UNIUNEA EUROPEANĂ
GUVERNUL ROMÂNIEI
Instrumente Structurale 2007-2013

Programul Operaţional Sectorial „Creşterea Competitivităţii Economice“
„Investiţii pentru viitorul dumneavoastră“
CENTRUL DE CERCETARE PENTRU NANOTEHNOLOGII DEDICATE SISTEMELOR INTEGRATE ŞI NANOMATERIALE AVANSATE PE BAZĂ DE CARBON – CENASIC
Proiect co-finanţat prin Fondul European de Dezvoltare Regională

IMT-BUCUREŞTI

Current development at IMT-Bucharest: ‘Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials - CENASIC’

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Project Coordinates

- Sectoral Operational Program - Increase of Economic Competitiveness
- Priority Axis 2 – Competitiveness through research, technological development and innovation
- 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
- Evaluation result: 29/30 pts.
- Implementation deadline: April 2015
- Total value: 6,230 k euro

- Research Centre for Integrated Systems Nanotechnologies and Carbon Based Nanomaterials - CENASIC -

Main Project Aims

- Development of a research center within IMT-Bucharest, dedicated to technologies 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
    - 4 levels: clean room, technical level, plus 2 levels for labs and offices

Proposed Research Directions

- SiC technologies and functional micro-nanostructures
  - Processes for SiC-based micro- and nanostructures
  - Processes and development of wide band gap materials for high-frequency devices and for MEMS/NEMS with application in energy management
  - Processing for metamaterials and 3D nanostructures for integrated optical systems
- Technologies for graphene and hybrid MEMS/NEMS
  - Technologies for graphene synthesis and processing
  - Development and processing of graphene based hybrid materials for structural health monitoring microsystems
  - Technologies for graphene nanoribbons functionalization and integration in MEMS/NEMS
- Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics
  - Technologies for growth and processing of nanocrystalline diamond structures
  - Advanced technologies for nanocrystalline diamond-based sensors applied in scanning probe microscopy
  - Processing of micro- and nanostructures for nanocrystalline diamond resonators

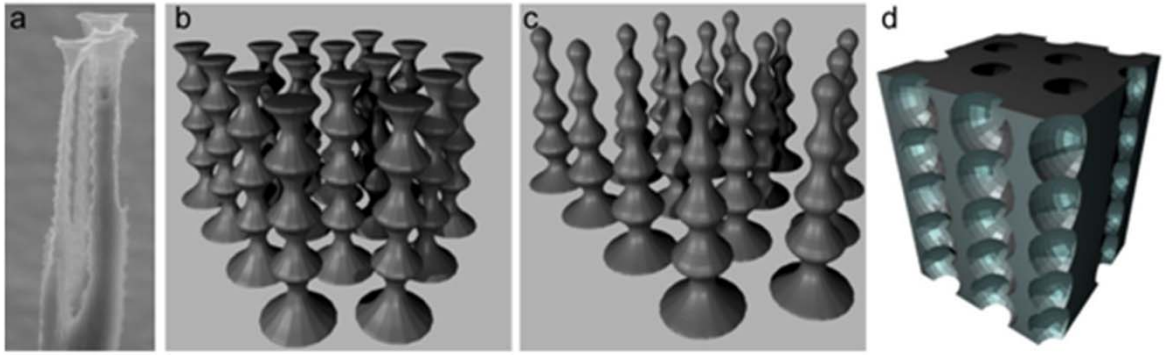
D.1 - SiC technologies and functional micro-nanostructures

D.1.1 - Processes for SiC-based micro- and nanostructures

- investigation of SiC/SiO_2 interfaces and of defects resulted from thermal processing and micro/nanostructuring
- technologies for 3D SiC nanostructured architectures (columns, macropores) for light confinement and guiding
- technologies for fast response/high temperature gas/pressure sensors realized on SiC substrates.

- performance parameters in SiC technology: determined by the quality of SiC-SiO2 interface (e.g., N2O atmosphere gives improved results)

- DRIE-based 3D structuring to obtain photonic crystals with large bandgaps or architectures for light confinement and waveguiding.



Examples of DRIE template and of various columnar structures targeted for fabrication.

D.1 - SiC technologies and functional micro-nanostructures

D.1.2 - Processes and development of wide band gap materials for high-frequency devices and for MEMS/NEMS with application in energy management

- realization of arrays of high frequency devices (SAW/BAW resonators) and NEMS/MEMS for non-conventional power generators (solar, wind power) by modification of SiC electronic properties with wide band gap semiconductors (oxide materials or GaN).
- Realization of piezoelectric nanogenerators for mechanical/vibrational energy conversion in electrical power using wide band gap materials integrated on SiC substrates.

- MBE-grown high-quality GaN/SiC, AlN/SiC thin films on SiC wafers for high-P / high-f devices/MEMS/NEMS: transistors, acoustic wave filters/resonators, piezoelectric layers and nanowires for micro/nano power generators (intermittent vibration energy harvesting), small piezoelectric wind power generation.

D.1 - SiC technologies and functional micro-nanostructures

D.1.3 - Processing for metamaterials and 3D nanostructures for integrated optical systems

- modeling, simulation, design and characterization of metamaterials, photonic crystals, and plasmonic systems.
- synthesis of SiC templates for imprinting metallic metamaterial and nanostructures with applications in photonics.
- novel 3D architectures used in microwaves and advanced structures of transmission lines, resonators, and antennas based on metamaterials integrated in thin dielectric membranes obtained by SiC microstructuring.

- two main objectives:
  1. design-implement-characterize innovative 2D metamaterials obtained by direct embossing of micro/nano SiC templates into metals (Au, Al).
  2. investigate micro/nano-perforated thin SiC membranes as a novel mid-IR metamaterial for efficient thermal radiation sources.

D.2 - Technologies for graphene and hybrid MEMS/NEMS

D.2.1 - Technologies for graphene synthesis and processing

- graphene synthesis based on epitaxial growth on SiC substrate
- optimization of the growth conditions and study of the obtained electro-mechanical characteristics
- realization of graphene nanoribbons

- PECVD fabrication, on SiC substrates
- study the effects of defects and edges - HVLT-STM, Raman, ab-initio DFT methods

D.2 - Technologies for graphene and hybrid MEMS/NEMS

D.2.2 - Development and processing of graphene based hybrid materials for structural health monitoring microsystems

- producing polymer-graphene hybrid materials with controlled physical and chemical characteristics
- structural characterization of the hybrid polymer-graphene thin layers
- technologies for deformation sensors based on polymer-graphene compounds

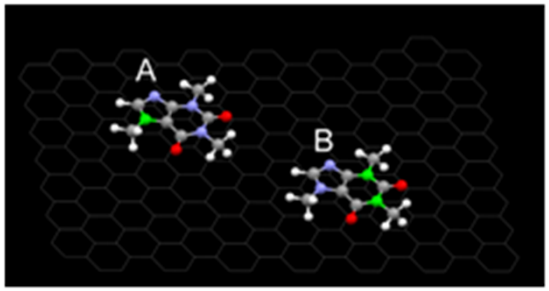
- address the main open topics in such nanocomposites: physical/chemical homogeneity of graphene nanoribbons; dispersion homogeneity; interface properties with the polymeric matrix; stability.
- development of an RDI technological platform for: design, development and optimization of micro/nano sensors for detection of strain and vibration - structural health monitoring of automotive and construction components.
- analytical methodology: MD-modeling the interface chemistry; modeling micro/nanosensors performance parameters as a function of process parameters.

D.2 - Technologies for graphene and hybrid MEMS/NEMS

D.2.3 - Technologies for graphene nanoribbons functionalization and integration in MEMS/NEMS

- processes of chemical functionalizations on the entire graphene surface or parts of it
- technologies for graphene nanoribbons sealing on functionalized substrates
- technologies for graphene layers nanostructuration for gas separation by molecular diffusion in integrated membranes systems
- technologies for graphene nanoribbons integration in MEMS/NEMS

- graphene layers used as filtering/gas separation membranes - pressures as high as 1 atm., impermeable to standard gases.
- EBL-based (EBID/E) structuring for creating controlled pores - selective molecular diffusion (e.g., extraction of H from synthesis NH3, separation of CO2 from CH4, removal of SF6 from electrical installations.
- graphene sealing on microstructured substrates (e.g, SiO2) for integration of membranes - by functionalization schemes using perfluorophenil azides.



Schematic illustration of functionalized carbon nanoribbons (two cafeine molecules addsorbed on a single layer crystal of graphene)

D.3 - Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics

D.3.1 - Technologies for growth and processing of nanocrystalline diamond structures

- production of nanocrystalline diamond layers on SiC substrates
- deposition of nanocrystalline diamond via thermal CVD processes
- deposition of nanocrystalline diamond via plasma enhanced CVD processes

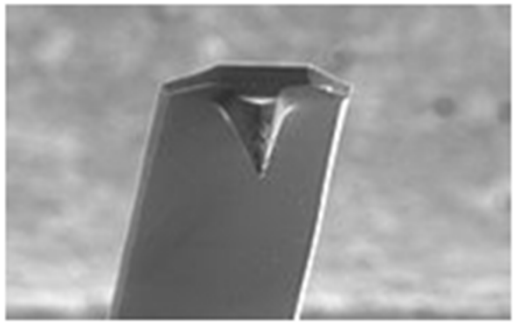
- PECVD based fabrication.
- characterization by SEM-EDX, STS, Raman: crystallography, defect density of states in the band gap.

D.3 - Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics

D.3.2 - Advanced technologies for nanocrystalline diamond-based sensors applied in scanning probe microscopy

- processing of diamond-based cantilevers for tapping-mode atomic force microscopy
- processing of diamond-based cantilevers for lateral force microscopy
- synthesis of nano-engineered diamond scanning probes for assessing nanomaterials and quantum devices

- monolithic fabrication of diamond cantilevers, using micromachining using wet and plasma etching.
- application-oriented diamond scanning probes (cantilevers, resonators): e.g., for readout of quantum devices properties (density of states).

