

*Research Center on Nanotechnology Applied to  
Engineering of Sapienza University (CNIS)*

*Sapienza Nanotechnology & Nanoscience  
Laboratory (SNN-Lab)*

*Prof.* **Maria Sabrina Sarto**

*Sapienza University of Rome, Italy*



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# NANOTECHNOLOGY AT SAPIENZA



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# C N I S

## Research Centre for Nanotechnology Applied to Engineering of “Sapienza” University

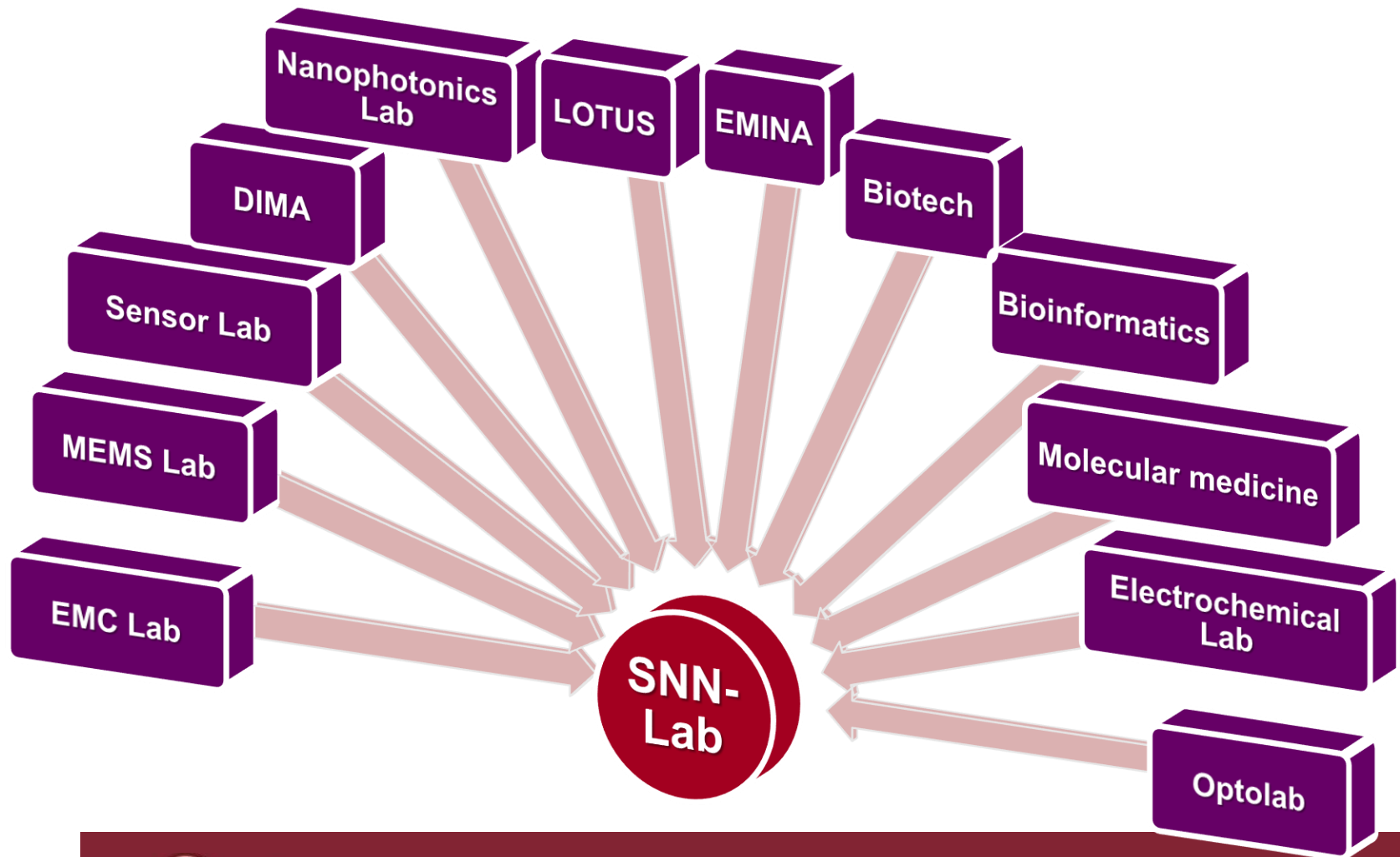
- Founded in 2006
- **Aim:** To promote and develop research activities in nanotechnology, finalized to the technological transfer and to the creation of new materials and devices for wide field of applications (engineering, electronics, energy, aerospace, medicine, biotech, ...)
- **Multidisciplinary:** More than 80 Professors from different scientific areas and faculties (Engineering, Science, Medicine, Pharmaceutical Science) and 15 Departments
- **Laboratories:** a Core Facility (SNN-Lab) and network of specialistic Department Labs



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# SNN-Lab: a Research Infrastructure in Sapienza aimed at multidisciplinary research in Nanotechnology



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# Sapienza Nanotechnology & Nanoscience Laboratory – SNN-Lab

A 400 m<sup>2</sup>-core facility at Sapienza University focused on advanced research and technology transfer

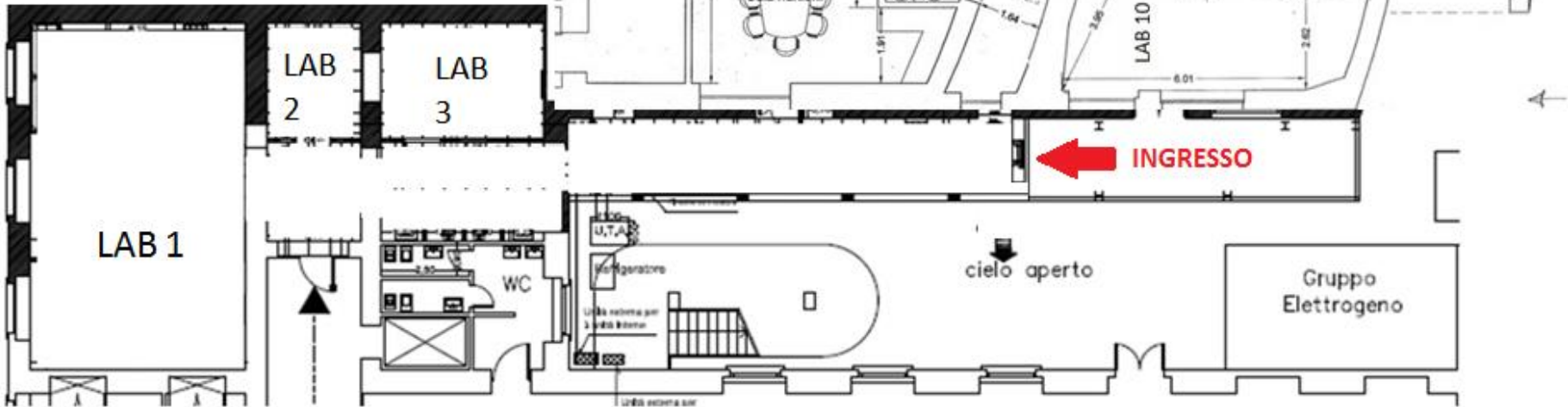


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**Total Area: 400 mq**  
**Installed power: 168 kW**

- **Microscopies and characterizations at nanoscale:** LAB1, 2, 3
- **Nanofabrication:** LAB5,10
- **Processing and chemistry:** LAB 6,7
- **Genomics and bioinformatics:** LAB 4,8,9
- **Meeting room**



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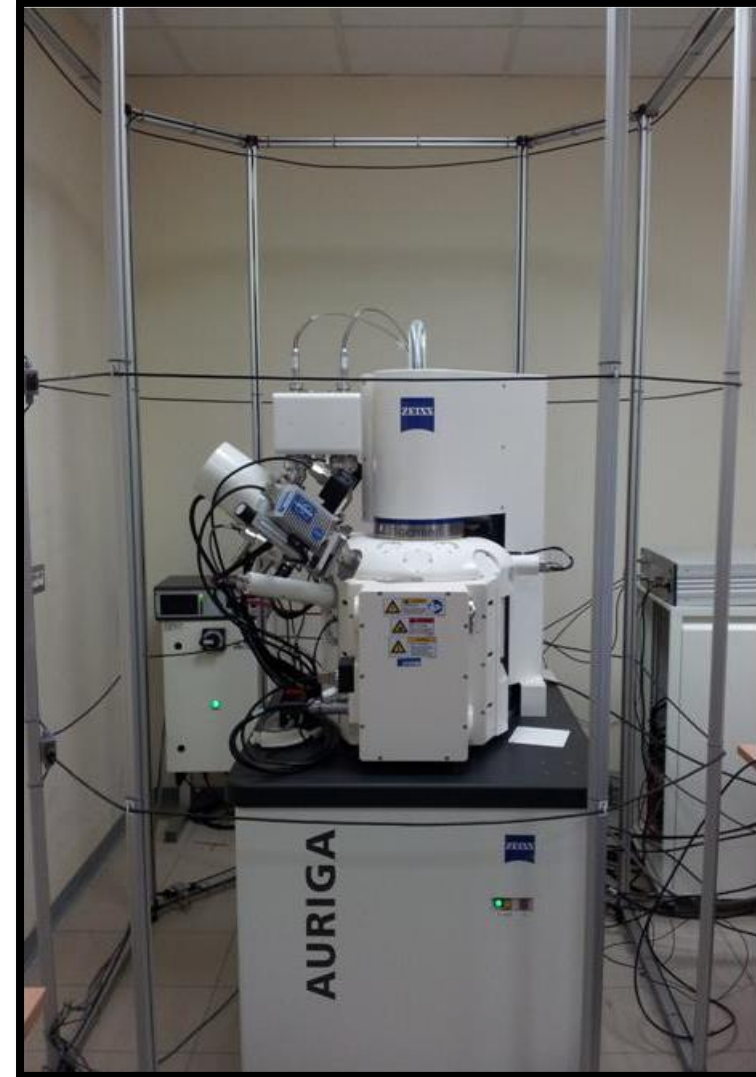


# AREA 1: Microscopies and characterization at Nanoscale

## Electronic Microscopy Platform/ nanofabrication /nanomanipulation:

*HR FESEM Zeiss Auriga Microscopy (resolution 1 nm), equipped with:*

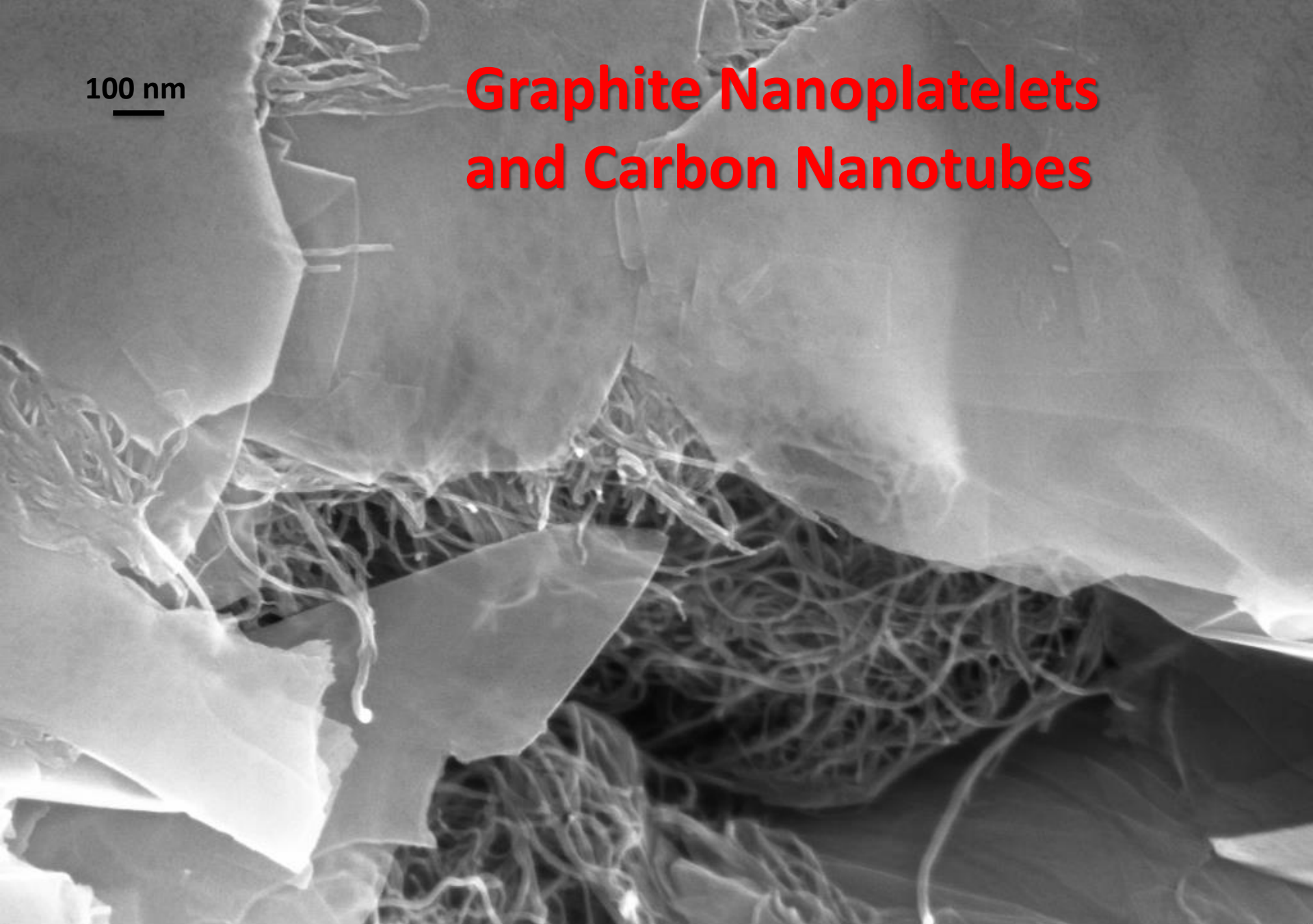
- STEM detector
- Microanalysis EDS  $\leq 123$  Mn-K $\alpha$  eV (Bruker)
- Electron Beam Lithography - EBL (resolution 7 nm) (Raith)
- Focused Ion Beam– FIB (resolution 2.5 nm) and GIS
- 4 nanomanipulators Klendieck for electrical / mechanical characterizations on areas of 50 nm<sup>2</sup>





