micropumps and microvalves with various actuation principles (electrostatic, piezoelectric, pneumatic, electroosmotic), microreservoires, microchannels, micromixers, microfilters. Microfluidic analysis include: fluid dynamics in microstructures (flow under pressure, thermal flow, fluid mixing), electrokinetics, diffusion, bubble-drop formation, fluid-structure interaction

►**Electro-thermo-mechanical and piezoelectric analysis** (steady state and transient).

►**Coupled field simulations:** thermo-mechanical simulations; electro-mechanical simulations; multiphysics, fluid-solid interaction

►**General (macro to micro scale) simulations that include:** Linear and nonlinear types of simulations in static, modal, harmonic and transient regime (including contact problems); Analysis with parameter variation, goal driven optimizations; Material data variation (various types of materials and material models); Fluidic simulations with various types of fluids (Newtonian and non-Newtonian), in laminar or turbulent flow, free surfaces, surface tension phenomena, etc.

→ **Consultancy regarding design and simulation optimization**

→ **Training in COVENTOR and ANSYS:** hands-on courses, access to computer network and software.

►**Software facilities:**

COVENTORWARE 2008.010 Computer aided design and simulation of MEMS and microfluidic components used in microsystems for bio-medical applications: **Design modules:** 2D layouts, editing technological processes, 3D models of ready-to-manufacture devices; static and transient analysis, coupled phenomena approach

ANSYS Multiphysics 11.0: provides high-fidelity engineering analysis tools that enable the accurate simulation of **complex coupled-physics behavior**. Combine industry-leading solver technology for all physics disciplines - structural mechanics, heat transfer, fluid flow and electromagnetics - with flexible coupled-physics simulation methods, and parallel scalability. Include also **FEM simulations, Structural, thermal, acoustic, electromagnetic and coupled field analyses, CFD, Pre and Postprocessor**

COMSOL Multiphysics 3.4 (enabling parallel computation)- a powerful interactive environment for modeling and solving all kinds of scientific and engineering problems **based on partial differential equations (PDEs)**

MATLAB 7.8-7.9 and Simulink: a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. Using the MATLAB product, you can solve technical computing problems faster than with traditional programming languages, such as C, C++, and FORTRAN.

Modules: Optimization Toolbox; Extended Symbolic Math Toolbox; Partial Differential Equation Toolbox; Genetic Algorithm and Direct Search Toolbox; Statistics Toolbox; Neural Network Toolbox; Curve Fitting Toolbox; Spline Toolbox; Signal Processing Toolbox; Image Processing Toolbox; Simulink

Visual Studio 2008 Pro: for in –house development of specific applications

Solidworks Office Premium 2008: 2D and 3D design for complex geometries

Mathematica 7; software environment for technical and scientific computing, mathematical computings

Origin PRO 8; Data analysis and graphing software for scientists and engineers

Examples of applications

Application: ***Lab-on-chips for control of chemical processes to obtain molecular imaging products used in medical diagnosis (FP6 Project "Lab-on-a-chip implementation of production processes for new molecular imaging agents")***

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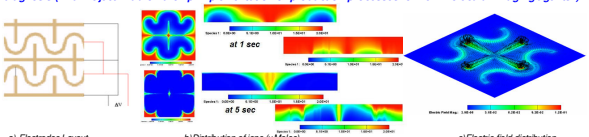
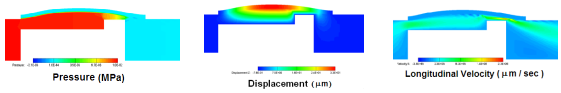
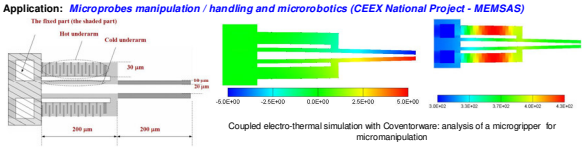


a) Electrodes Layout *b) Distribution of ions (μMoles)* *c) Electric field distribution*



Coupled Fluid-Structure analysis of a pneumatically actuated micropump used in fluid flow control, integrated in lab-on-chip for molecular imaging

Application: ***Microprobes manipulation / handling and microrobotics (CEEX National Project - MEMSAS)***



Coupled electro-thermal simulation with Coventorware: analysis of a microgripper for micromanipulation

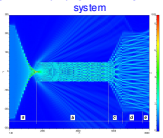
Application: - Filters for biological cells separation

