17th World Micromachine Summit
26th -28th April 2011, Ras Al Khaimah

Romania: *Country Report*

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National Institute for R&D in Microtechnologies (IMT-Bucharest)

Outline

- Introduction: Recent developments in Romania
- Towards a strategy in nanotechnology
  - Evaluation and recommendations
- Correlation with European Technology Platforms:
  - Nanoelectronics
  - Nanomedicine
- New scientific results
- New research infrastructures
  - National Institute for R&D in Microtechnologies
  - Other National R&D Institutes

Recent developments in Romania

- Impact of the economic crisis
  - Substantial decrease of the public funding (recovery since 2011)
- Reinforcing quality of evaluation in national R&D programs
  - External evaluators
- Prospective studies to define priorities
  - One of them is devoted to nanotechnologies
- Structural funding for competitiveness (investments in new infrastructures, financing private sector etc.) and human resources

Nanotechnology in Romania: a prospective study *(NANOPROSPECT)*

Definition accepted for Nanotechnology (NT). NT assures the creation and use of materials, devices and systems by controlling the matter at nanometric scale, namely at the level of atoms, molecules and supramolecular structures. The essence of NT consists in the ability to work at these levels in order to generate bigger structures with a fundamentally new molecular organization.

Nanotechnology includes *convergent technologies* (micro-nano-bio-info) if they are related to phenomena and structured at “nano” scale, for example technologies like nanoelectronics or nanobiotechnologies, which suffered profound changes by structuring at “nano” scale.

Nanotechnology in Romania: a prospective study *(NANOPROSPECT)*

- project financed by the National Authority for Scientific Research in Romania (2010-2011)
- coordinated by IMT-Bucharest (with a consortium of other 10 other institutes and universities)

Objectives:

The project analyses the Romanian potential for applications, as well as for international cooperation, putting forward a *national strategy for nanotechnology, in correlation with the EU strategy.*

This strategy, apart from the priority research directions, will suggest measures to accelerate innovation, industrialization of results in RD, full use of experimental facilities, formation of interdisciplinary competencies etc. A key aspect is the responsible development of NT, i.e. EHS (environment, health, safety).

► Extensive electronic databases with free access and advanced search mechanism, presenting Romanian institutions active in nanotechnology domain

NANOPROSPECT databases
- Search form -

Keywords ☐ thick this box to search for the exact expresion entered above

☐ Organizations
☐ Groups active in nanotechnologies
☐ Specialists active in nanotechnologies
☐ Infrastructures
☐ Partnerships
☐ Equipments
☐ Projects (relevant for nanotechnologies)
☐ Published patents relevant to nanotechnologies
☐ Scientific papers related to nanotechnology published in periodicals (journals)
☐ Products
☐ Technologies
☐ Courses related to nanotechnologies
☐ Books related to nanotechnologies

Search

http://www.imt.ro/NANOPROSPECT/databases-search

NANOPROSPECT involves researches from *Romanian diaspora*, including Dr. Mihail C. Roco, senior adviser for nanotechnology, National Science Foundation, USA, architect of National Nanotechnology Initiative (US, January 2000).

Dr. Roco was an invited guest at the Symposium "*Perspectives of nanotechnology in 2020 and the Romanian researchers in this area*", organized in Bucharest on 19th of January 2011.

Mihail Roco received "Doctor Honoris Causa" degree from University "Politehnica" of Bucharest and visited research laboratories at this university and also at IMT-Bucharest, National Institute of Materials Physics, National Institute for Laser, Plasma and Radiation Physics. He also participated to meetings at local subsidiaries of foreign companies with activities related to the nanotechnology domain.

Mihail Roco visiting the technological area at IMT-Bucharest

Preliminary recommendations related to a possible national strategy – Excerpts 1-

Progress in nanotechnology at national but lack of strategy

- numerous projects and important acquisitions for performing equipment were financed, *but*:

- the lack of a plan that would concentrate the research for specific domains in which there is a critical mass and an interest from economy and society is acutely sensed.

- the lack of a strategy that would cover all the important aspects for the development of Nanotechnologies at National level is also sensed.

Human Resources. Education

- a difficult problem, specific to the present situation in Romania, is the limited involvement from the Universities in the R&D activities and in the interaction with the industry. The reform promoted by the new Law of National Education should facilitate the adjustment of the Romanian Universities to world level of exigency.

Prospect domains

- A selection for the domains in which there is an active, multidisciplinary community is necessary and an innovative ecosystem can be created, based on a critical mass and on competitive advantages.
- In order to select these domains one must take into consideration the interests of large companies activating in Romania, as well as the state policy for national development.

Preliminary recommendations related to a possible national strategy – Excerpts 2 -

Infrastructure

- Since providing complete experimental facilities is expensive and integrating human resources takes time, the most efficient way to benefit from material database is to form experimental facilities networks, facilities which are working in close connection with "competence centers"
- The "networks of facilities" should provide scientific and technological services, as well as direct access – as much as possible – to the infrastructure of the interdisciplinary research teams, Ph.D. students and innovative companies.

Interaction with industry

- R&D interaction with industry in nanotechnologies becomes really attractive through the interest shown by large companies, and also through creating clusters of companies that are interested in the applications for a certain domain. There can also be established *scientific and technological platforms* at the national level, including R&D institutions and companies. These platforms could be similar to the European technological platforms, but they must be more focused on certain technologies and "niches" in the application domains: this focalization is absolutely necessary for obtaining results (a large profile would only lead to the fragmentation of the activities, discrediting in fact the advantages of the "platform")
- In absence of a critical mass for the interaction with the industry, the "small-steps method" should not be overlooked; for example: cooperation with companies from abroad, or creating "spin-offs".

• Areas of interest in national projects

Projects on "Nanoelectronics, photonics and integrated nanosystems" (starting 2007)

Nanoelectronics

• Experimenting new materials and technologies for nanostructures and integrated circuits at nano scale
• Experimenting new systems architectures for nanoelectronics
• Experimenting new concepts (principles) of nanoelectronic devices
• Transparent electronics

Photonics

• New photonic materials (artificial materials: photonic crystals, negative refraction index materials etc.)
• New photonic technologies and photonic biosensors for non-intrusive systems of in vivo diagnosis and treatment
• Photonic technologies for advanced manufacturing processes at micro and nano level and for process and quality control

Micro- and nano-systems

• Developing components and Microsystems for communication systems; reconfigurable and flexible intelligent Microsystems
• Microfluidic technologies, micro /nanobiosensors, laboratories in one chip, "microarrayas", micro – and nanostructures and micro- and nanosystems for medical diagnosis and treatment (including nanomedicine)
• Microsensors and actuators (including 3D)
• Technologies for heterogeneous integration and 3D assembly/encapsulation for allowing the realization of complex systems on one chip
• Convergent technologies: micro-nano-bio-info

Projects on "Advanced materials" (starting 2007)

• Advanced materials for generating, transporting and using energy
• Materials protecting the environment in processes connected to their production and use
• Advanced materials for modern transportation means
• Advanced materials and biomaterials for increasing the quality of life
• Advanced materials for niche sectors of the economy

• Areas of interest in international projects

Research areas of EU FP7 projects with Romanian participation:

- **Information & communication technologies (ICT)**

ICT-2007.3.6 Micro/nanosystems; ICT-2007.8.1 Nano-scale ICT devices and systems

- **Nanosciences, nanotechnologies, materials & new production technologies (NMP)**

NMP-2007-1.1-1 Nano-scale mechanisms of bio/non-bio interactions 2; NMP-2007-1.1-2 Self-assembling and self-organisation; NMP-2007-1.3-5 Coordination in studying the environmental, safety and health impact of engineered nanoparticles and nanotechnology based materials and products; NMP-2007-2.1-1 Nanostructured polymer-matrix composites 3; NMP-2007-2.1-2 Nanostructured coatings and thin films; NMP-2007-2.1-3 Characterisation of nanostructured materials 2; NMP-2007-2.2-2 Nanostructured materials with tailored magnetic properties 2; NMP-2007-2.3-1 - Highly porous bioactive scaffolds favouring angiogenesis for tissue engineering 2; NMP-2007-3.1-3 - Integrated Risk Management in Industrial Systems

NMP-2008-1.1-1 Converging sciences and technologies (nano, bio, info and/or cogni); NMP-2008-1.1-3 Examining capacity building in nano-bio-technology; NMP-2008-1.2-1 - Pilot lines to introduce nanotechnology-based processes into the value chain of existing industries 2; NMP-2008-4.0-13 ERA-NET on nanomedicine; NMP-2008-4.0-3 Nano-technology enabled applications for integrated, cost-effective volume production; NMP-2009-1.3-1 Activities towards the development of appropriate solutions for the use, recycling and final treatment of nanotechnology-based products

- **Energy**
- **Knowledge-Based Bio-Economy (KBBE)**
- **PEOPLE-2007-1-1-ITN Marie Curie Action: "Networks for Initial Training"**
- **REGPOT-2007 Micro/nanosystems**
- **SME-1 Research for SMEs**

Participation to the European Technology Platform for Nanomedicine

Romanian institutions members of the **European Technology Platform for Nanomedicine (ETP):**

- National Institute for R&D in Microtechnologies – *mirror group Romania*
- National Institute of R&D for Non-ferrous and Rare Metals , Bucharest
- Institute of Physical Chemistry of the Romanian Academy, Bucharest

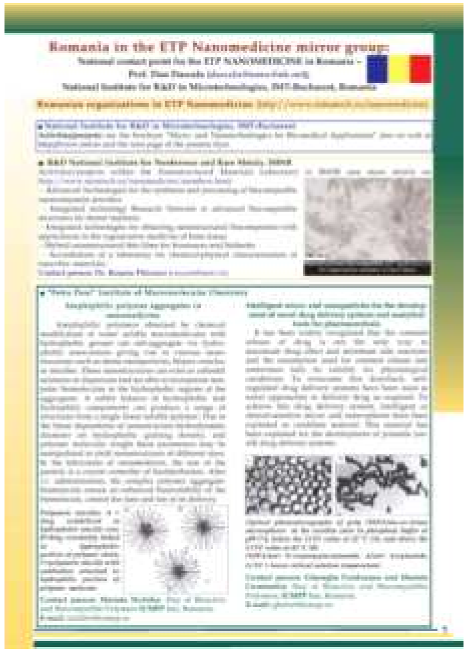
Other institutes with expertise and activities in nanomedicine:

- “Victor Babes” National Institute for Pathology and Biomedical Sciences, Bucharest
- Institute for macromolecular chemistry “Petru Poni”, Iasi
- National Institute of R&D for Technical Physics , Iasi

Activities :

- participation of Romanian entities to the Conferences organised by Nanomedicine, General Assembly meetings and meetigs of the ETP working groups

- presenting the collaboration offers of Romanian research groups with the aim to increase visibility and attract partners interested in cooperation in nanomedicine



- **Participation to EuroNanoMed ERA-NET calls for proposals**
  - **1 project coordinated by the Institute of Cellular Biology and Pathology of the Romanian Academy (Call 2010)**

Interest in Nanoelectronics

19 Romanian organizations indicated nanoelectronics as a domain where they have significant results or potential for future development (*NANOPROSPECT survey, Dec. 2010*): 10 research institutes, 3 companies and 6 universities.

There are **34 recent projects** devoted to nanoelectronics (12 international and 22 at national level).

The main thematic areas are new and have a high impact in nanoelectronics: carbon nanotubes based nanoelectronic circuits, GaN for improved communications or environment monitoring, nanomagnets, nanowires, etc. The most important resources in terms of specialists and equipments are located in research institutes.

Partnerships are developed with research laboratories across Europe – example: European Associated Laboratory "Smart MEMS/NEMS for Advanced Communication and Sensing – Smart MEMS" including IMT-Bucharest RF MEMS LAB (Romania); FORTH, Heraklion (Greece); LAAS-CNRS, Toulouse (France)

Participation to the European Technology Platform for Nanoelectronics

Romania in ENIAC Joint Undertaking (JU)

eniac JOINT UNDERTAKING

'A public - private partnership on nanoelectronics research, development and innovation, strengthening European competitiveness and sustainability'

- Infineon Technologies Romania - 1 project ("MOTOR BRAIN"   - common project with IMT-Bucharest)

- IMT-Bucharest - 4 ongoing projects:

• "Nanoelectronics for Safe, Fuel Efficient and Environment Friendly Automotive Solution - SE2A"; Coordinator: NXP Semiconductors Netherlands BV (call ENIAC 2008-1)

• "Micro and Nano Technologies based on wide band gap materials for future transmitting receiving and sensing systems – MERCURE"; Coordinator: Thales Research and Technology, France (call ENIAC 2009)

• "Reconfigurable Microsystem Based on Wide Band Gap Materials, Miniaturized and Nanostructured RF-MEMS – NANOCOM"; Coordinator: Thales Research and Technology, France (call ENIAC-2010-1)

• "Nanoelectronics for Electric Vehicle Intelligent Failsafe Drive Train - MOTOR BRAIN" (call ENIAC-2010)

Events - nanoelectronics

NanoElRei Summit: „NanoElectronics in Romania: Research-education-industry”, April 20, 2010, Bucharest

Organized at the initiative and with the participation of Dr. Andreas Wild, the Executive Director of ENIAC-JU

The event highlighted that Romania became a full member of ENIAC-JU, i.e. public funding is provided to Romanian participants in successful projects.

The purpose of the Summit was to underline the potential of Romania for nanoelectronics, as illustrated by the international companies with subsidiaries in this country and the academic institutions (universities and research institutes) attending the event.

2nd edition of the NanoElRei Summit - planned on May 31, 2011 in Bucharest

Partnership with Infineon Technologies in various activities

1 **ENIAC JU project -** partnership Infineon Technologies, Infineon Technologies Romania, IMT-Bucharest

Events organized in common with IMT-Bucharest

- NanoElRei Summit – 1st edition in April 2010, 2nd edition planned in May 2011

- **Workshop on Automotive Electronics** organized by Infineon Technologies at International Semiconductor Conference CAS 2010 (annual event; organizer: IMT-Bucharest)

- Meetings to discuss collaboration opportunities in research projects, together with Renault Technologie Roumanie and participation to an automotive cluster

- Infineon Technologies will coordinate the organization in Romania of the **ESSDERC/ESSCIRC Conference** in 2013 (the organizing committee is formed also by IMT-Bucharest, Univ. “Politehnica” of Bucharest and Technical University “Gh. Asachi” Iasi)

IMT-Bucharest: National Institute for R&D in Microtechnologies

- A new structure, since 1st of December 2010, focusing on:
  - Micro- and nanosystems (European Centre of Excellence);
  - Integration of micro-nano-biotechnologies;
  - Research in new materials (carbon-based, but not only);
- Accommodating a new generation of scientists, with people getting their Ph. D. abroad
  - A pool of postdoctoral studies
- Continuing the investments until 2013
  - Extending continuously the services provided by IMT-MINAFAB
- Extending cooperation with industry
  - In European consortia (especially within ENIAC-JU)
  - Partnerships with *Infineon Technologies Romania* and *Honeywell Romania*

IMT-Bucharest
Department for scientific and technological research

MIMOMEMS

- “Research Centre of Excellence” “Micro- and nanosystems for radiofrequency and photonics”

CNT-IMT

- “Centre of Nanotechnologies (affiliated to the Romanian Academy under the aegis of the Romanian Academy)”

CINTECH

- “Research centre for integration of technologies”

CENASIC

- “R&D centre for nanotechnologies and carbon–based nanomaterials”

Research Centre of Excellence
“Micro- and nanosystems for radiofrequency and photonics” MIMOMEMS

Micromachined structures, microwave circuits and devices Laboratory (L4)

- Scientific research and technological development of micromachined microwave and millimetre wave devices and circuits on silicon GaAs III Nitrides acoustic devices using micromachining and nano-processing of wide band gap semiconductors, experimental devices based on Carbon nanotubes and graphene ; education and training activites

Micro and Nano-Photonics Lab (L3)

- Research, education and training activity in the field of micro/nano-photonics and optical MEMS

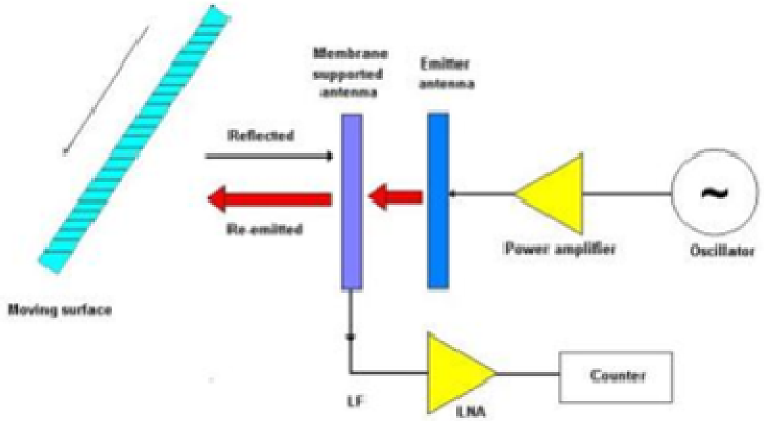
Micromachined structures, microwave circuits and devices Laboratory

Recent results in ENIAC projects

"Nanoelectronics for Safe, Fuel Efficient and Environment Friendly Automotive Solution - SE2A"

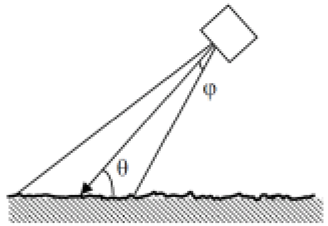
2009-2011; Coordinator: NXP Semiconductors Netherlands BV

Basic principle/proof of concept for the true speed sensor at 77 GHz



Narrow beam width is desirable for accurate detection

Doppler type ground speed sensors provide a better solution than sensors which measure the rotation speed of the wheels, that fail if the road is wet or covered with ice, or the surface is dirt. This solution is used in modern SUV cars.



f_0	microwave frequency
v	vehicle speed
c	speed of light
α	radiation angle

$$f_d = f_0 \cdot (2v/c) \cdot \cos\alpha$$

$$\frac{c}{2 f_0 \cos(\theta+\phi)} f_d \le v \le \frac{c}{2 f_0 \cos(\theta-\phi)} f_d$$

The proof of concept was done with horn type emitting antennas, membrane supported monolithic integrated direct (video-type) receiver modules based on GaAs micromachining for 77 GHz, designed and manufactured by IMT-Bucharest and FORTH Heraklion

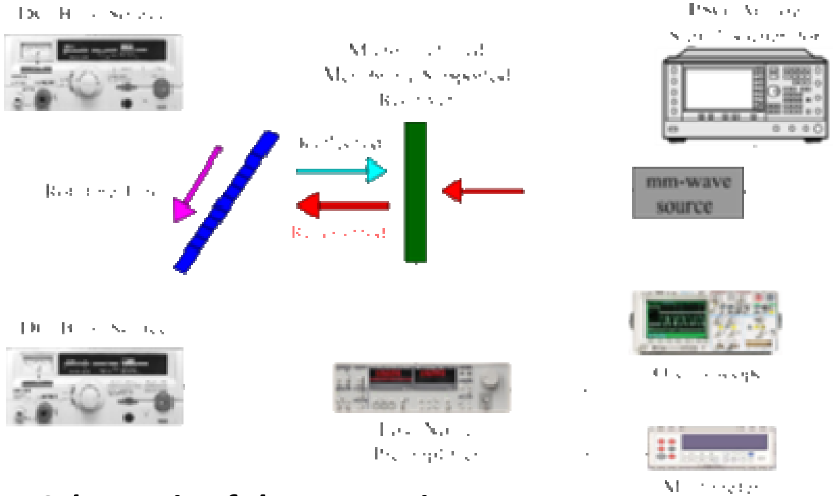
- **The signal generated by the synthesizer feeds the emitting horn antenna. The signal from generator was amplitude modulated).**
- **Via the two lobs of the membrane supported folded slot antenna the signal arrives to the moving surface. The reflected signal from the moving surface (slightly shifted in frequency due to Doppler effect arrives to the direct receiver and is mixed with the incident signal.**
- **The output signal is amplified and displayed on an oscilloscope. The displayed signal frequency is dependent on the speed of the moving object**

Contact person, IMT: Dr. Alexandru Muller, alexandru.muller@imt.ro

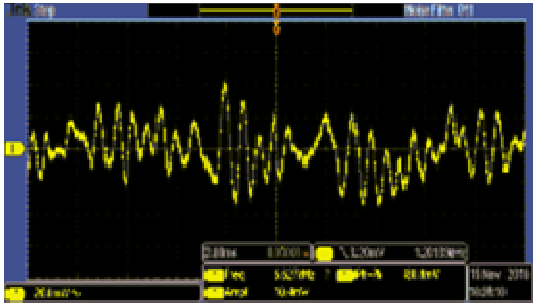
Ground speed sensor at 77 GHz (2)

