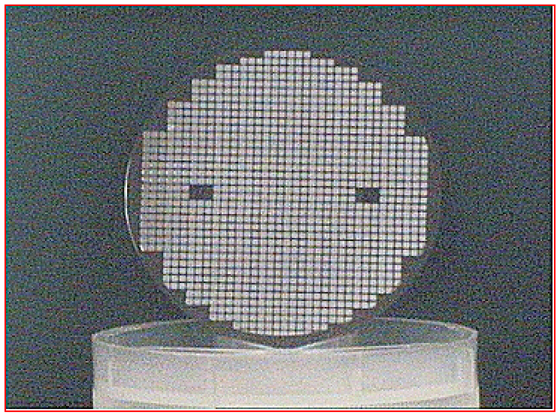
LATEMAR

Materials and Processes for Micro & Nano Technologies Labs



MATERIALS & MICROSYSTEMS LABORATORY

Physics and Electronics Depts of Politecnico di Torino

http://www.polito.it/micronanotech

Mission

- fundamental research on materials and processes for MEMS and NEMS
- design and realization of MEMS and NEMS
- technological transfer
- education

Staff

- 5 Professors
- 5 Permanent Researchers
- 8 TD Researcher
- 9 Fellowships / Post Doc
- 10 PhD students
- 3 Technicians
- 1 Administrative

MATERIALS & MICROSYSTEMS LABORATORY

Physics and Electronics Depts of Politecnico di Torino

http://www.polito.it/micronanotech

Collaborations with Universities & Research Institutes

UC Berkeley – USA
UCLA- USA
University of Wisconsin – USA
Linkoping University – Sweden
Minatec – France
Université Paris – Diderot - France
EPFL – Switzerland
Ioffe Physico-Technical Institute St. Petersburg – Russia
University of Mining and Metallurgy of Krakow – Poland
Instituto Superior Técnico – Portugal
Instituto de Engenharia de Sistemas e Computadores – Portugal
Istituto di Chimica dei plasmi C.N.R. in Bari – Italy
CEFSA C.N.R. Institute in Trento – Italy
C.N.R. Institute in Bologna – Italy
C.N.R. Institute in Parma – Italy
INRIM in Torino – Italy
Environment Park, Torino, Italy
Bruno Kessler Foundation, Trento, Italy
Istituto per la Ricerca Contro il Cancro (IRCC) of Candiolo (Turin) – Italy
Telethon Foundation
Universities of Napoli, Catania, Bologna, Brescia, Trento, Verona – Italy
University Cattolica of Sacro Cuore, Piacenza - Italy