SolidWorks Office Professional: allows 2D and 3D design of complex geometry, capable to export CAD files to other simulation software tools

SolidWorks 3D Design of a microfilter (fluid volume) used in *lab-on-chip for molecular imaging*

Application: - Laser heated system used in lab-on-chip for molecular imaging:

Electro-thermal simulation with **Coventorware 2008:** Simulation of electromagnetic field propagation through the designed optical system



Propagating field through the optical system

►Hard facilities

- **Dual IBM 3750 Server** with 8 quad-core Intel Xeon MP 2.93 GHz processors, 196 GByte RAM and 1 TByte HDD + 876 GByte external storage
- **Computer network used for training**

Applications:

-**We provide access and consultancy to soft and hard facilities for solving different research problems for industry and academic;**

- **We organized and provide access to the training network for seminars, courses, labs for students**

Contact: http://www.imt.ro/ Simulation, Modelling and Computer Aided Design Laboratory:

Raluca Muller (raluca.muller@imt.ro); **Oana Nedelcu** (oana.nedelcu@imt.ro); **Irina Stanciu** (irina.stanciu@imt.ro), **Rodica Voicu (rodica.voicu@imt.ro; Victor Moagar-Poladian** (victor.moagar@imt.ro), **Catalin Tibeica** (catalin.tibeica@imt.ro).

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Using the infrastructure

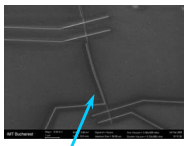
Research

Interdisciplinary groups

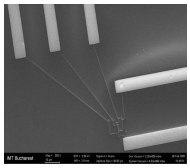
- **Preliminary considerations.** IMT is dealing with a variety of technologies and a variety of applications in dozens of projects. *The structure of the institute is rather stable*, whereas the new and complex problems are tackled by using a kind of "*variable geometry*", combining the basic research laboratories and their resources in "**interdisciplinary groups**". The most relevant groups are presented below:
- **MIMOMEMS** is an association of two research laboratories (RF-MEMS and Photonics, respectively) **financed by the European Union** as a "**centre of excellence**".
- **Centre of nanotechnologies** (under the aegis of the Romanian Academy of Sciences) is also **an interdisciplinary group**, coupling the activities in nanotechnology and nanobiotechnology:
  - Laboratory of nanotechnology (established in 1996);
  - Laboratory for nanostructuring and nanocharacterization;
  - Laboratory for molecular nanotechnology (set up in 2009);
  - Laboratory for computer simulation and design.

IMT - MINAFAB

NANOSCALE LAB



Structure obtained using conventional lithography and EBID for 4 probes measurements of electrical properties of a polymer nanowire (Cooperation IMT Bucharest – UCL)



Polymer nanowire electrically contacted using EBID (Coopertaion IMT Bucharest – UCL)

Research Topics

- **Nanolithography with sub 20 nm resolution;**
- **Three-dimensional nanostructures;**
- **CNT based interconnections for next-generation integrated circuits**
- **CNT based nanodevices**
- **SAW devices with nanometer interdigitated electrodes;**
- **Optical devices, holograms, micro lenses, gratings**
- **Development of Nanodevices using E-beam induced deposition and etching**
- **Development of circuits for communications based on photonic crystals**

Cooperation

- **FP7 CATHERINE Project FET- STREP:** Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts
- **INFN- Roma**
- **MIMOMEMS**
- **UCL**
- **Inst. Biodinamica**
- **INCDFLPR**
- **Zoom - Soft SRL**

NANOBIOLAB

Laboratory mission: Development of biochips (microarrays, biosensors) for biological materials investigation and detection (proteins, DNA, enzymes) on various substrates (silicon, glass, polymers).

Equipments:

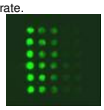
Plotter microarray (GeneMachines OmniGrid Micro)

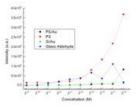
Scanner microarray (GeneTAC UC4)

Results

1. Microarray technology: functionalization of different surfaces (glass and silicon wafer) in order to immobilized DNA and Proteins used in medical diagnosis.
2. Enzyme-based sensors for toxins detection. The sensors are made of interdigitated electrodes deposited on a silicon substrate.