The measuring set-up (detail)

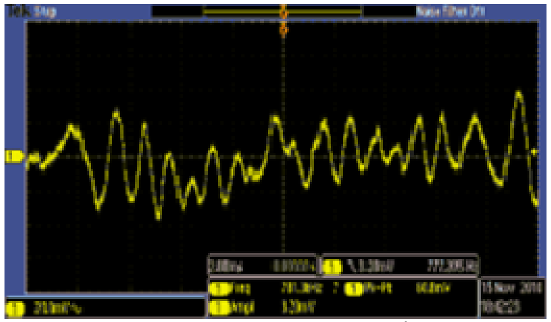
For the demonstration the moving surface was a fan



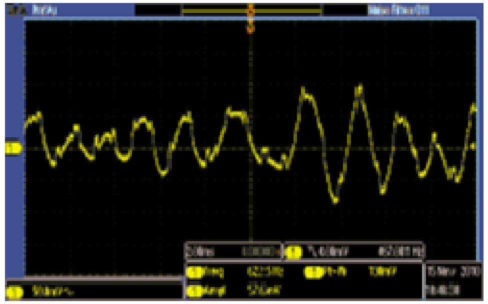
Schematic of the measuring setup



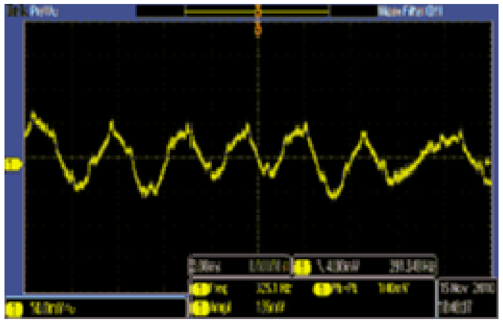
Frequency = 1120 Hz; Fan DC Bias = 12.3 V



Frequency = 780 Hz; Fan DC Bias = 7.8 V



Frequency = 465 Hz; Fan DC Bias = 3.9 V



Frequency = 282 Hz; Fan DC Bias = 2.7 V

The output signal displayed on the oscilloscope

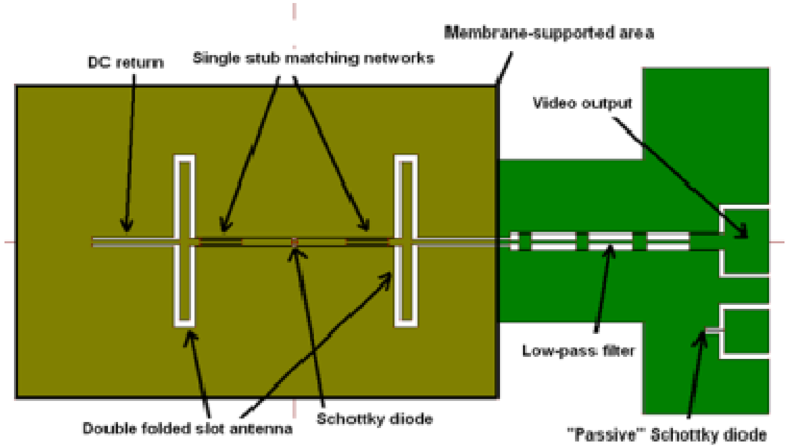
In the final stage an AlGaAs/GaAs HEMT transistor based oscillator will be manufactured to generate the 77 GHz signal

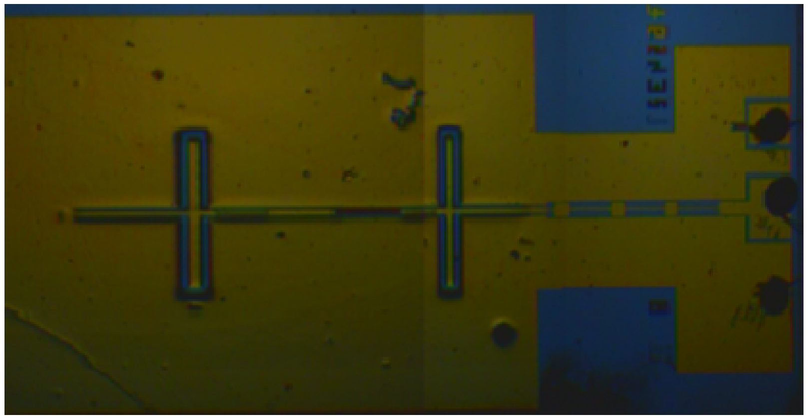
Ground speed sensor at 77 GHz (3)

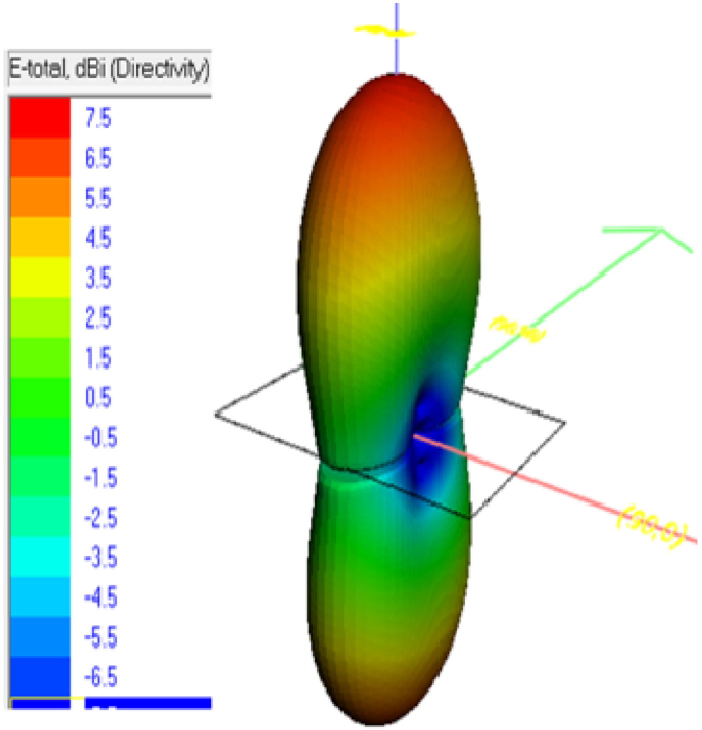
THE RECEIVER

GaAs membrane supported antenna integrated with Schottky diode

developed by IMT-Bucharest and FORTH – Heraklion partner in the project







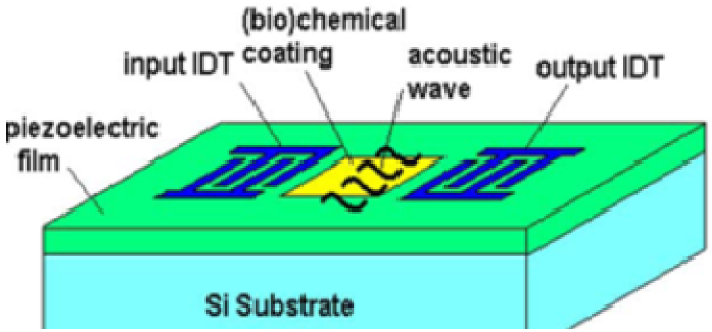
“Micro and Nano Technologies based on wide band gap materials for future transmitting receiving and sensing systems – MERCURE” *2010 -2012;*

Coordinator THALES Research & Technology (TRT)

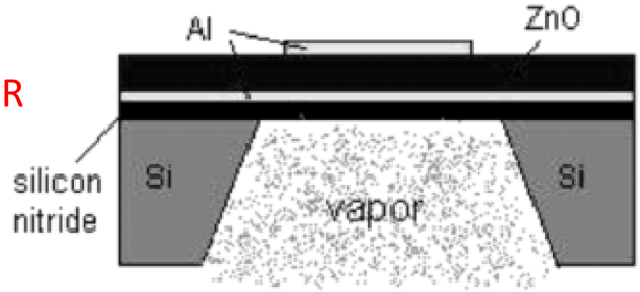
Gas sensors based on acoustic devices (SAW and FBAR) operating in the GHz frequency range

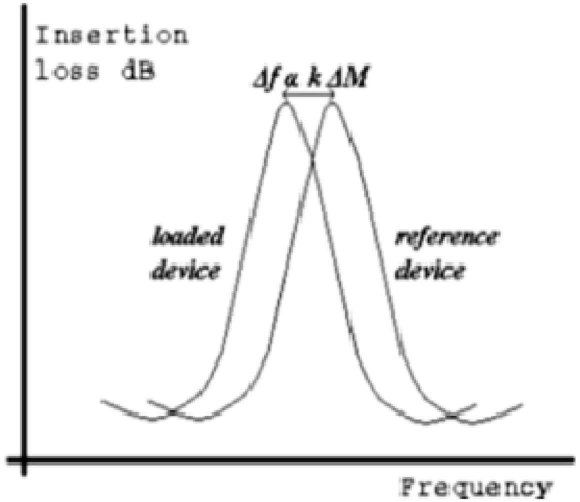
Sensor principle: Shifting of resonance frequency as function of adsorbed gas mass

SAW



FBAR



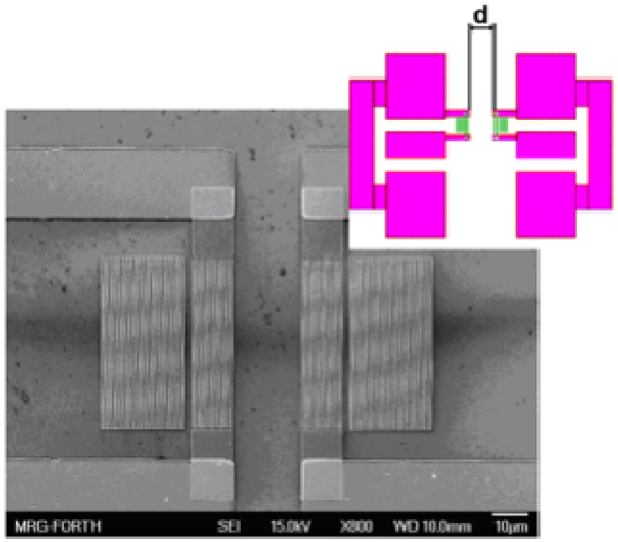


Mass sensitivity of the SAW/FBAR gas sensors is proportional with f^2

An as high as possible resonance frequency is desired!

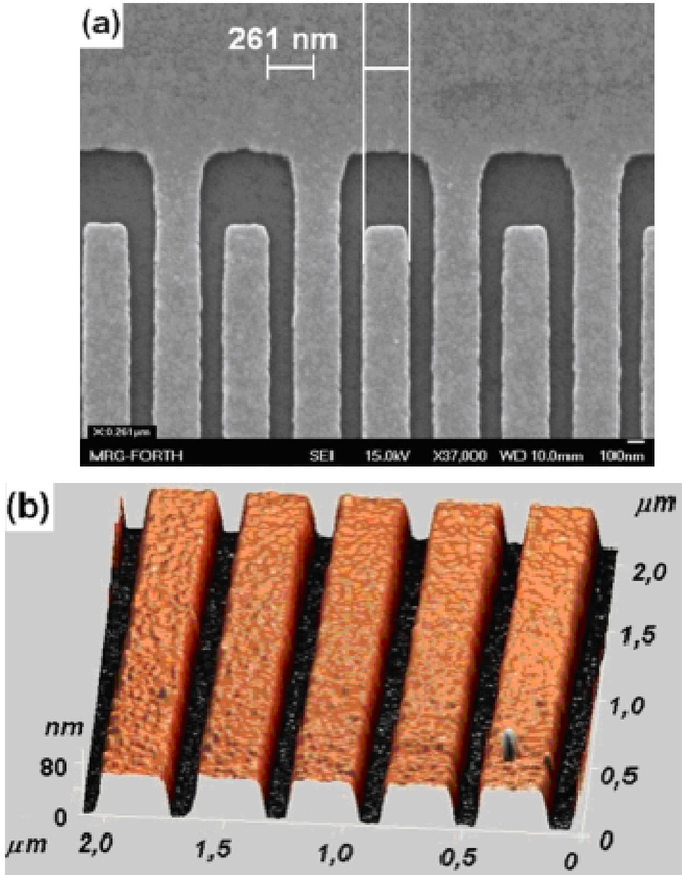
Contact person, IMT: Dr. Alexandru Muller, alexandru.muller@imt.ro

Resonators used: (a) SAW devices on GaN/Si for 5.6 GHz – last results IMT-FORTH (2010)



SEM photo of the test structure. The distance between the IDTs was d= 20 µm; for the other test structures it was d=100, 200 and 600 µm. The inset presents a schematic of an entire structure, including the connection pad

A. Muller, D Neculoiu, G. Konstantinidis, A. Dinescu, G. Deligeorgis, A. Stavrinidis, A. Cismaru, M. Dragoman and A. Stefanescu "SAW devices manufactured on GaN/Si for frequencies beyond 5 GHz," IEEE Electron Devices Lett. Vol. 31, No 12, Dec 2010, pp1398-1400.



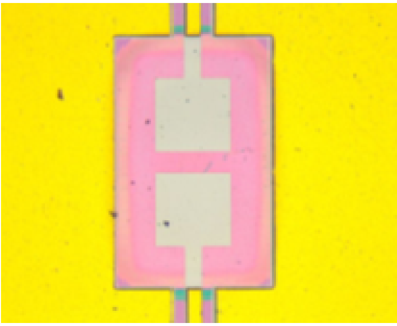
Detail of the nanolithogrphic process with fingers and intedigits nominally 200 nm wide developed on the GaN surface: a) SEM photo and b) AFM image

The highest resonance frequency reported up to now on GaN based SAW resonators

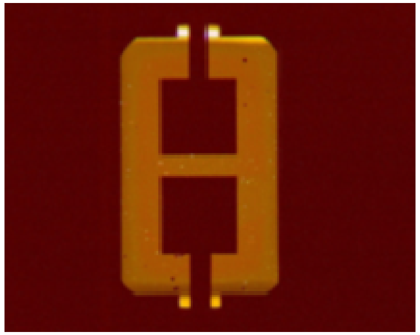
Resonators used: (b) 6.3 GHz Film Bulk Acoustic Resonator Structures Based on a Gallium Nitride/Silicon Thin Membrane

- 340 nm (GaN) + 200nm (buffer) thin membrane supported FBAR structure based on silicon micromachining
- 50nm thin Mo metallization

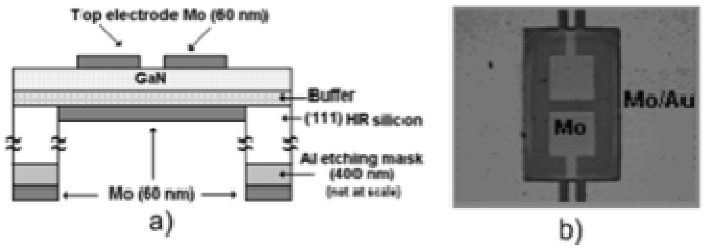
GaN/Si wafers from NTT AT Japan

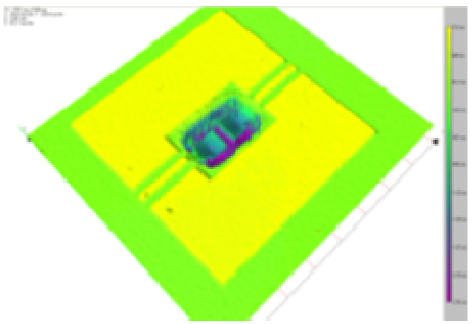


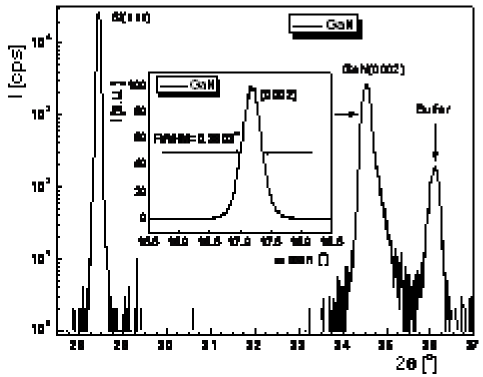
Top view with top illumination

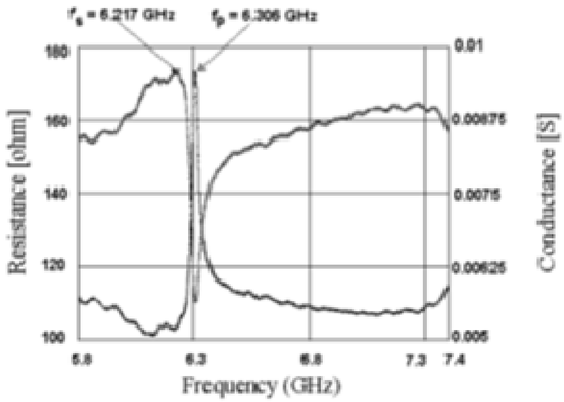


Top view with bottom illumination









A. Müller, D. Neculoiu, G. Konstantinidis et al. "6.3 GHz Film Bulk Acoustic Resonator Structures Based on a Gallium Nitride/Silicon Thin Membrane" Electron Devices Letters, vol 30, no 8, August 2009, pp 799-801

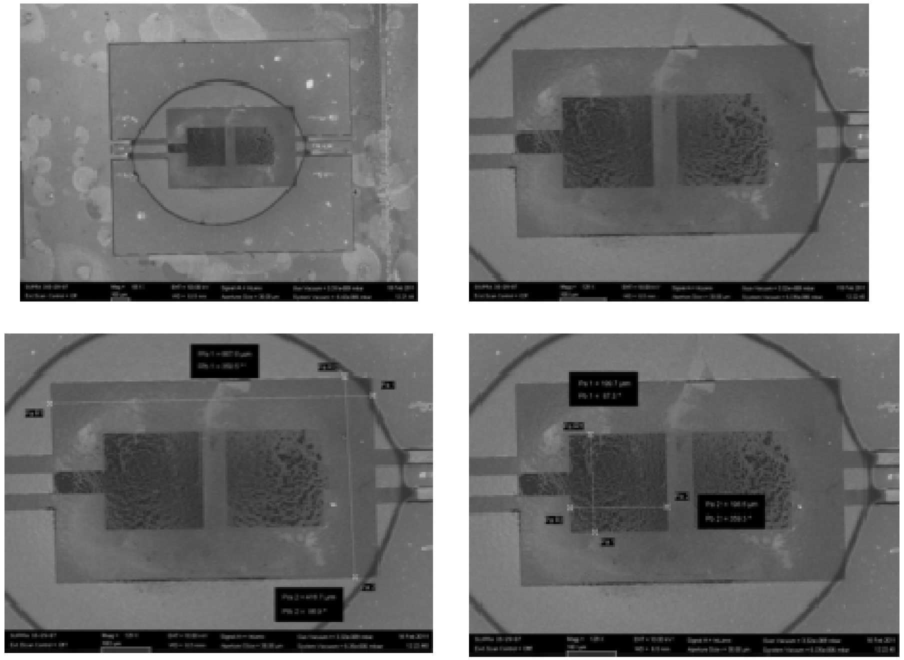
The highest resonance frequency reported up to now on GaN based FBAR resonators

IMT- FORTH 2009

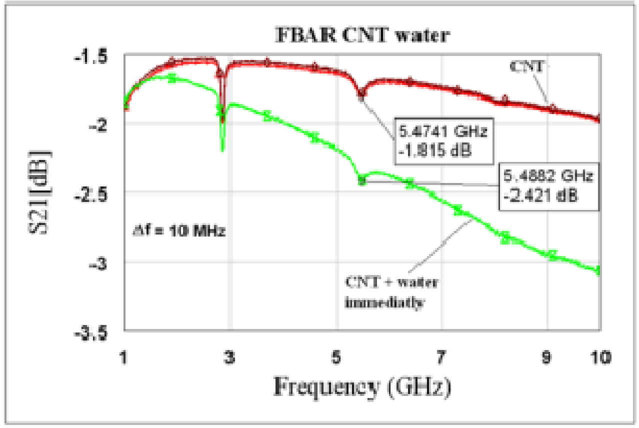
niac

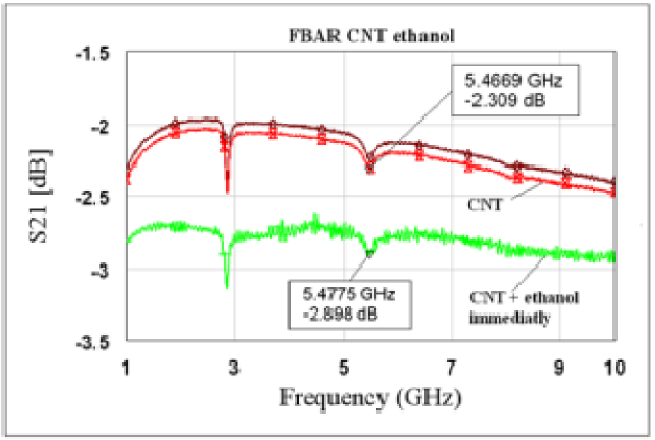
First results

Qualitative determination of Ethanol and water sensing based on a GHz FBAR structure using Carbon nanotubes as coating layer



The FBAR structure was covered with CNTs as a coating layer with adsorbant properties for water and ethanol



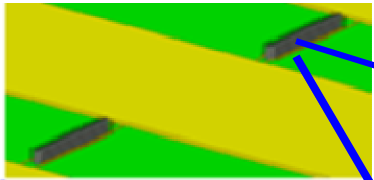


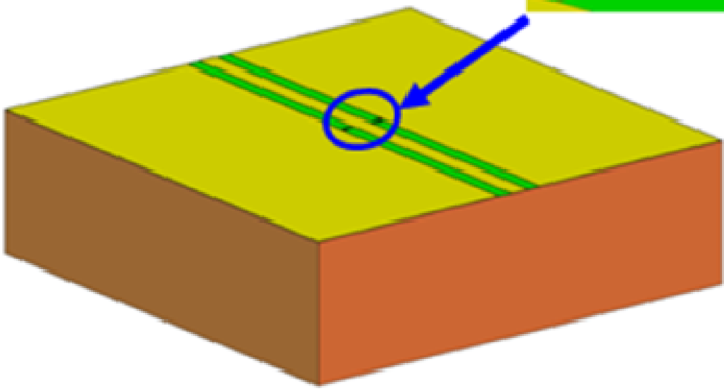
A shift of about 10 MHz in the resonance frequency after water (up) and ethanol (down) is pulverized on the structure

Setups for precise quantitative determinations of the sensitivity will be developed for the next stage. Also other selective coating layers will be developed.

