Equipments and Experimental Laboratories

About Experimental laboratories

On the next pages one may find information about the main equipments available in IMT. In some cases an equipment, or a group of equipments are located in a special room and they are managed by a certain RTD laboratory, part of the organizational structure. In such a case we are speaking about an "experimental laboratory". The person in charge is usually a researcher, with his/her own research interest and motivation. However, apart from the usual cooperation between labs, the "experimental laboratories" should be accessible (directly or indirectly) to any researcher from IMT. Moreover, the "services" provided by these "experimental labs" should be also available outside IMT. A typical situation is that of experimental labs created by some research laboratories in the characterization area (class 100,000), which has a special support infrastructure for providing demanding operating conditions of delicate equipments. All looks like a "joint venture" of individual research laboratories in an special area provided by the institute.

Another important concept is that of an interdisciplinary group working as a "research centre", due to interactions of two or more research labs. The MIMOMES Centre of Excellence financed by EU provides such an example: it is the result of combined activities of RF MEMS and Photonics laboratories, respectively. The second case corresponds to the so-called "Centre for nanotechnologies", grouping other laboratories. This centre, also mentioned below, is functioning "under the aegis" of the Romanian Academy (this is a "purely scientific" interaction, without administrative or financial consequences).

A. Experimental laboratories in the characterization area (class 10,000 to 100,000).

Centre of Nanotechnologies an interdisciplinary group, involving a few RTD laboratories, was developed as follows:

Monica Simion (monica.simion@imt.ro) working on the Micro Plotter to prepare a protein C reactive microarray slide

Laboratory of nanotechnology (L1) with the following experimental laboratories:

Experimental laboratory for "Microarrays", or NanoBioLab

- Microarray Scanner, GeneTAC UC4 (GenomicSolutionsLtd., UK) used for reading the chips, DNA detecting and deposition.

Technical specifications: The system has two-color lasers - green (532nm) and red (635nm)-coupled with high performance optics optimized to maximize collection of fluorescence signal while minimizing the damage caused by photobleaching. Resolution: from 1μm/pixel; Resolution for a standard microscope slide: 5μm/pixel. Includes also a workstation with powerful software that automates the identification and quantification of microarray data.

- Micro Plotter - GeneMachines OmniGrid Micro (Genomic Solutions Ltd., UK): designed for producing DNA or protein microarrays on slides.

Technical specifications: x/y resolution: 1 1μm; available pins: 50, 100, 200μm; humidity control during processing; flexibility in array configuration;

Applications *Protein Arrays:* - study tens of thousands of proteins in as short a time as possible; - producing high density protein arrays on specialized slides; - automated hybridization and imaging of cDNA and oligonucleotides now allow the consistent high throughput study of antibody/antigen interactions;

Protein Assays: immuno-assays, protein-protein interaction assays, enzyme assays;

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Experimental laboratory for surface spectroscopy, with:

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

Technical specifications: The PARSTAT 2273 consists of (i) hardware capable of ± 10 V scan ranges, 2 A current capability (1.2 fA current resolution), 100 V compliance, >1013 Ω input impedance, <5 pF of capacitance and 10μHz to 1 MHz built in analyzer for impedance measurements; (ii) Electrochemistry PowerSuite software required for data analysis and ZSimpWin - EIS modeling software package.

Applications: *microelectronics* – development of new processes and materials with improved electrical properties; *energy* – development of new fuel cell devices as clean energy sources; *sensors area* - development of electrochemical immunosensor devices for food, pharmaceutical chemistry and clinical diagnostics industry; *solar cells area* – development of new structures with improved parameters; *biomedical applications* - implant biocompatibility studies; *fundamental studies of physico-chemical phenomena at bio-hybrid interfaces*;

Mihaela Miu (mihaela.miu@imt.ro) investigating the electrocalalytic activity of the gold nanoparticle electrode array with SECM

- **Scanning electrochemical microscope** (SECM) (HEKA, Germany): HEKA ElProScan is an Electrochemical Probe Scanner for various investigations of electrochemical active surfaces.

Technical specifications: - The HEKA ElProScan is the only system which can perform measurements in an extremely wide current range up to 2 A. It also 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.