SEM images of PS/Au samples after the BSA printing





Fluorescence intensity as a function of the protein target concentration

Applications

Protein Arrays: (i) study tens of thousands of proteins in as short a time as possible; **(ii)** automated hybridization and imaging of DNA and oligonucleotides allowing antibody / antigen interactions study; **Protein Assays:** immuno-assays, protein-protein interaction assays, enzyme assays

Main Partners: University of Bucharest, Faculty of Chemistry, Diagnostic SA (DDS), Genetic Lab.

Impedance Spectrometer - PARSTAT 2273 (Princeton Applied Research)

General Specifications: hardware capable of ± 10 V scan ranges, 2 A current capability (1.2 fA current resolution), 100 V compliance, >10^{13} Ω input impedance, <5 pF of capacitance and 10μHz to 1 MHz built in analyzer for impedance measurements

Description: *Impedance spectroscopy (IS)* could be applied for:

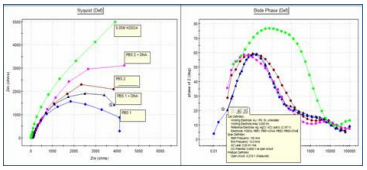
→ **materials and fabrication processes characterization**

→ **electrochemical system interfaces and corresponding physical and chemical phenomena characterization**

→ **bio-electrochemical systems characterization** - label-free detection tool for analyzing of interfacial properties changing by binding of charged biomolecules on surface and for biomolecular interactions studies for biosensor applications - *DNA hybridisation on electrodes analysis; biotin-avidin complex or cellular growing on the electrode surface*

Results (see figures):

Porous silicon as sensing layer for DNA binding



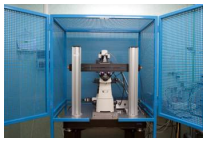
Scanning Electrochemical Microscope - Heka ElProScan

System components

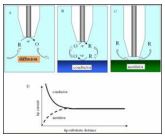
• Positioning system with 3 stepper motors (XY - 100 nm or 15 nm stepper motors) and a piezo translator (5 nm resolution and 100 mm scan range, closed loop regulated) mounted on a granite portal including fundamental plate

• Bipotentiostat/Galvanostat PG 340 with two low current Preamplifiers

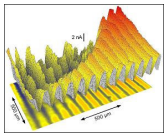
• Software POTPULSE with SCAN extension



Principle of detection



Directly measuring of the catalytic activity of biosensor microelectrode arrays



Applications:

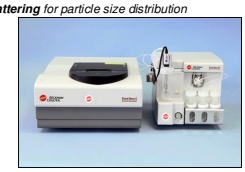
- *Constant - distance Nano-SECM → Substrate imaging (Topography);*
- *Temperature-Controlled SECM;*
- *SECM for local corrosion investigation;*
- *Chemical reactivity → Heterogeneous electron transfer reactions studies; Electrocatalysis*
- *Probing patterned biological systems*
- *Bio SECM - Membrane transport*

Zeta Potential & Particle Size Analyzer - Delsa™ Nano Series

Principle of detection:

Photon Correlation Spectroscopy - Dynamic Light Scattering *for particle size distribution*

Electrophoretic Light Scattering *for Zeta Potential*



Analyses:

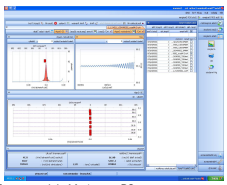
• Diffusion coefficient that depends on: temperature, liquid viscosity and particle size

• Particle size distribution (nm – mm)

• Molecular Weight (103-1012 Daltons) and chain conformation

• Micellization;

• *Zeta Potential*



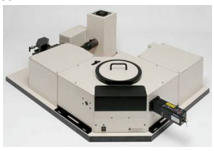
Zeta potential of Au/ macroPS

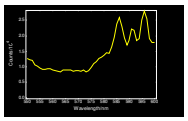
Applications

- **Formulation / tableting**
- **Final QC**
- **Formulation stability**
- **Research**
  - **Virus, bacteria**
  - **protein applications (aggregation)**
  - **bio-nanoparticles**
  - **Lyposomes, lipids, polysaccharides**
  - **Colloid drug carrier systems**
  - **Parenteral and oral drugs**
  - **micelles**
- **Zeta potential of tablet surface**

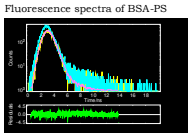
Fluorescence lifetime and steady-state spectrometer (FLSP 920) - Edinburgh Instruments

Technical characteristics: steady state and time resolved fluorescence spectrometer; the sensitivity of the system guarantees a signal to noise ratio of 6000:1 for water Raman spectrum measured with excitation at 350 nm, emission at 397 nm, with a 1 second integration time and 5 nm spectral bandwidth.