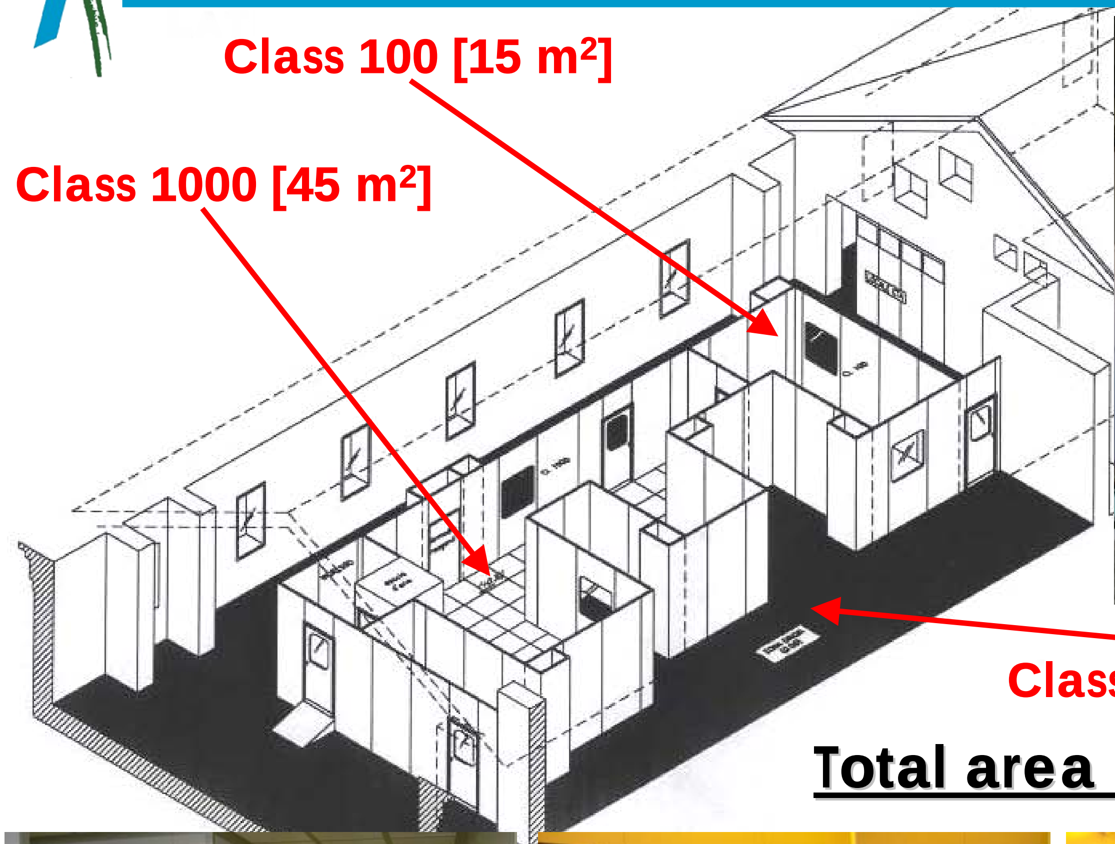
Collaborations with industries

Vishay Semiconductor Italiana
Olivetti i-jet S.p.A.
STMicroelectronics
LPE S.p.A.
Varian, Vacuum Technologies
Avago Technologies
Fujitsu Lab.
Mitsui-Carbon Nano Technology
Brewer Science
Grinp S.r.l.
Elettrorava S.p.A.
Zaniboni
AQM
Cyanagen S.r.l.
Biodiversity S.p.A.
Euroclone S.p.A.
Tecnobiomedica S.p.A.
Papiro S.r.l.

CLEAN ROOMS IN CHIVASSO

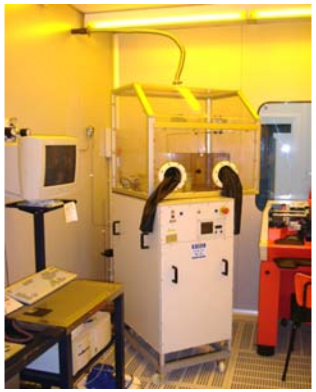
Class 100 [15 m²]

Class 1000 [45 m²]



Class 10.000 [90 m²]

Total area 150 m²



TECHNOLOGICAL & CHARACTERIZATION FACILITIES

Coventor + Comsol

Thin Films growth technologies
- Metal evaporation systems: thermal + electron gun
- Magnetron sputtering
- Plasma Enhanced Chemical Vapor Deposition (PECVD)
- Low Pressure CVD (LPCVD)
- Silicon oxidation
- Electroplating

Optical - Laser Lithography

Spinner

Mask-Aligner Single & Double-Side

Electron Beam Lithography

Etching: (WET/DRY/powder blasting)
- HF, BOE, HCl, … / CF_4, SF_6, CHF_3, H_2
- KOH, EDP

Anodic Bonding

Hot Embossing

AFM/STM Lithography

Microscopies

Optical
FE-SEM + EDX
AFM / STM
SNOM

UV-Vis Spectrometer

Micro-Photoluminescence

Micro-FT-IR Spectrometer

Micro-Raman Spectrometer

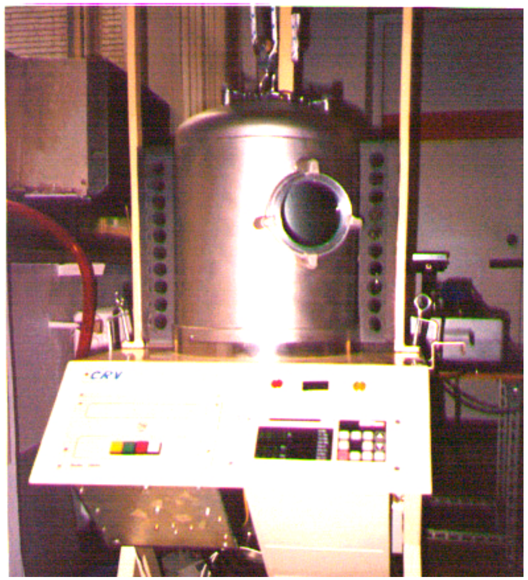
Micro-Xray Diffractometer (XRD)