100 nm

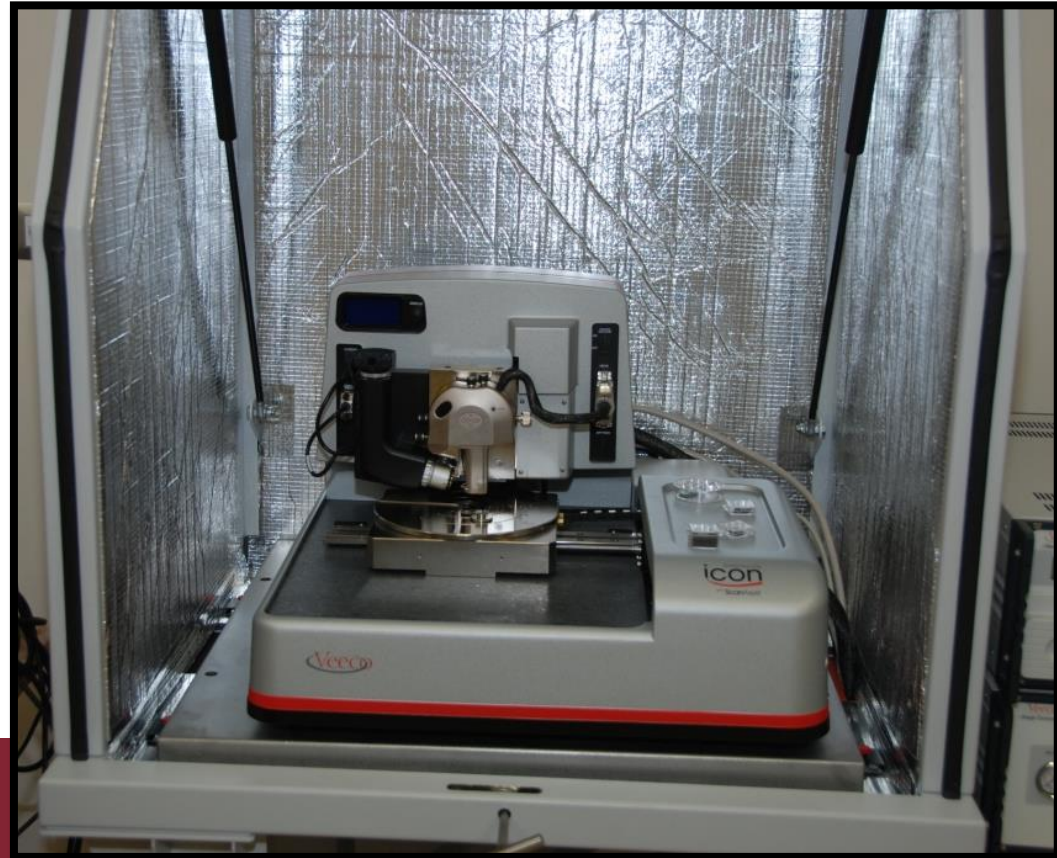
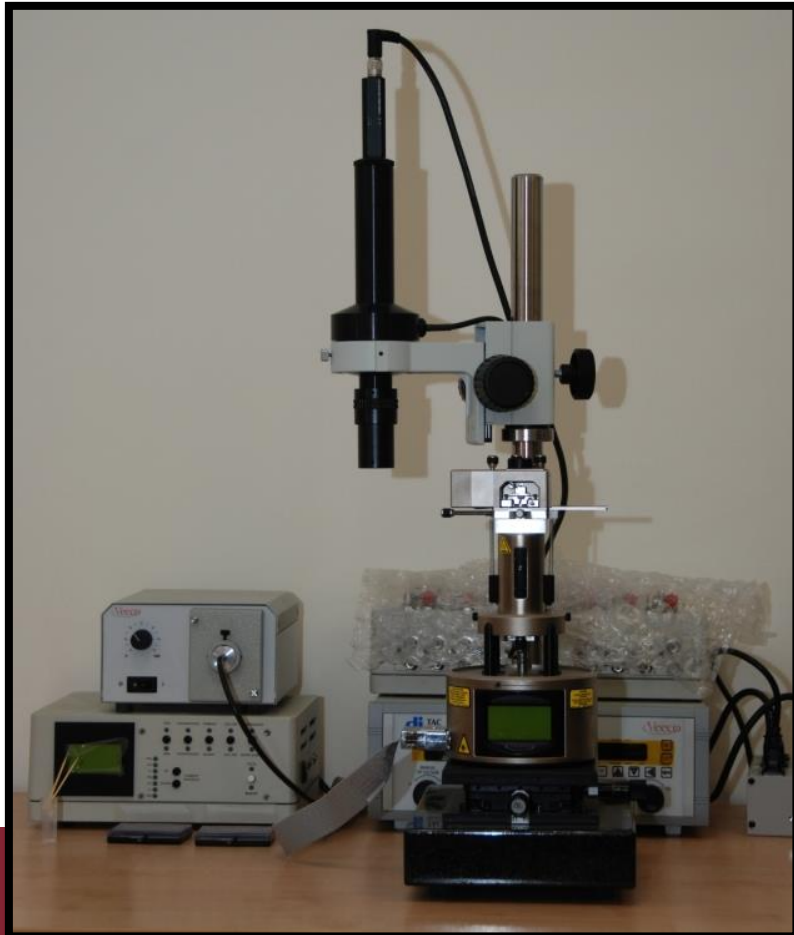
# Graphite Nanoplatelets and Carbon Nanotubes



# AREA 1: Microscopies and characterization at Nanoscale

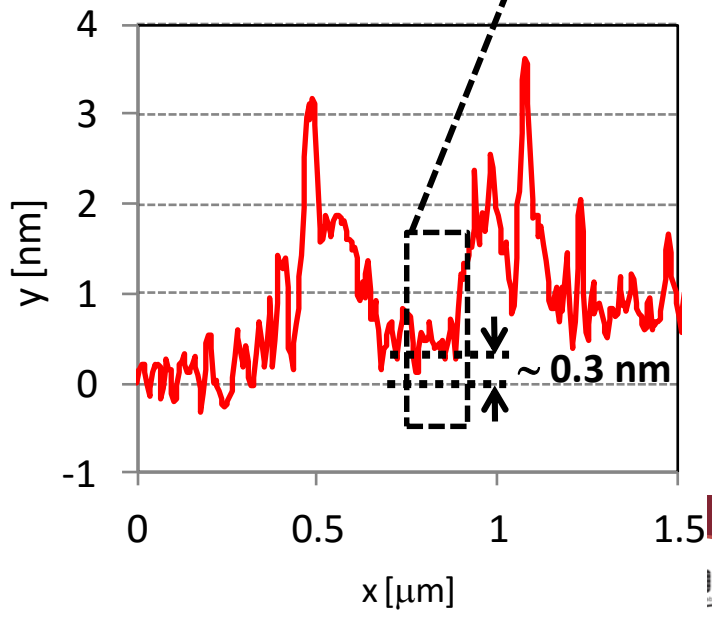
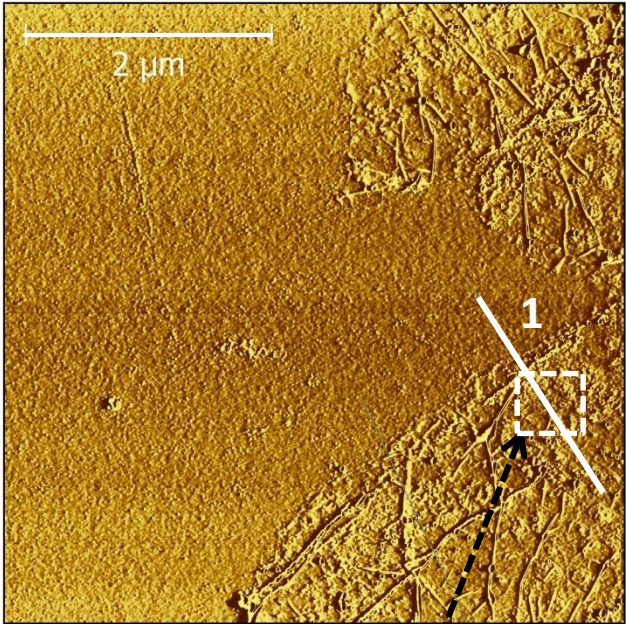
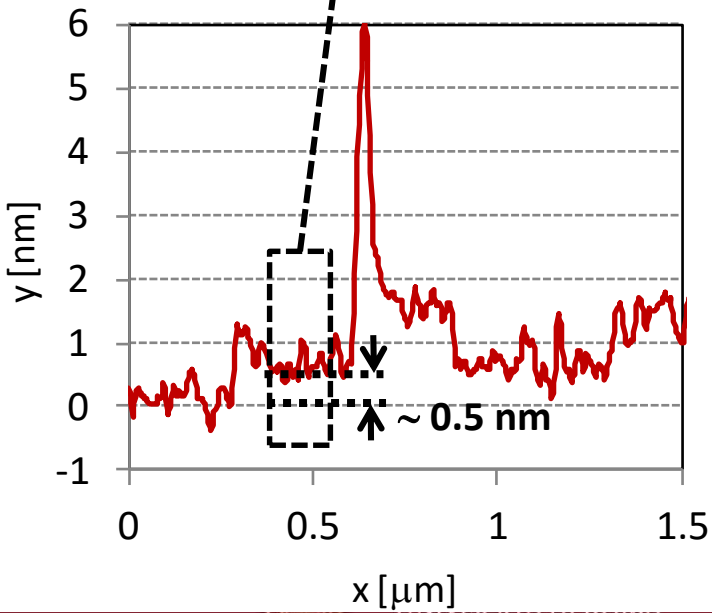
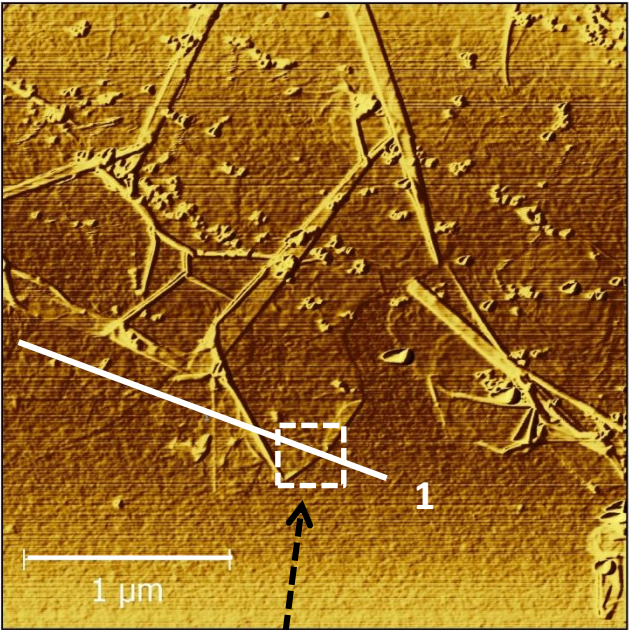
## Atomic Force Microscopy - AFM – Bruker (ex-VEECO) for nanocharacterization and nanomanipulation

- ICON (controller Nanoscope 5 + Harmonics)
- Multimode (controller Nanoscope 3)



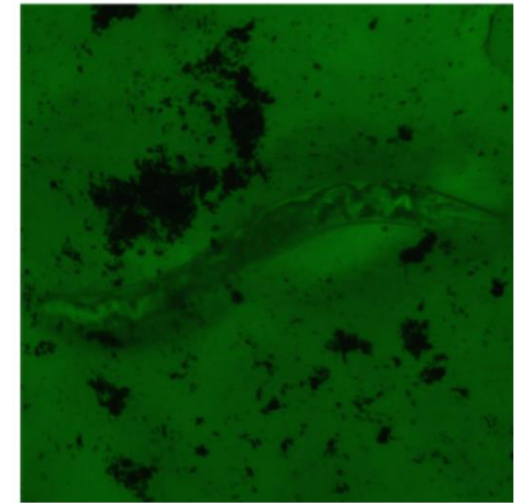
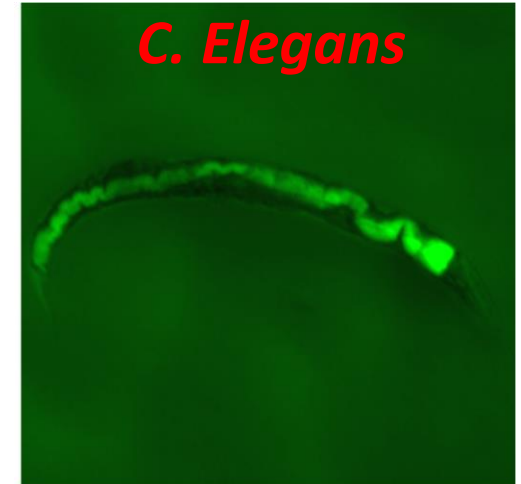