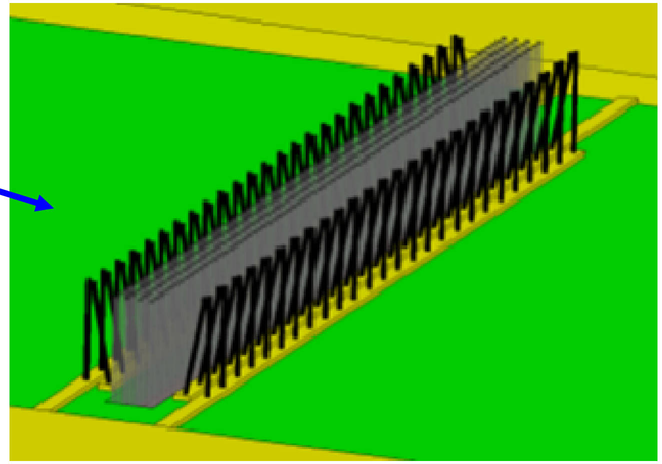
Design of a RF NEMS switch based on carbon nanotubes

Modeling of RF NEMS switch based CNT has been done with IE3D from Zeland

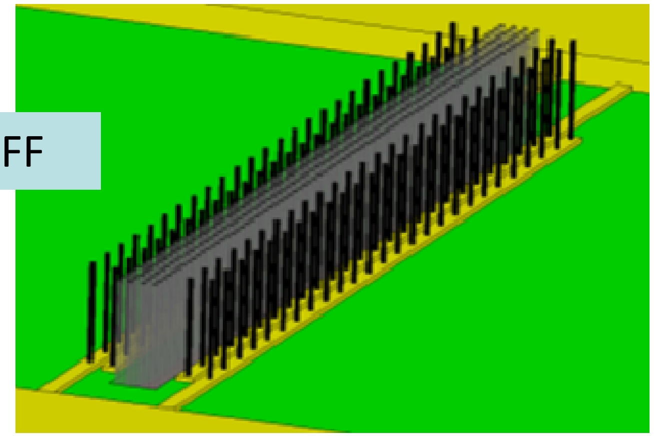




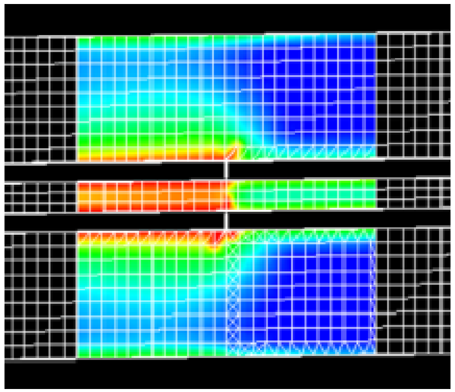
ON



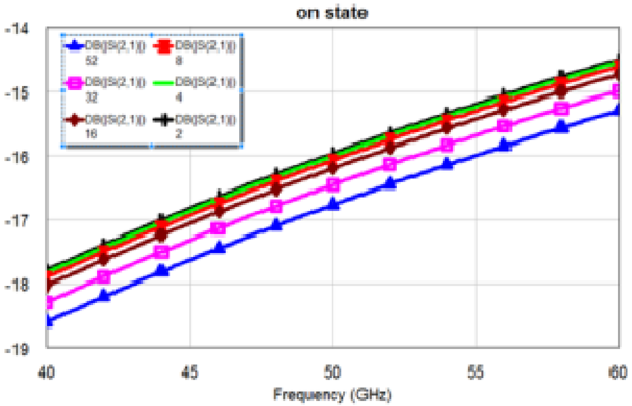
OFF



52 +52 CNT tweezers-
ON STATE



Current distribution in the "on" state



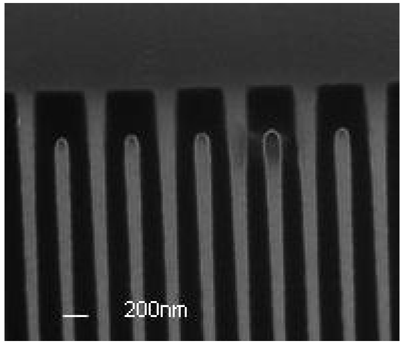
Simulated values for S21 in the "on state" for different numbers of CNTs

RF NEMS switch based on CNTs is obtained by CPW lines. The central line is connected to the ground by 52 + 52 CNT tweezers

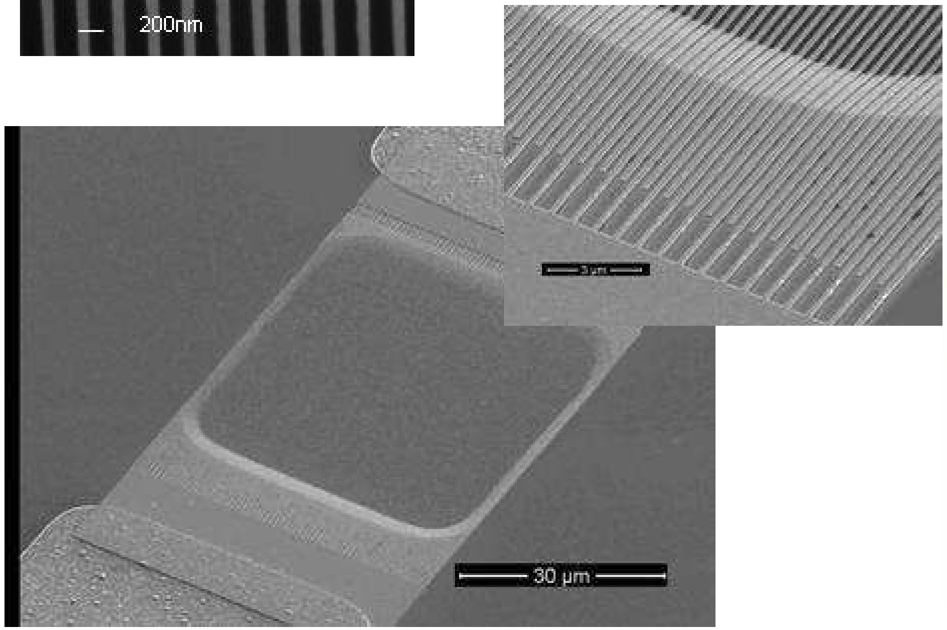
niac

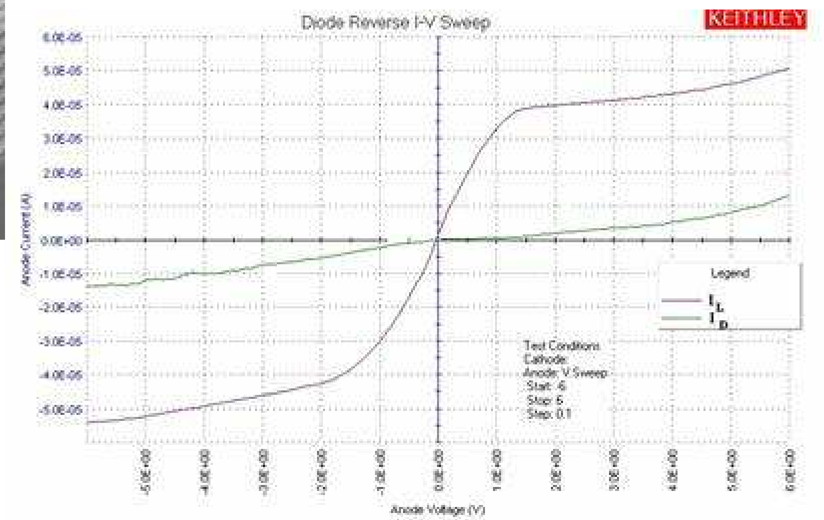
Micro and Nano-Photonics Laboratory

MSM photodetector based on subwavelength interdigitated electrodes



- **interdigitated Schottky contacts with fingers spacing of 80, 100, 200 nm, finger width of 80 nm , finger length of 100 µm.**
- **optically active area: 0.01 mm^2**
- efficient and ultrafast photodetection compared with conventional MSM device
- transit time < 5 ps $\Rightarrow$ 100 GHz bandwidth
- capacitance < 2 pF





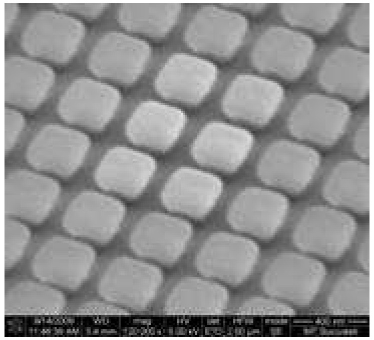
I-V characteristics in dark and under illumination

SEM images

Contact person: Phys. Elena Budianu (elena.budianu@imt.ro)

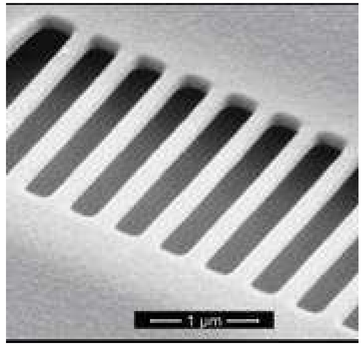
μ- and n-optics

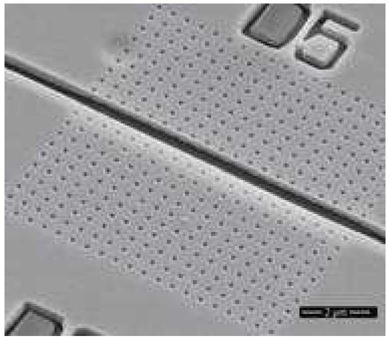
Structures obtained by 3D Electron Beam Lithography in multi-layer resists

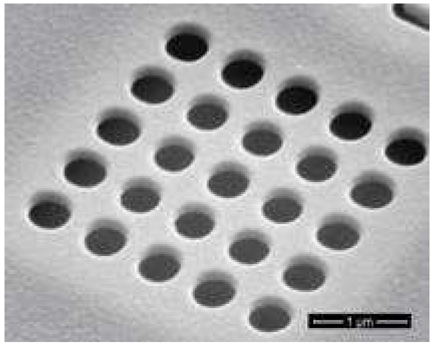


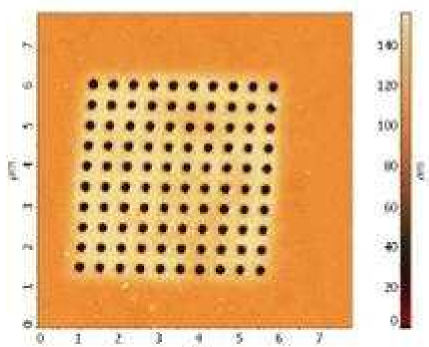
T shape structures in *PMMA950K/PMMA495K*

Suspended waveguides obtained using *PMMA 950K/LOR*









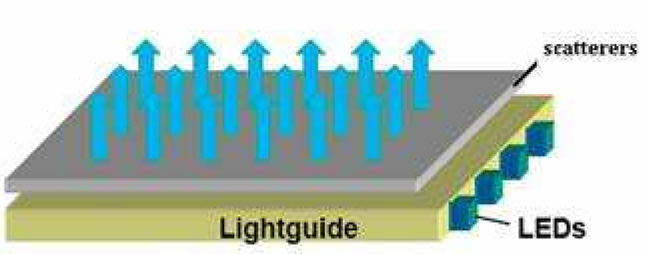
PMMA photonic crystals obtained using the system *PMMA 950K/LOR* (SEM and AFM images)

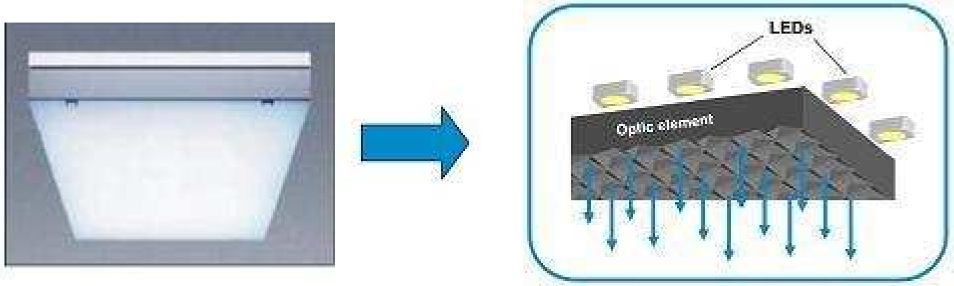
Contact persons: Dr. Paula Obreja, Dr. Dana Cristea (paula.obreja@imt.ro; dana.cristea@imt.ro)

FP7 project (IP-priority NMP)- Flexible Patterning of Complex Micro Structures using Adaptive Embossing Technology FLEXPAET

Aim: Development of an innovative process chain for high volume production of large-area micro structured surfaces

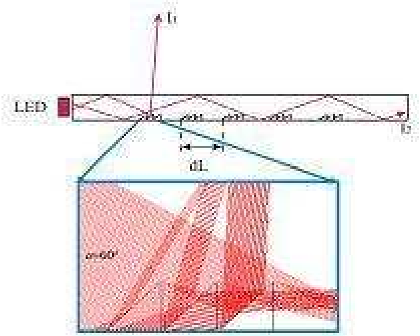
Applications

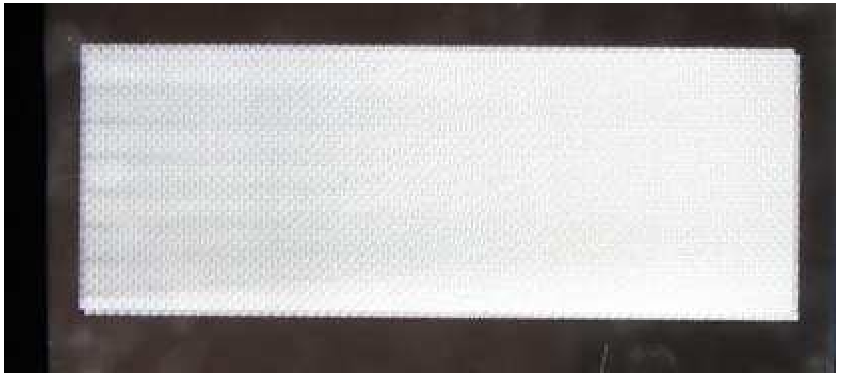




- **backlight technology**
- **light ceiling**

Optimized embossing- results

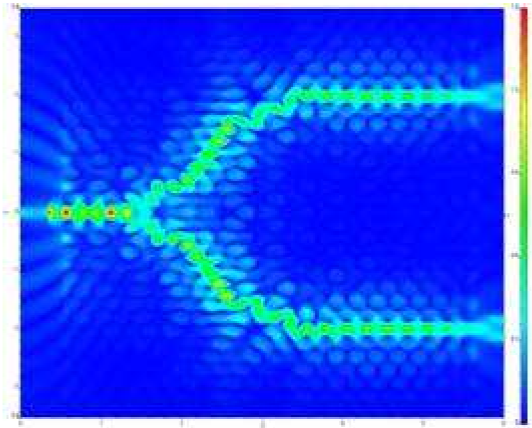




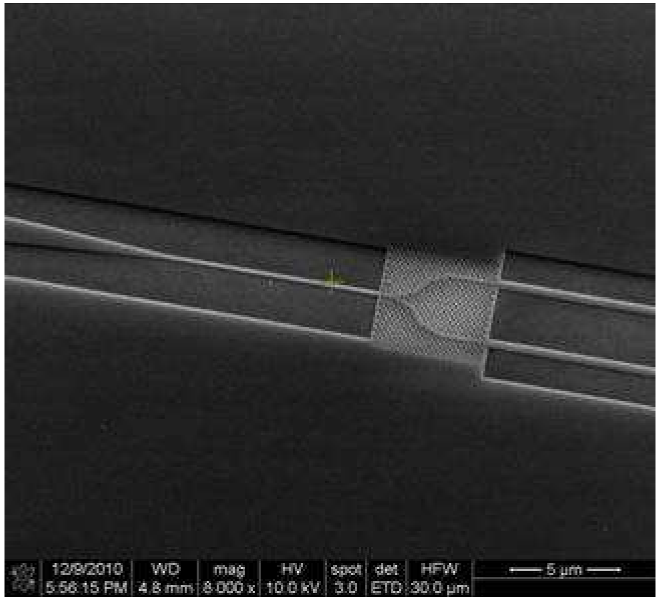
Embossed test slide 90mm x 250mm backlight

Contact person: Dr. Dana Cristea (dana.cristea@imt.ro)

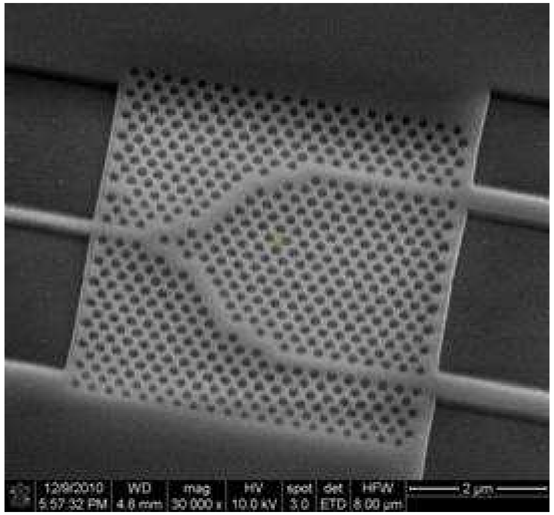
Photonic crystals (PCs) devices, obtained in Si_3N_4 using EBL nanolitography



FDTD Simulation **of the electro-magnetic radiation propagation (λ= 635 nm) in an optical waveguide divisor, obtained in Si_3N_4 photonic crystals**



Contact person: Dr. Mihai Kusko (mihai.kusko@imt.ro)



Experimental PCs optical waveguide divisor configuration integrtated with an optical waveguide, using EBL nanolithography

Contact persons: Dr. Raluca Muller, Dr. Adrian Dinescu (raluca.muller@imt.ro; adrian.dinescu@imt.ro)

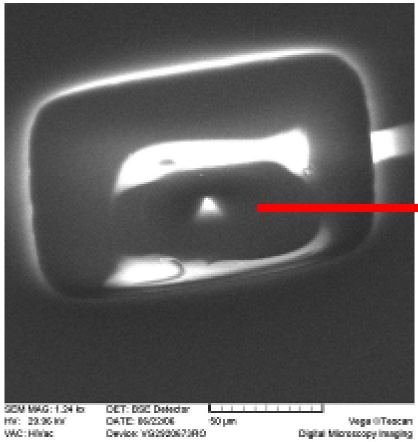
Centre of Nanotechnologies (CNT-IMT)
Coordinator: Prof. Dan Dascalu