Profilometer

Contact Angle

Electrical characterizations

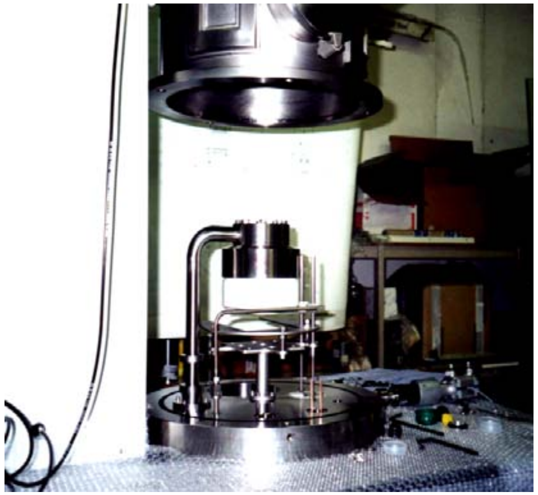
TECHNOLOGICAL FACILITIES



Metal growth

- **<u>Thermal evaporator</u> [CRV system]**

- **E<u>-beam evaporator</u> [ULVAC EBX-14D system]**



Thin film growth

- **<u>r.f. magnetron sputtering</u>**

- TeO_2, Silica:Ge, Silica:Sn, CeO_2 and YSZ.
- 3 RF magnetron sources, UHV chamber;
- thermal control during deposition up to 1000 °C.

TECHNOLOGICAL FACILITIES

Thin film growth

• **<u>Low pressure CVD</u>**

- poly crystalline 3C-SiC, c-Si
- Pressure ~ 200-300 mT
- Temperature up to 2000 °C (heater) → 1600 °C (substrate)
- 4" maximum substrate diameter
- 3 process gas lines (SiH_4, C_3H_8, H_2, [NH_3])

Thin film growth

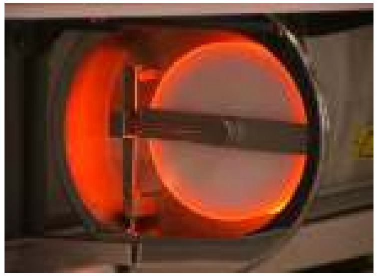
•13.56 MHz **<u>Plasma Enhanced CVD</u>**
amorph. and mc Si based alloys (SiC_X, SiN_X, SiO_X)

•2.45 GHz **<u>Electron Cyclotron Resonance CVD</u>**
poly-cryst. Si-based materials, a-SiN_X, a-SiO_X

•Load-Lock chamber

•several gas lines (SiH_4, C_3H_8, NH_3, H_2, CO_2, N_2)