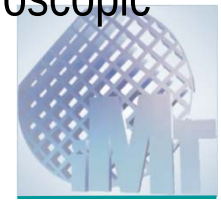


D.3 - Technologies for nanocrystalline diamond and applications in MEMS/NEMS and precision mechanics

D.3.3 - Processing of micro- and nanostructures for nanocrystalline diamond resonators

- development of micro- and nanomechanical high frequency resonators, stable at high temperatures, from nanocrystalline diamond
- realization of disk resonators from nanocrystalline diamond
- production of high quality diamond torsion resonators with arbitrary organic functionality by the development of a combinatorial chemistry platform

- high-f resonators for RF components (e.g., band-pass filters) and chemical sensors
- keeping high Q while decreasing resonator size: diamond has 2.25x, and 1.57x greater acoustic velocity than Si, and SiC respectively. Added enhancement: laser heating parametric amplification.
- optimize the chemical coating of diamond torsion resonators to improve detection sensitivity: combinatorial approach
  - Starting from -OH terminated and -H terminated diamond surfaces - electronically-active defects play a dominant role at the nanoscale
  - Implement a library of coatings and characterize the properties (IR, spectroscopic ellipsometry).



New Labs and Main Equipments [1]

- 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)
  - MBE (AlN,GaN,.../SiC), ALD, RF-sputtering
  - 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)
  - PECVD

New Labs and Main Equipments [2]

- 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

Other Performance Indicators

- 10 new R&D positions (5 specialists attracted from abroad)
- 5 positions for doctoral students on the project thematic
- Internship programs for scientific and technological training (3-7 students)
- 33 new types of R&D services offered through the IMT-MINAFAB collaboration interface

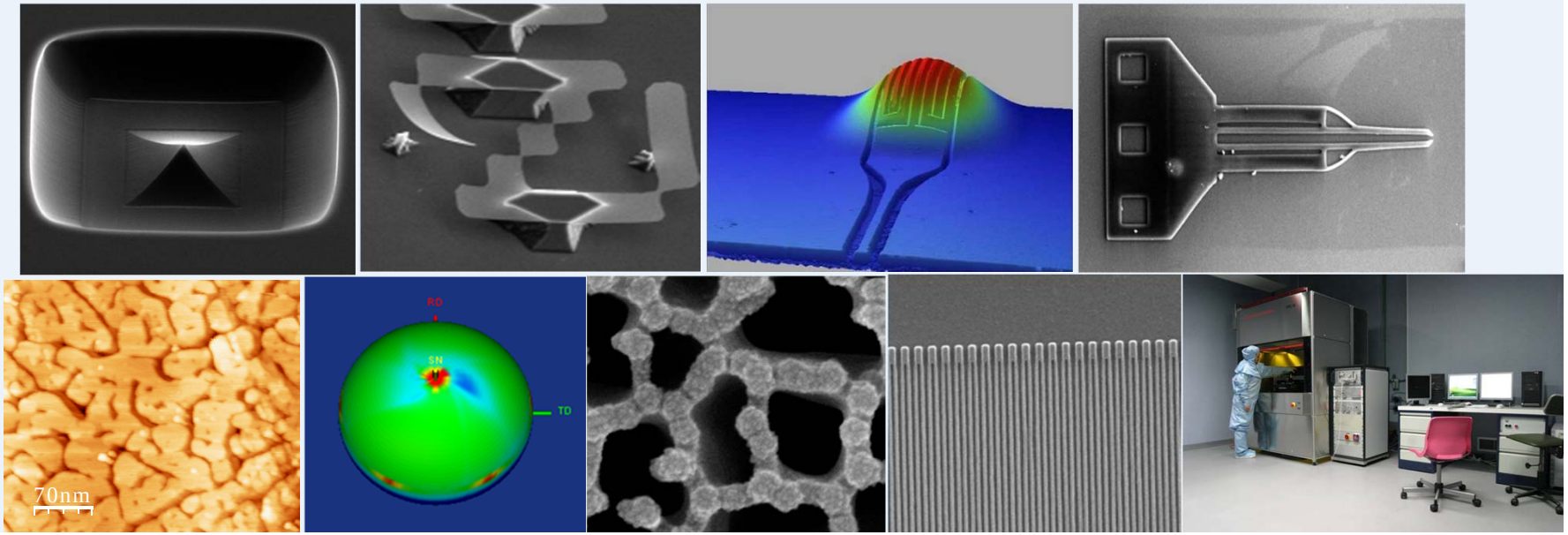
CENASIC context - IMT- MINAFAB

New CENASIC center in existing IMT-MINAFAB infrastucture

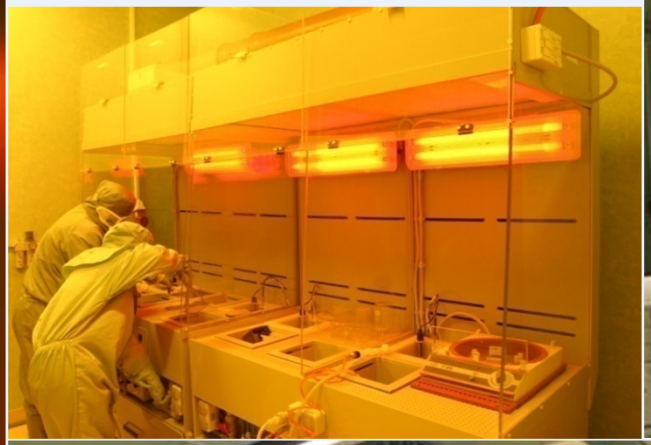
Fabrication:	Carbon-dedicated PECVD tool	
	Horizontal furnace	
	Molecular beam epitaxy	
	ALD, RF-sputtering	
	...and	LPCVD/PECVD tools
		RIE/DRIE tools
		Nanolithography tool, *etc*
Characterization:	FTIR	
	Confocal Raman SNOM upgrade, TERS, *etc*	
	...and	electrical from DC to 110 GHz on wafer
		surface and materials structural analysis tools
		mechatronics setups, *etc*
Simulation:	Computing cluster upgrade	
	...and	Coventorware, Ab-init, ANSYS, *etc*

Clean-room facilities

- Class 1,000 clean room (220 sqm) for the mask shop and the most demanding technological processes - since 2008
- Class 100,000 clean room (200 sqm), mostly for the analysis/characterization equipments - since 2008
- Class 10,000 clean room (130 sqm), for thin films by CVD techniques, DRIE, RTP, etc. (to become operational).
- Plus 200 sqm. - CENASIC, class *1,000,* reaching a total of 700 sqm.




SENTECH
SI 220
Clean room,
class 1,000



Clean room, class 10,000

System for heat recovery

PECVD + LDS

Rapid thermal processing

LPCVD

Equipment overview [1]

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

Equipment overview

Pattern generator for mask manufacturing
DWL 66 fs
Heidelberg Instruments Mikrotechnik, Germany

Mask manufacturing for all semiconductor applications
Minimum pattern : 1µm

Direct writing - HeCd 442-nm laser - (wafers, different substrate types) using various photosensitive coatings (positive and negative resists, SU8, photosensitive polyimide)

-3D structuring in thick photosensitive materials

Equipment overview

Dip Pen Nanolithography Writer
NSCRIPTOR
NanoInk, Inc., USA

Scanning probe lithography technique for patterning in nanometre range.

Direct writing method that can use molecular and biomolecular “inks” on a variety of substrates: polymers, sol-gel precursors, nanopowder, complex molecules, quantum dots etc.

Pattern width down to **30 nm**.

Equipment overview

RIE Plasma Etcher
Etchlab 200
SENTECH Instruments, Germany)

Conventional and non-conventional processes:

- **Etching:** Si, SiC, SiO2, polySi, Si3N4, TiO2, SU8, PDMS, PMMA

- Physical-chemical reactions at room temperature for the **modification of the surfaces** (contact angle, superficial polymerization, hydrophilic and/or hydrophobic surfaces).

- Plasma RF treatments for **improving the substrate adherence.**

Equipment overview

Electron Beam Evaporation and DC sputtering system
AUTO 500
BOC Edwards, UK

Film deposition processes:
- **DC sputtering**
- **e-beam evaporation**

Chamber size: 500mm x 500mm

Coating materials: Al, Ni, Cr, Au, Pt, Ti, W, etc

Up to 6 coatings in a single vaccum process (4 e-beam, and 2 sputtering)

Resolution: 0.1nm

NanoScale Lab

Electron beam lithography and nanoengineering workstation *e_Line* Raith, Germany

- **high resolution FE SEM**
- **direct writing Electron Beam nanoLithography (EBL)**
- **nanomanipulation: e-beam induced deposition (EBID), e-beam induced etching (EBIE)**

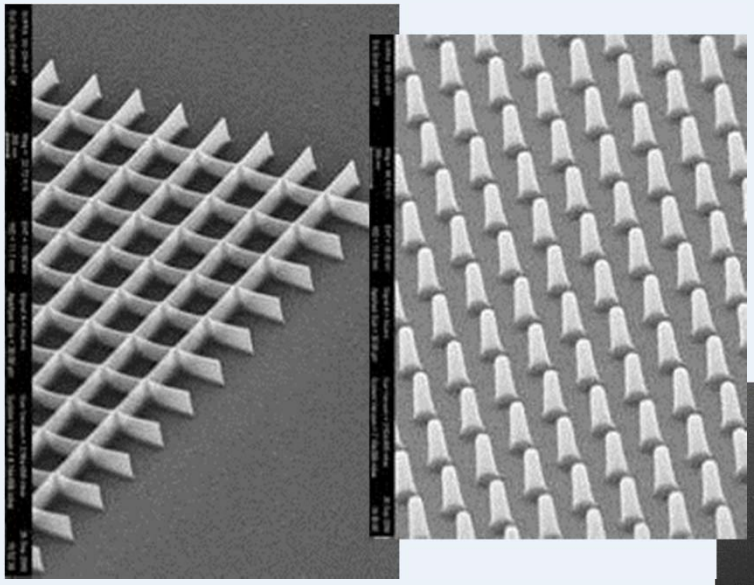
Stage:
laser interferometer;
100mmx100mm;
2nm resolution