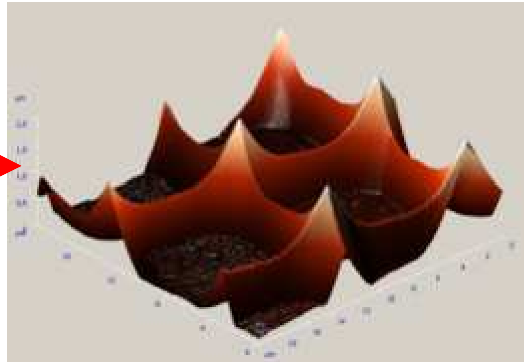
- **Laboratory of nanobiotechnologies (L1)**
  - Acting laboratory head: Dr. Mihaela Miu (mihaela.miu@imt.ro)
- **Laboratory for characterization and structuring at the "nano" scale** (L6)
  - Laboratory head: Dr. Adrian Dinescu (adrian,dinescu@imt.ro)
- **Laboratory of molecular nanobiotechnology** (L9)
  - Laboratory head: Dr. Radu Popa (radu.popa@imt.ro)

Laboratory of Nanobiotechnologies

Biochips for biological materials investigation

Design and fabrication of (opto)electrochemical biosensor platform/laboratory on a chip systems

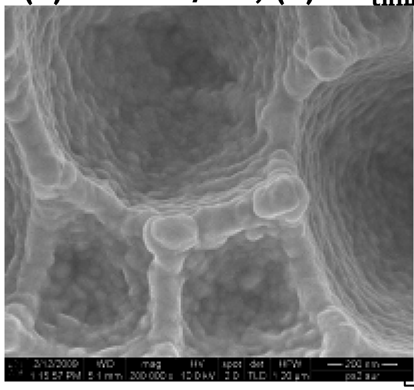


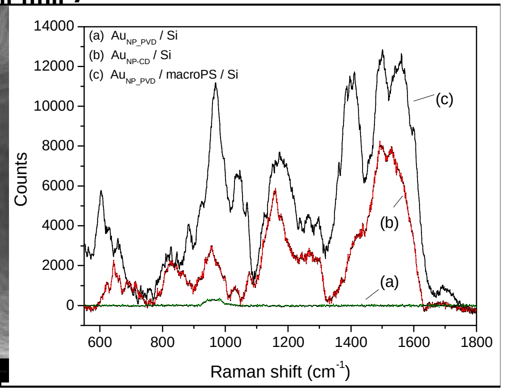


Electrical detection (microelectrode positioned in reaction chamber) → *Electro-optical detection* (porosified nanoelectrode arrays positioned in reaction chamber)

Ref.: *Hybrid electro-optical nanosystem for neurons investigation,* M. Miu et al, *Solid State Sciences* 12 (11), 1917-1922 (2010)

Development of SE(I)RS active surfaces: (a) AuNPs / Si; (b) $Au_{thin\ film}$ / nanoSi

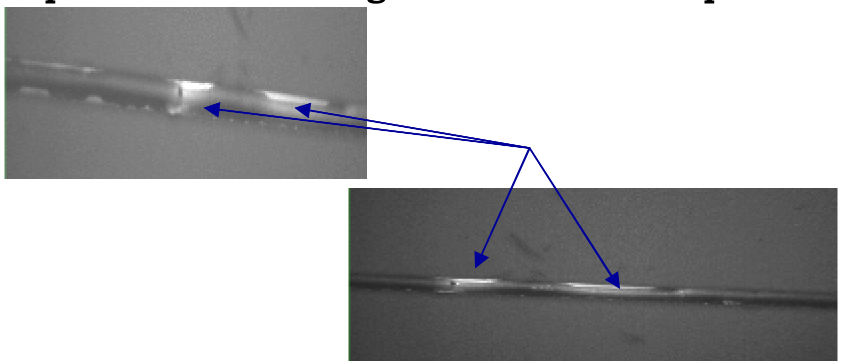




Ref.: *Nanostructured Au/Si substrate for organic molecule SERS detection,* T. Ignat et al, *Superlatt. Microstruct.*, 46 451-460 (2009);
M. Miu et al, *ECS Transactions*, 25 (11) 45-55 (2009);

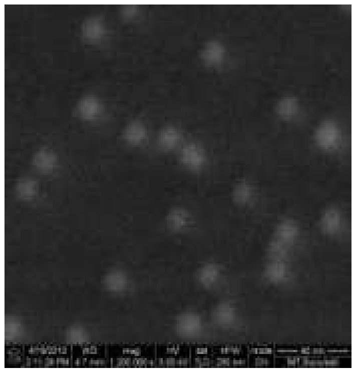
PN II IDEI Project (2007-2010): Study of silicon-protein type biohybride nanostructured surfaces with applications in bio(nano)senzing

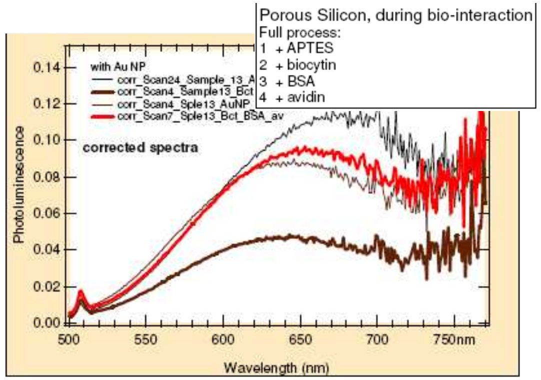
Microfluidic chip on silicon for electrophoretic separation of DNA fragments and PCR amplification



Ref.: *Technology for Silicon Micro-device for DNA Identification by Polymerase Chain Reaction*, M. Simion et al, *Patent* nr. 122.612/ 30.09.2009;
*Microfluidics Silicon structure for electrophoresis separation of DNA fragments,*M. Simion et al, *Sensor Letters* 6 (4), 585–589 (2008);

Development of *plasmonic* biosensors based on metals – silicon nanoassemblies





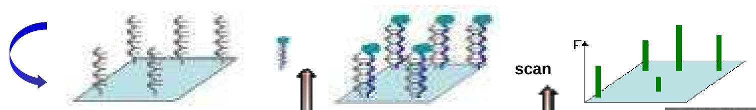
Brancusi Program set up by the foreign affairs ministries of Romania and France.

Development of substrates for alternatives methods of diagnosis base on Microarray Technology

DNA

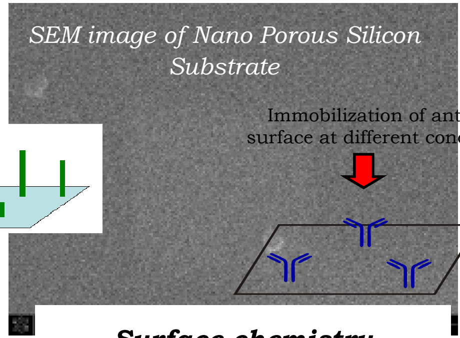
Proteines

Detection of HPV viruses



Hybridization using human DNA samples labels with CY3 fluorophore

Fluorescence-based detection

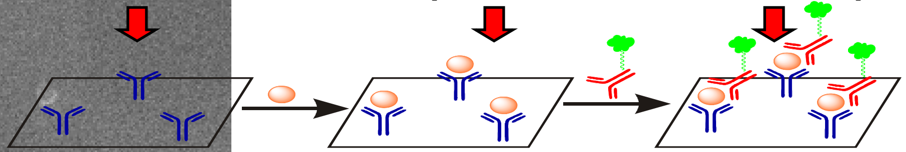


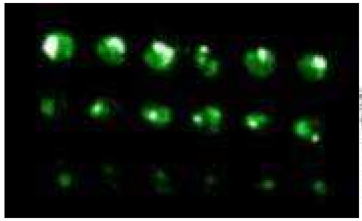
C-reactive proteine

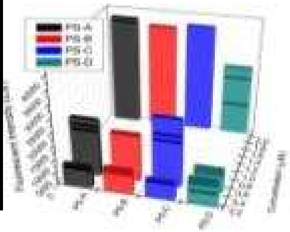
Immobilization of antibody on surface at different concentrations

Incubation with the protein of interest

Fluorescence detection of the immunocomplex

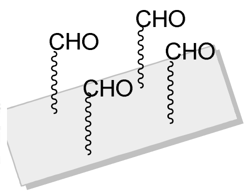




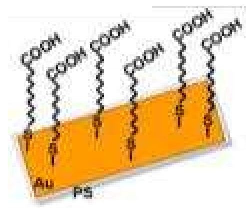


Scanned image of **DNA hybridization** on functionalized PS and reproducibility tests between arrays

Surface chemistry

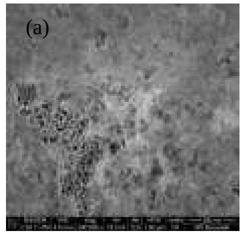


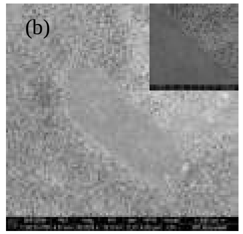
Aldehyde-functionalized

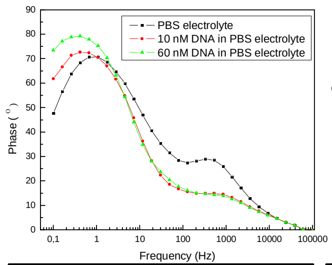


Thiol –functionalized PS/Au slides

SEM images of PS surface: (a) after immobilization of CRP; (b) after reaction with labelled antibody

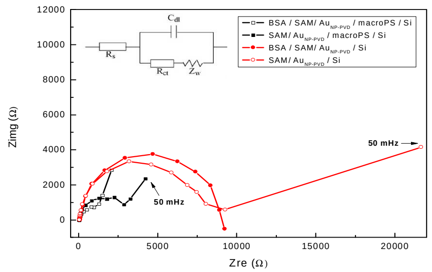


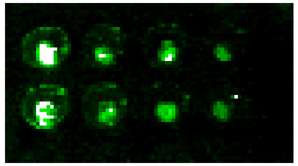




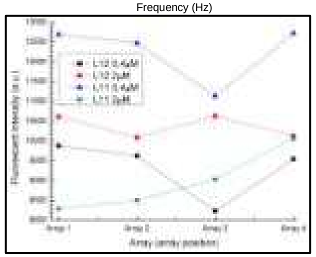
Label free detection by electrochemical impedance spectroscopy of different concentration of DNA in electrolyte solution

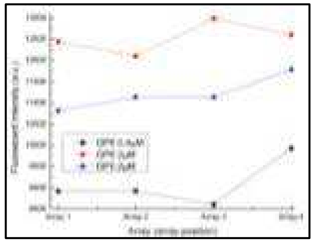
Electrochemical impedance analyses of functionalisation processes





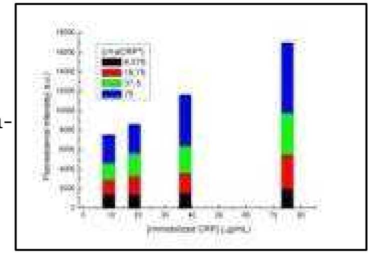
Scanned image with spotted antigen – labelled antibody reaction at different concentration of spotted protein and antibody.

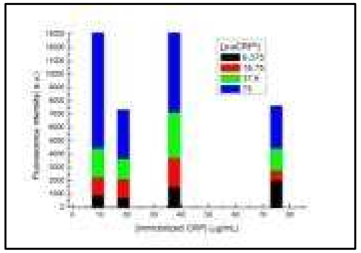




Fluorescent hybridization signal for HPV sequence

MNT-ERA project (2008-2010): A system-in-a-microfluidic package approach for focused diagnostic DNA microchips;
PN II Parteneriate project (2007-2010): Multi-Alergen Biochip by MicroArray technology





Fluorescence intensity as function of the immobilized **p-*a*CRP** and **m-*a*CRP.**

Ref.: *Surface nano structuration role in detection of HPV using microarray technology*, M. Simion et al, **Journal of Nanoscience and Nanotechnology** in press
Study of CRP immobilization on nanostructured silicon M. Simion, **Mater. Sci. and Engineering: B**, 169 (1-3), 67-72 (2010);
Electrochemical characterization of BSA/11-mercaptoundecanoic acid on Au electrode, T. Ignat, **Materials Science and Engineering B** 169, 55-61 (2010)
Porous Silicon Used As Support for Protein Microarray M. Simion, **Superlattices and Microstructures**, 46(1-2), 69-76, 2009

MULTIFUNCTIONAL NANOPARTICLES

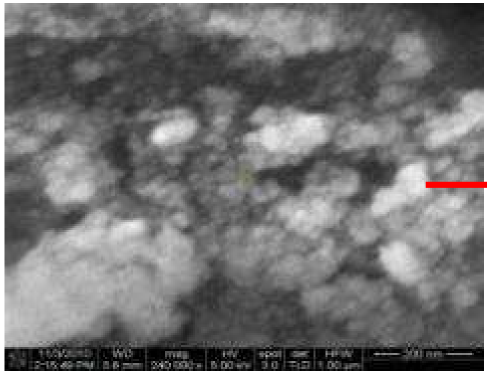
1. CANCER TREATMENT

2. RISK ASSESMENT

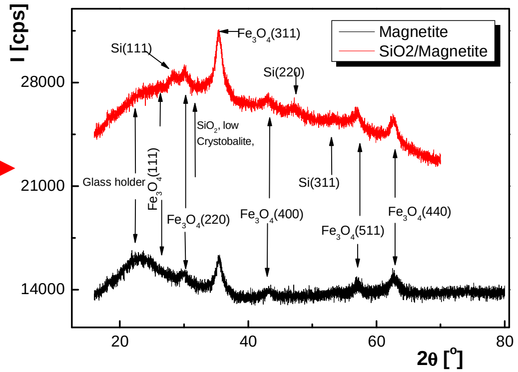
MEDICINE

1. DRUG DELIVERY

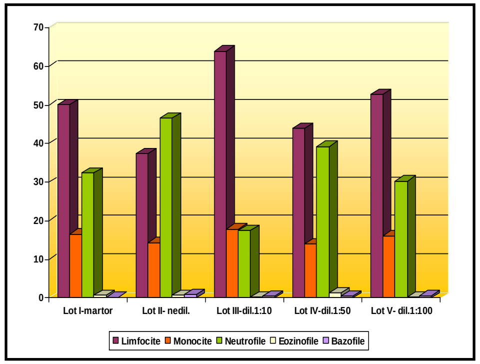
Superparamagnetic microparticules = nanostructured silicon carrying iron oxides *(SPION)* and drugs integrated in an organic matrix for controlled delivery process direct to specific sites



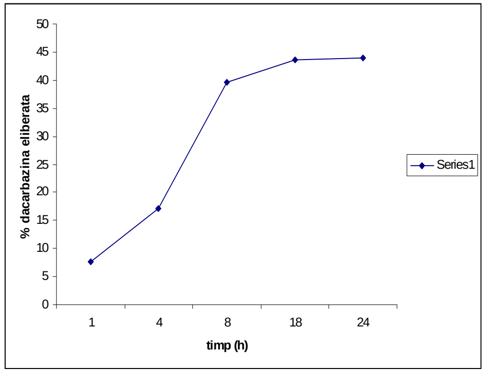
SEM image of the nanostructurated silicon microparticles impregnated with magnetic NPs (9-10 nm)



XRD analysis of the *SPION* system



The biocompatibility demonstrated by *in vivo* tests



Delivery of the dacarbazine from the SPION system, using HPLC method

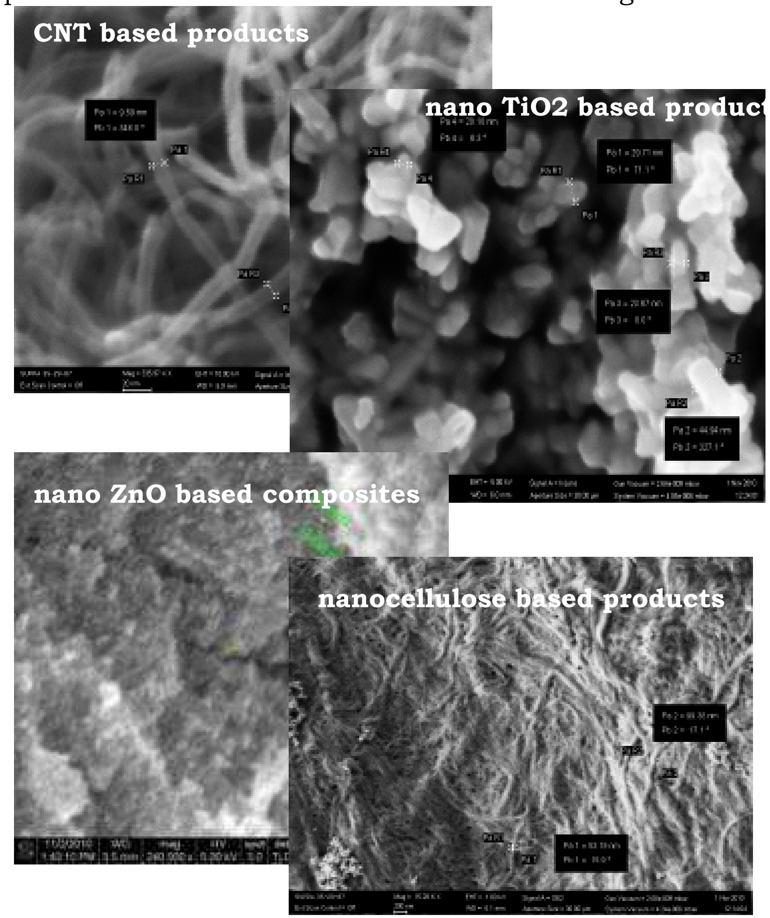
PN II Parteneriate project (2007-2010): Silicon based multifunctional nanoparticles for cancer therapy

Ref.: *Study of Nanocomposite Metal/Porous Silicon Material*, M. Miu et al, J. of Alloys and Compounds 496 (1-2), 265-268 (2010);

Nanostructured silicon particles for medical applications, I. Kleps et al, *Journal of Nanoscience and Nanotechnology (JNN)*, Vol.9, 1-7, 2009;

2. Innovative solutions for the sustainable design, use, recycling and final treatment of nanotechnology-based products

Specific organic and inorganic nanomaterials / associated products have been selected and will be investigated in detail:

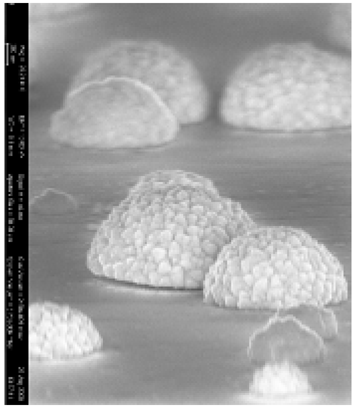


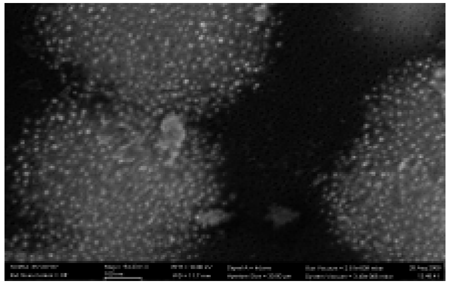
FP7* Collaborative Project 247989 (2010-2013)*: Development of sustainable solutions for nanotechnology - based products based on hazard characterization and LCA (NanoSustain)

FP7-NMP-2010-LARGE-4 (2011-2014): Development of reference methods for hazard identification, risk assessment and LCA of engineered nanomaterials (NanoValid)

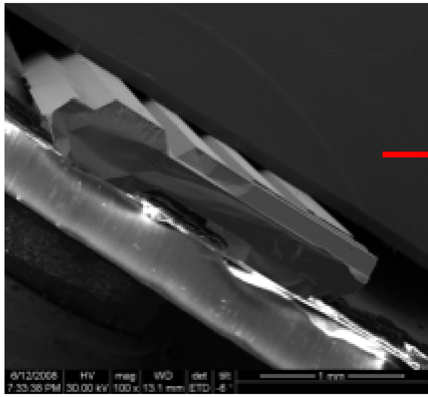
NANOCOMPOSITE STRUCTURES FOR CLEAN ENERGY

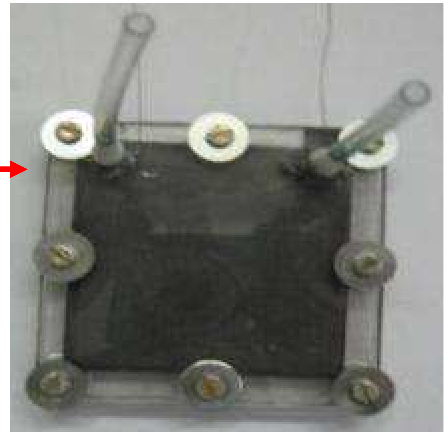
ELECTROCATALYTIC NANOMEMBRANE / MINIATURISED HYBRID DIRECT METHANOL FUEL CELL



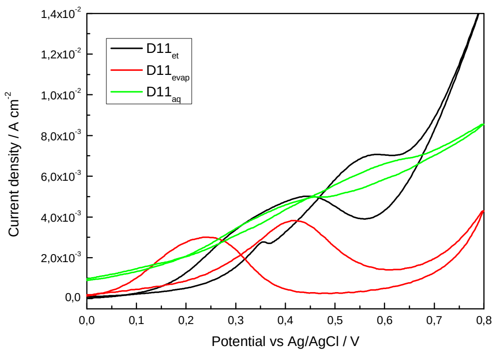


The nanoSi support improves the adesion / dispersion of Pt nanocatalyst

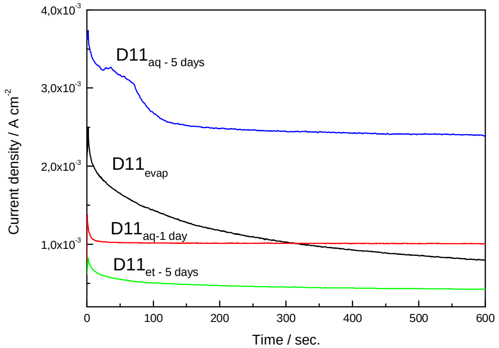




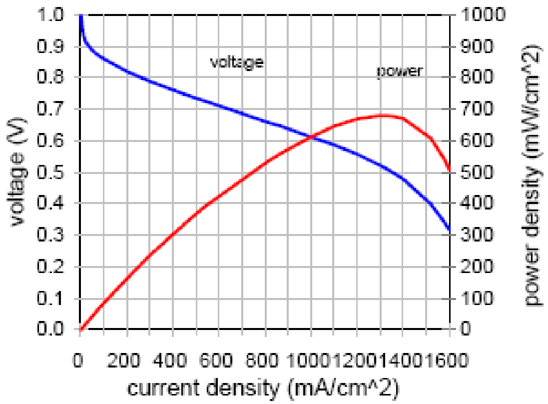
Electrochemical tests of Pt - nanoSi nanoassemblies



PtNPs significantly reduce the barrier to methanol oxidation and also a larger amount of methanol is oxidized at the electrode



The long term stability of PtNPs dispersed in nanoSi matrix is improved due to the vicinity of Si fibrils.