# Graphene



# AREA 1: Microscopies and characterization at Nanoscale

- X-ray diffractometer - XRD
- Zeiss fluorescence confocal optical microscopy for *live imaging*
- *Correlative microscopy (FESEM-Optical microscopy)*



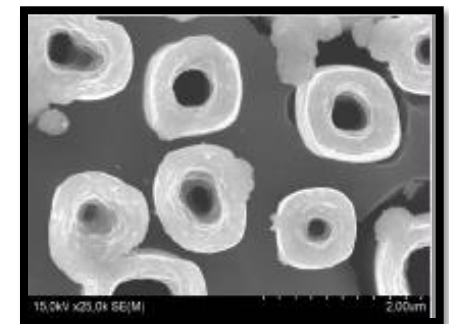
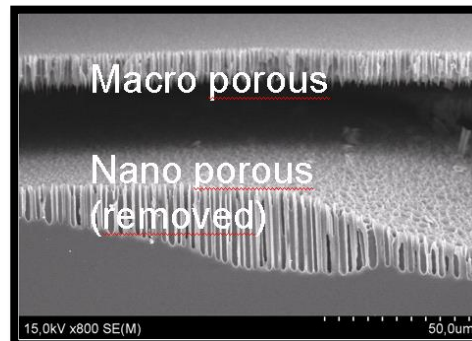
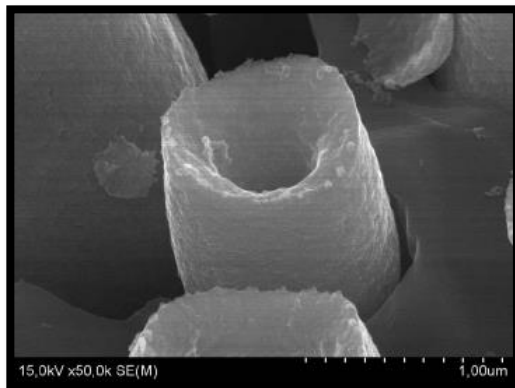


# AREA 2: Nanofabrication

**MWCVD deposition system for growth of silicon nanowires and carbon nanostructures, with a load lock chamber**

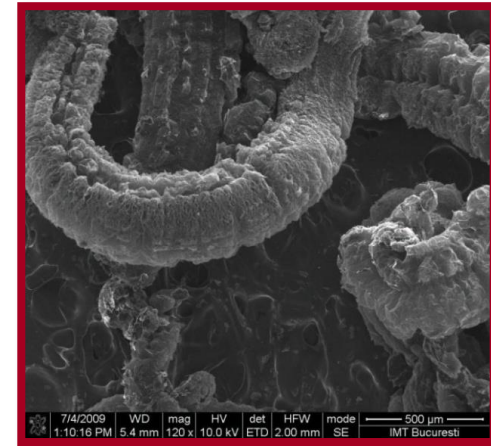
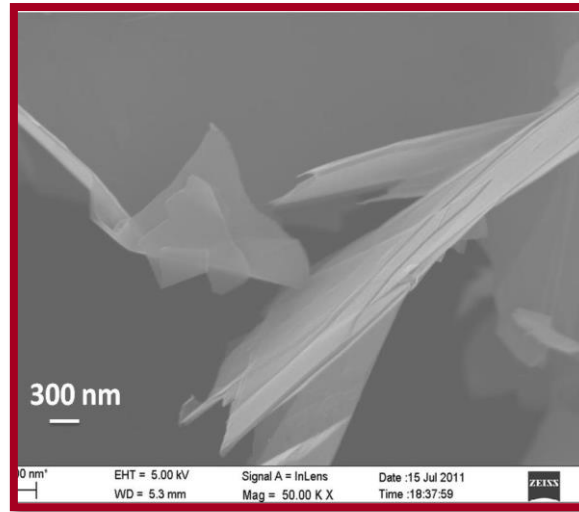
## Applications:

- Nanostructured Solar Cells
  - NW-Si / ZnO junctions
  - Macroporous silicon thin films
- NW-MOS transistors, for biological nanosensors



# AREA 2: Nanofabrication

- Muffle furnace (1400 ° C) for the production of graphene / graphite nanoplatelets (GNP)
- Rotational Rheometer with electro-module
- Nanocomposite processing and production



# AREA 3: Processing and Chemistry

- Fume hood
- Metal Sputtering
- Carbon evaporator
- Furnace
- Functionalization /  
targeting of molecular  
and supramolecular  
structures

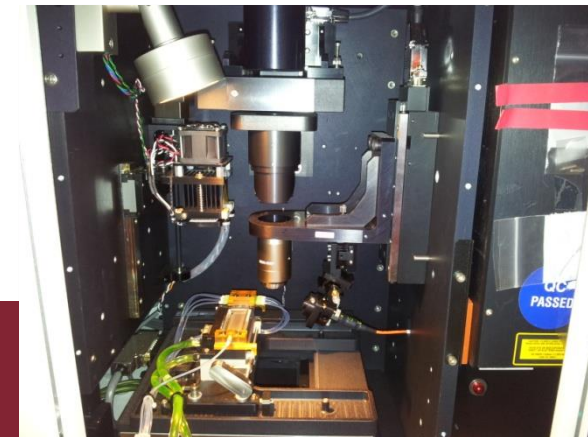
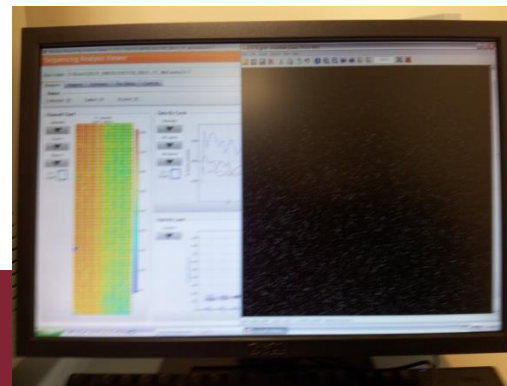




# AREA 4: Genomics and bioinformatics

## DNA sequencer (Illumina)

- Platform for experiments on a genomic scale high-throughput sequencing of nucleic acids integrated with bioinformatics methods of data analysis.
- Technology of next generation genomic sequencing (NGS), design of experiments, data analysis.



# AREA 5: Meeting room



# Linee di ricerca

- *Grafene*
- *Nano-strutture e nano-dispositivi per l'elettronica e la fotonica*
- *Materiali nano-strutturati per dispositivi di accumulo e conversione di energia*
- *Nanomateriali e superfici multifunzionali intelligenti per applicazioni industriali*
- *Nano- e micro-dispositivi per applicazioni biomolecolari e sopramolecolari*
- *Funzionalizzazione e ingegnerizzazione di sistemi biologici*
- *Genomica e bioinformatica*



# ***Nano-strutture e nano-dispositivi per l'elettronica e la fotonica***

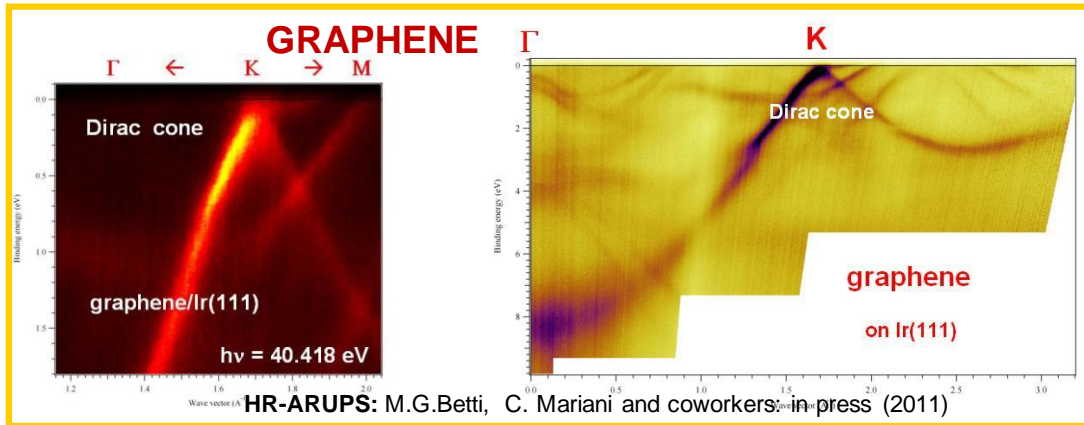


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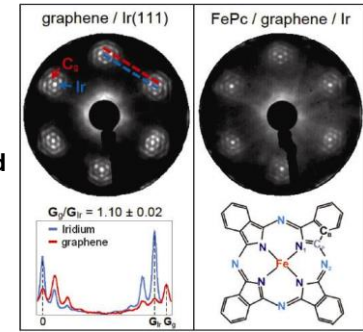
# New molecular architectures over a surface

Maria Grazia BETTI and Carlo MARIANI (Physics Dept.)



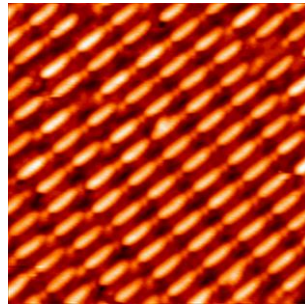
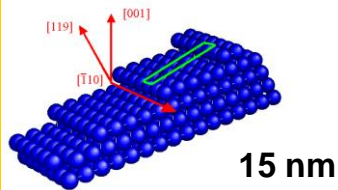
## INDUCED-ASSEMBLING ON GRAPHENE

graphene-induced ordered metal-phthalocyanine array



## SELF-ASSEMBLING

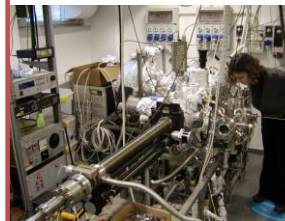
aromatic oligomers on metal surfaces



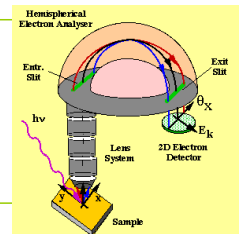
M.G. Betti and coworkers:

- J. Phys. Chem. A 111, 12454-12457 (2007)
- Phys. Rev. B 79, 115446-1-7 (2009)
- Phys. Rev. Lett. 100, 027601 (2008); Phys. Rev. B 81, 085412 (2010)

## UHV surface science laboratory LOTUS



- **HR-ARUPS**
- Work function
- LEED
- O-MBE deposition facilities
- Low Temp.: down to 25 K



high-resolution angle-resolved UV photoemission, **HR-ARUPS**

monochromatized UV source (21.22 eV, 40.18 eV)

- SCIENTA 2D (energy-momentum) multi-channel-plate detection
- Resolution: \* < 4 meV (gas phase) \* < 0.2°

- Low-energy electron-diffraction (LEED)
- Auger
- Thermal Desorption Spectr. (TDS)
- O-MBE deposition facilities
- clean liquid phase deposition facility



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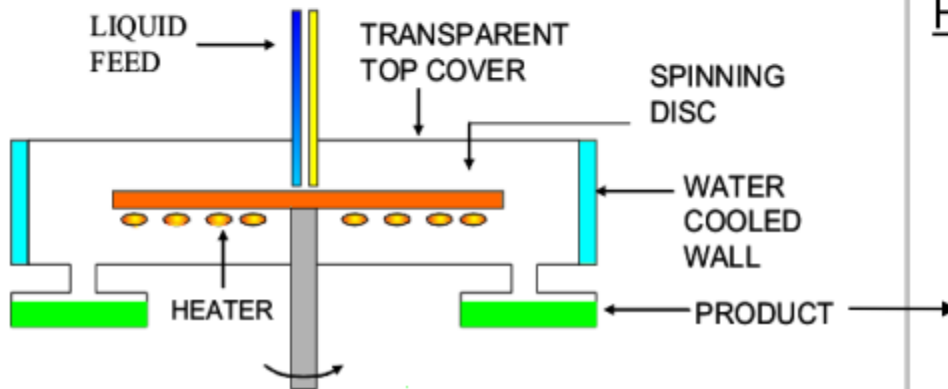


# PROCESS INTENSIFICATION IN NANOTECHNOLOGIES

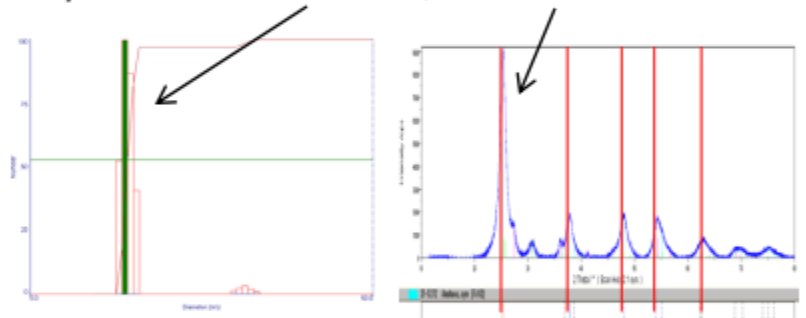
Angelo Chianese, Mariapaola Parisi, Marco Stoller

Laboratory of Nanoparticle Production, Chemical Engineering Department

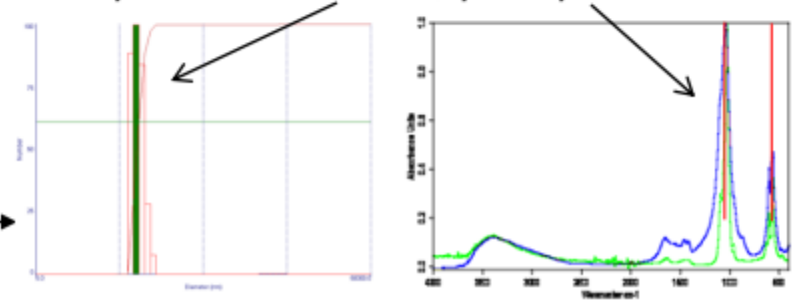
The spinning disc reactor is capable to produce continuously at high flow rates narrow distributed pure nanoparticles by chemical precipitation with very low energy consumption ( $\approx 0.1$  kW/kg).