Minimum line width:
10-20nm

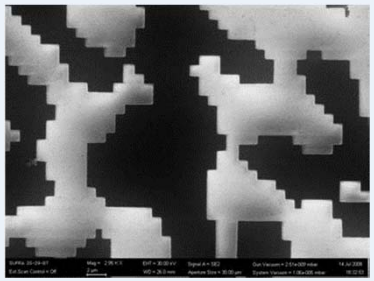
Stitching accuracy:
40nm

NanoScale Lab

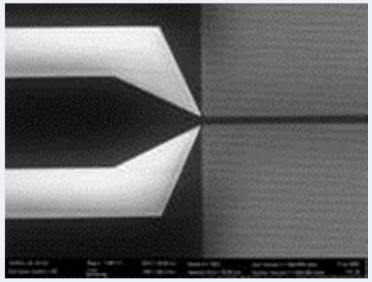
High aspect ratio (12:1) structures in PMMA

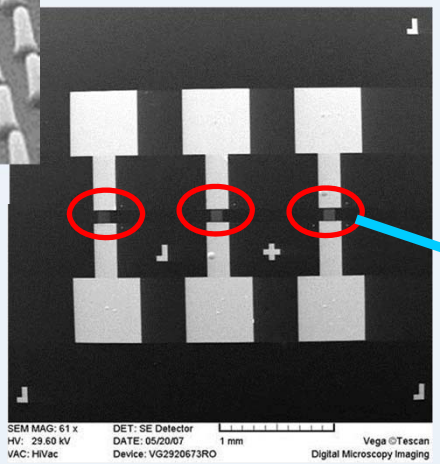


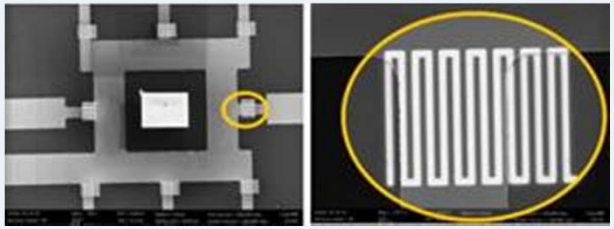
Diffractive Optical Element (DOE) for photonics applications



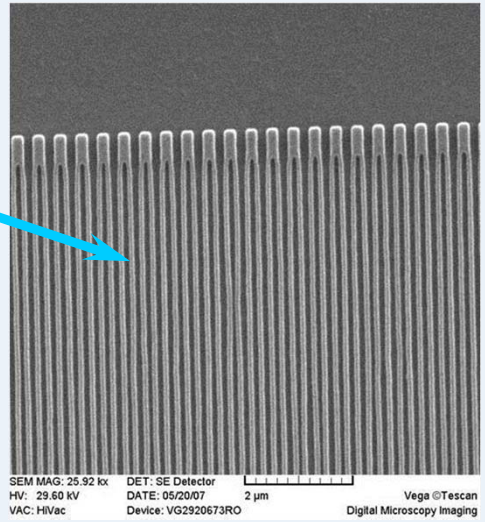
Photonic cristals in PMMA on silicon for near IR applications







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



Mix-and-match lithography for 300 nm fingers used for SAW devices (Cooperation IMT Bucharest- IESL FORTH)

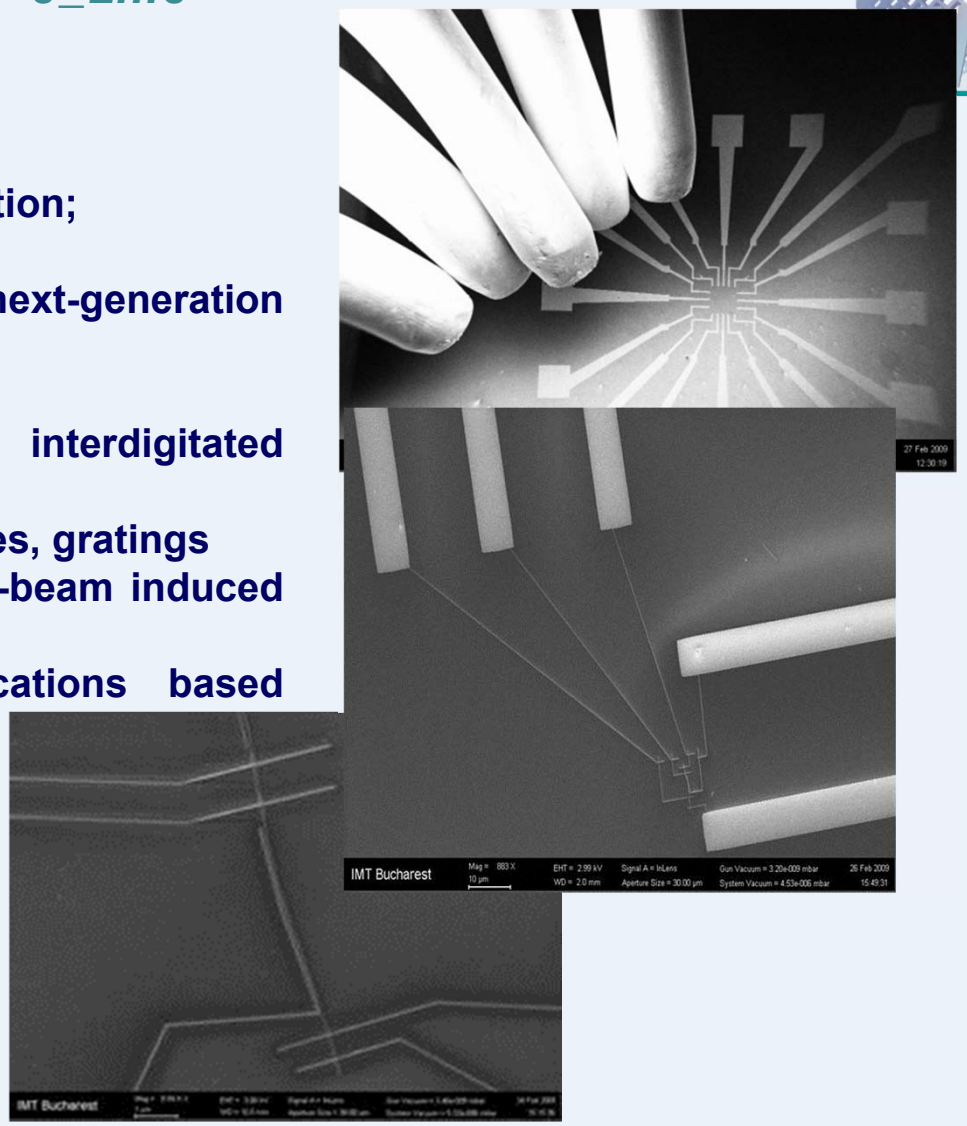
NanoScale Lab

Research Topics

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

Cooperation

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



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

NanoScale Lab

Field Emission Gun Scanning Electron Microscope (FEG-SEM)
Nova NanoSEM 630
FEI Company, USA

- ultra high resolution in the nanoscale range, for a variety of applications that involve sample characterization, analysis for S/TEM sample preparation

Research

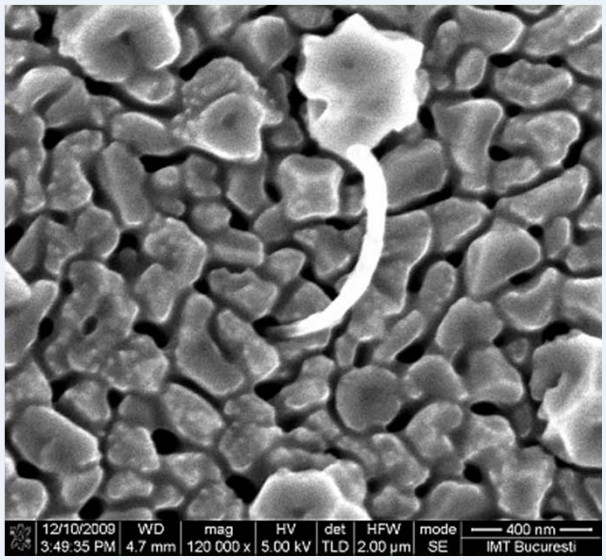
- Materials Qualification
- Surface morphology inspection
- Nanometrology
- Device Characterization

Main current cooperation

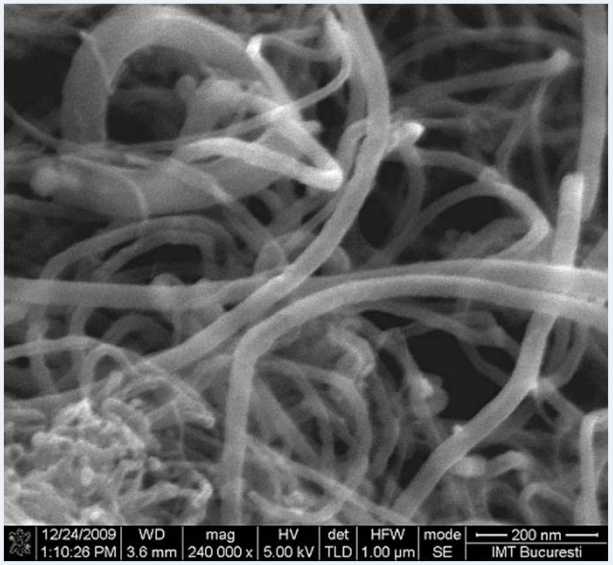
- *INFN Rome*
- *FORTH Heraklion*
- *Univ. Salerno*
- *Univ. Kyoto*