TECHNOLOGICAL FACILITIES



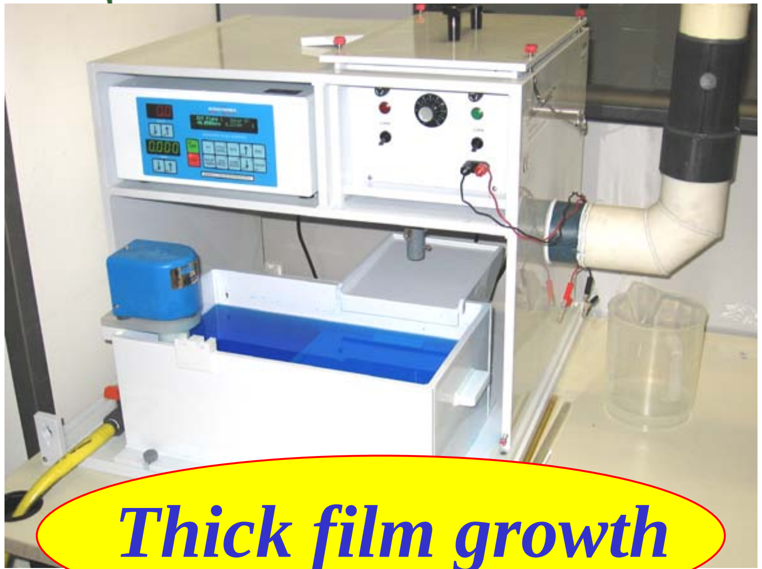
Thin film growth

Furnace system for oxidation and annealing

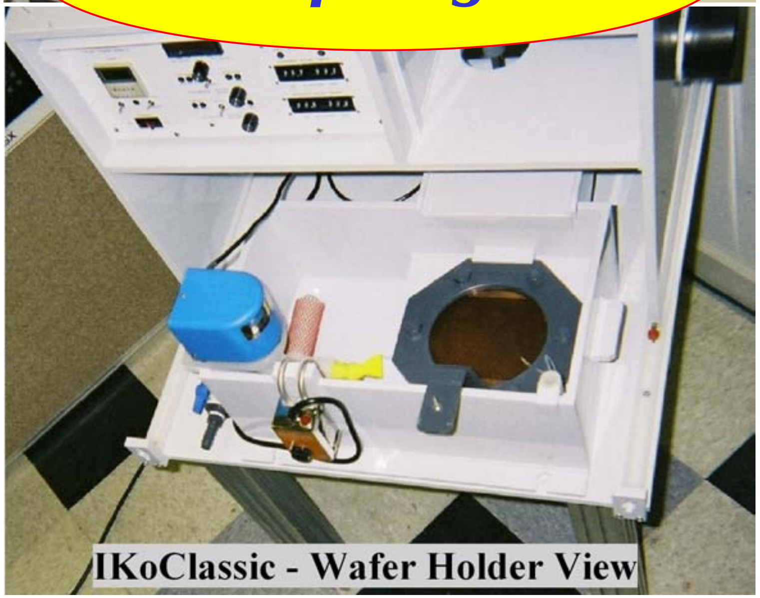
Tempress ***System***

- 5 zones temperature control, 1100 mm at constant temperature
- Digital Temperature Controller (DTC) for high accuracy temperature control.
- Process temperature up to 1200 °C

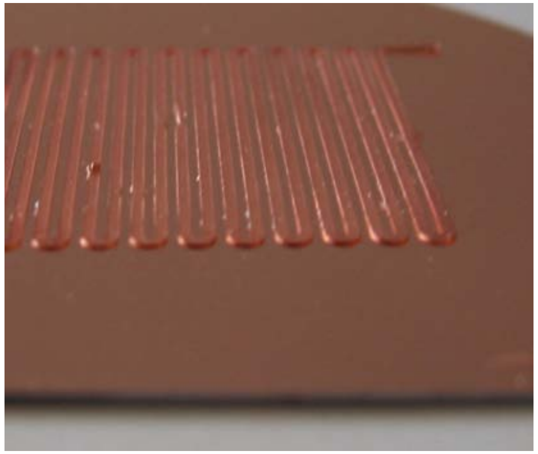
Electroplating



Thick film growth



- IKoClassic Standard Model from ECSI ElectroChemical Systems (Inc. 136 Chestnut St. Midland Park, NJ 07432).
- bench-top tool designed for fabricating MEMS, NEMS and High Density Interconnects
- range of feature size from nanometers to several millimeters
- It is able to electroplate any metal or alloy that can be electroplated in aqueous solutions including Copper, Nickel, Palladium, Gold, Platinum, Tin, Lead, Iron, Silver, Permalloy, Palladium-Nickel and Solder
- It is equipped to electroplate 4" wafer size and/or wafer sections with the appropriate set of wafer holder and anode. programmable operation.
- IKO with the FIBRotools Technology allows high control on the uniformity of the deposition by minimizing peeks of current density at the edges of the patterns and compressing and levelling the diffusion layer by the motion of the reciprocating anode.