Titanium Dioxide for photocatalysis  
peak size: 9.45 nm; >90% anatase



Hydroxyapatite for biomedical applications  
peak size: 90 nm; pure product



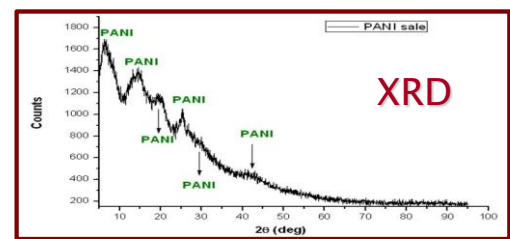
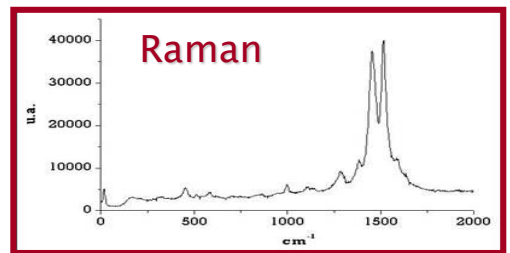
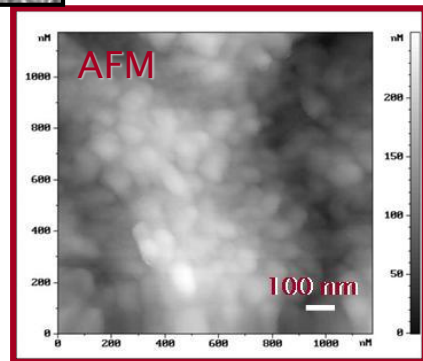
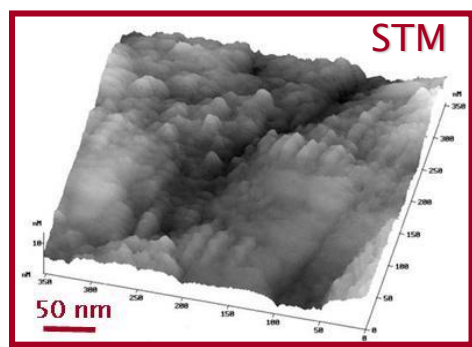
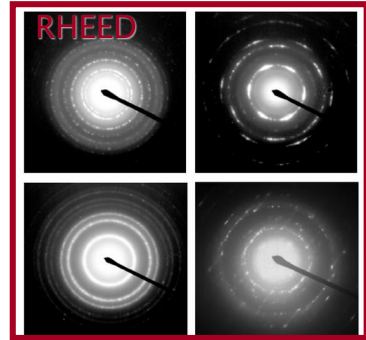
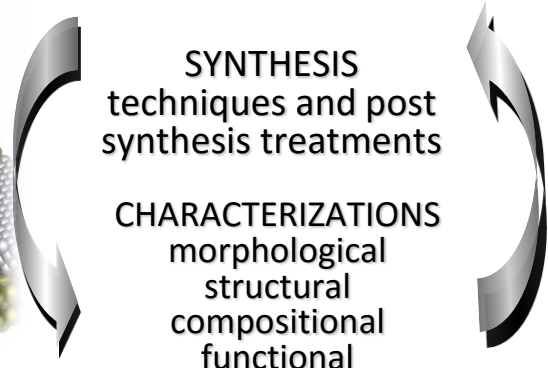
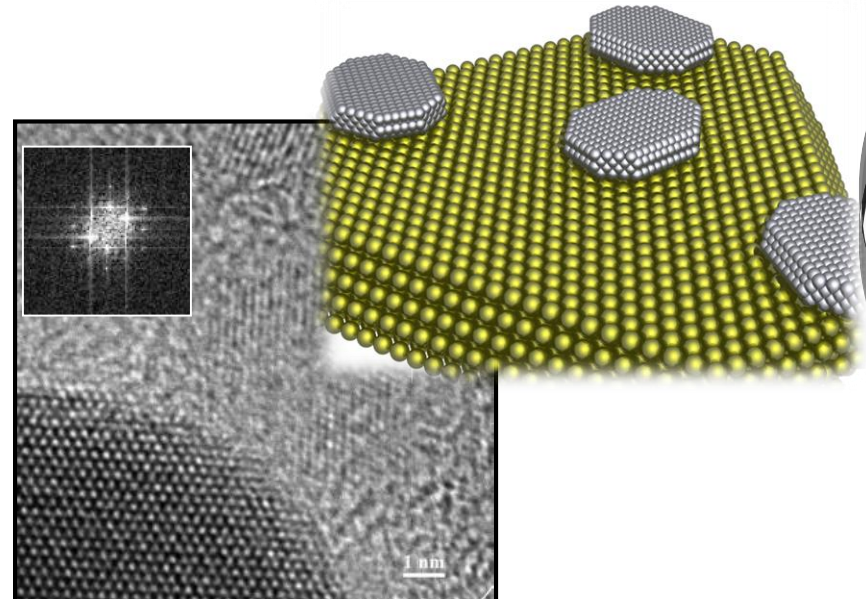
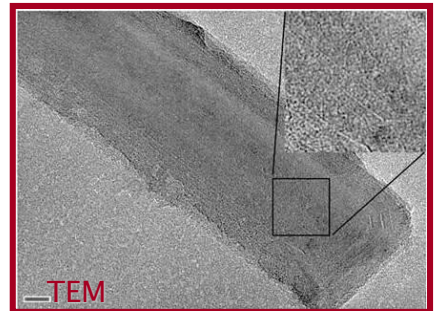
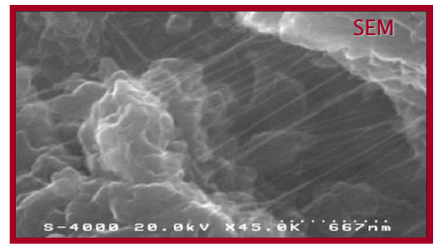
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# Synthesis and characterizations of Carbon based nanomaterial

M. Rossi, D. Passeri, R. Matassa - EMINA Lab - Dept. of Fund. & Appl. Sciences for Eng. (SBAI)  
 in collaboration with M.L. Terranova et al (Tor Vergata University and MINAS Lab)



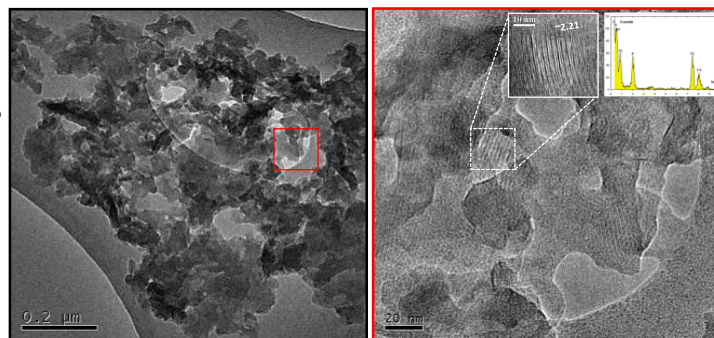
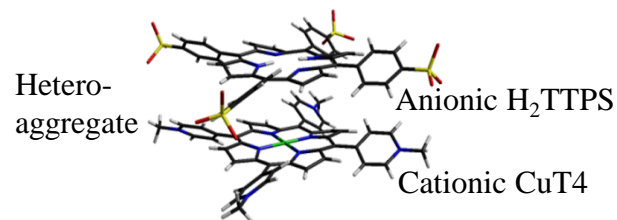
# Structural Characterization of Nano-Materials

Ruggero Caminiti group<sup>1</sup>, Roberto Matassa<sup>2</sup>, (<sup>1</sup>Chemistry Dept., <http://webcamini.chem.uniroma1.it> Energy Dispersive X-ray Diffraction Laboratory, and <sup>2</sup>Fund. Appl. Sciences for Eng. Dept.)

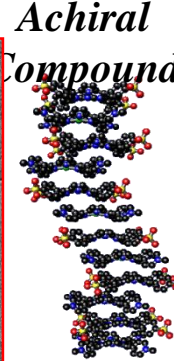
## Materials & Previously Structural Informations

## Radial Distribution Function

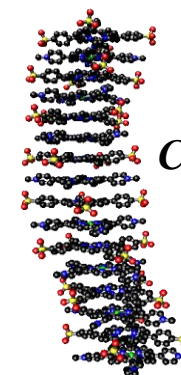
## Nano-Objects Resolved



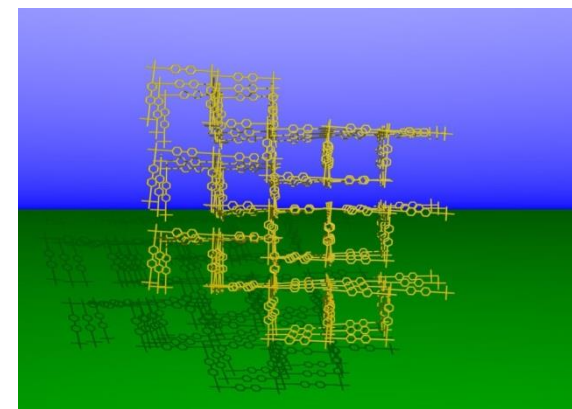
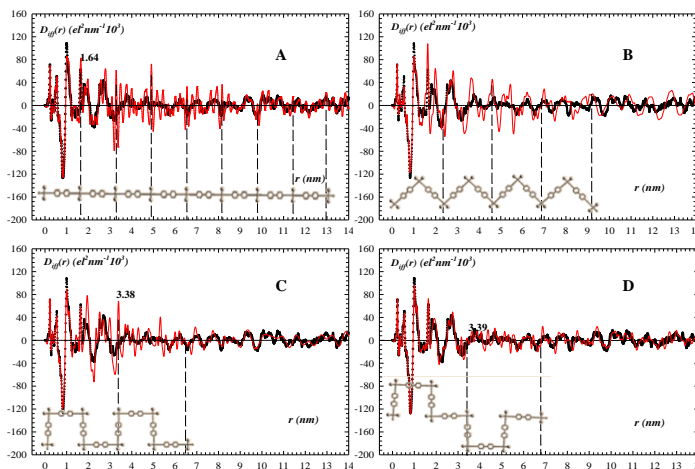
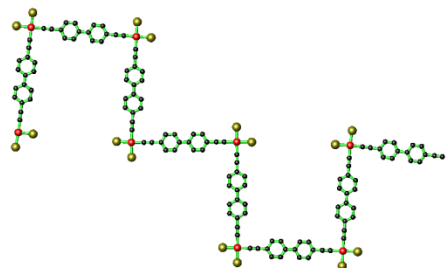
Achiral Compound



Chiral Compound



Platinum Organonic Oligomers  
&  
Only Not Complete Monomer  
Crystallographic Informations



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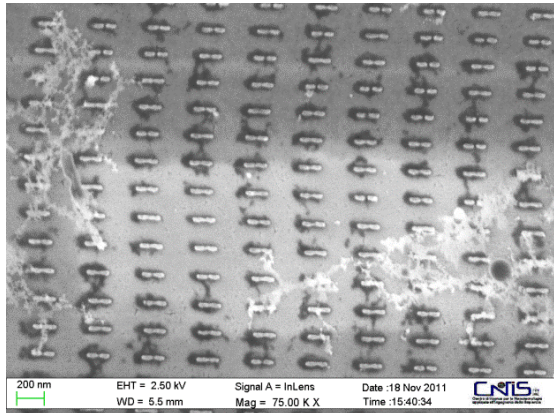
# Nanophotonics

C. Sibia, R. Li Voti, M. Centini, G. Leahu, M.C. Larciprete, A. Belardini, A. Benedetti,  
Dip. di Scienze di Base e Applicate per l'Ingegneria – Sez. di Fisica

## NANO-ANTENNE PLASMONICHE NONLINEARI

Coll. con A. Passaseo, CNR Lecce.