The Tafel graph - Performances of the test structures: *I–V* and power density characteristics of the miniature fuel cell

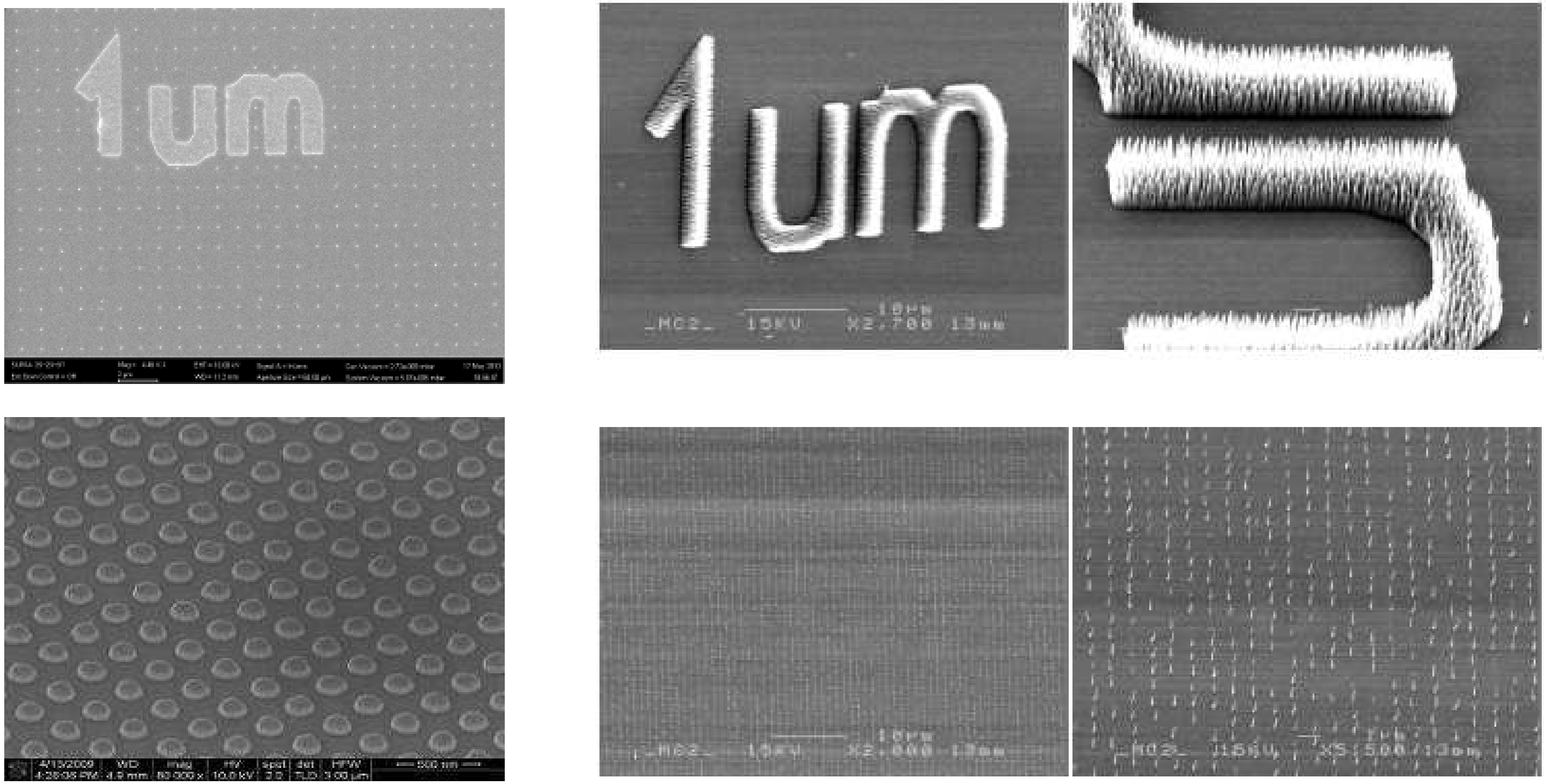
PN II IDEI Project (2007-2010): *Study of membrane - electro-catalyst nanocomposite assemblies on silicon for fuel cell application*

PN II Parteneriate project (2007-2010): *Miniaturised power source for portable electronics realised by 3d assembling of complex hybrid micro- and nanosystems*

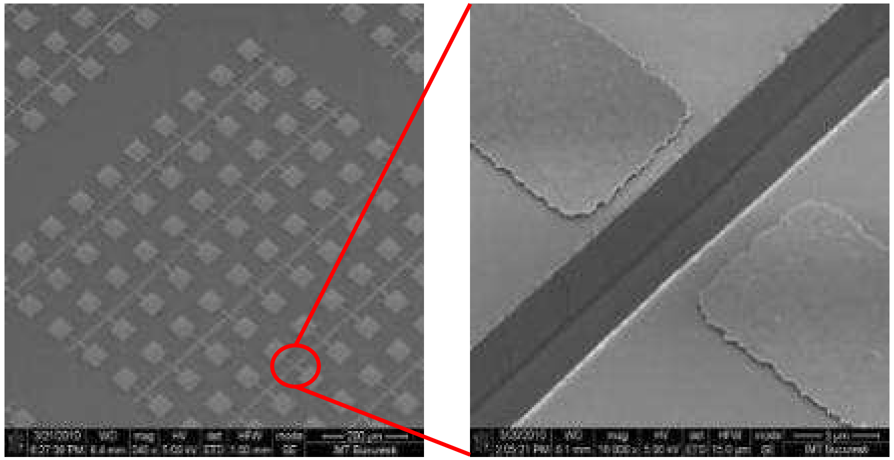
Ref.: *Electrocatalytic activity of platinum nanoparticles supported on nanoSilicon,* M. Miu et al, Fuel Cells 10, 259-269 (2010);
Metallic - semiconductor nanosystem assembly for miniaturized fuel cell applications, M. Miu Superlatt.Microstruct 46 291-296 (2009)

Laboratory for characterization and structuring at the “nano” scale

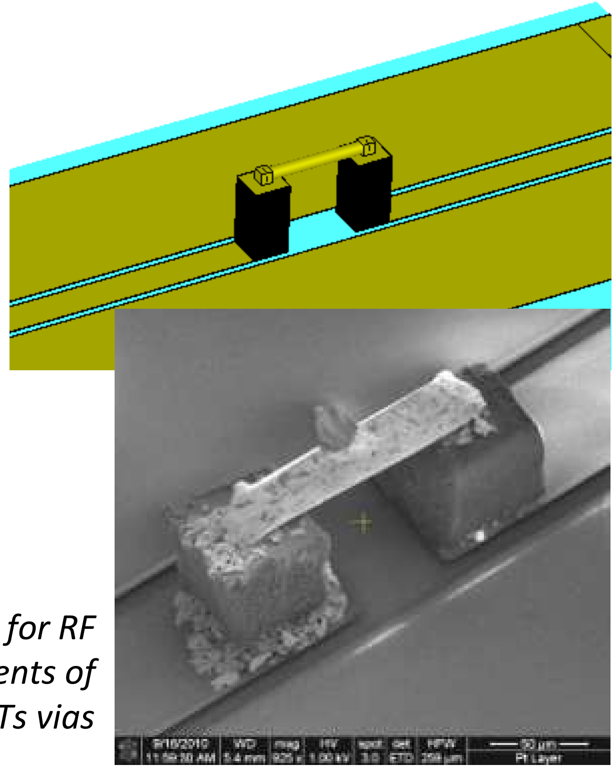
FP7 Project “Carbon nAnotube Technology for High-speed nExt-geneRation nano-InterconNEcts” – CATHERINE; Grant agreement no.: 216215



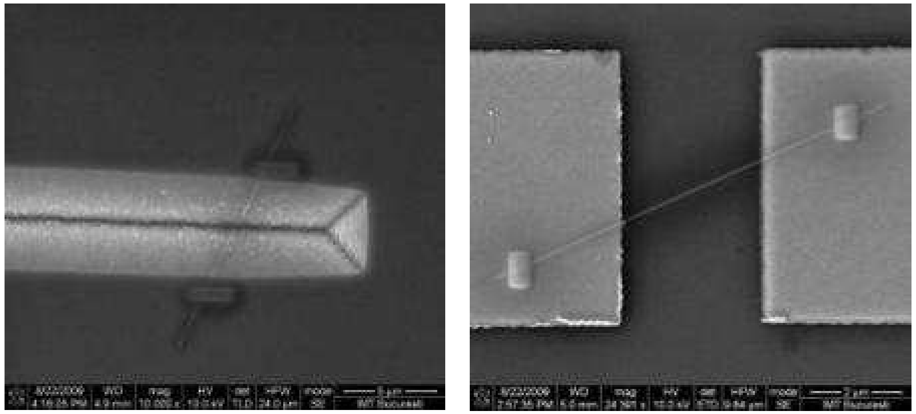
Arrays of Ni nanodots used as catalyst for CNTs growth



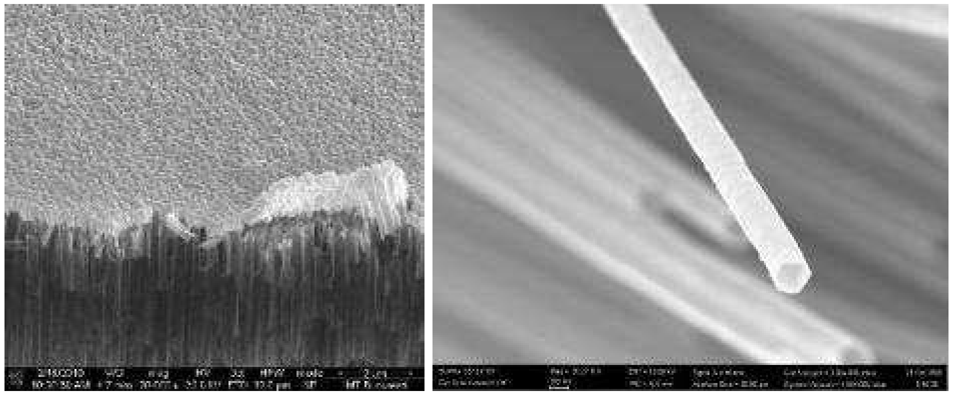
Test fixture for combined mechanical and electrical characterization of CNTs



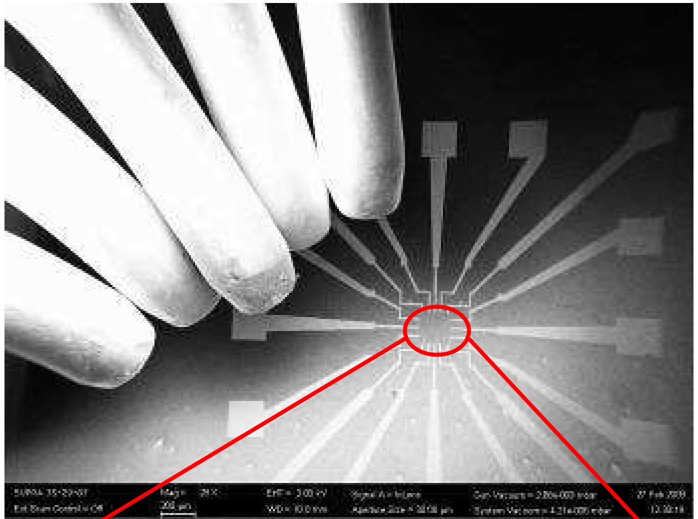
Test vehicle for RF measurements of vertical CNTs vias

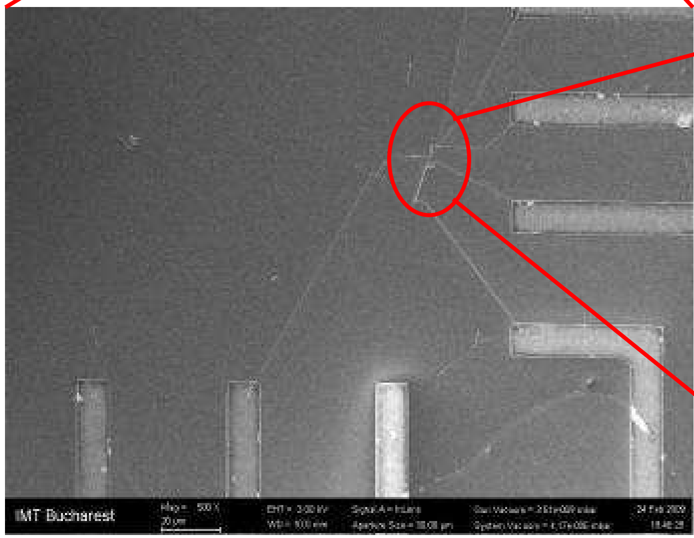


CNTs glued on the substrate using EBID technique for mechanical and electrical properties measurements



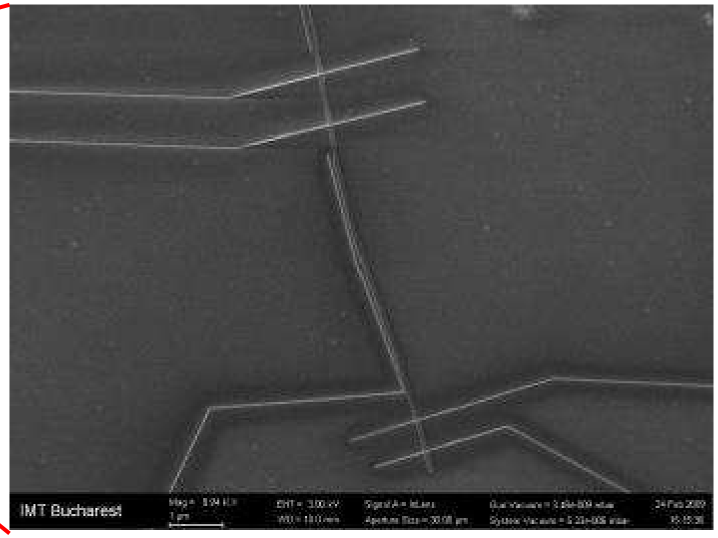
The CNTs are grown in the pores of an alumina membrane that is covered with gold

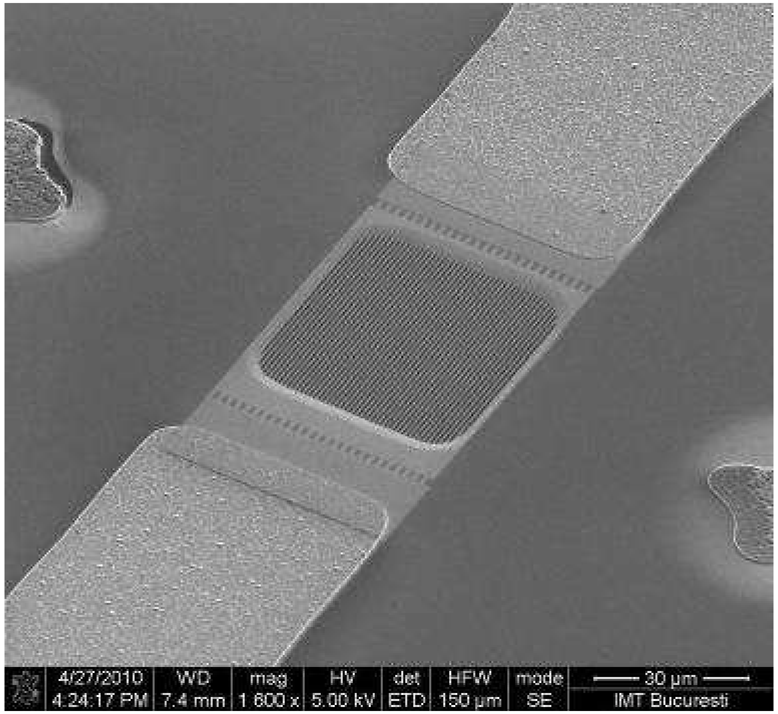




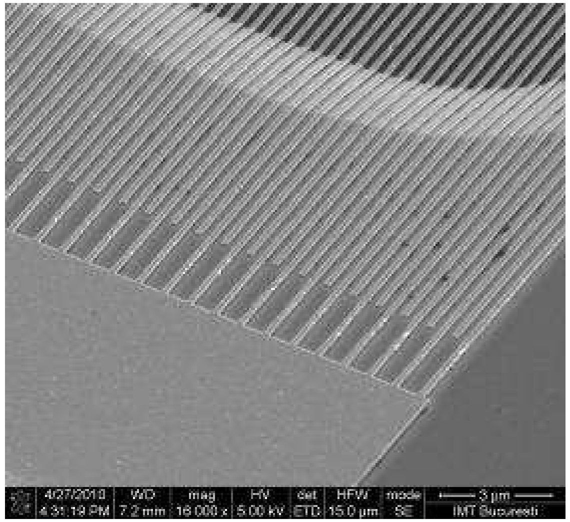
EBID technique used for polymer nanowire characterization

(collaboration with UCL Louvain)