Fluorescence spectra of BSA-PS



Fluorescence decay of BSA-Cy3

Applications: photophysics, photochemistry, biophysics and semiconductor study. Complex intermolecular interactions can be revealed by lifetime measurements

Biomedical field: study of enzymes, dynamics and structure of nucleic acids, protein folding and DNA sequencing;

Pharmaceutical sector: for monitoring drug interactions by studying the energy transfer mechanisms using fluorescence lifetimes as the indicator.

Materials physics: study semiconductors and novel structures such as quantum wells and quantum dots or for the quality control monitoring in a wafer foundry, to characterise the doping or impurity level present.

Rigaku SmartLab X-ray Thin film Diffraction System

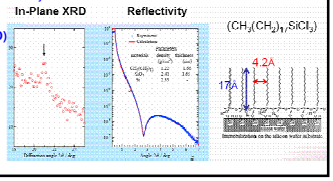
Technical characteristics:

- 9kW rotating anode, 200mm wafer
- Triple axis, vertical goniometer
- Independent Theta - Theta rotation
- Horizontal sample position; X-Y Micro Area Mapping

X-Ray methods and applications for structural Analysis:

- **X-ray Powder diffraction (XRPD)**
- **High resolution X-ray diffraction (HRXRD)** - phase analysis, crystal orientation, thermal stability
- **X-ray reflectometry (XRR, including HRMR XRR)** - layer thickness, density, roughness, interface layers;
- **Grazing incidence diffraction (GIXRD) -** texture analysis and pole figures
- **In-plane grazing incidence diffraction (IPGID)**
- **Small angle X-ray scattering (SAXS)**
- **Single crystal diffraction (SCD)**

In-Plane XRD **Reflectivity**



Results: Investigation of the $CH_3(CH_2)_{17}SiCl_3$ organic film monolayer

New! Laboratory for Molecular Nanotechnology (1)

• Interdisciplinary laboratory established in 2009, relying on state of the art equipment (belonging to various labs and available through IMT-MINAFAB).

• Combination of top-down techniques (e.g., nanolithography and nanopatterning), bottom-up approaches (e.g., self-assembly), and nano-microscale microscopy tools to study functional properties obtained from the interaction of (bio)molecules with nano/micro objects.

• ***Central idea*: joining theoretical/simulation and experimental approaches in search for new insights on:**

- **electron transport mechanisms in chemically doped (bio)molecules**
- **interaction with nanostructures and enhanced device architectures for optimal signal extraction**

Current focus: theoretical and experimental studies towards physical DNA sequencing technologies:

(i) optimal surface immobilization and chemical modification of DNA single-strand molecules in view of STM/STS-based analysis of nucleobase detectability/ identification;

(ii) optical-electrical manipulation of DNA strands and controlled presentation to 1D sensing nanostructures (nanotubes, nanowires)

Laboratory for Molecular Nanotechnology (2) - Main Tools

• **Modeling and simulation**:

- SIESTA: package for ab-initio molecular dynamics and electronic structure calculations (molecules and solids)
- CoventorWare, ANSYS: multiphysics analysis for MEMS

• **Processing and characterization**:

- Dip Pen Nanolithography Writer – *NSCRIPTOR*, NanoInk
- Electron beam lithography and nanoengineering workstation – *e_Line*, Raith
- Field Emission Gun Scanning Electron Microscope (FEG-SEM) - *Nova NanoSEM*, FEI
- Scanning Probe Microscope - *NTEGRA*, NT-MDT
- Scanning Near-field Optical Microscope – *alpha 300S*, Witec
- Scanning Electrochemical Microscope – *ElProScan*, HEKA
- X-ray Diffraction System – *SmartLab*, Rigaku
- High Resolution Raman Spectrometer – *LabRAM*, HORIBA
- Micro-Nano Plotter – *OmniGrid*, Genomic Solutions
- Force-Sensing Optical Tweezers - *NanoTracker*, JPK Instruments (near future)
- Wafer bonding system - SB6L, SUSS MicroTec (near future)

Integrated Polymer Chip
for biophotonic and optical interconnections

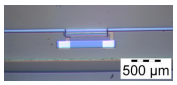
Joint research project in the frame of the FP6 Network of Excellence M