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Experimental laboratory for surface spectroscopy:
- **Autolab TWINGLE** - Dual Channel E-SPR (Metrohm Autolab, The Netherlands): Designed for high quality and high accuracy measurements, both electrochemical and surface plasmon resonance (SPR), the Autolab TWINGLE is a compact double channel instrument, having a reference channel option that can be used to correct for experimental errors and/or matrix effects.
Technical specifications: no. of channels: 2; fixed wavelength: 670 nm; sample volume: 20 - 150 µl; manual offset of SPR angle: 62° -78°; dynamic range: 4000 m°; angle resolution: ‹ 0.05 m°; baseline noise: 0.1 m°; minimum molecular weight: 180 Da; refractive index range: 1.26 - 1.38 (BK7 slider).
Applications: Biosensors (in combination with amperometry/impedance spectroscopy); conducting polymers; enzymes; membrane proteins; DNA - DNA interactions; protein - virus interactions; peptide - antibody interactions.

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Autolab TWINGLE - Dual Channel E-SPR

Experimental laboratory for X-Rays diffraction, with:
- **X-ray Thin film Diffraction System** (triple axis rotating anode) - SmartLab -9kW rotating anode, in-plane arm (Rigaku Corporation, Japan).
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).
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/ crystall, trace, small area/quantity);

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Mihai Danila (Mihai.danila@imt.ro) introducing in the sample in the XRD for investigation the Pt nanocystallite orientation and size

Experimental laboratory for nanoparticles, with:
- **DelsaNano Zeta Potential and Submicron Particle Size Analyzer** - Allegra X-22 (The Beckman Coulter, USA): Is a new generation of instruments that use photon correlation spectroscopy (PCS), which determines particle size by measuring the rate of fluctuations in laser light intensity scattered by particles as they diffuse through a fluid, for size analysis measurements and/or electrophoretic light scattering (ELS), which determines electrophoretic movement of charged particles under an applied electric field from the Doppler shift of scattered light, for zeta potential determination.
Technical specifications: High sensitivity size and zeta potential measurement for particles from 6 Angstrom to 7 micron in suspension with concentration ranging from 0.001% to 40%. Zeta potential measurement of solid surface or film Range: -100mV - +100 mV. Fully automatic pH or additive titration for both size and zeta potential.
Measurement Temperature Range: 10° C - 90° C, Environmental Operating Specifications: Temperature: 10° C - 40° C Humidity: 0 - 90% w/o condensation, Light Source: Laser diode, 658 nm, 30 mW, Scattering Angle: 15°, 30°, 160.
Applications: Preparation of colloidal dispersions: of nanoparticle Au, Pt, Ag, Fe, $Fe_2O_3/Fe_3/O_4$; SiO_2, TiO_2, SnO_2 or of core-shell systems, functionalized or non-functionalized; capillary phenomena which are important in the wetting of powders; coating of surfaces; absorption of impurities; Biomedical/Pharmaceutical: Proteins, lipids, polysaccharides, bacteria, blood cells, viruses, colloids drug carrier systems, drugs in aqueous suspension, micelles for biomaterials

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- Fluorescence spectrometer - FLS920P (Edinburgh Instruments, UK)
Technical specifications: The steady state mode uses single photon counting whilst lifetime measurements are based on Time Correlated Single Photon Counting: the technique widely accepted to be the method of choice for maximum sensitivity, dynamic range, accuracy and precision. 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 1 second integration time and 5nm spectral bandwidth.
Characteristics: Lifetime ranges 10ps-10 s; UV-Vis-NIR spectral range; Single Photon Counting sensitivity
Applications: - Biomedical field: study of enzymes, dynamics and structure of nucleic acids, protein folding and DNA sequencing, use a-priori fluorescence lifetime knowledge of the fluorescent probe to characterise various systems.
- 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.
-Pharmaceutical sector: for monitoring drug interactions by studying the energy transfer mechanisms using fluorescence lifetimes as the indicator.