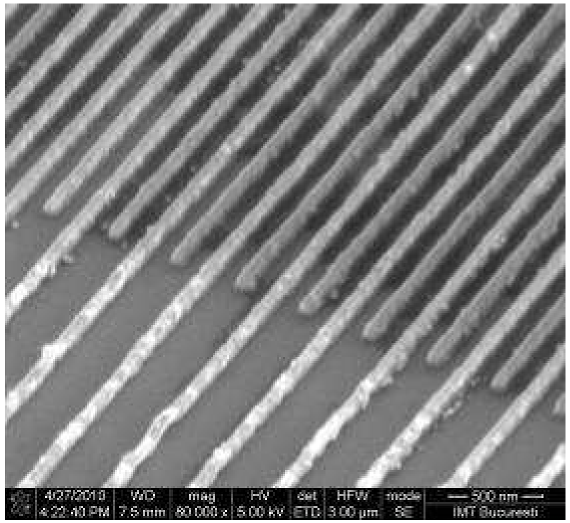




MSM photodetector on silicon fabricated using Electron Beam Lithography



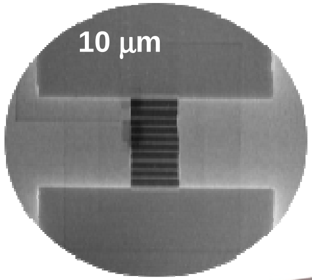
200nm line width



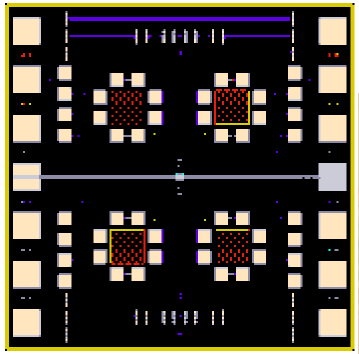
100nm line width

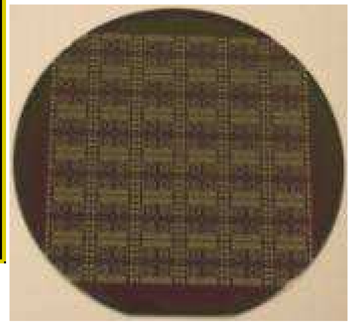
Laboratory of molecular nanobiotechnology

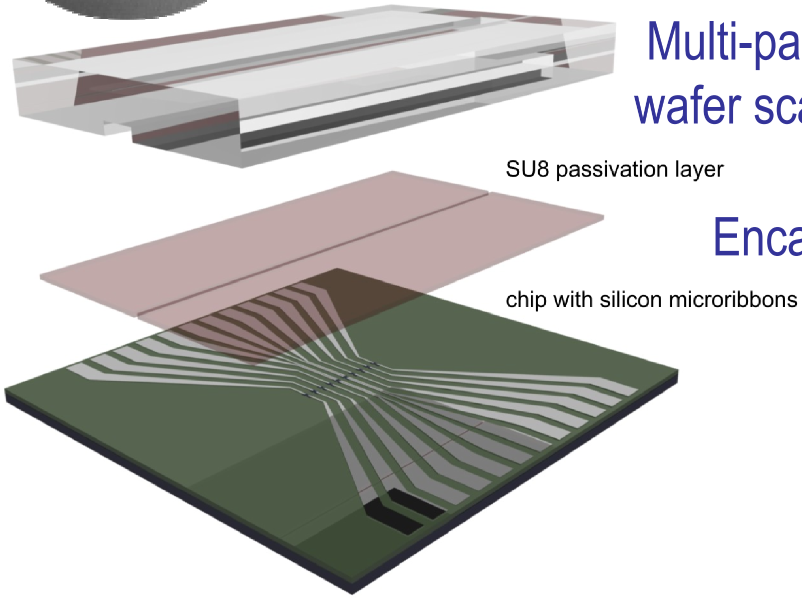
Silicon-based Lab-on-Chip Devices



State-of-the art SEM nanolithography

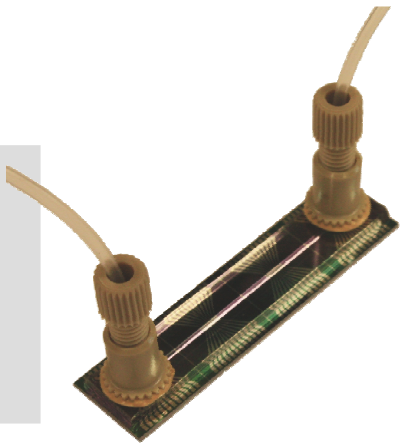


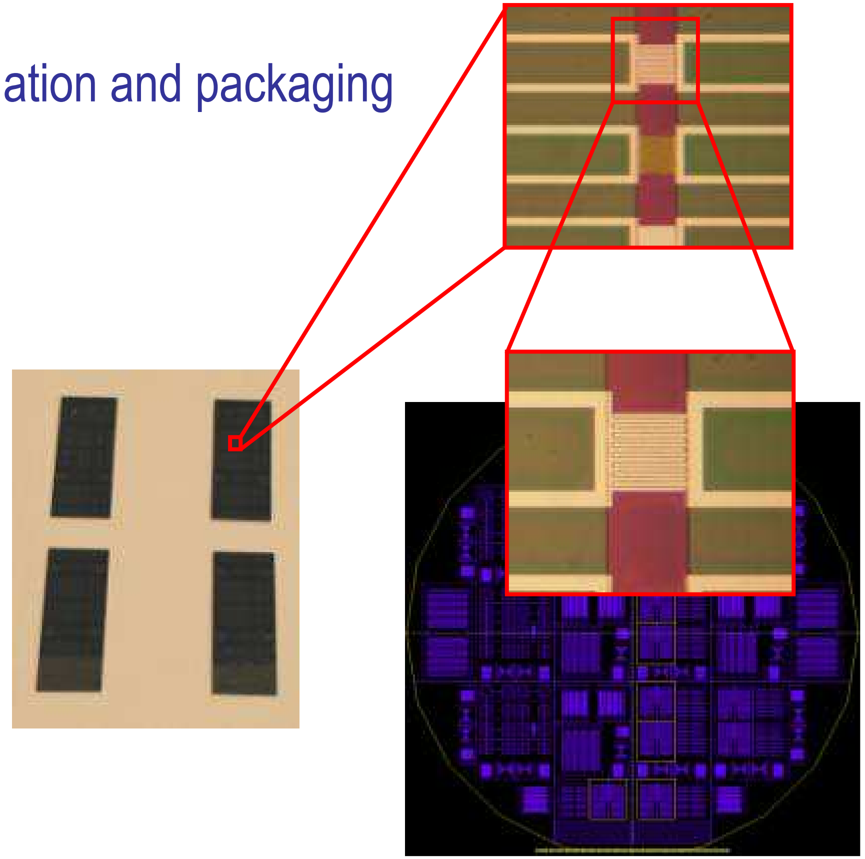




Multi-parameter chip design, wafer scale processing

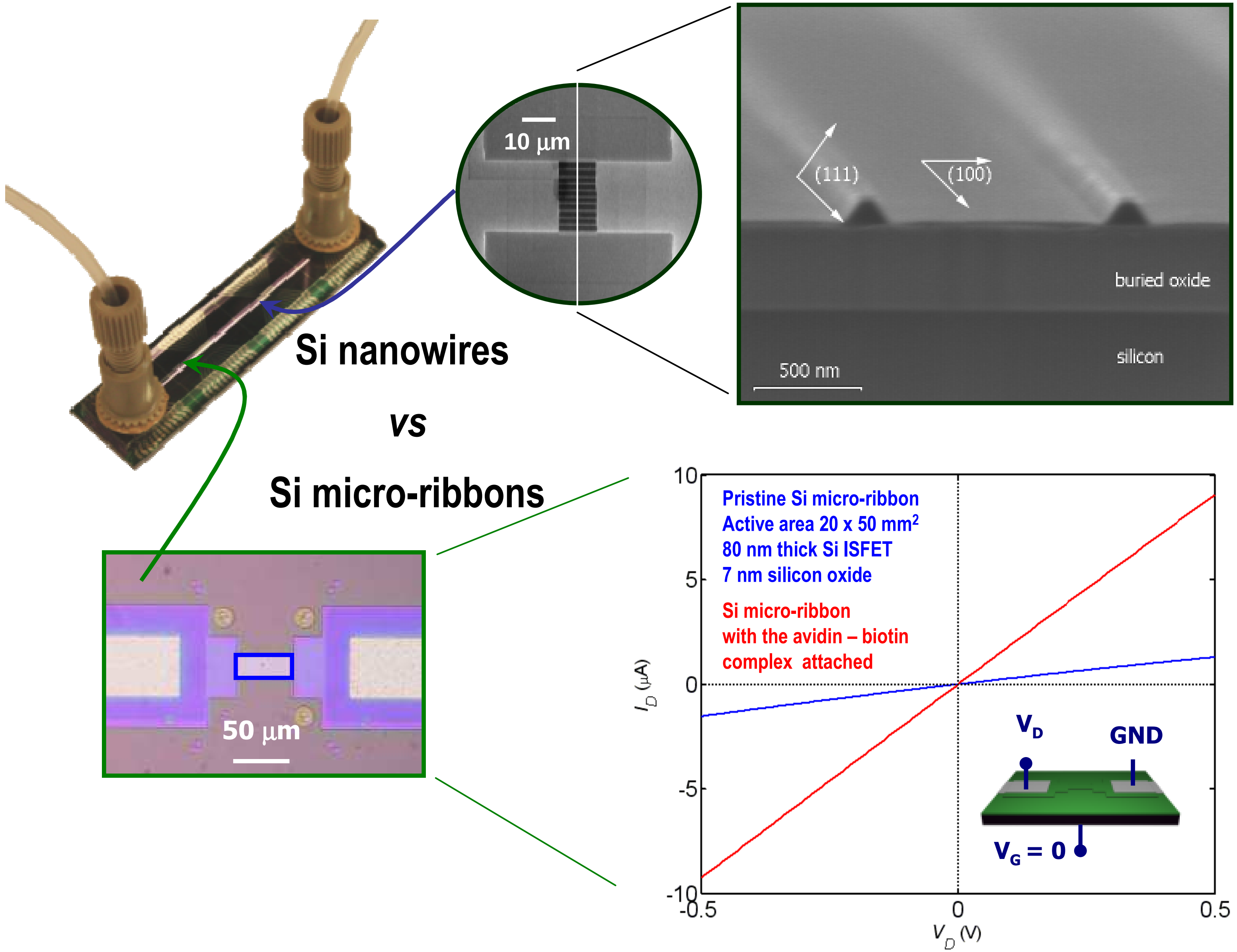
Encapsulation and packaging





Sensitive elements based on:
- Si nano-/micro-ribbons and nanowires
- interdigitated electrodes

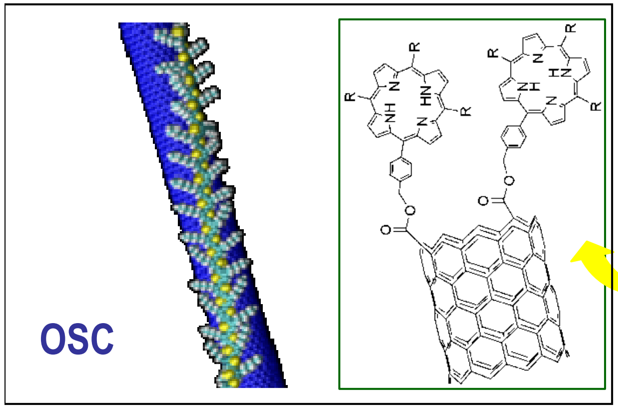
Biosensing for real-time detection

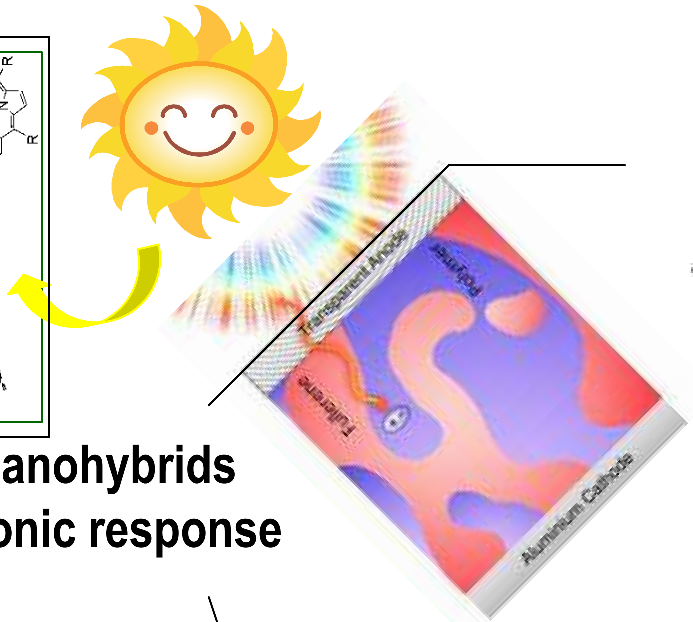


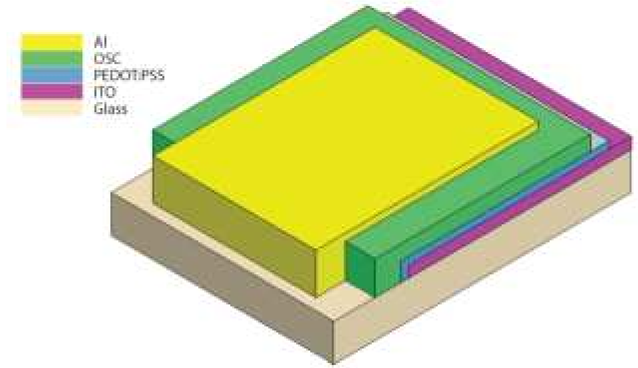
Validating protocols for pathogen detection

Light Harvesting Devices

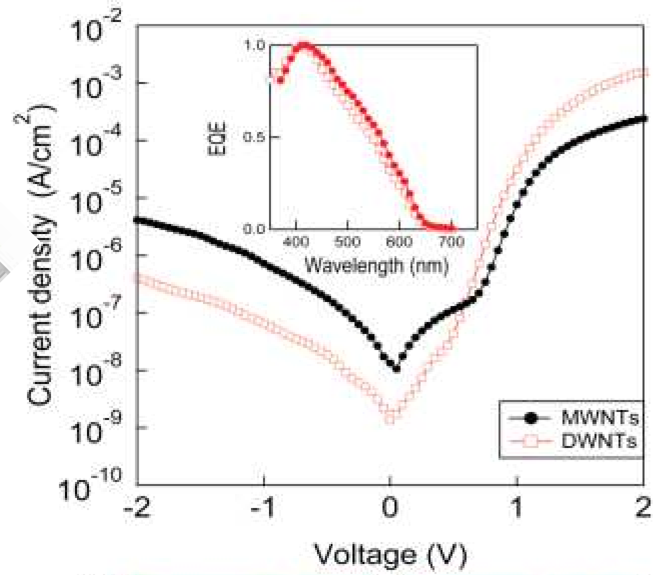
...coming soon in a special issue of ChemSusChem

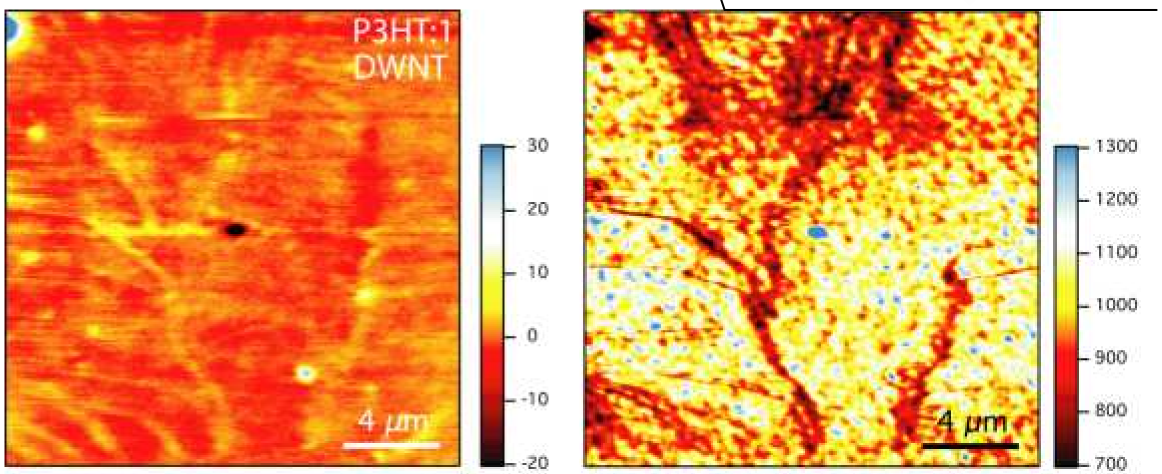


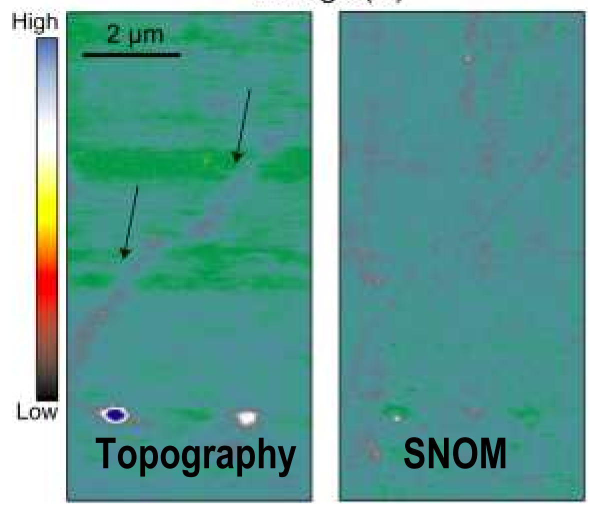




Organic SemiConductor nanohybrids with enhanced optoelectronic response







Tuning of molecular superstructure (SNOM analysis)

IMT-Bucharest
Department for scientific and technological research

MIMOMEMS

- “Research Centre of Excellence” “Micro- and nanosystems for radiofrequency and photonics”

CNT-IMT

- “Centre of Nanotechnologies (affiliated to the Romanian Academy under the aegis of the Romanian Academy)”

CINTECH

- **“Research centre for integration of technologies”**

CENASIC

- “R&D centre for nanotechnologies and carbon–based nanomaterials”

Activity related to renewable energies

Wafer back surface doping
Thermal oxidation

↓

Surface texturization

↓

Active area oxide removing

↓

Active area diffusion

↓

Metalic contact

↓

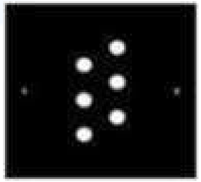
Metal patterning by lift-off

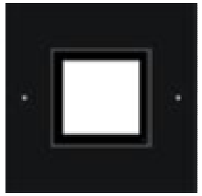
↓

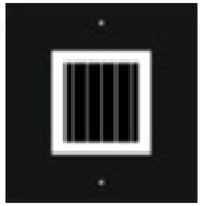
Front and back surfaces metal deposition

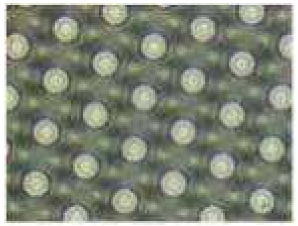
↓

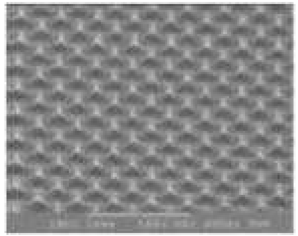
Metal etching

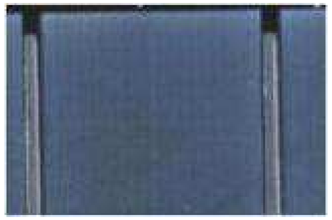








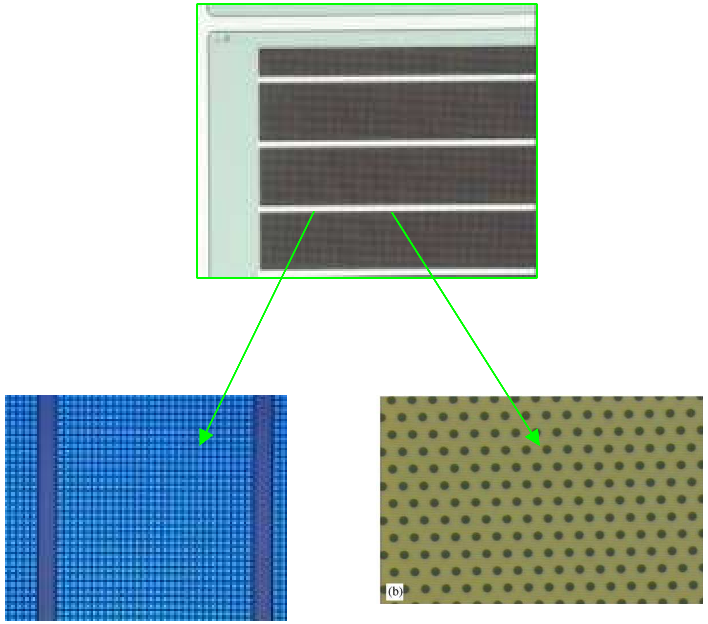




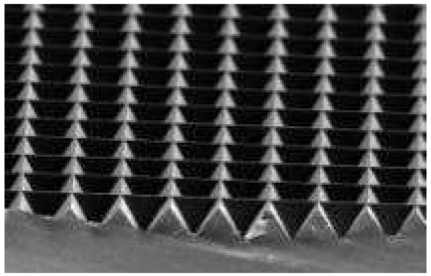
Technological flow of TEXTURIZED SOLAR CELLS