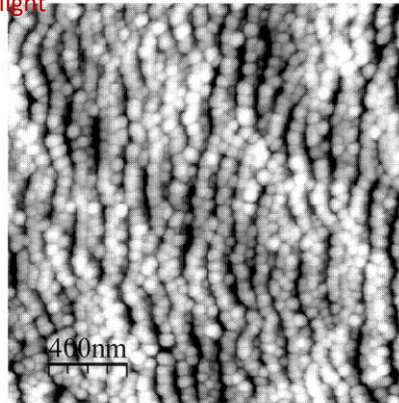
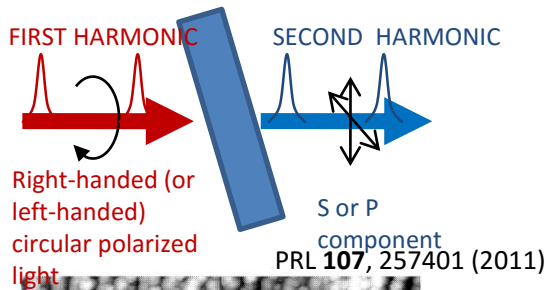
Enhancement da localizzazione del campo e.m. nel gap di nanoantenne deposte su materiale altamente nonlineare GaN



## NANO-FILI DI ORO

Coll. con F. Buatier de Mongeot,  
Dip. Fisica Università di Genova.

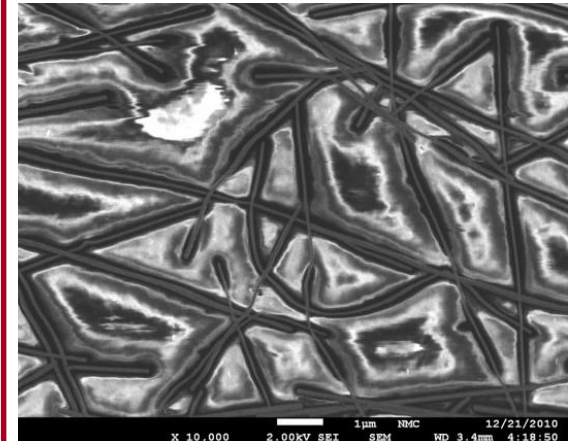
Misure nonlineari di seconda armonica di chiralità estrinseca mediante.



## NANO-FILI DI ARGENTO

Coll. con I. Nefedov, Aalto University (Finland).

Analisi di rifrazione negativa con materiali metallici nanostrutturati. Schermatura della radiazione infrarossa.



# Self-assembling integrated photonics

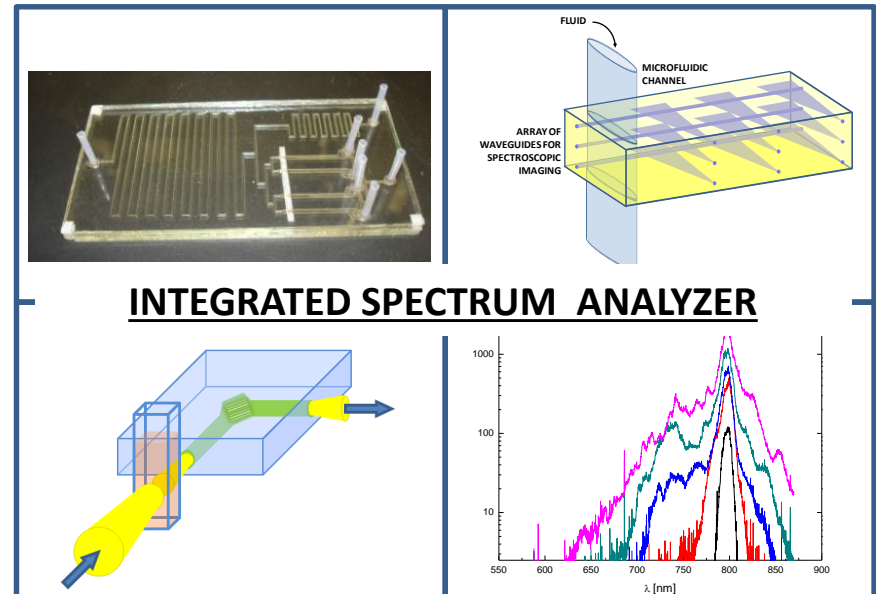
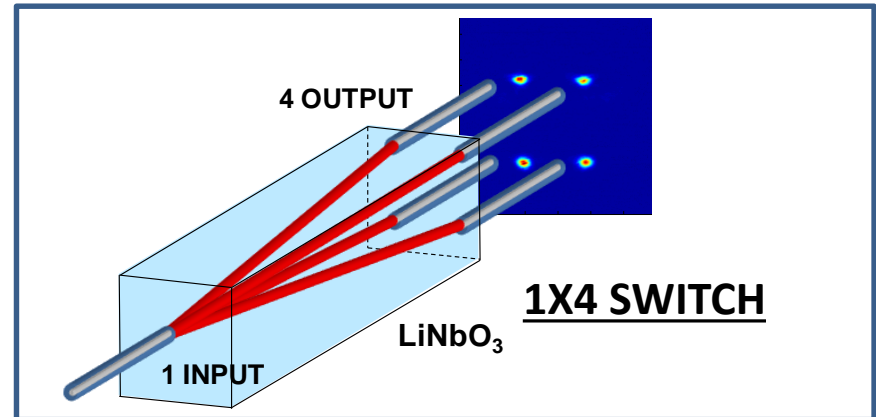
E. Fazio et al. (Fundamental Applied Sciences for Engineering)

Active and passive  
integrated photonic circuits  
using solitonic waveguides  
in  
electro-optic  
lithium niobate chips

## APPLICATIONS:

- OPTICAL SIGNAL PROCESSING FOR ICT
- OPTIC AND PHOTONIC SENSORS
- PHOTONIC ANALYSIS IN LAB-ON-CHIPS
- PARALLEL LASER SOURCES ON CHIP
- INTEGRATED SPECTRUM ANALYZERS

<http://www.upholab.eu>



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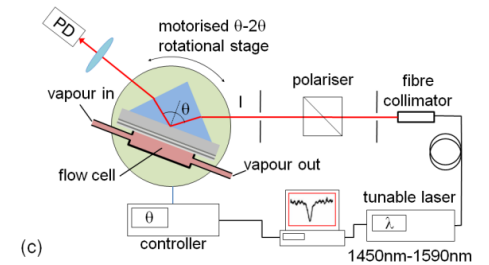
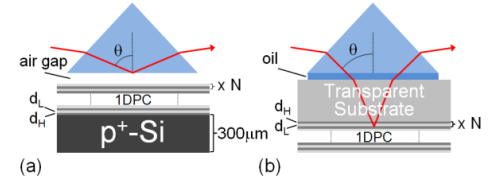
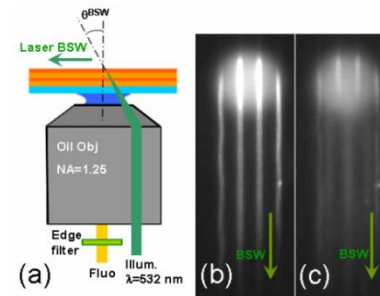
# Biophotonics

F. Michelotti , *Fundamental & Applied Sciences for Engineering Dept.*

## MOLECULAR PHOTONICS LAB

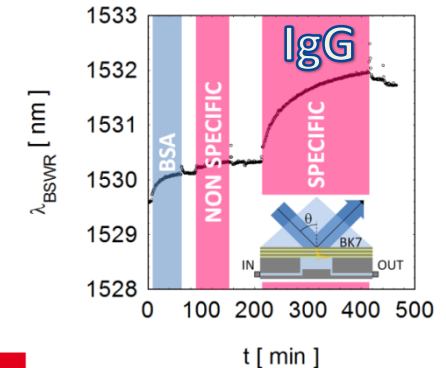
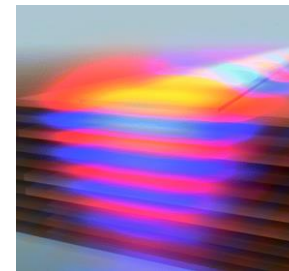
### Novel Photonic Concepts for:

- Label-free Biochips
- Single molecule biosensing
- Fluorescence microscopy
- Super resolution microscopy
- Gas sensing



### Applications:

- OMICS
- Early Cancer Detection
- Binding kinetics
- Point of Care
- Gas detection and sorting



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INSTITUTE FOR CANCER RESEARCH AND TREATMENT

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apply innovation™

ENEA

Fraunhofer  
IOF

POLITECNICO  
DI TORINO



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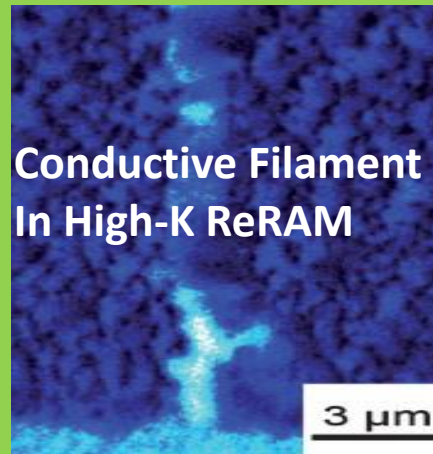
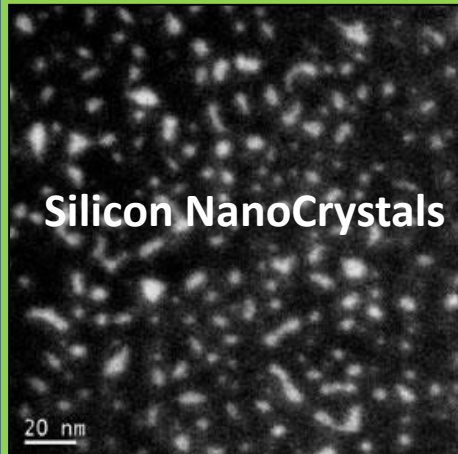
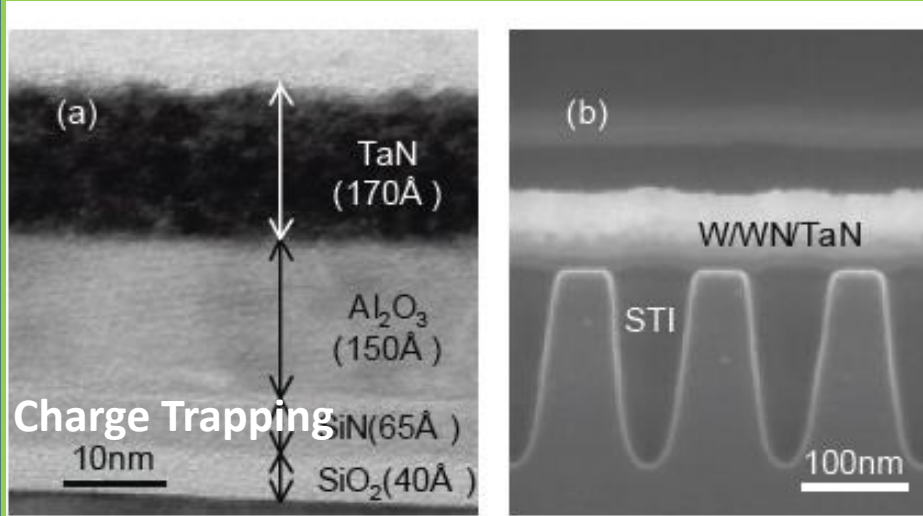
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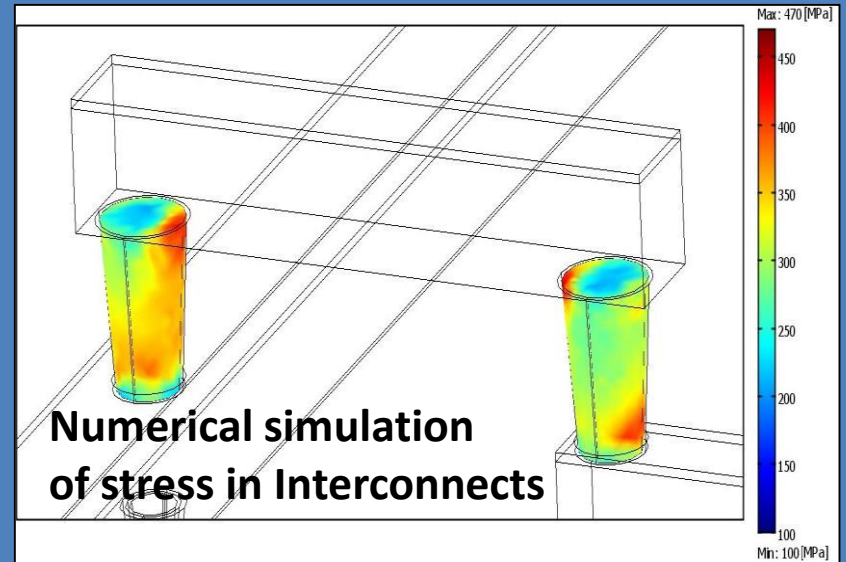
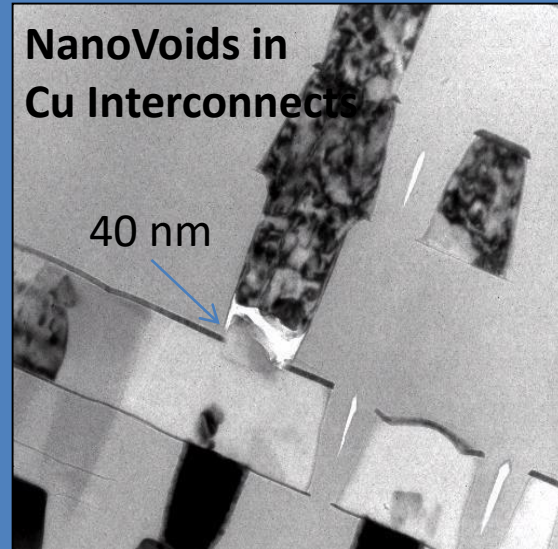
# NanoElectronics

F. Irrera, R. Rao, P. Lorenzi - DIET

## Memory in future nodes



## Reliability issues



# New Molecules for Organic Electronics

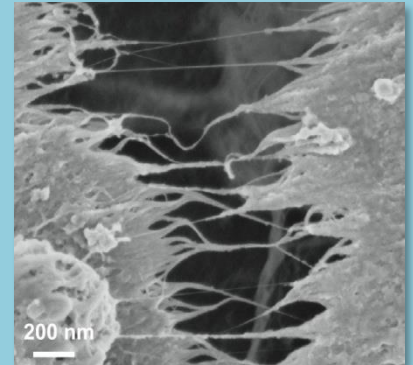
Leonardo Mattiello (Fund. Appl. Sciences for Eng. Dept.)