NanoScale Lab

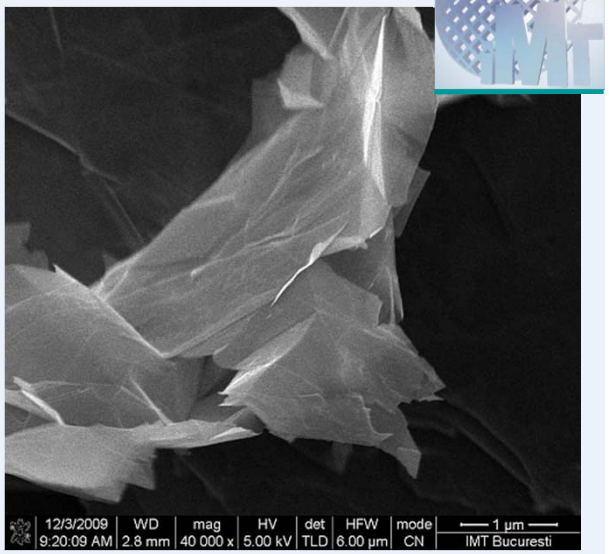
Nova NanoSEM 630



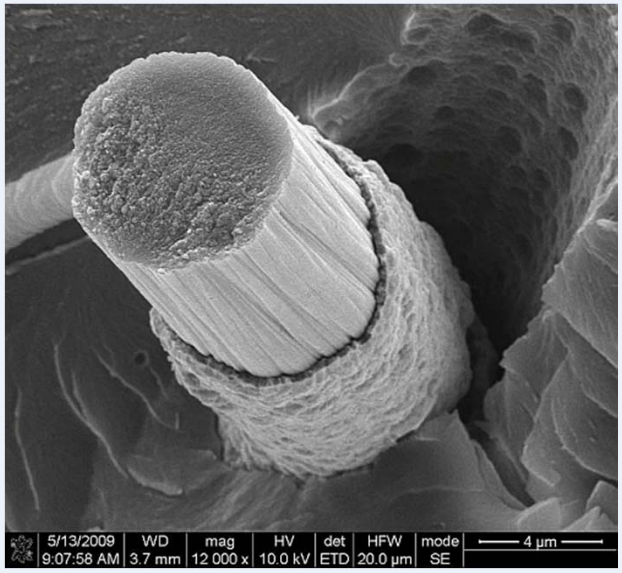
Carbon nanotube grown in porous Al2O3
(IMT Bucharest for **FP7 CATHERINE**)



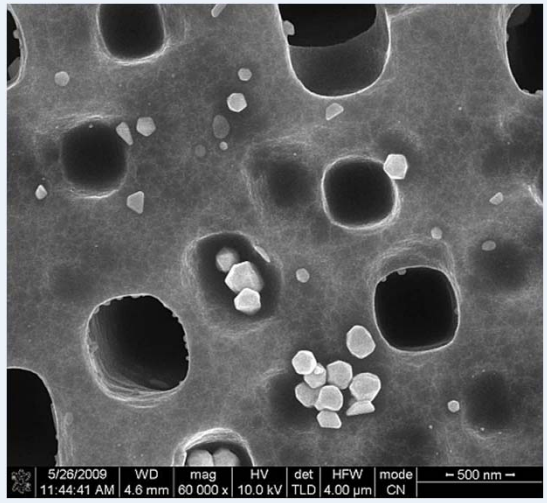
CNT "buckypaper"
(IMT Bucharest for **national project**)



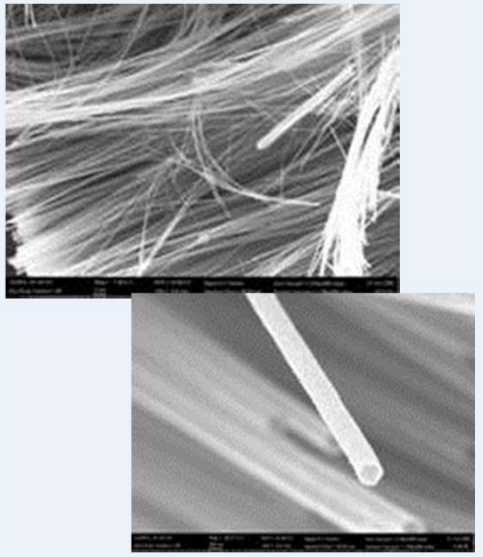
Graphene flakes
(IMT Bucharest, **national project**)



Nanofiber bundle coated with Ni, embedded in polymer susbtrate - applications in aeronatics (radar screening) - sample from INFN Rome



Au nanoparticle clusters on porous Si
(**national project**, biosensing)



HR CNT bundle

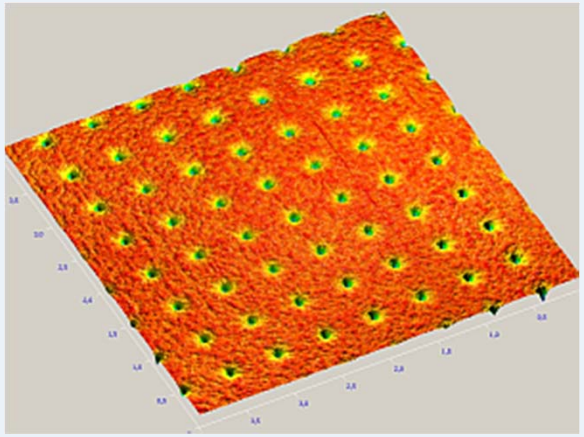
NanoScale Lab

Scanning Probe Microscope
NTEGRA Aura
NT-MDT Co., Russia

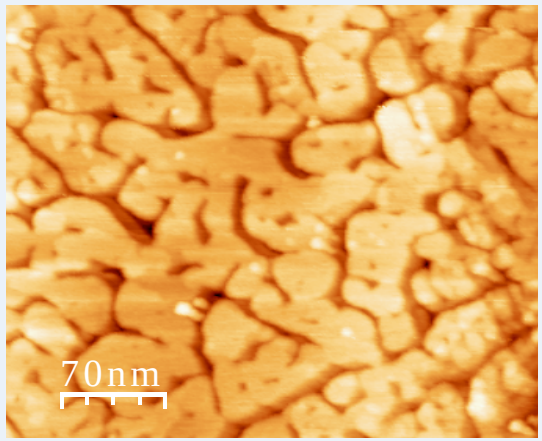
- **AFM - dry**
- **AFM - wet cell**
- **STM**
- **LFM**
- **etc.**

Research

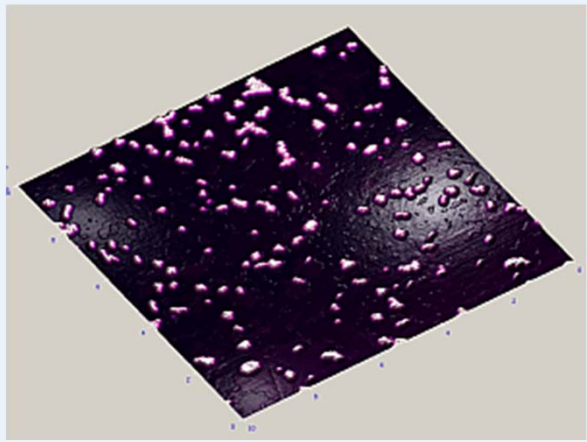
- Surface morphology inspection
- Quantitative measurement of surface features at nanometric level
- Nano-surface texture/ roughness measurement
- High-resolution surface profilometry
- Evaluation and optimization of thin film coatings for various applications (optical, packaging, paintings, wear-resistant etc)
- Grain and particle size analysis
- Surface cleaning and polishing studies
- Morphological studies of biological and biocompatible materials



AFM: EBL 80nm pits



STM: Terrraces of template stripped gold



AFM: Latex nanoparticles on quartz

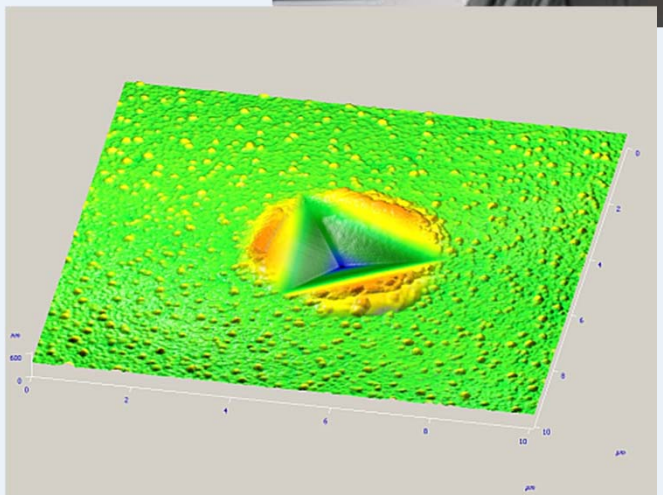
NanoScale Lab

Nanomechanical Characterization equipment
Nano Indenter G200
Agilent Technologies, USA

Research

•High resolution *mechanical characterization* of a wide variety of materials in small volumes, thin films and coatings:
-metals,
-semiconductors
-ceramics
-biocompatible material.

•Determine:
-hardness,
-film adherence
-wear behaviour, etc.