MULTI-MATERIAL MICRO MANUFACTURE: Technologies and Applications **(4M)**

Co-operation with Institute for Microstructure Technology , Forschungszentrum Karlsruhe (FZK), Germany

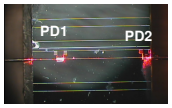
IMT role: chip design, fabrication of silicon photodiodes

FZK role: fabrication of PMMA waveguides on the Si chip with photodiode, characterization, process optimization for integration with microfluidic channels

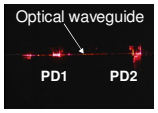


PMMA waveguide coupled with Si photodiode

The goal of this project was to analyze the possibility of realizing compact chips for biophotonic sensors by heterogeneous integration of optical waveguides, photodetectors and electronics within a polymer microfluidic chip

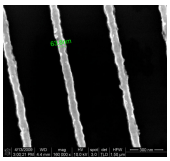


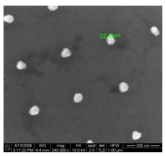
Optical signal detected by the second PD depends on the optical properties of the surrounding medium



Metallic nanostructures- process development

The process combines ***2D and 3 D Electon Beam Litography in a PMMA bi-layer, metal deposition and lift-off***



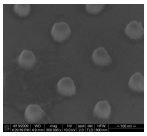


Cooperation IMT-FORTH Heraklion Greece
FP7 project MIMOMEMS
(European Centre of Excellence in Microwave, Millimetre Wave and Optical Devices, based on Micro-Electro-Mechanical Systems for Advanced Communication Systems and Sensors)

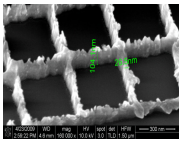
IMT role: process and structure design
Nanolithography, lift-off, characterization

FORTH role: metal deposition

Metallic nanostructures for plasmonics and for nanoelectrodes



Metallic master for photonic crystals (ϕ << 100 nm)



Metallic master for high aspect ratio grating obtained by EBL in PMMA by-layer, metal deposition and lift-off

Using the infrastructure

Education

Education: the new M. Sc. Courses

New Master (M. Sc. Courses) at the Faculty for Electronics, Communications and Information Technology, University "Politehnica" of Bucharest. starting just now (October 2009):

Specializations and disciplines provided by IMT *(with access to experimental facilities)*

- Microsystems
  - Intelligent sensors and microsystems;
  - Microphysical characterization of structures
- Micro- and Nanoelectronics
  - Advanced Technological Processes
- Electronic Technology for Medical Applications
  - Micro- and Nanotechnologies for Medical Applications

Using the infrastructure

Industry

	Partnership in RTD activities, sharing the IP resulting from research	Scientific and technological services, including design and consultancy	Direct access, "hands-on" activities (after appropriate training)
Research groups outside IMT	Usually financed by a contract of partnership.	Typically, specific activities performed by IMT as subcontractor (computer design, characterization, technological processing etc.), with no IP rights.	Direct access of researchers from partner organizations, as part of common research and technology development (RTD)
Educational bodies for Ph.D. and postdoctoral studies, M.Sc. studies, "hands-on" training etc.	Supported by an individual grants or following an agreement with universities, specifying the cost and intellectual property issues.	Occasional.	As part of a common research activity, or providing training on a commercial basis.
Companies (industry)	*Special NDA and IP (industrial property) use agreements.*	*Providing services on a commercial basis.*	*Companies may use their own IP rights.*

"Open centre": developments expected

- **At the level of IMT**
  - Continuing the policy of attracting the cooperation with industry:
    - Providing room in the technological area for the equipments of companies;
    - Developing joint services with companies working in the field;
    - Attracting the interest of important companies with subsidiaries in Romania
  - Consolidating the connection with universities:
    - Four M.Sc. courses fully sustained by IMT to be implemented next academic year;
    - Increasing the number of Ph.D. students working out their thesis in IMT;
- **National**
  - **Network of fabrication facilities in the micro- and nanotechnology created by a few institutes;** this initiative of IMT was accepted by other three national institutes; the project of ROMNET-MINAFAB was put forward
  - Financial support from public funding
    - Direct, subsidies for a facility of national interest
    - Indirect, a support programme facilitating the access of SMEs to technological facilities
- **European, international**
  - Entering in a European network of facilities
  - Finding customers (a policy of collecting and disseminating information on various occasions; extending the area of interest)

Detailed description: http://www.imt.ro/MINAFAB

Thank you for your attention!