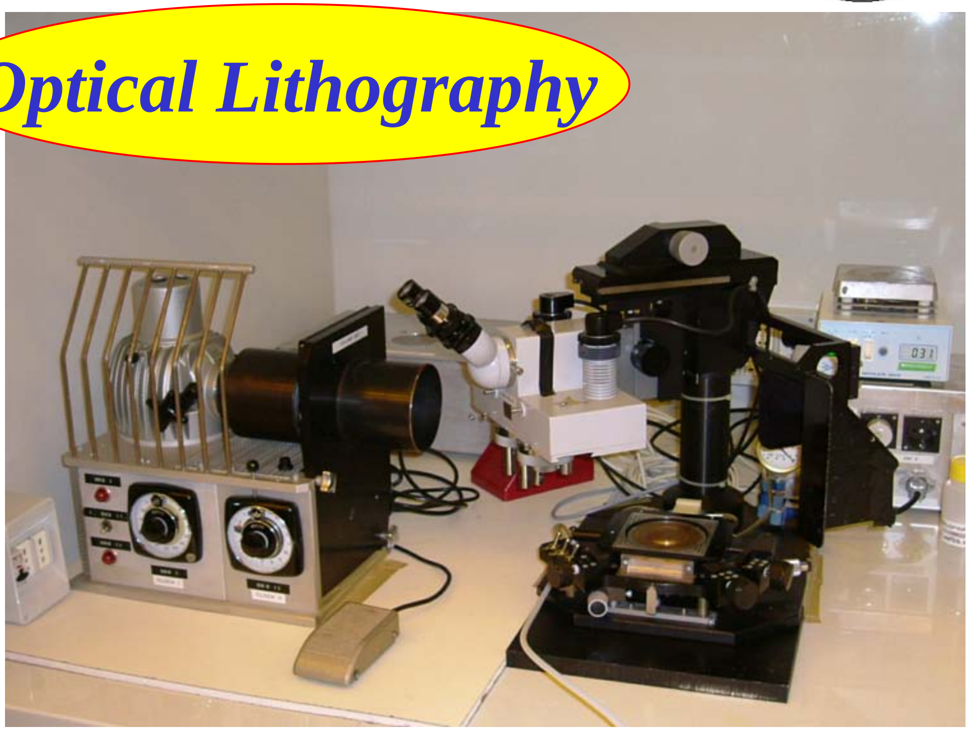


TECHNOLOGICAL FACILITIES

Photolithography set-up
⇒ actual resolution ~ 2 µm…

- Wafer size: 4" max.
- Wafer/substrate thickness: 0 ÷2.5 mm.
- Exposure wavelength: 365 nm
- Exposure source - 200 watt high pressure mercury arc lamp

Optical Lithography



…now upgraded with front-back double alignment

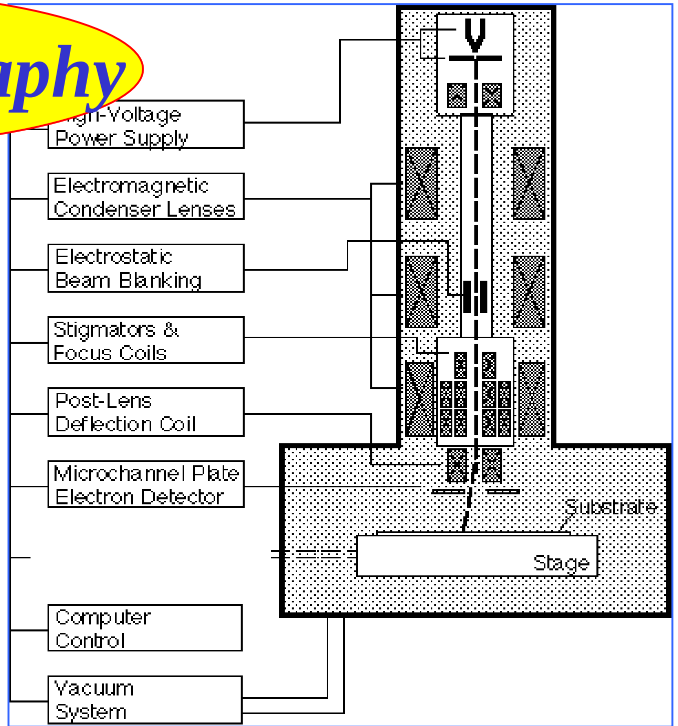
TECHNOLOGICAL FACILITIES

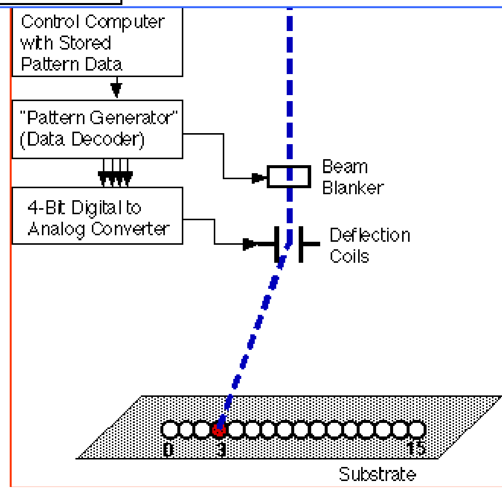
E-Beam Lithography

SEM JEOL JSM 6400

with e-beam facility by RAITH

Beam Voltage	5-35 kV
Beam Current	$10^{-12} \div 10^{-5}$ A





Lithography process

1. **Pattern Design (CAD)**
2. **Pattern Definition (PMMA exposure to e-beam)**
3. **Pattern Transfer (Etching [wet or dry])**