Contact person, IMT: Dr. Elena Manea, elena.manea@imt.ro

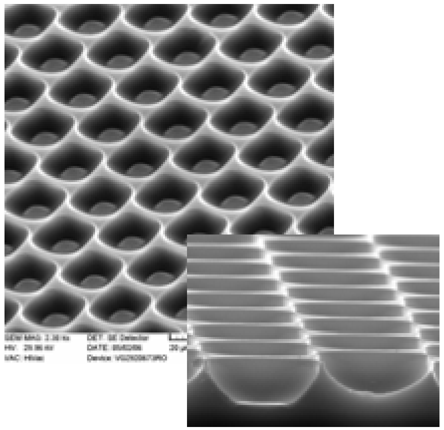
Surface texturization using micromachining processes



Masks for texturization process



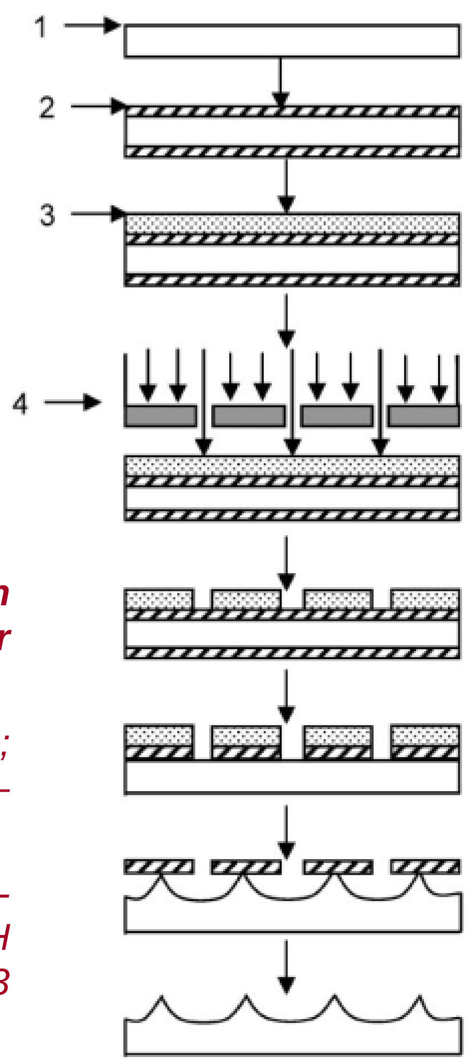
Silicon texturized of pyramidal type



Honeycomb silicon texturization

Technological flow
for surface texturing

(1) silicon wafer,
(2) 1000nm thick silicon dioxide layer used as a masking layer for etching,
(3) positive photoresist
(4) photolithographic process using mask.

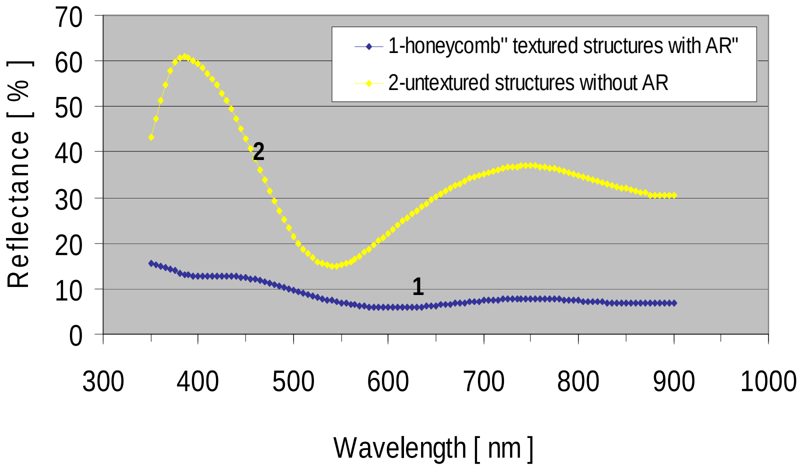


Surface texturization processes studied for solar cells applications:

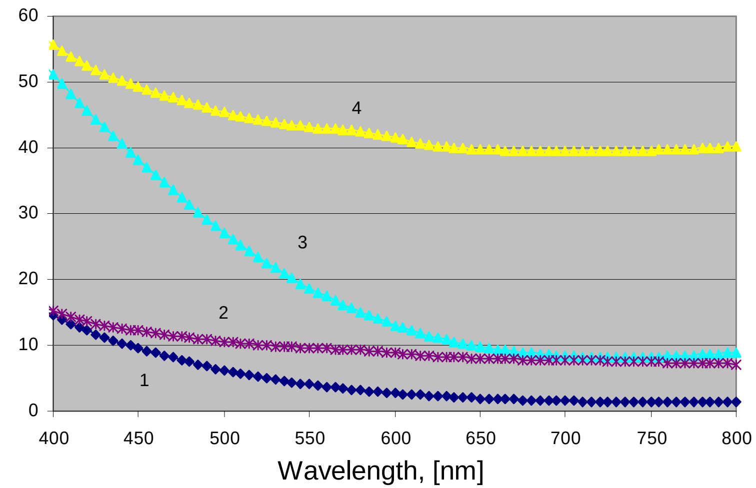
⇒Honeycomb etching; $HNO_3:HF:NH_4F:H_2O$ – through a window of 4µm;

⇒ Pyramidal etching on p-silicon wafers <100>; KOH 40% through windows of 3 and 10µm

Optical characterization of texturized surfaces

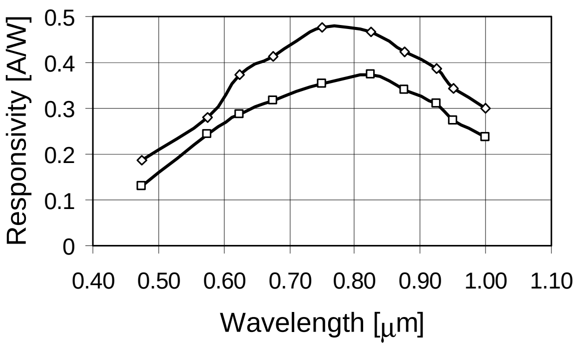


The spectral dependence of the reflectivity for honeycomb-textured and untextured structures



The spectral dependence of the reflectivity for inverted pyramids textured (1,2) and untextured (3,4) structures with (1,3) or without (2,4) ARC

By using of the texturization processes the light losses by front surface reflection were drastically reduced, below 5 % and this contributes to enhance of the conversion efficiency of crystalline silicon solar cells.



Spectral characteristic of structures – responsivity;
1- texturized structures; 2- untexturized.

The honeycomb-texturized structures exhibit responsivity higher by a factor of 1.37 at maximum of the spectral curve. The maximum difference between the texturized and untexturized structures appears at 750nm due to the SiO2 layer.

New research infrastructures financed from Structural Funding

Programme related to Competitiveness

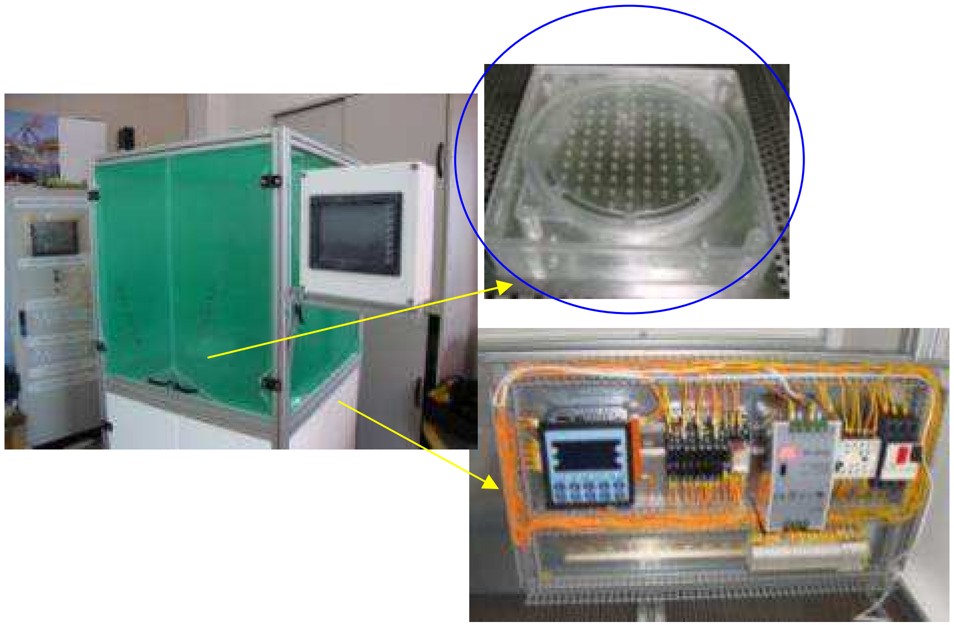
Microfluidic Factory for Assisted Self-Assembly of Nanosystems MICRONANOFAB

- Sectoral Operational Program - Increase of Economic Competitiveness
- Priority Axis 2 – Research, Technological Development and Innovation for Competitiveness
- Major domain of intervention 2.2 – Investments in RD&I infrastructure
- Operation 2.1.2: Complex research projects fostering the participation of high-level international experts
- Project duration: 36 months starting July 2010

The project involves 3 domains of large scientific interest: **microfluidics, nanotechnology and biotechnology.**

Objectives

- Creation of some technological platforms for microfluidic systems with an extensive applicative potential which can be developed during future national and European projects or collaboration and partnerships with national or international companies, research institutes or universities.
- Realization and patenting of prototype laboratory mini-equipments.
- Creation of a multidisciplinary collective, competitive on an European level, able to tackle interface problems in the field of bio-nano-engineering.



Home made equipment for dry etching of silicon with XeF2: the mechanics, reactor cover gas distribution system, control panel, electronic control system

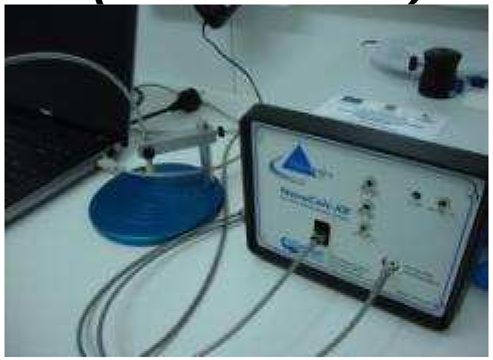
Wafer -/Substrate Bonder System (SB6L)

Manufacturer: Suss MicroTech
Bonding processes: Si to Si; Si to Glass; Polymer and Adhesive
Features: Lower hot bond chuck with temperature control from ambient to 500°C; Negative High Voltage DC power supply for Anodic bonding; Flexible process: can accommodate polymer and adhesive bonding of different substrates
Performance: temperature control ± 3°C; temperature uniformity ± 2%; process force >8kN; process vacuum pressure < $5*10^{-4}$ mbar

ICP Deep Reactive Ion Etching SystemPlasmalab System 100

Manufacturer: Oxford Instruments
Etching processes:Deep Si etching (Bosch and Cryogenic)
Features: Single wafer processing; 5 KW maximum ICP power; 300 W maximum substrate electrode power; Temperature control for substrate electrode; 2 ultrafast MFC close coupled to the ICP source (for smooth sidewalls).
Performance: Si etch rate: 7.5 µm/min; wafer non-uniformity: less than 3%; wafer to wafer non-uniformity: less than 3%; etching profile: 90°±1° vertical side-walls; selectivity: 50:1 for PR mask or 200:1 for SiO_2; mask aspect ratio: 20:1

Refractometre for layer thickness measurements (NanoCalc-XR)



Manufacturer: Mikropack
Thickness measuring: SiO_2; Si_3N_4; photoresist; metal films. Transmission and reflection measurements of anti-reflective & hardness coatings; Wide wavelength (250nm to 1050 nm); Can measure up to 10 layer stacks.
Performance: Resolution: 0.1 nm; Thickness range: 10nm to 100µm; Defect and roughness tolerant measurements; Database for a broad range of materials; Measurement speed 100 ms to 1s

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Examples of new research centres

Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials – CENASIC, IMT-Bucharest

- Sectoral Operational Program - Increase of Economic Competitiveness
- Priority Axis 2 – Research, Technological Development and Innovation for Competitiveness
- Major domain of intervention 2.2 – Investments in RD&I infrastructure
- Operation 2.2.1: Development of present R&D infrastructure and generation of new R&D infrastructures (laboratories, research centres)

- Thematic priority: 4. Materials, processes and innovative products
- Implementation: 36 months - Oct.2010-Sept.2013
- Total value: 6,230 k euro

CENASIC - Proposed Research Directions

- **SiC technologies and functional micro-nanostructures**
  - o Processes for SiC-based micro- and nanostructures
  - o Processes and development of wide band gap materials for high-frequency devices and for MEMS/NEMS with application in energy management
  - o Processing for metamaterials and 3D nanostructures for integrated optical systems

- **Technologies for graphene and hybrid MEMS/NEMS**
  - o Technologies for graphene synthesis and processing on large metallic substrates
  - o Development and processing of graphene based hybrid materials for structural health monitoring microsystems
  - o Technologies for graphene nanoribbons functionalization and integration in MEMS/NEMS

- **Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics**
  - o Technologies for growth and processing of nanocrystalline diamond structures
  - o Advanced technologies for nanocrystalline diamond-based sensors applied in scanning probe microscopy
  - o Processing of micro- and nanostructures for nanocrystalline diamond resonators

CENASIC - Main Project Aims

- **Creation of a new and modern center within IMT-Bucharest, dedicated to nanotechnologies based on carbon nanomaterials: SiC, graphene, nanocrystalline diamond**

- Focused research approach for this RD area, through:
  - **dedicated technological facilities**:
    - **clean room** - 200sqm, class 1000/100 (adjacent and complementary to the CVD+dry-etching clean room)
    - **advanced equipments** for synthesis, processing, characterization, simulation
  - organization in **new experimental labs**
    - 4 new labs in the clean room
    - other 4 new/renovated labs
  - **construction of new spaces for: R&D/education/collaborations**
    - new building on an existing constructed footprint - over 1000 sqm
    - 5 levels: clean room, technical level, plus 3 levels for labs and offices

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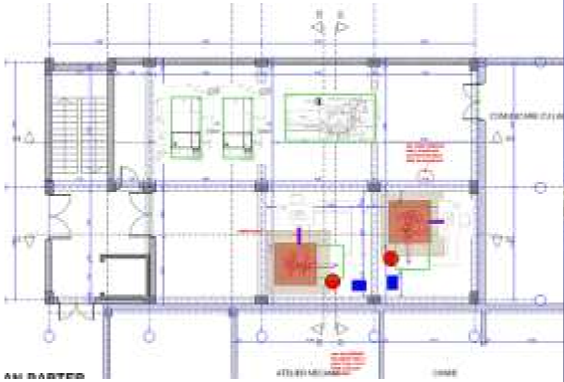
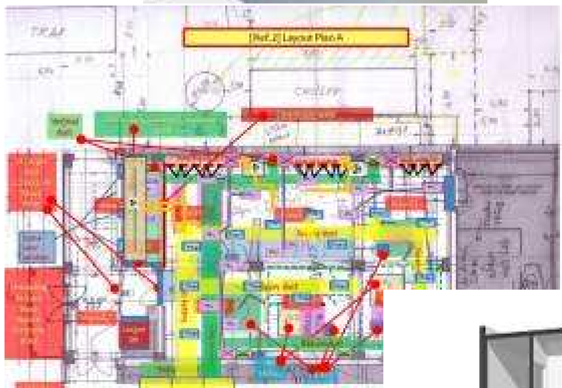
  - Processing of micro- and nanostructures for nanocrystalline diamond resonators

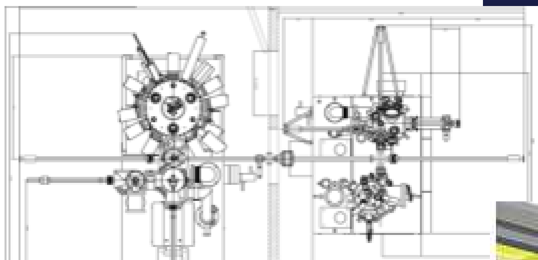
CENASIC - New Labs and Main Equipments

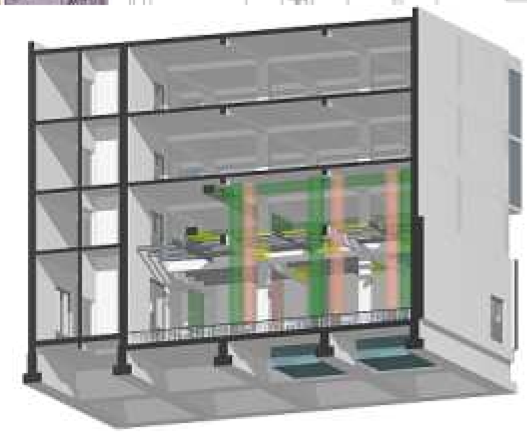
- **Laboratory for Thermal processes (clean room - level 1)**
  - multiprocess furnace - oxidation, annealing, diffusion
- **Laboratory for Processing of carbon based nanomaterials and nanostructures (clean room - level 1)**
  - Ultrahigh vacuum deposition system with coupled characterization - MBE (AlN,GaN,.../SiC) + LT-HV-STM
  - RIE/DRIE (existing)
- **Laboratory for Thin layer spectrometry (clean room - level 1)**
  - wideband FTIR spectrometer (UV-Vis-NIR-IR-THz)
- **Laboratory for Graphene technologies (clean room - level 1)**
  - vertical furnace "activator" - max. 1900C, dopant activation, growth of graphene on SiC
- **Laboratory for Chemistry of hybrid interfaces (level 1)**
  - wetbenches etc.
- **Electro-mechanical and sample preparation room (level 1)**
  - microsectioning equipment, microprocessing, wafer dicing
- **Laboratory for Electromechanical testing and reliability (level 3)**
  - internal stress measurements, lock-in amplifiers
- **Laboratory for Simulation and design for carbon-based MEMS/NEMS (level 4)**
  - new HPC server

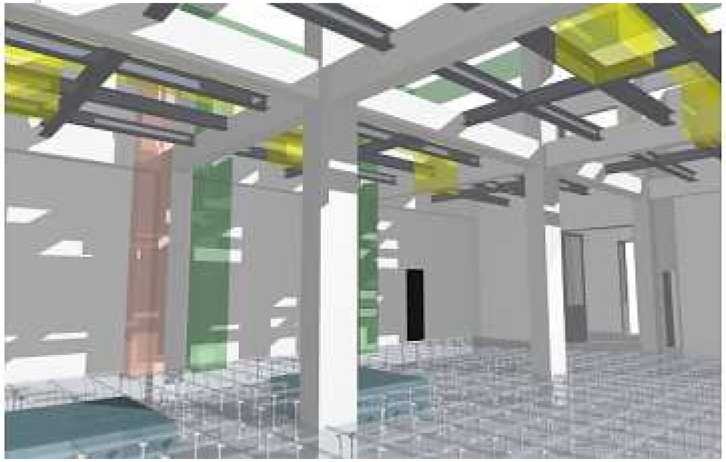
❑ Total: 37 R&D equipments / approx. 3.9Meuro











Under construction!