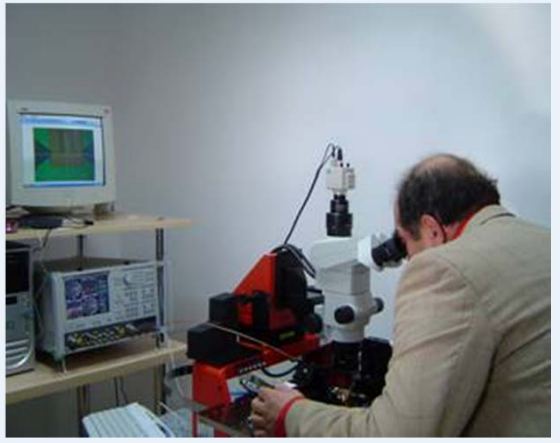
Al indentation study

MIMOMEMS labs

MIMOMEMS

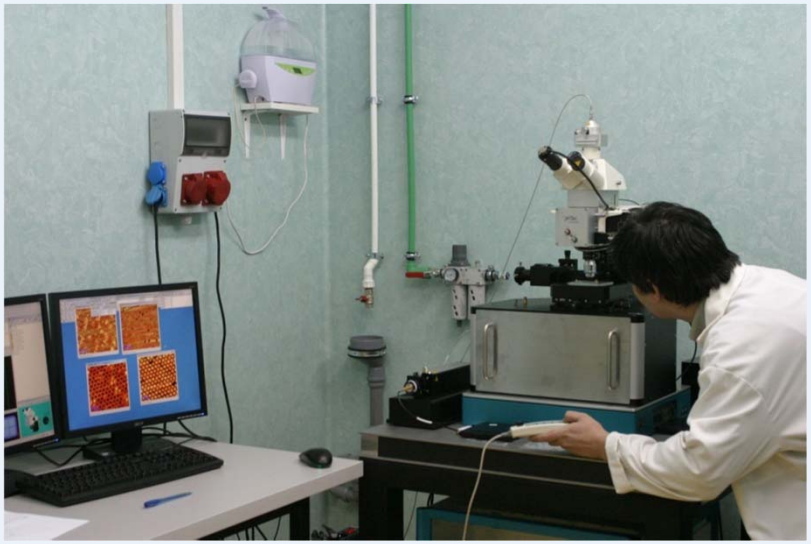
Equipments acquired in the MIMOMEMS project

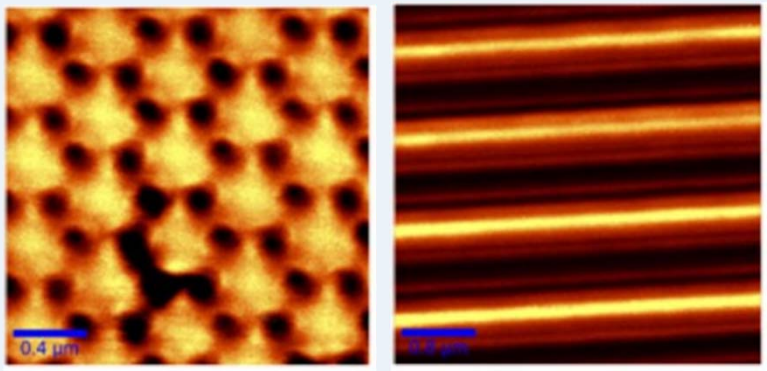
- **Vector Network Analyzer (VNA) up to 110 GHz** and **on wafer measurement facilities in order to upgrade the 0.8-65 GHz existing on wafer characterization system**
- **Frequency synthesiser up to 65GHz**
- **Au plating facility for semiconductor wafers**
- **White light interferometer- optical profiling system for research applications**
- **Near field scanning optical microscope (SNOM)**



MIMOMEMS labs

Scanning Near-field Optical Microscope
alpha 300S
Witec, Germany





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

Operating Modes:

***Near-field microscopy*: transmission, reflection, collection, fluorescence**

***Confocal microscopy*: transmission, reflection, fluorescence, can be upgraded with a Raman spectrometer**

***Atomic Force Microscopy* contact and AC-Mode**

Applications:

- Imaging the optical properties of a sample with resolution *below the diffraction limit* with applications in nanotechnology, nanophotonics, nanooptics and plasmonics
- Life sciences
- Materials research
- Single molecule detection.

Cooperation examples:

- MIMOMEMS-REGPOT-FP7
- FLEXPAET-IP- FP7/NMP

XRD lab

X-ray Diffraction System (triple axis rotating anode)
SmartLab
Rigaku Corporation, Japan

Technical characteristics:

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

X- Ray methods and applications for structural Analysis:

X-ray Powder diffraction (XRPD)

High resolution X-ray diffraction (HRXRD) - phase analysis, crystal orientation, thermal stability

X-ray reflectometry (XRR, including HRMR XRR) - layer thickness, density, roughness, interface layers;

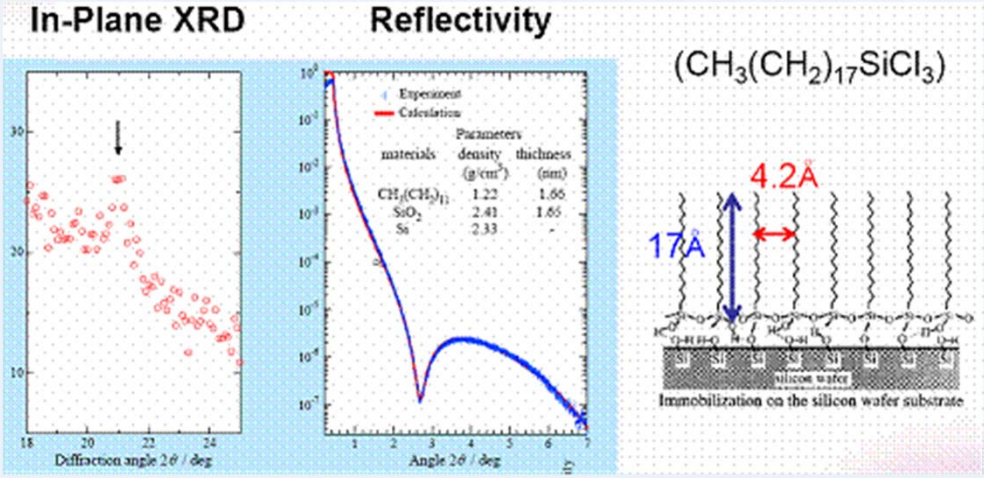
Grazing incidence diffraction (GIXRD) - texture analysis and pole figures

In-plane grazing incidence diffraction (IPGID)

Small angle X-ray scattering (SAXS)

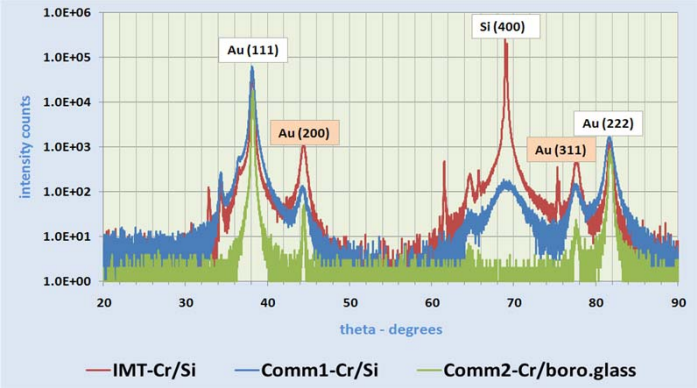
Single crystal diffraction (SCD)

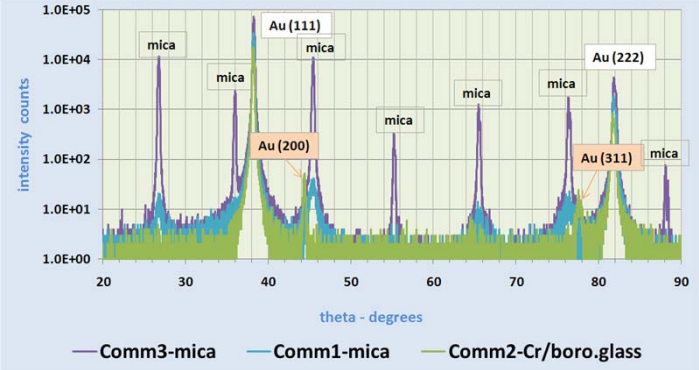
Investigation of the $CH_3(CH_2)_{17}SiCl_3$ organic film monolayer