TECHNOLOGICAL FACILITIES

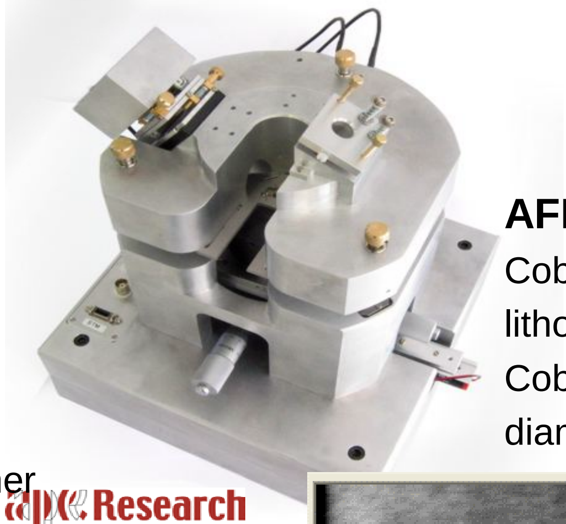
AFM Lithography

Operation:

- contact mode
- non-contact mode
- lateral force microscopy
- tapping mode
- lithography

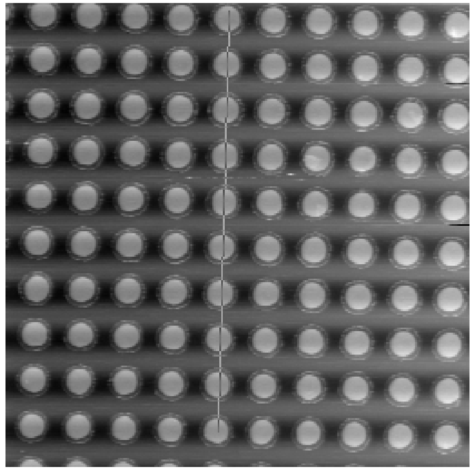
Technical features:

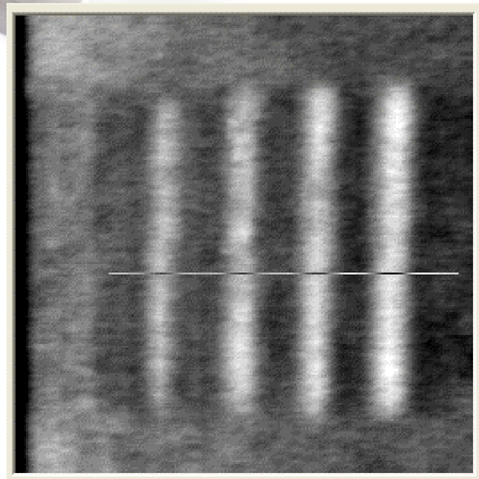
- X-Y high resolution flexure scanner
- Integrated capacitive feedback sensors.
- Resolution < 1.6 nm in High Voltage mode.
  < 0.16 nm in Low Voltage (LV)
- Position accuracy: 10 nm
- Z Scanner
  - Range 10 μm (HV)/1 μm (LV) .
  - Resolution < 0.16 nm in HV mode.



AFM imaging:

Cobalt dots realized by optical lithography, thermal evaporation of Cobalt and a lift-off step (1μm diameter, 2μm step)





Facilities of Nanolithography Tool:

- Local anodic oxidation on metal films and semiconductor substrate
- Nano-scratching and Nano-indentation on polymeric films.
-Current driven lithography on PMMA layers.
-Local anodic oxidation on a n-type Si wafer:

Local anodic oxidation on metal films and semiconductor substrate.
Line length 950-1000 nm, line width 90-130 nm; dimensions depending on applied voltage.
Local oxide height as a function of the applied voltage.

TECHNOLOGICAL FACILITIES

Wet Etching

Two benches devoted to wet etching inside class 1000 and class 10.000

TECHNOLOGICAL FACILITIES

STS 320PC Reactive Ion Etching

The STS 320PC Reactive Ion Etching is a turbo-pumped system, with a PC-based process controller and an integrated optical-emission end-point detector. It is surmounted by a glove box for a secure insertion and extraction of samples from the process chamber. It has 5 process gases (N_2, H_2, O_2, SF_6 and CHF_3 currently) regulated by MFCs.