Fluorene derivatives as organic electroluminescent materials used in **flexible OLEDs** and **white light OLEDs**

SOLD OUT



**Functional nanostructures** obtained by electropolymerization of fluorene derivatives on carbon nanotubes electrodes



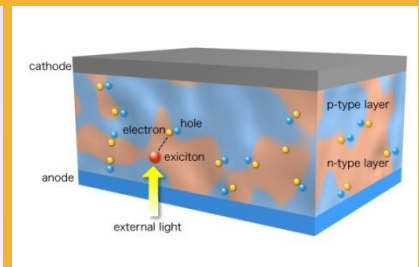
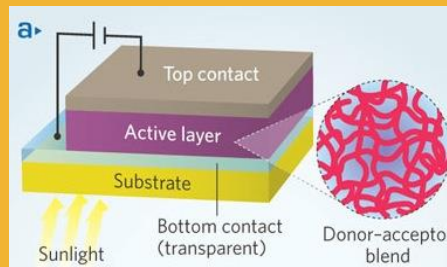
PF deposited on the SWCNTs/FTO electrode

New erbium organic compounds as light sources for 1.54- $\mu\text{m}$ -wavelength devices in optical communications (**InfraRed OLEDs**)



Four ErQ-based IR OLEDs on a single glass substrate

Bifluorenylidene derivatives as electron-accepting materials for **Organic Photovoltaics**



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# Nano/Microelectromechanical Systems

M. Balucani, P. Nenzi, R. Crescenzi, K. Kholostov, A. Pasquale, F. Tripaldi - DIET



In collaboration with:

*N.P. Belfiore et al. DIMA*

*C.M. Casciola et al. DIMA*

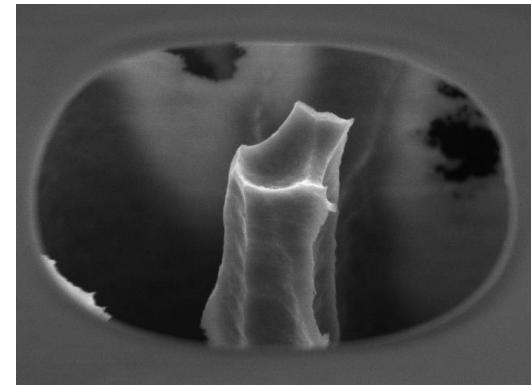
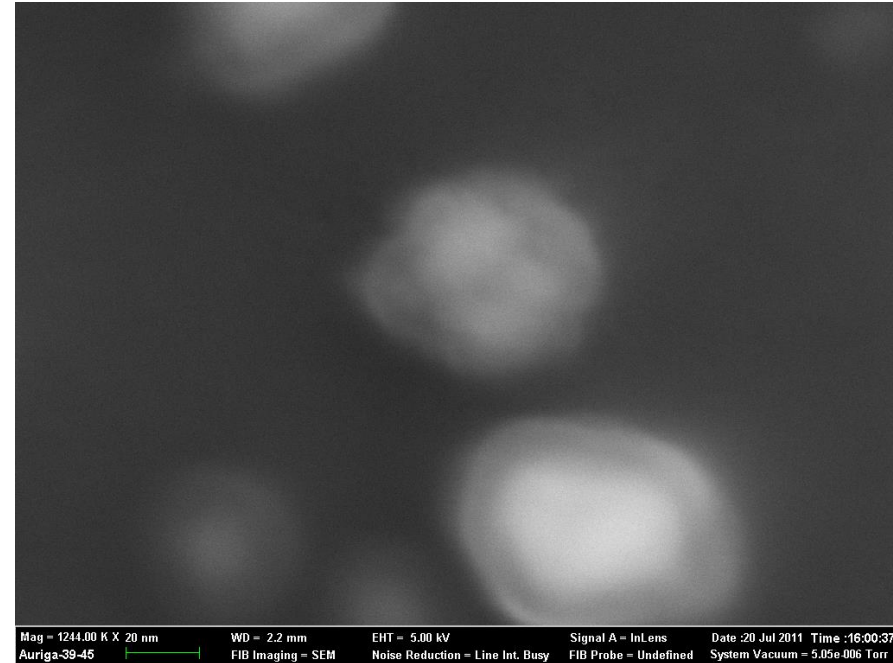
*G. D'Inzeo et al. DIET*

*F. Palma et al. DIET*

- Nano/Micro porous structures
- Microwire and Microneedle
- Nanoparticles and Nanopillars

Application in:

- ***HDI High Density Interconnection***
- ***Field Emitter Arrays***
- ***THz Antenna***
- ***Solar Cell and Energy Harvesting***
- ***NEMS/MEMS Switch, Gears and NEMS/MEMS sensors and actuators***
- ***Microfluidics and Biomedical devices***



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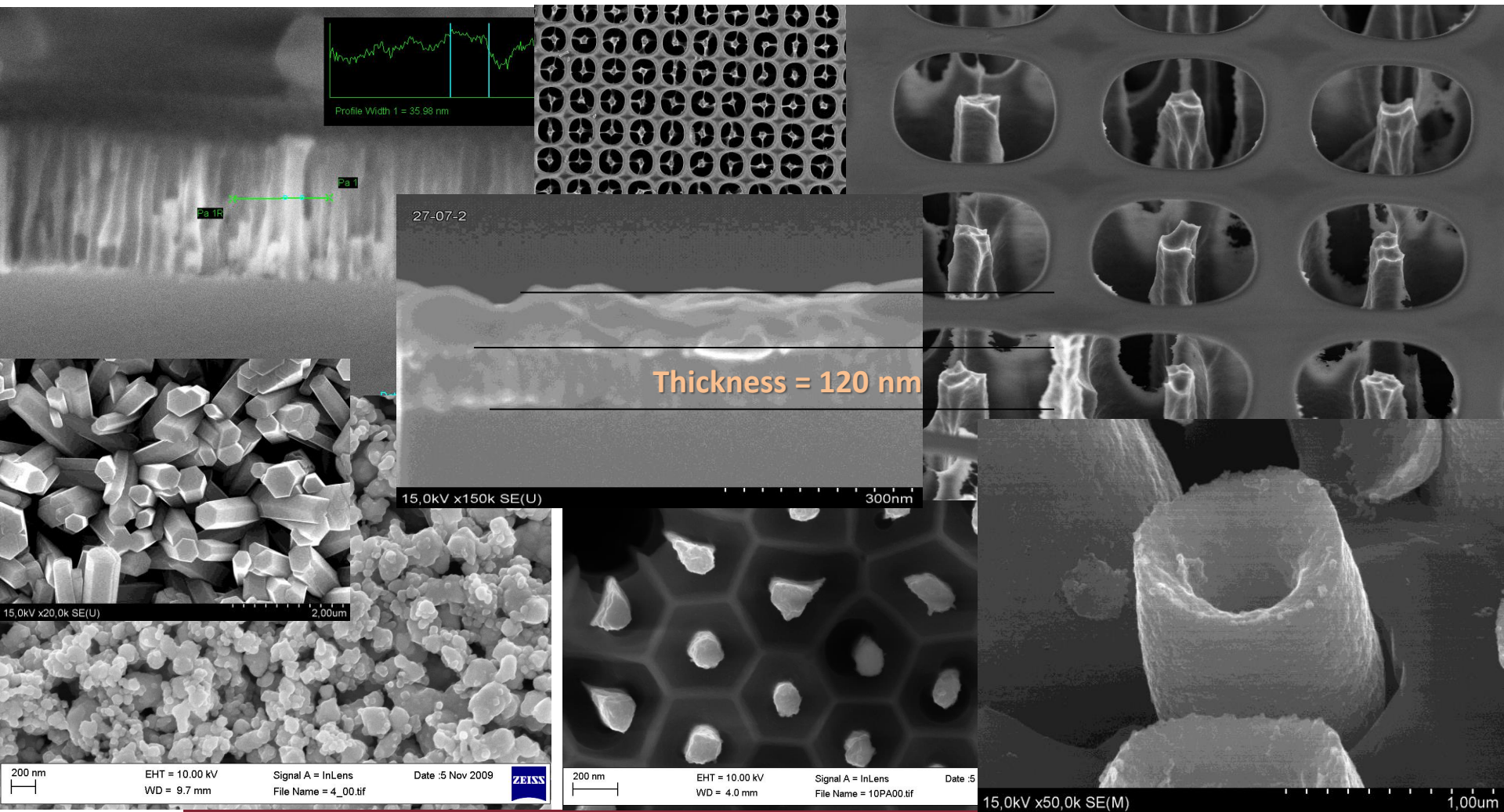
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# Nano/Micromechanical Systems

M. Balucani et al. - DIET



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# MEMS-based Micro-Robotics with applications

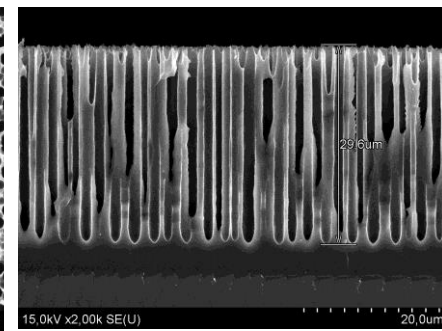
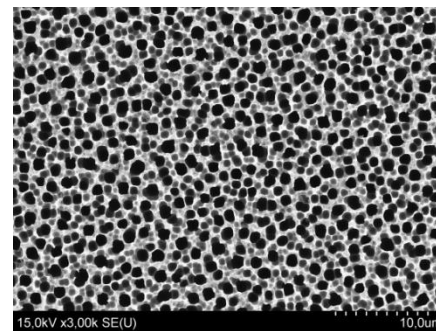
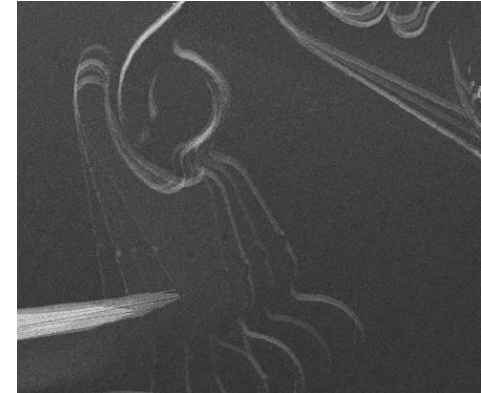
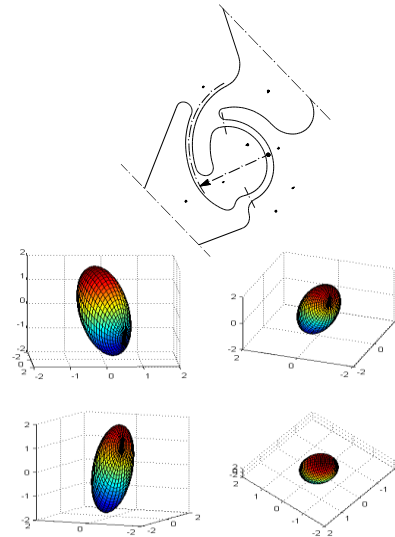
Belfiore, N.P., *DIMA*; Balucani, M., Crescenzi, R., Nenzi, P., *DIET*

## Micro-Robotica

- Geometria
- Caratterizzazione e ottimizzazione della cinematica e della dinamica
- Attuazione e sensing
- Robot in silicio poroso
- Controllo

## Micro-Manipolazione

- Micro-Manipolazione in SEM assistita da realtà aumentata
- Caratterizzazione meccanica in nano-scala con e senza anisotropia (silicio poroso)
- Nano-Tribologia



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# ***Nanostrutture e nanomateriali multifunzionali per applicazioni energetiche e industriali***

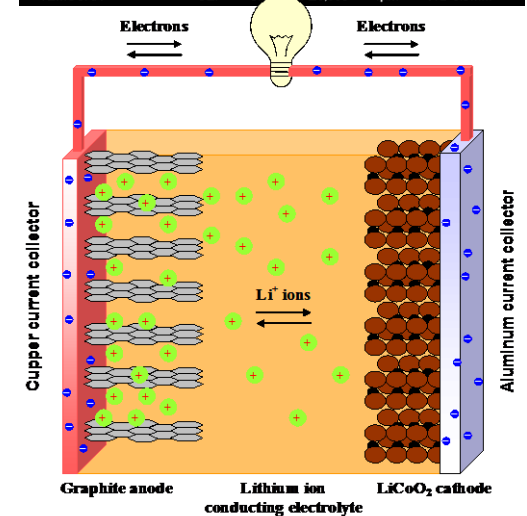
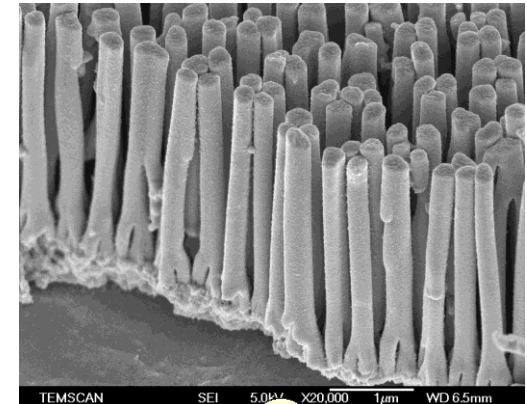


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# Nanomaterials for energy storage and conversion

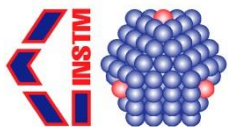
D. Gozzi (Chemistry Dept.), F. Palma (Information, Electronics and Telecommunication Dept.),  
M. Pasquali (Fund. Appl. Sciences for Eng. Dept.)