Already in CENASIC ……

A new area in the IMT support centre for MIcro- and NAnoFABrication IMT-MINAFAB

Equipment for low pressure chemical vapor deposition of thin layers LPCVD, AnnealSYS

General Characteristics
- ✓ Wafer diameter: 4 inch
- ✓ Reactor: Quartz tube with stainless steel flanges
- ✓ Heating: Electrical furnance
- ✓ Control of temperature: Digital PID temperature. Controller" for three zones

Deposition processes: Silicon Oxide; Silicon Dioxide; Silicon Nitride; Polysilicon
Other processes: Annealing; Diffusion

AS-One 100 RTP Rapid Thermal Processor AnnealSYS

APPLICATIONS
- ✓ Rapid Thermal Oxidation (RTO)
- ✓ Rapid Thermal Nitridation (RTN)
- ✓ Crystallization and Densification
- ✓ Compound semiconductor annealing
- ✓ Diffusion; Silicidation
- ✓ Glass reflow
- ✓ Sintering (contact alloying)

Plasma Enhanced Chemical Vapor Deposition PECVD (SPTS LPX-CVD)

Features:
- ✓ Single Wafer processing
- ✓ Fully automatic loadlock
- ✓ LF RF Generator 1000W@380kHz
- ✓ HF RF Generator 600W@13.56MHz

Etchlab SI 220 Reactive Ion Etching System Sentech Instruments

General Characteristics:
- ✓ High etch rate
- ✓ Low damage
- ✓ Superior homogeneity
- ✓ Remote field control via serial field bus
- ✓ SENTECH's plasma process systems operating software

- Information presented by other national R&D institutes
  - for Materials Physics
  - for Nonferrous and Rare Materials
  - for Electrical Engineering

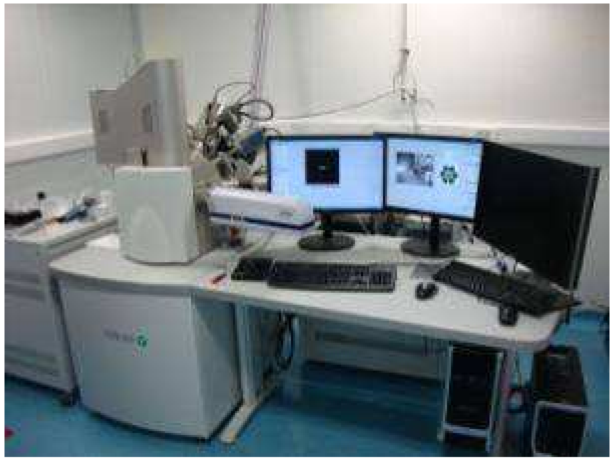
National Institute of Materials Physics - NIMP

www.infim.ro

NIMP is devoted to **fundamental and applied research** in the fields of **solid state physics and materials research**.

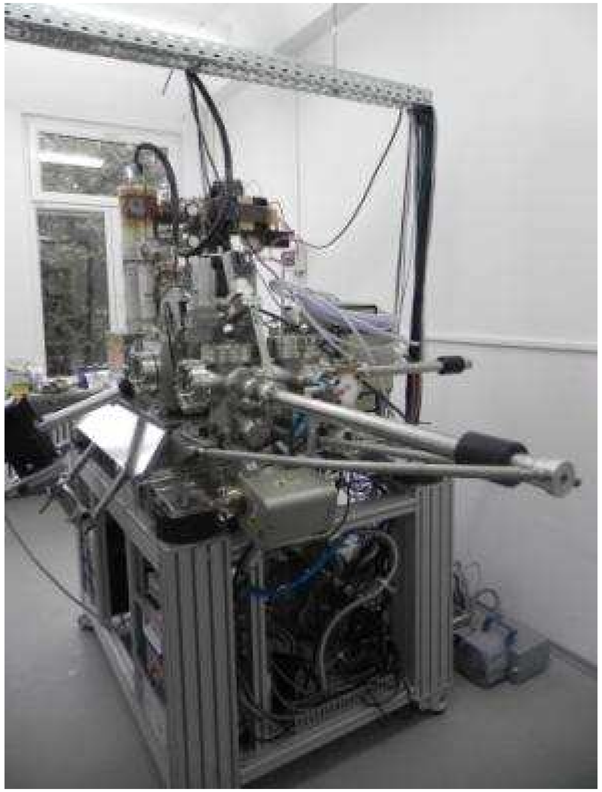
New equipments at NIMP

- in the Euro-Regional Centre for Studies of Advanced Materials, Surfaces and Interfaces (http://www.infim.ro/projects.html) - financed from **STRUCTURAL FUNDS**, Sectoral Operational Program - Increase of Economic Competitiveness

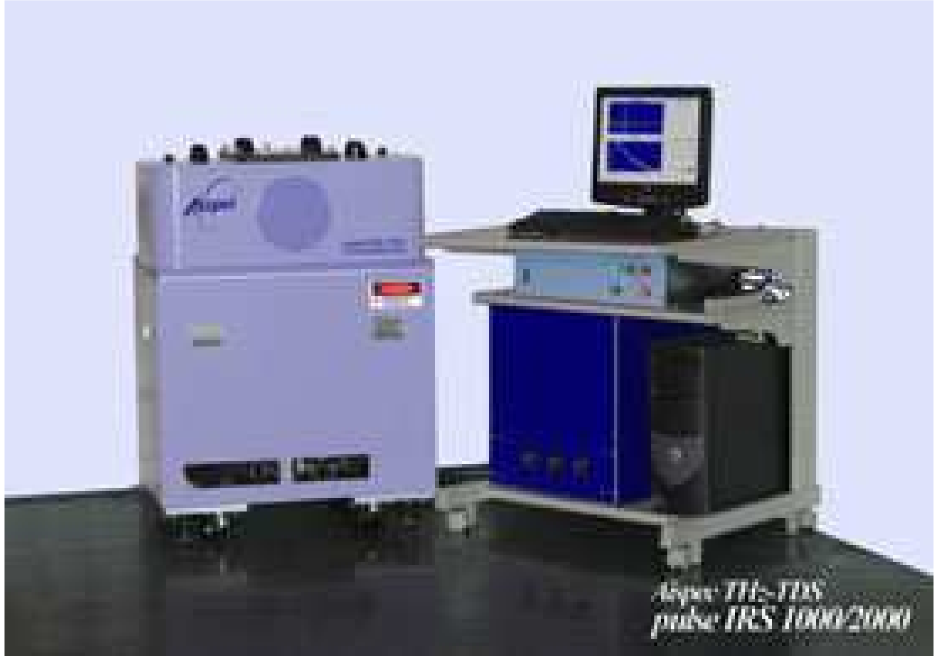


The analytical high-resolution transmission electron microscope JEM ARM 200F (left) and the dual system SEM-FIB Tescan Lyra 3 XMU (right) installed at the National Institute of Materials Physics.

The new clean room facility including: photolithography (EVG620); nanolithography (Hitachi S3400N+Raith Elphy Quantum); metallization plants (BESTEC).



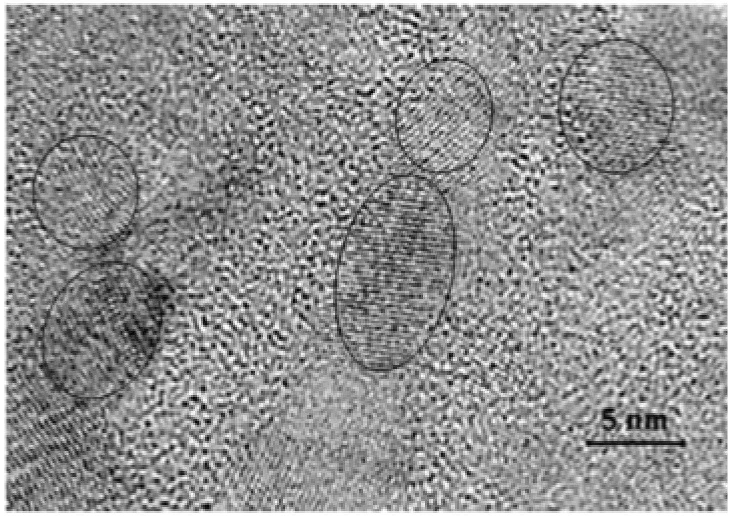
New setup for photoemission electron microscopy (PEEM) and low-energy electron microscopy (LEEM); resolution of about 10 nm in the PEEM mode, and about 5 nm in the LEEM mode)



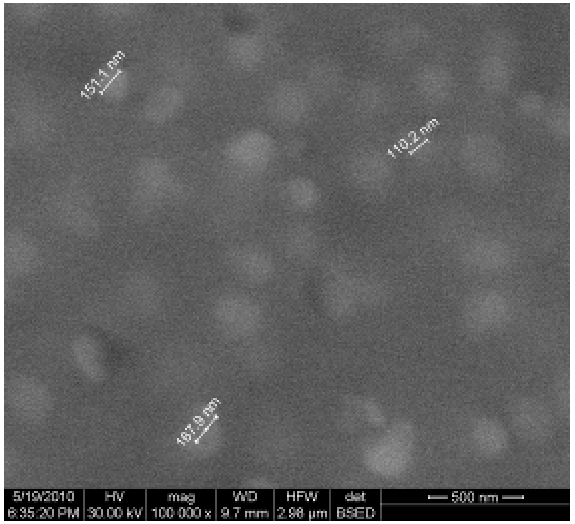
THz-TDS instrument from Aispec (from 40 GHz up to 7 THz)

The R-XAS X-ray absorption spectrometer (from Rigaku, can work in EXAFS and XANES modes)

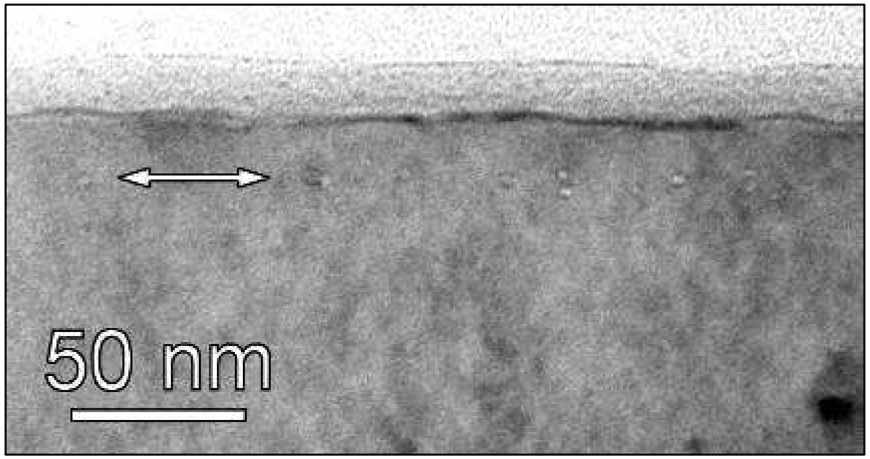
Some recent results



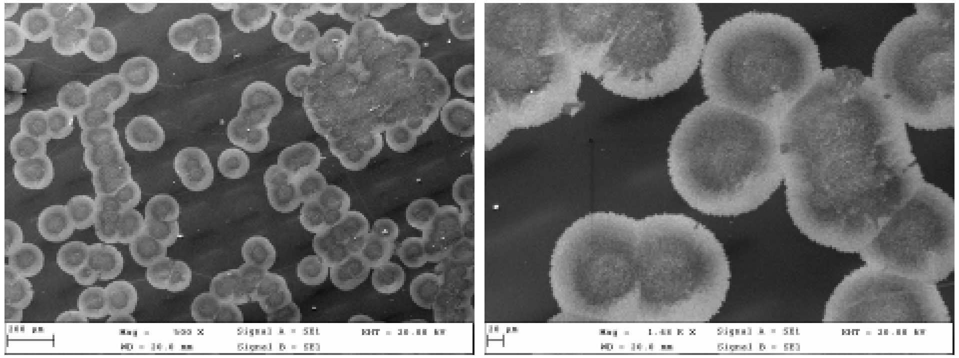
HRTEM image of the Si – SiO_2 structure (for studying quantum confinement of potential barriers in nanodots).
M. L. Ciurea; ciurea@infim.ro



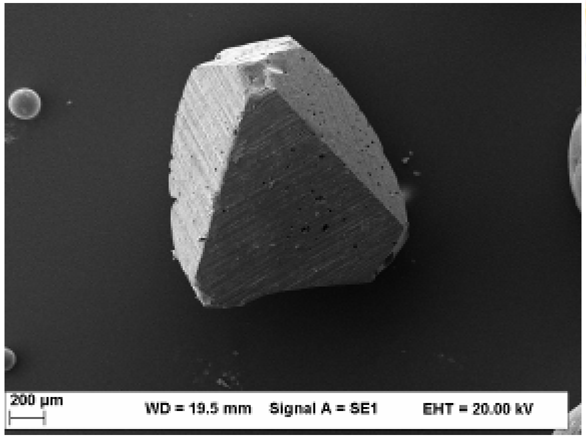
SEM image of GC annealed at 715C, revealing CaF_2 particles embedded in the glass matrix. Glass-ceramic system ($49SiO_2$–$30Al_2O_3$-$20CaF_2$-$1SmF_3$) for luminescent devices.
M. Secu; msecu@infim.ro



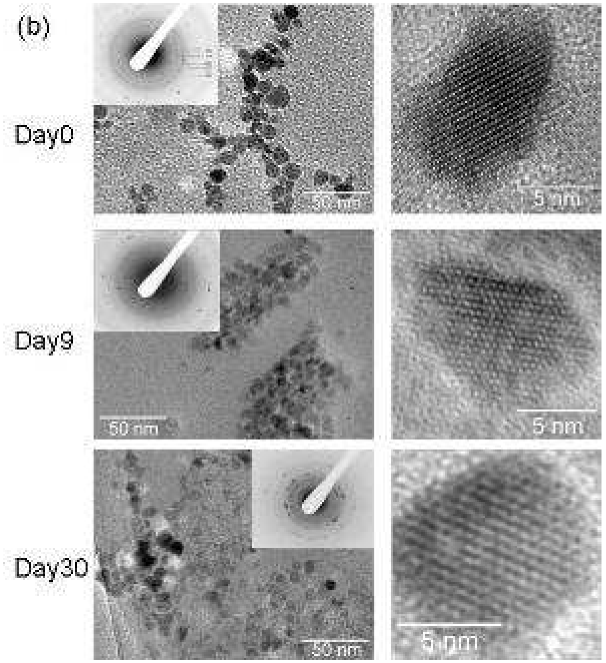
Cross-section TEM image showing the formation of a string of nanocavities (arrow) at 20 nm below the surface of a Si wafer plasma hydrogenated at 50 W and laser annealed (smart-cut with hydrogen implantation and laser thermal annealing).
C. Ghica; cghica@infim.ro



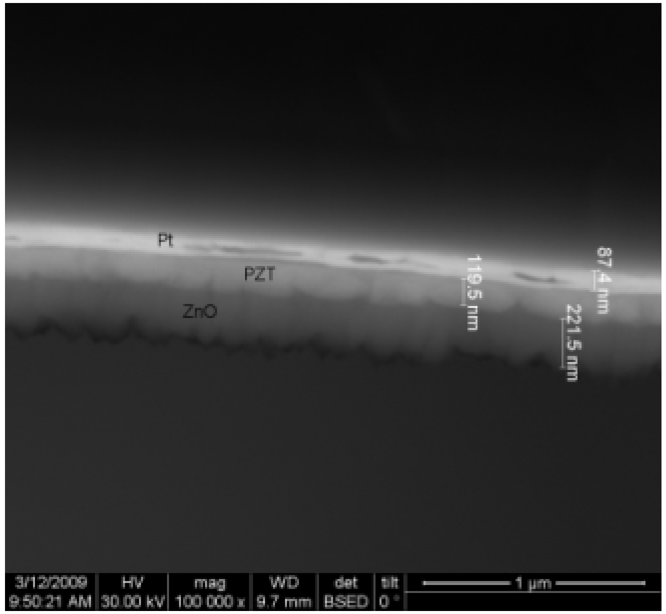
Quantum nanodots deposited by screen-assisted evaporation
(patent; M. Popescu; mpopescu@infim.ro).



Optical micro elements for IR region



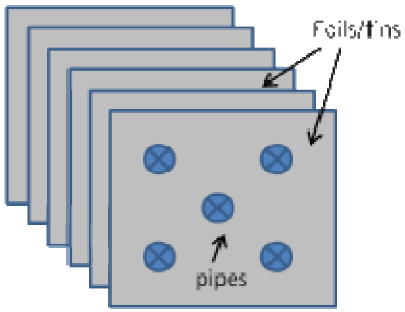
Degradation of magnetic nanoparticles (iron oxide) studied with HR-TEM. The particles are used as contrast agents in MRI (magnetic resonance imaging). C. Ghica; cghica@infim.ro



The cross-section SEM photograph of a ZnO-PZT structure grown by PLD on a Pt/Si substrate. The metal-ferroelectric-semiconductor (MFS) structures are used for non-volatile memory applications.
L. Pintilie; pintilie@infim.ro

National Institute for Nonferrous & Rare Metals

Method to enhance thermal conductivity using ZnO nanostructured coatings



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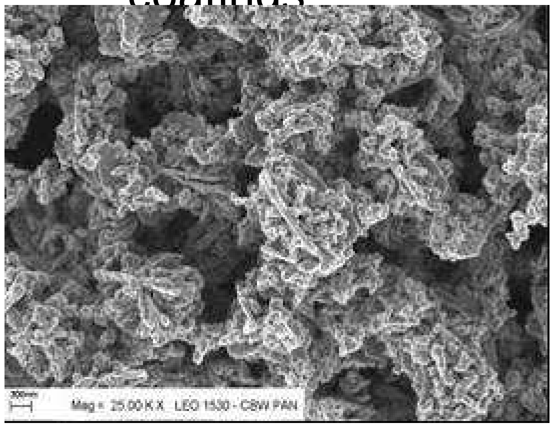

Acknowledgement:
National Programme
IDEAS-Complex
Exploratory Research
Project PCCE ID 106
financed by UEFISCDI
(2010-2012)

An innovative one-step and low cost hydrothermal method was proposed to produce stable suspensions of zinc oxide nanoparticles that are sprayed or spin-coated on the surfaces of thin foils.

Functionalization using Co-doped ZnO nanostructures with flower-like structures will be used as a diluted magnetic semiconductor material with simultaneous 4 times enhancement of thermal conductivity.

Ref. J. Fidelus, R. R. Piticescu, R.M. Piticescu, W. Lojkowski, L. Giurgiu, "***Solvothermal Synthesis of Co-doped ZnO Nanopowders***" **,** *Z. Naturforsch.* 2008, *63B.*

Contact: Dr. Radu R. Piticescu, National Institute for Nonferrous & Rare Metals, Nanostructured Materials Laboratory, 102 Biruintei Blvd., Pantelimon, Ilfov, Romania, Tel/Fax +40213522048, e-mail rpiticescu@imnr.ro

National Institute for R&D in Electrical Engineering ICPE-CA

UHV Magnetron Sputtering & Electron Beam Evaporation System ATC2200 AJA INT.

Functional Parameters:

-Bas pressure min. 5x10-8 torr,

-Evaporation work pressure, 5 x 10 -8 torr.

-Sputtering deposition from four 2” magnetron sputtering sources.

By this equipment can process thin films and multilayers of: Conductive materials, Magnetic materials, Resistive materials, Semiconductors, Izolators

For Micro-Electro-Mechanical Systems (MEMS)

“PROMIT” project financed from STRUCTURAL FUNDS

Hall Effect Measurement System Lake Shore Model 7604

The full-scale resistance range of the standard Model 7604 is from 10 mΩ to 10 MΩ, or from 10 μΩ to 10 MΩ with the 76020 AC Current option.

The standard Model 7604 measures up to two samples at room temperature or with the supplied LN2 pour-fill bucket Dewar, while an optional 4-sample module provides up to four consecutive measurements without changing the hardware configuration.

The Model 7604 Hall effect measurement system can determine sample resistance, resistivity, Hall coefficient, Hall mobility, carrier concentration, and current-voltage characteristics.

The Hall software automatically records data for 4-contact Van der Pauw samples, 6-contact Hall bar samples, and 4-lead magneto-transport measurements to be used for further processing, analysis, and display.

High Resolution Transmission Electron Microsope (HRTEM)

The instrument is dedicated to studies regarding propreties and network structure of different types of materials:

- ✓ Bulk materials
- ✓ Thin layers
- ✓ Wires
- ✓ Powders (properly processed until electronic transparency level)
- ✓ Conductive, semi – conductive or nonconductive samples,
- ✓ Magnetic or feroelectric materials
- ✓ With crystaline or amorphous structure

Highlights:

- ✓punctual spatial resolution : 0.24 nm
- ✓magnification: 50x-1.000.000x

Project financed from STRUCTURAL FUNDS: "Modernization of the infrastructure for promotion of research potential in electrical engineering for applications in priority economic thematic areas of Romania as EU member state. - PROMIT"

Conclusion

- **Reinforcement of the experimental infrastructure in various R&D organizations**
  - **Providing services for industry and education, through IMT-MINAFAB (presented extensively at MMS 2010), see www.imt.ro/MINAFAB;**
- **Increasing interaction with industry (companies abroad and local subsidiaries of multinational companies)**

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- Presented by Prof. Dan Dascalu (CEO and President of the Board of IMT-Bucharest, www.imt.ro). Contact dan.dascalu@imt.ro

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Thank you for your attention!