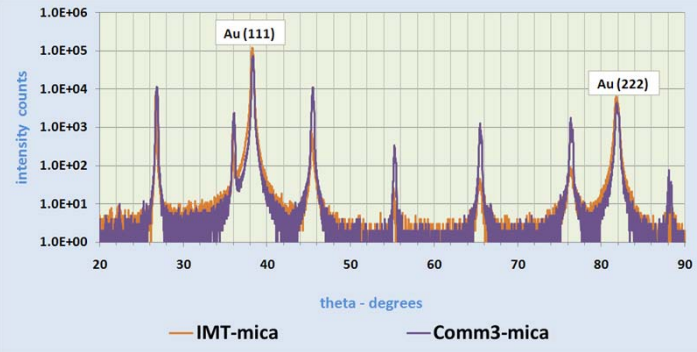


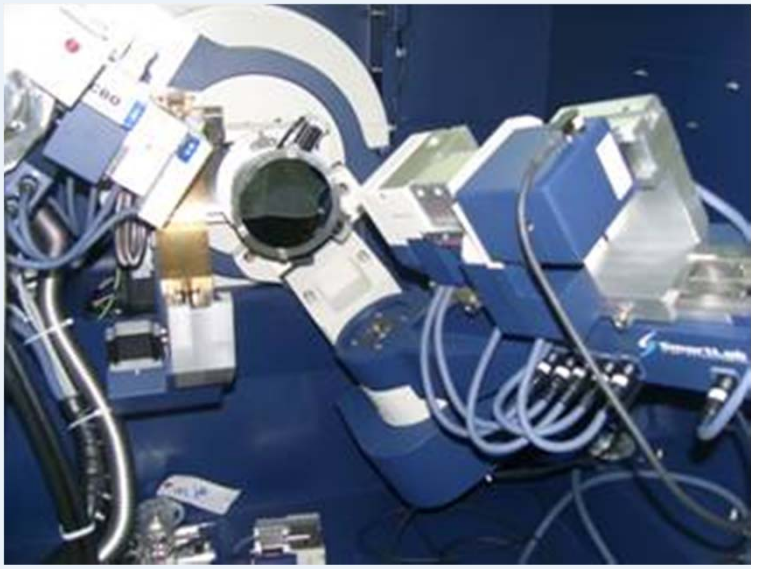
SmartLab

XRD lab

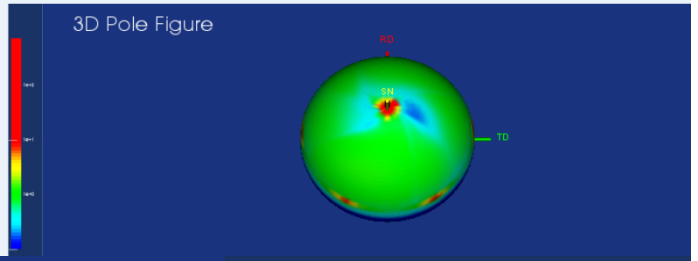


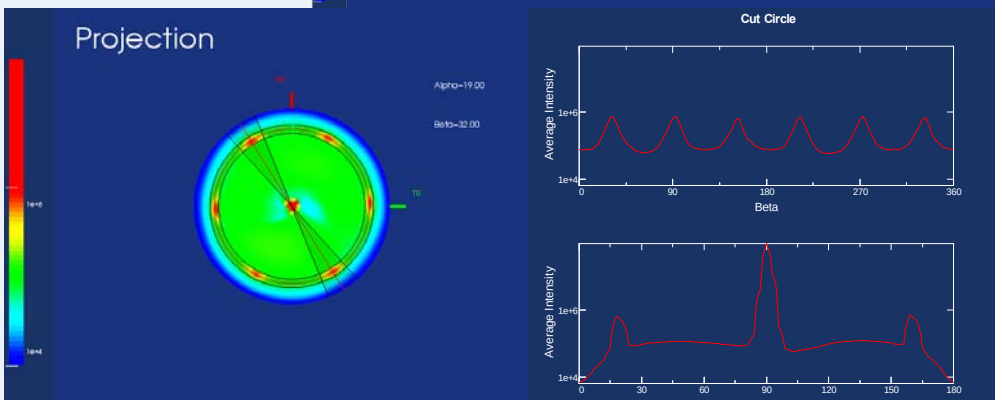






Investigation of IMT-optimized Au 111 deposition



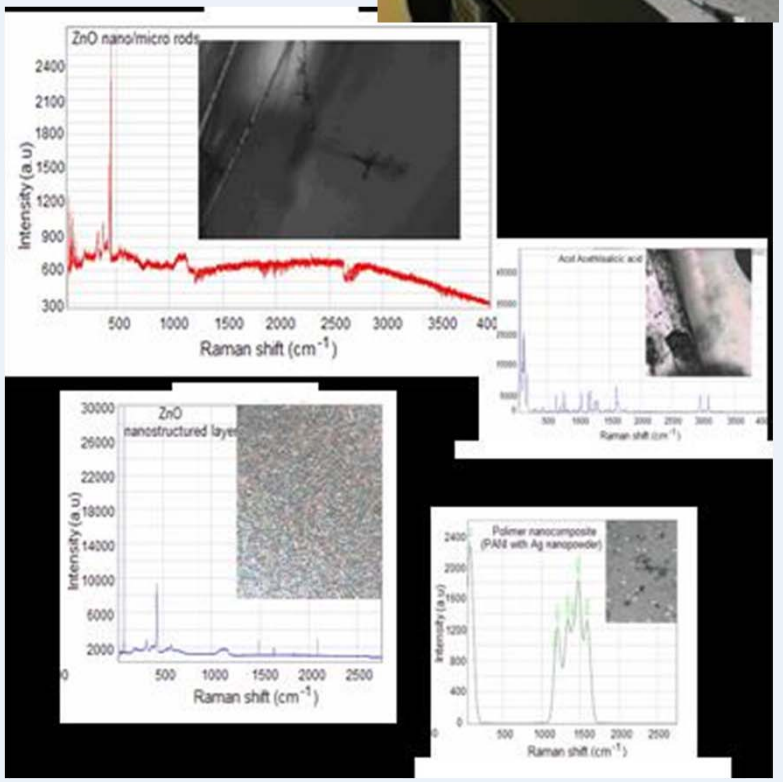


RAMAN lab

High Resolution Raman Spectrometer
LabRAM HR 800
HORIBA Jobin Yvon, Japan

μ- Raman investigations of micro/nano structures

- composition and phase (crystalline/amorphous) of composites materials;
- nature of oxides on compound semiconductors;
- polymers characterizations and polimer nanocomposites;
- chemical and biological detection using SERS technique;
- micro/nano structures characterization - micro/nanorods, carbon nanotubes (CNT), self
- self assembled molecule (SAM) on functionalized substrate for nano- bio applications



Nanobiotechnology laboratory: NanoBioLab

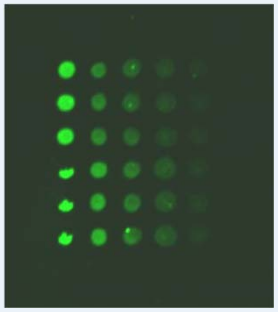
NanoBioLab

Micro-Nano Plotter
OmniGrid
Genomic Solutions Ltd., UK

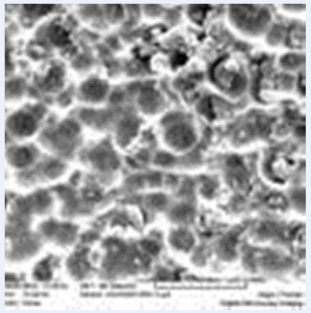
Dip and spot a given volume of sample solution onto a solid surface

Print speed:
10,000 spots/11 slides in less than 3.5 hr

Vacuum wash station for washing between sample transfers; humidity control minimizes sample evaporation



Microarray sample



Au/PS samples after BSA printing - SEM

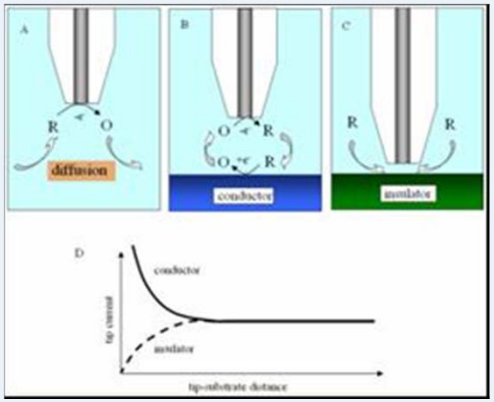
Cooperation example:
- DNASIP-ERA-NET- focused diagnostic DNA chips

NanoBioLab

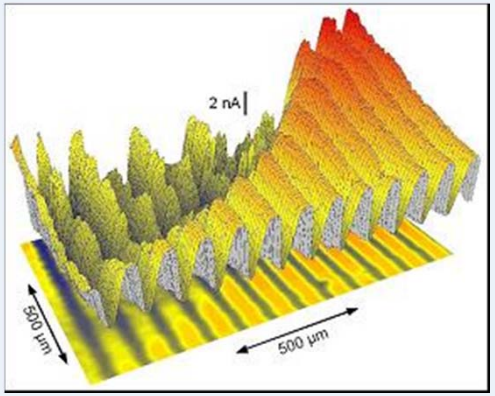
Scanning Electrochemical Microscope
ElProScan
HEKA, Germany

- Positioning system with 3 stepper motors (XY - 100 nm or 15 nm stepper motors) and a piezo translator (5 nm resolution and 100 mm scan range, closed loop regulated)
- Bipotentiostat/Galvanostat PG 340 with two low current Preamplifiers
- Software POTPULSE with SCAN extension

Principle of detection



Directly measuring of the catalytic activity of biosensor microelectrode arrays

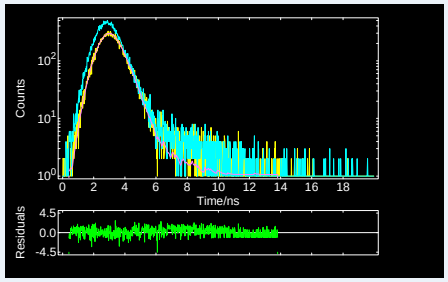


Applications:

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

NanoBioLab

Combined Time Resolved and Steady State Fluorescence Spectrometer - *FLS920P* - Edinburgh Instruments, UK



Fluorescence decay of BSA-Cy3

Applications: photophysics, photochemistry, biophysics and semiconductor.

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

Pharmaceutical : monitoring drug interactions**.**

Materials physics: study nanostructures such as quantum wells and quantum dots; characterisation of doping or impurity level in semiconductors.

Zeta Potential and Submicron Particle Size Analyzer - *DelsaNano* - Beckman Coulter, USA

Applications

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

Reliability lab

Testing for reliability

- **Semiconductor Characterization System (DC) with Wafer Probing Station - *4200SCS/C/-***
  - various modules- (Keithley Instruments, USA)
- **Mobile Thermal Airstream System - *ThermoStream TP04300A-8C3-11*** (Temptronic, USA)
- **Damp heat Climatic chamber** (Angelantoni, Italy)
- **Electrodynamic vibration system with thermal and electrical tests - *TV 55240/LS*** (TIRA, Germany)
- **Thermal shock chamber - *TSE-11-A*** (Espec Europe, Germany)
- **Universal Ovens with electrical testing - *UFB 400*** (Memmert, Germany)
- **Highly Accelerated Stress Test Chamber - temperature, humidity, pressure, polarization - *EHS-211M*** (Espec Europe, Germany)
- **Free Fall Shock Machine - *0707-20*** (MRAD, USA)

CAD/CAE/Multiphysics

Simulation, Modeling, CAD / CAE, Multiphyiscs

High power computing hardware - IBM x3850 HPC server
32 cores XEON X7350 @ 2.93 GHz
RAM 200 GB
HDD 1.5 TB

Coupled analysis for MEMS
CoventorWare (COVENTOR, USA)

ARCHITECT, DESIGNER, ANALYZER, MemElectro, MemMech, CoSolveEM, MemETherm, MemPZR, MemPZE, Damping MM, InertiaMM, MemHenry, MemCFD, Netflow, SwitchSim, ReactSim, MemFSI, BubbleSim, DropSim, SEMulator3D, EM3D

Ansys Multiphysics (ANSYS, USA) - structural, thermal, acoustic, electromagnetic and coupled field analyses, CFD
COMSOL Multiphysics

Photonic components - simulation, modeling and design
Opti FDTD, Opti-HS, OptiBPM, OptiGrating (Optiwave, Canada)