- **Non conventional photovoltaic cell:**
  - DSSC (Dye Sensitized Solar Cell) with the photoactive electrode realized by CVD-grown CNTs functionalized with TiO<sub>2</sub>
  - Hybrid organic/unorganic based on SWCNTs and MWCNTs in polymeric matrix
- **Nanostructures for energy storage:**
  - Nanofibers and nanocomposite for high-capacity electrodes lithium batteries
  - Nanocomposites filled with CNTs and nanocrystals of La/Nd/Gd/TbNi<sub>5</sub> for nanoelectrodes in nickel based batteries
  - CNTs-based Nanocomposites for supercapacitors







# Nanostructured Coatings



T.Valente, C.Bartuli et al., LIMS - Lab. Mater. Surf. Eng., Dept Chem. Eng. Mater. Env.

Plasma sprayed coatings from nanostructured feedstock materials with improved wear resistance and thermal barrier properties.

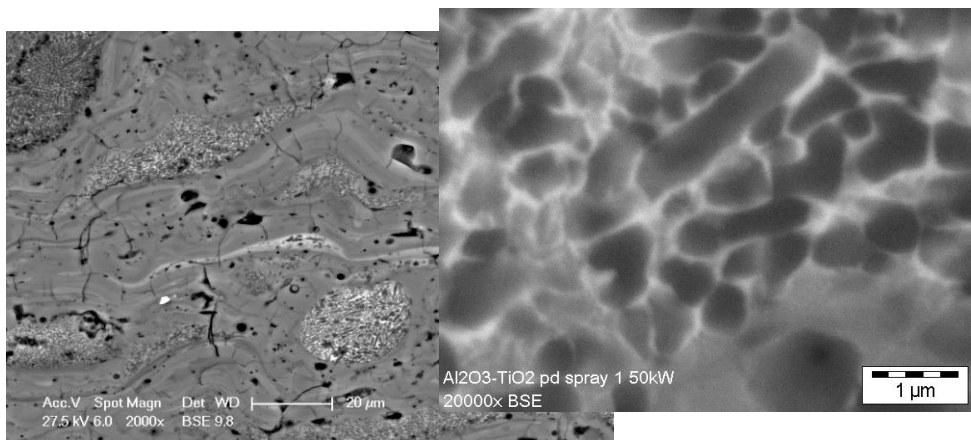
European Network **IP Nanoker** “*Structural Ceramic Nanocomposites for top-end Functional Applications*” (INSTM, Thales Alenia Spazio, Fiat Avio, Volvo, Colorobbia)

**Wear resistant engine components, alumina-titania:**

**Wear loss = -30%; Friction coeff. = -5%**

**Turbine blades, YSZ:**

**Thermal shock resistance = +50%**



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# Nanomateriali multifunzionali per applicazioni elettriche ed elettromagnetiche

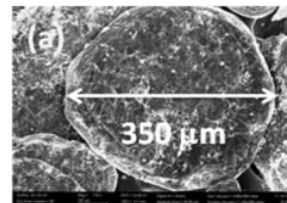
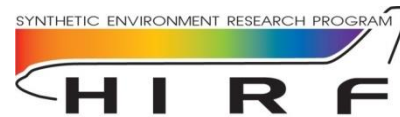
M.S. Sarto, M. D'Amore, A. Tamburrano, G. De Bellis, A. D'Aloia (DIAEE)

- Synthesis and multifunctional characterization of GNP and GNP-based composites
- Nanostructured multifunctional EM shields and radar-absorbing materials
- CNT-based nanointerconnects
- Nanostructures thin films:

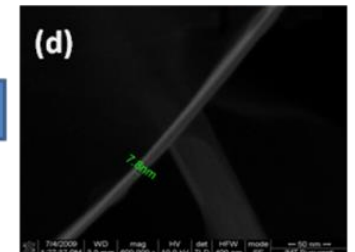
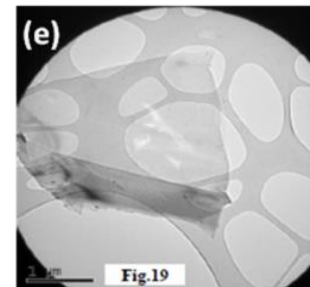
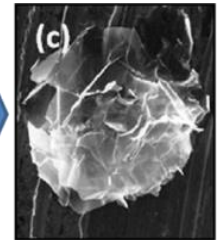
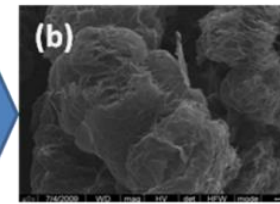
Low-emission nanostructured thin films for solar control and EMI shielding

*Wideband FSS*

– *Stress sensor for smart tire*



Materiale di partenza



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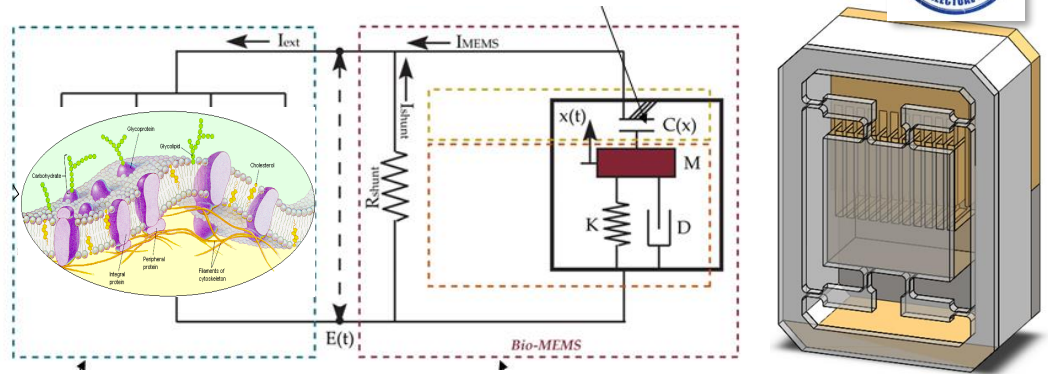
# Dinamica dei Micro/Nano-Sistemi

A. Carcaterra, A. Sestieri, N. Roveri, A. Scorrano, G. Pepe - DIMA

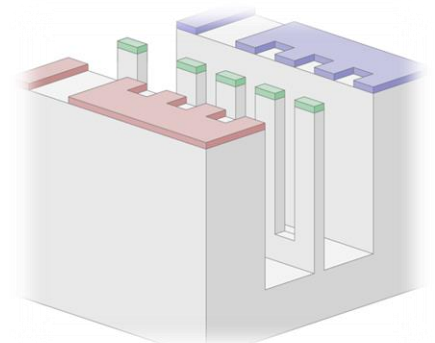
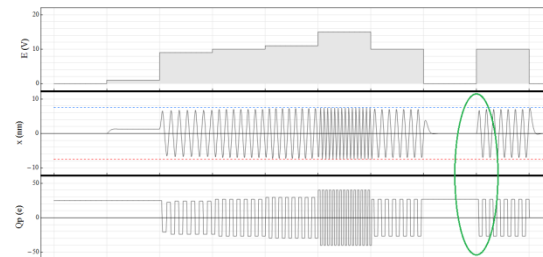
*Micro-diffuse/sensing for real-time detection of grip*



*Micro-motor powered by a neuron cell*



*Electro-mechanical modeling and functional performance of nano-mechanical transistor based on vibrating structures*



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***Nano- e micro-dispositivi per  
applicazioni biomolecolari e  
sopramolecolari***

***Funzionalizzazione e  
ingegnerizzazione di sistemi  
biologici***



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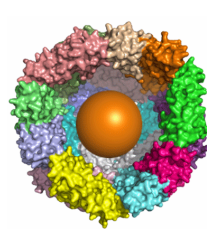


# Nanoparticelle multifunzionali per il “delivery” mirato di farmaci e diagnostici

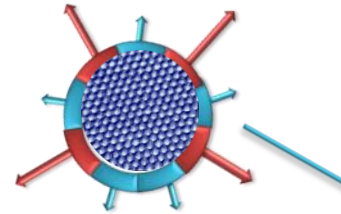
A. Boffi, Dip. di Scienze Biochimiche; B. Botta, Dip. Chim. e Tecnologia del Farmaco

## Vettori per terapie mirate

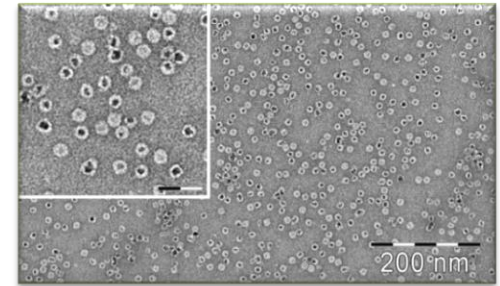
- **Imaging tessuto specifico**
- **Identificazione di recettori**
- **Trasporto di mezzi di contrasto**
- **Trasporto di farmaci**



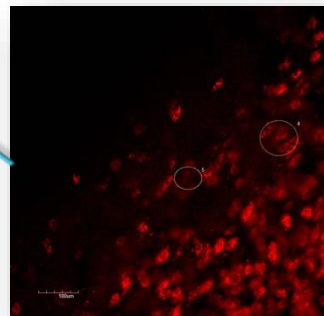
Nanoparticella di ferritina ...



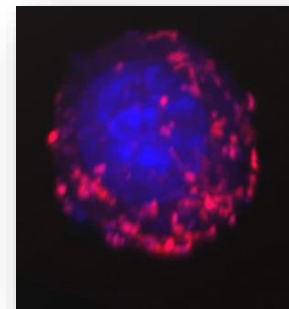
...fluorescente e paramagnetica



...al microscopio elettronico...



...su tessuto tumorale....



...su cellula tumorale (melanoma).



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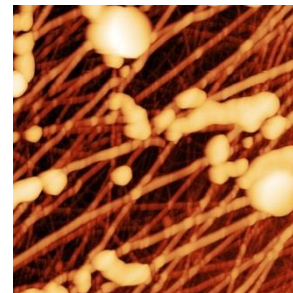
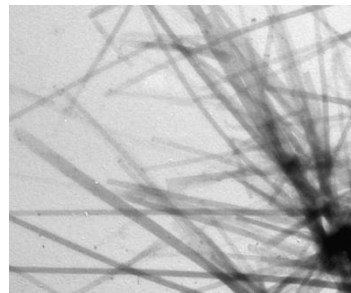
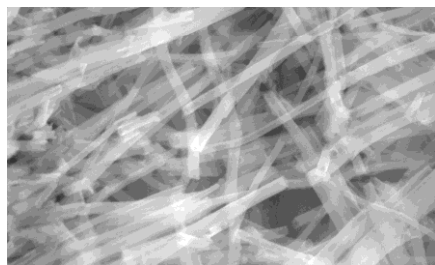


# Synthesis and characterization of rigid unconventional surfactant from biological precursors

L. Galantini, N.V. Pavel, A. D'Annibale, Dip. Chimica



- New rigid surfactants synthesized starting from natural bile acids.
- Their self assembly is studied by using microscopy and spectroscopy techniques.