Adina Bragaru (Adina.bragaru@imt.ro) working for nanoparticle centrifugation and characterization

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- Centrifuge - Allegra X-22 (Beckman Coulter);
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Laboratory for nanoscale structuring and characterization (L6), created the following experimental labs:

Experimental laboratory for Electron Beam Lithography (EBL)/Scanning Electron Microscopy Laboratory (SEM)/Energy Dispersive X-ray Spectroscopy (EDX) - NANOSCALE-LAB;

- Scanning Electron Microscope SEM - Vega II LMU and Pattern Generator - PG Elphy Plus (TESCAN s.r.o, Czech Republic and RAITH GmbH, Germany); - A Nanolithography Equipment composed of a SEM/EDX and EBL pattern generator which can investigate different samples at nm range (SEM resolution 3 nm, smallest geometry line in the range of 30-50 nm) is used for different sample investigations, EDX analysis, direct writing in PMMA of nanometric configurations and for students training in microscopy and nanolitography.

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Experimental laboratory for E-line Nano Engineering Work Station;

- Electron beam lithography and nanoengineering workstation - E_Line (RAITH GmbH, Germany). EBL - Direct writing Electron Beam nanoLithography is an ideal tool for nanotechnology research and a versatile equipment with specific requirements for interdisciplinary research: options for nanomanipulations; EBID-Electron Beam Induced Deposition;

Applications: • Nanolithography with less than 20 nm resolution; • 3D 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;

FEG-SEM - Nova NanoSEM 630

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Experimental laboratory for SEM/FEG (Field Emission Gun);

- **Field Emission Gun Scanning Electron Microscope/FEG-SEM-Nova NanoSEM 630 (FEI)**; The FEI Nova NanoSEM 630 is a high-quality nanoscale research tool for a variety of applications that include sample characterization, analysis, prototyping, and STEM 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).

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Experimental laboratory for Scanning Probe Microscopy and Nanomechanical Testing;

- **Scanning Probe Microscope** (NT-MDT Co., Russia)

It is a versatile research SPM enabling to perform a broad range of techniques (AFM, LFM, C-AFM, EFM, SKPM, STM etc.) in various environments (including low vacuum and controlled atmosphere) for investigating the properties of samples at or near the surface. Depending of the sample and technique, different properties could be characterized together with topography (relative variations of conductivity, stiffness, electric field gradient and distribution, surface potential etc.). The modular design, high resolution, large scan range (100x100x10 μm) and accuracy provided by closed loop sensors allow addressing a wide range of applications:

Examples: • High resolution surface morphology inspection; •3D metrology of surface features at nm scale (texture, roughness, grain and particle size analysis etc) • Evaluation and optimization of thin films • Advanced characterization of polymer materials • Investigations of failure mechanisms in semiconductor and data storage devices • Studies of biological and biocompatible materials etc.

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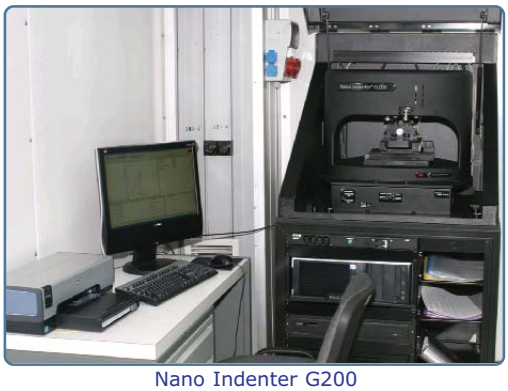
- **Nano Indenter G200, Agilent Instruments (former MTS Nano-Instruments)**: G200 is a nanomechanical characterization equipment operating by instrumented indentation and scratch testing. It provides access to various mechanical properties of small-volume samples, such as thin films, but could be equally applied to investigate bulk samples. It is equipped with CSM (Continuous Stiffness Mesurement) module for performing measurements in dynamic regime. Accuracy and repeatability of the measurements are guaranteed by implemented methods according to ISO 14577.

• maximum load : 500 mN; • load noise floor : 100 nN; • maximum indentation depth : 500 μm; • displacement noise floor: 1 nm; • position accuracy: 1 μm

Applications: Studies of mechanical properties of materials on small scales or near surfaces with high spatial resolution (hardness, elastic modulus, nano-scratch critical loads, stress-strain data). The provided information could be used for developing and/or optimizing application specific materials and processes or as input data for running simulations of the material behavior by finite-element analysis.



Nano Indenter G200

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