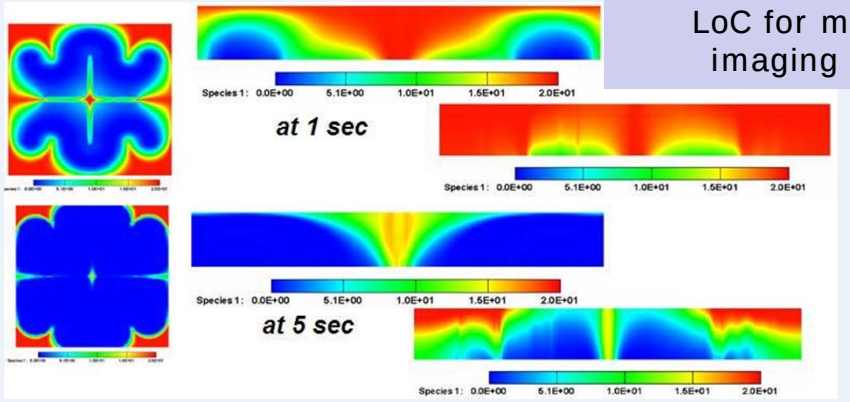
Microwave and millimeter wave circuits and microsystems: design and modeling
IE3D, FIDELITY (Zeland, USA)

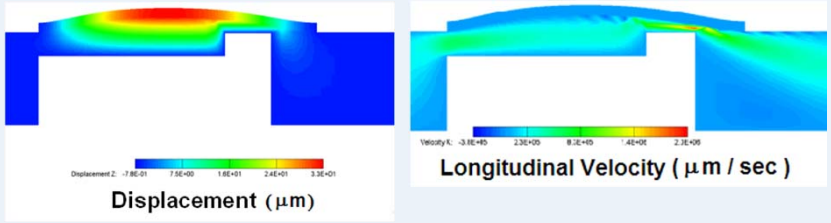
Quantum physics/chemistry : electronic structure calculations and *ab initio* molecular dynamics simulations of molecules and solids
SIESTA (ICMAB-SIESTA)

Other tools
TransMagic STANDARD (TWeatherford, USA)
SolidWorks Office Professional (SolidWorks, USA)- 3D CAD design software

CAD/CAE/Multiphysics

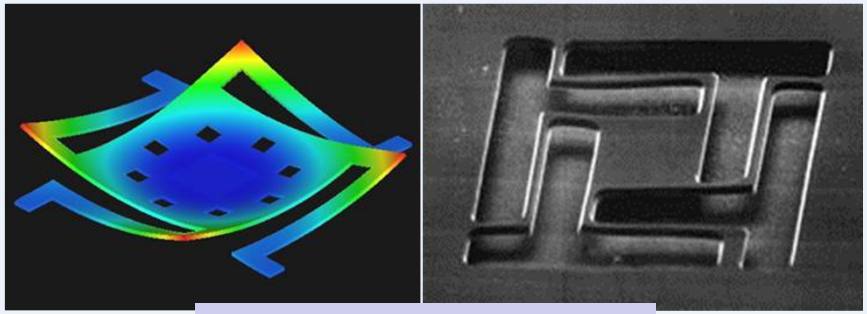
LoC for molecular imaging agents



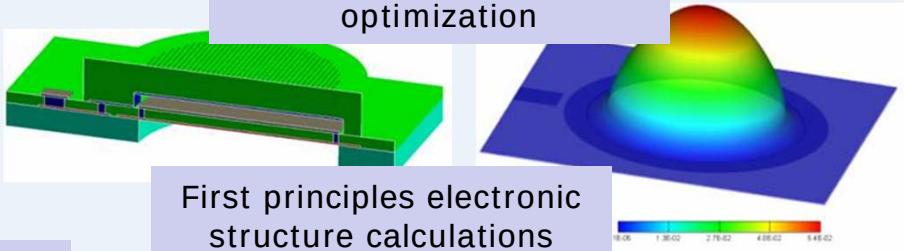


MI-Lab-on-Chip - FP6 STREP/NMP

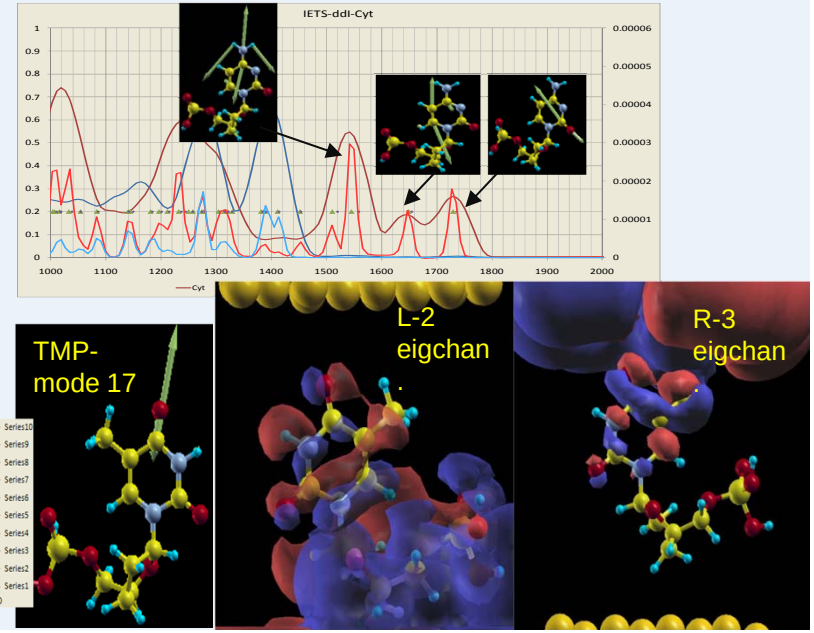
Si microreflector optimization



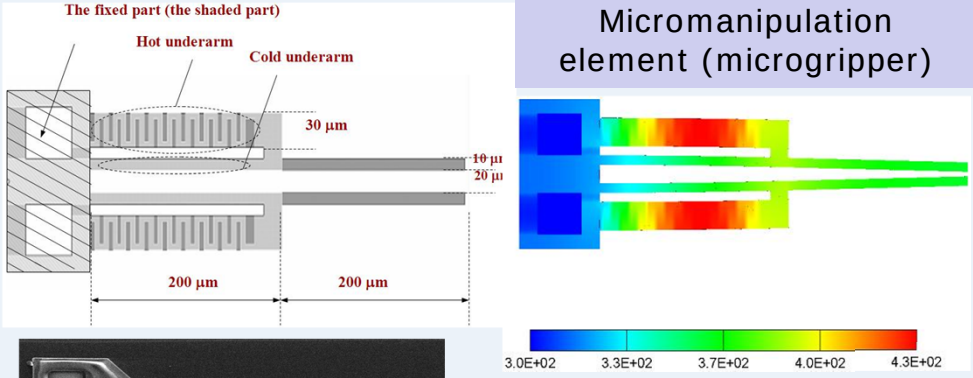
Capacitive microphone optimization

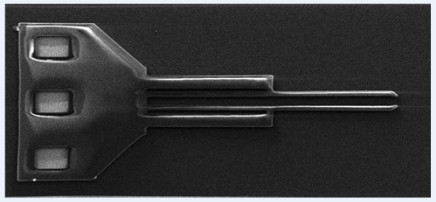


First principles electronic structure calculations



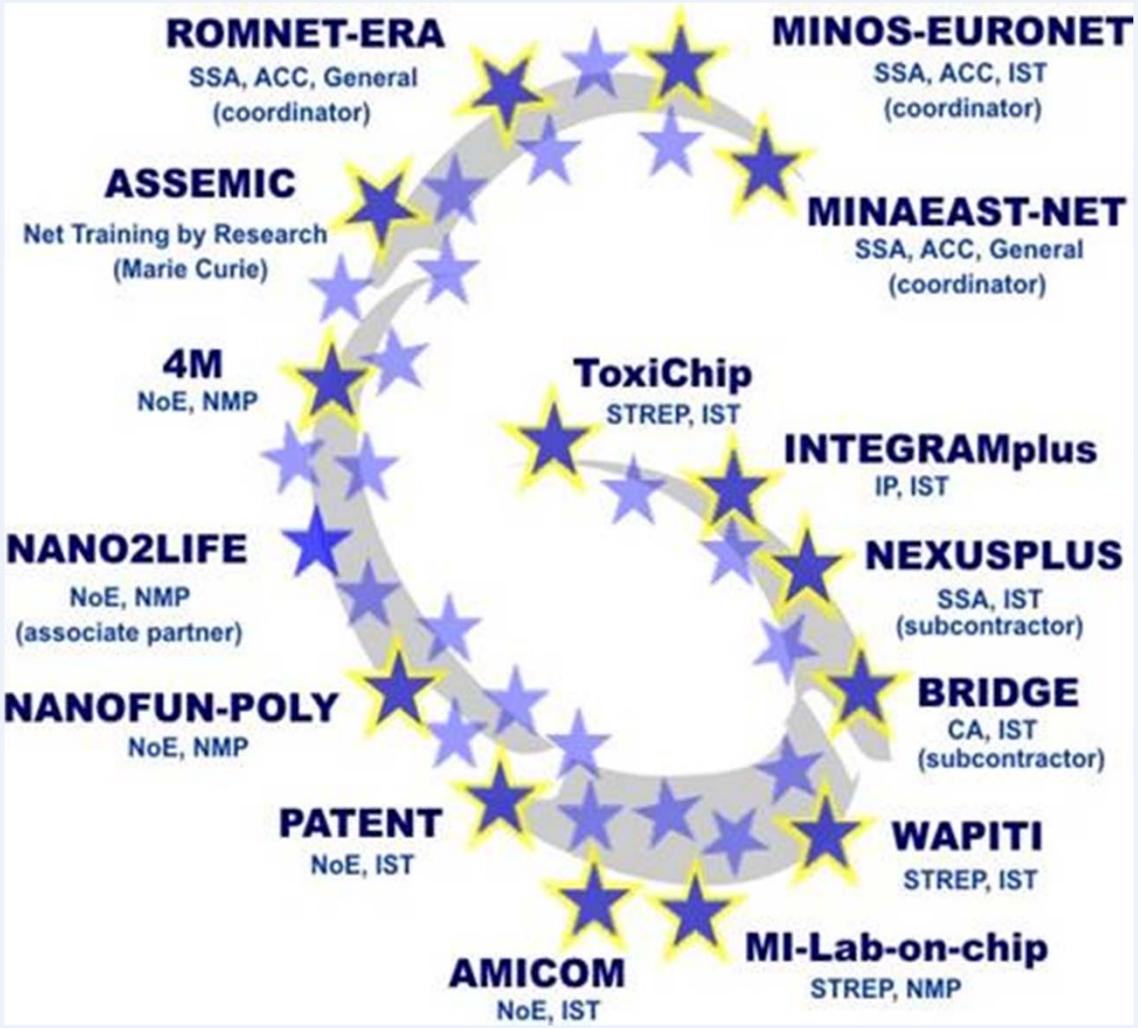
Micromanipulation element (microgripper)