SEM, TEM and AFM (by Simona Sennato CNIS) of Tubules from bile acid derivative self assembly

-Applications in **nanoscience, particularly in biomedical fields** because of their biological origin. We focused in particular on:

**Preparation of organic nanoparticles to improve efficiency of drugs, pesticides or cosmetics.**

-The project is carried out by exploiting collaborations with:

**University of Santiago de Compostela (Spain)**

**University of Costa Rica (Costa Rica)**

**Lund University (Sweden)**

**Hebrew University of Jerusalem (Israel)**

**Ben Gurion University of Bher Sheva (Israel)**



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# QUANTITATIVE EVALUATION OF BACTERIA IN ADHERENT OR BIOFILM LIFESTYLE ON NANO-PARTICLES

Piera Valenti, Francesca Berlutti, Fabrizio Pantanella

Dipartimento di Sanità Pubblica e Malattie Infettive, Sapienza Università di Roma; CNIS

**QUANTITATIVE EVALUATION OF BACTERIA IN ADHERENT OR BIOFILM LIFESTYLE:  
A CRUCIAL STEP IN THE DESIGN OF NEW NANO-STRUCTURED BIOMATERIALS OF MEDICAL INTEREST.**

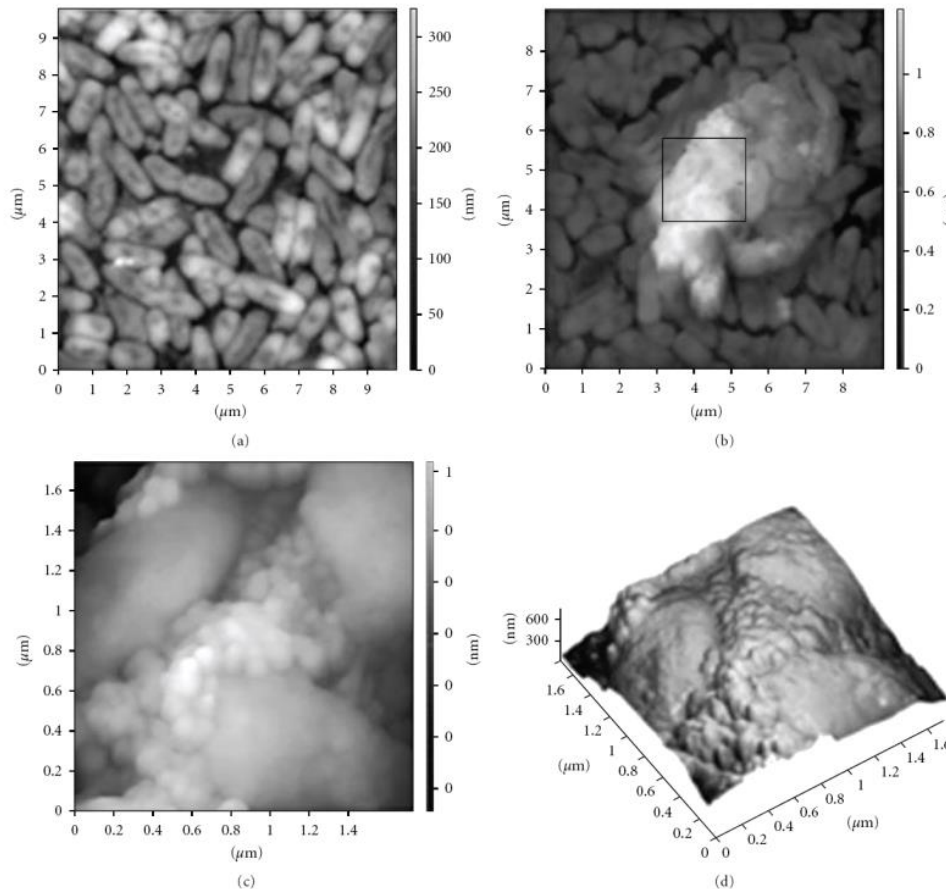


Figure: Atomic force microscopy images of *Pseudomonas aeruginosa* colonizing single wall carbon nanotube-coated glass bead (SWCNT-GB).

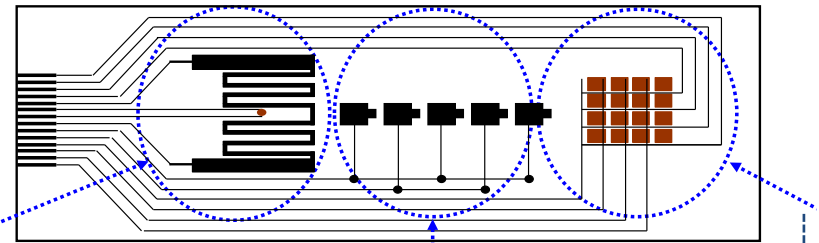
- (a) SWCNT-GB colonization by *P. aeruginosa* after three hours of incubation (adherent bacteria);
- (b) SWCNT-GB colonization by *P. aeruginosa* after 24 hours of incubation (biofilm);
- (c) higher magnification of delimited area in (b) showing extracellular matrix between bacterial cells;
- (d) three-dimensional view of the same area of (c).

# LAB-ON-GLASS systems

D. Caputo, G. De Cesare (Information, Electronics and Telecommunication Dept.)

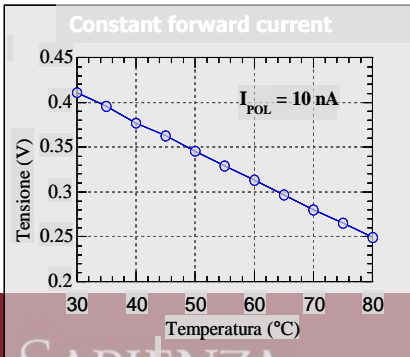
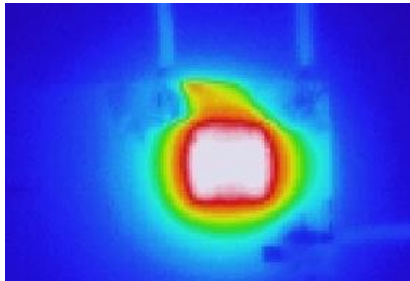
A. Nascetti (Astronautics, Electrical, Energetic Eng. Dept.)

*Integrated systems for bio-molecular analysis including preparation, moving and detection (Pat.Appl. RM2007A000028)*



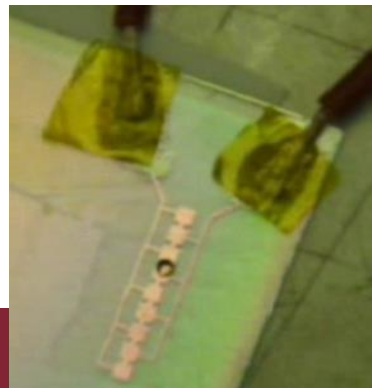
## DNA Analysis

Polymerasis Chain Reaction (PCR) in a PDMS chamber realized over a TiW-thin film based heater with temperature control (sensitivity 3.3 mV/K)



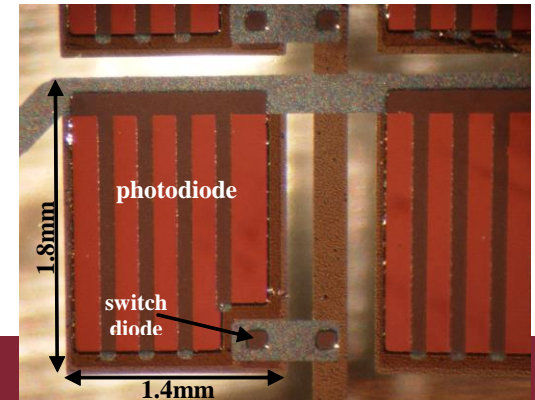
## Transport

Fluid drop transport via electrowetting over idrophobic surface (teflon)



## Detection

UV radiation sensor array for molecular dection





# Fabrication and Characterization of Super Hydrophobic Surfaces (SHS)

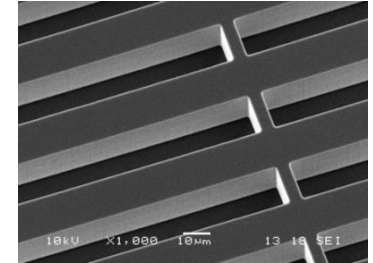
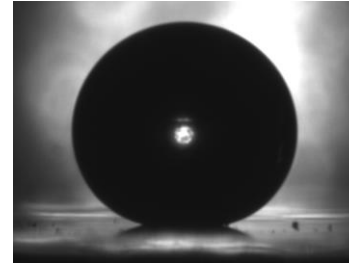
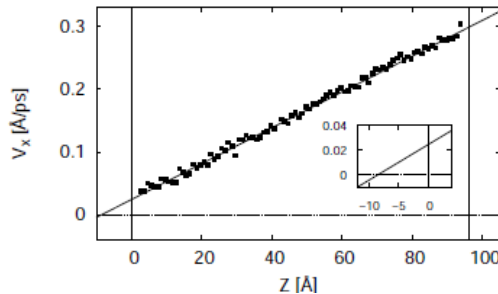
C.M. Casciola, G. Bolognesi, M. Chinappi, D. Gentili (Mech. & Aerospace Eng. Dept.)

in collaboration with M. Balucani et Al. (Sapienza Univ.), R. Di Leonardo (CNR), L. Bocquet, C. Pirat et Al. (UCB Lyon 1)

## Super Hydrophobic State:

low-surface-energy materials+surface roughness

**Physical Characteristics:** high contact angle ( $>160^\circ$ )  
low contact angle hysteresis  
high slip length ( $\sim 1\mu\text{m}$ ).



## Fabrication:

silicon wafer etching + silanization

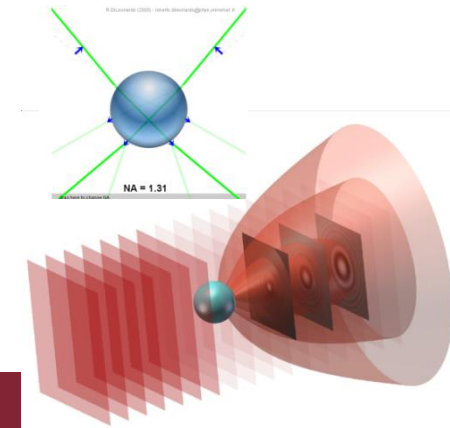
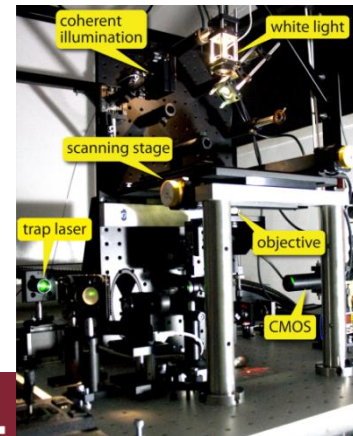
## Numerical Investigations:

MD simulations of water over defected OTS-SAM  
apparent slip depends on OTS-SAM defects

## Experimental Studies:

Micro Particle Image Velocimetry  
Optical Trapping Digital Holographic Microscopy

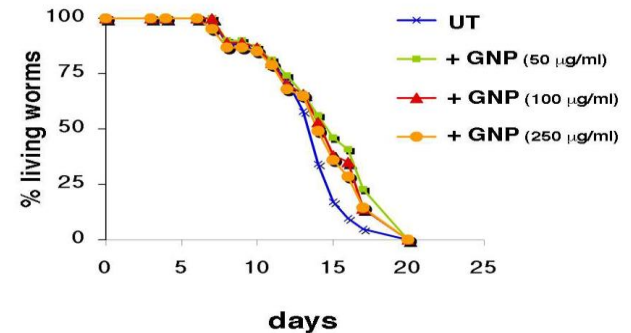
**Applications:** *flow drag reduction*  
*reducing Taylor dispersion*  
*controlled transportation of fluids*  
*superhydrophobic valve*  
*biosurface*  
*battery and fuel cell applications*



# Interazioni tra nanostrutture e sistemi viventi

D. Uccelletti, E. Zanni, M. Olivi, F. Castelli, C. Palleschi (BBMSLab)

- ❖ Studi tossicità acuta e cronica
- ❖ Genotossicità
- ❖ Sistemi modello validati e predittivi per meccanismi cellulari di patologie umane
- ❖ Risposte di dettaglio molecolare da singoli geni e da interi genomi
- ❖ Studi *in vivo* di *target delivery*



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# Biotec per la salute

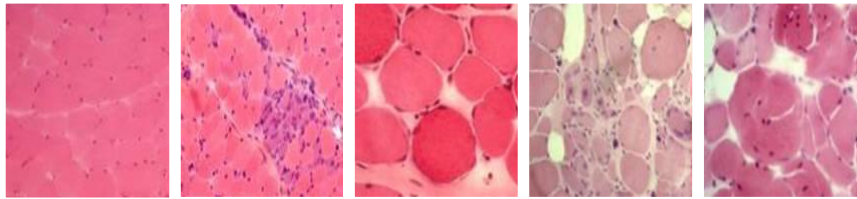
## Sviluppo di nuove metodologie terapeutiche basate sull'uso di RNA

Bozzoni I, Dip. Biologia e Biotecnologie

Tramontano A., Dip. Fisica – Botta B. Dip. Chim e Tecn. Farmaco

Una nuova strategia per la cura della ***Distrofia Muscolare di Duchenne*** modificare l'RNA messaggero mutato della distrofina attraverso molecole chimeriche di RNA "antisenso"

**Duchenne**



**CURA**

*Ripristinare l'integrità del tessuto muscolare*



-Progetto Telethon

-Accordo con associazione dei malati (Parent Project)

-Licensing all'industria (AMT) e contratto di ricerca per sviluppo pre-clinico



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# *Genomica e bioinformatica*



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*SNN-Lab is available for collaborations and research services*

*For SNN-Lab membership: <http://w3.uniroma1.it/sapienzanano>*

**THANKS FOR YOUR ATTENTION**

**SNN-Lab Director:**

Prof. Maria Sabrina Sarto

mariasabrina.sarto@uniroma1.it



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