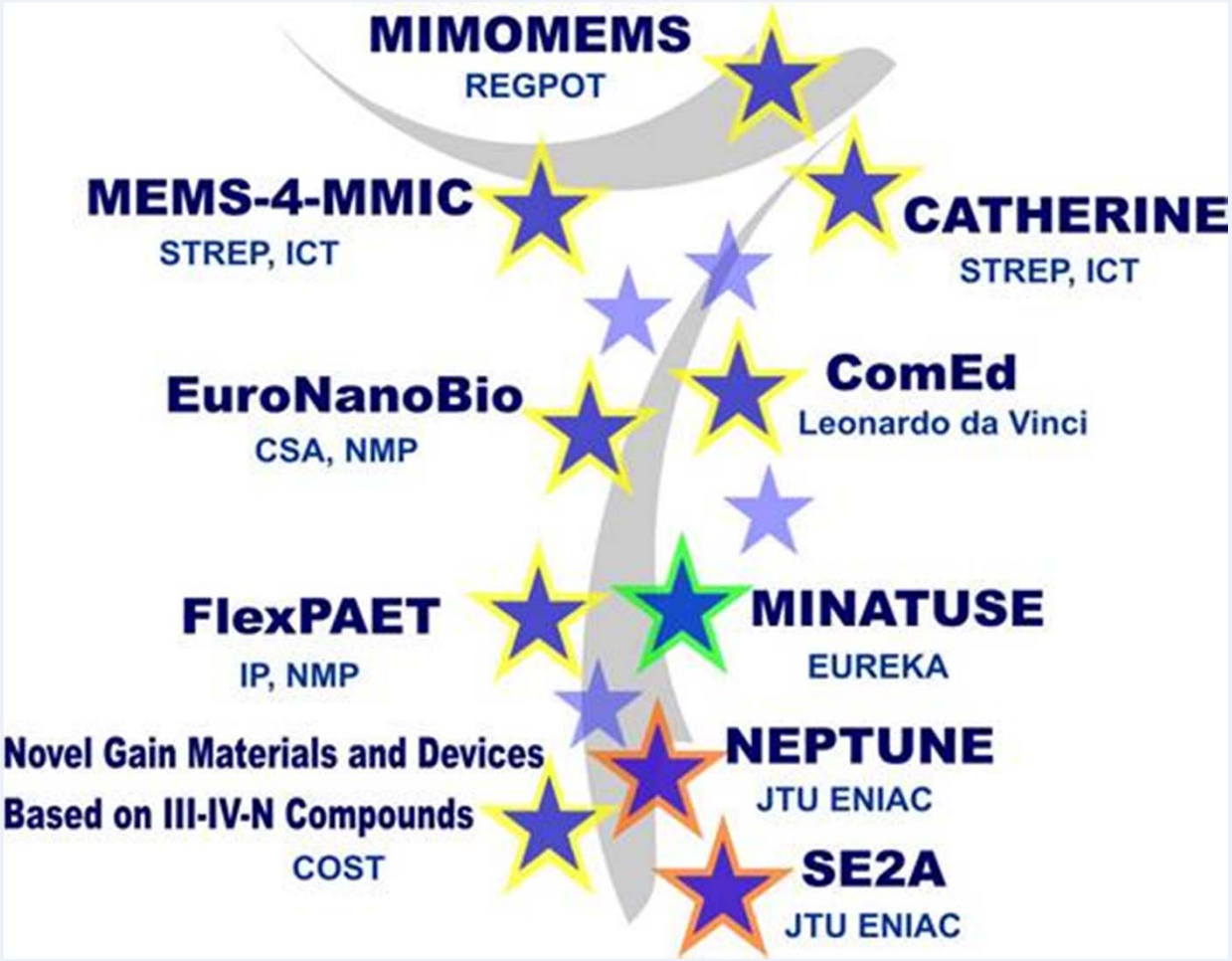
European projects [1]

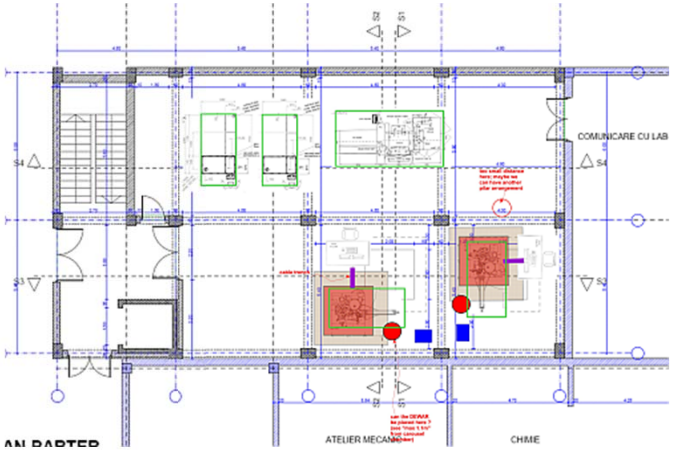
- FP6 projects

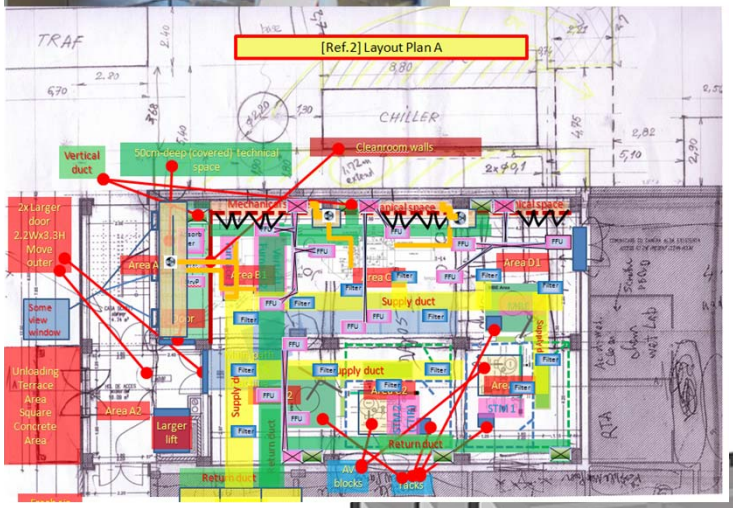


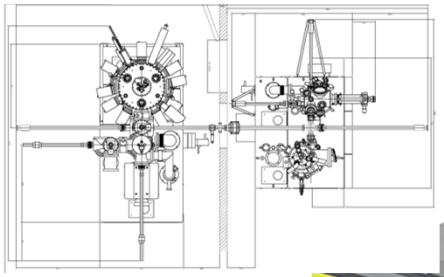
European projects [2]

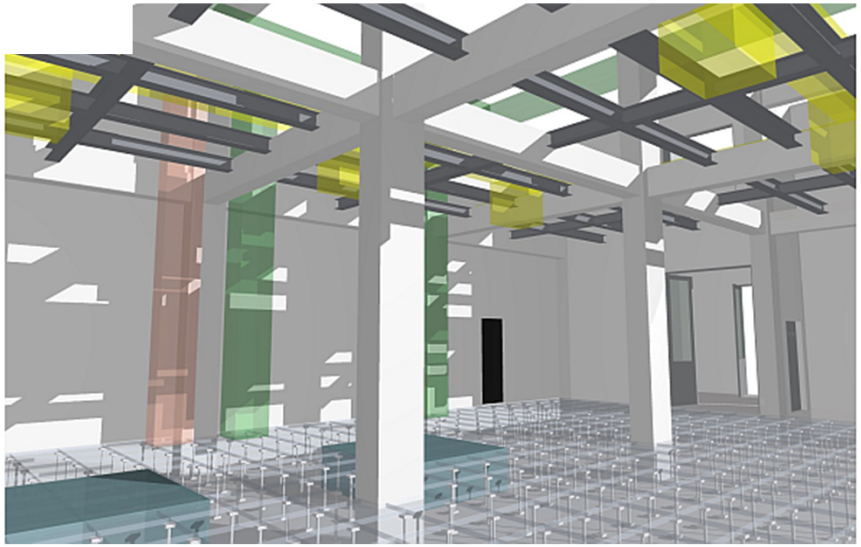
- FP7 (and related) projects

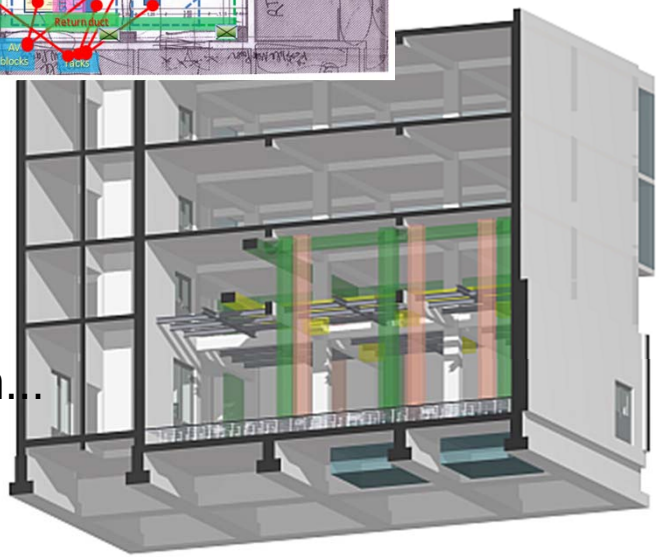












CENASIC

under

construction...

Thank you for your attention