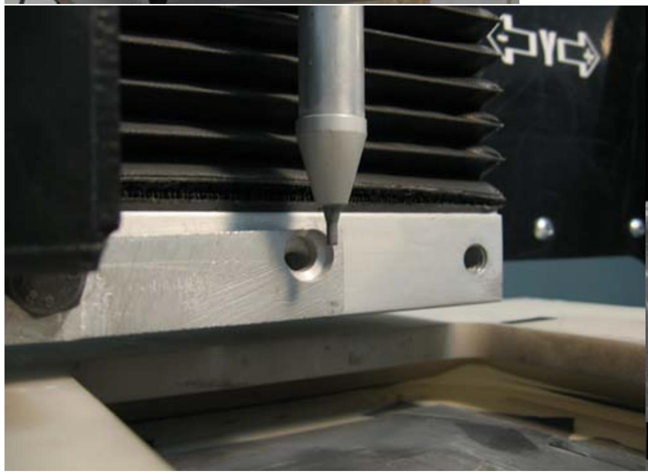
Plasma-etching Plasmafab 508

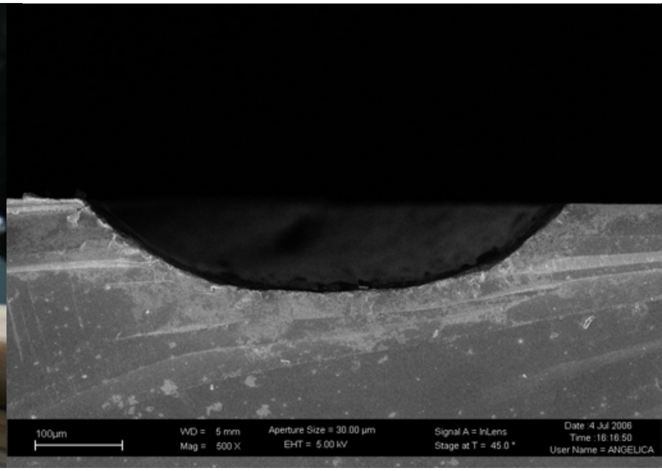
- Radio frequency (13.56 MHz) capacitive discharge
- 3 process gases regulated by MFCs (SF_6, CF_4, O_2)
- Max power 500W

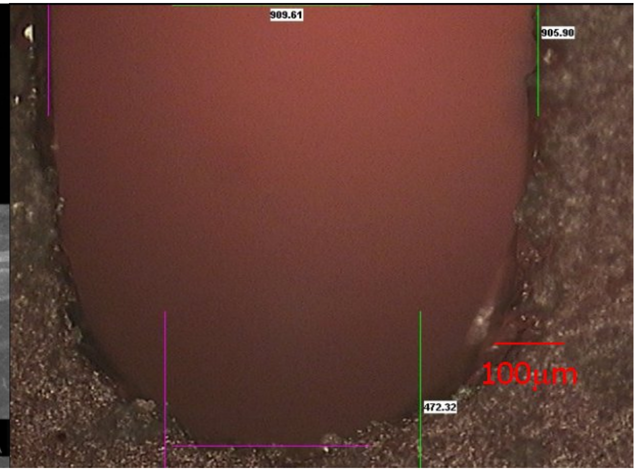
Dry Etching

Powder Blasting

Powder blasting, or abrasive jet machining (AJM), is a technique in which a particle jet is directed towards a target for mechanical material removal. It is a fast, cheap and accurate directional etch technique for brittle materials such as glass, silicon and ceramics. The particle jet can be optimized for etching, while an eventual mask (according to the geometries to be patterned) defines the small and complex structures. It is a fast process; the time to etch through a 1.5 mm thick quartz wafer with one nozzle is approximately 60 secs in our set-up based on a Model HME II Unit from S.S. White Technologies, Inc. (151 Old New Brunswick Road, Piscataway, NJ08854). The particles are accelerated towards the target with a high-pressure. The airflow is mixed with the particles by a vibrating feeder. The mixture is directed through a circular tungsten nozzle (with a diameter variable from 0.35 to 0.8 mm) at the end of the tube. The particles hit the target with a speed, depending on the air pressure, in a separate box. Particles are made of alumina with a grain size variable from 23 to 95 mm







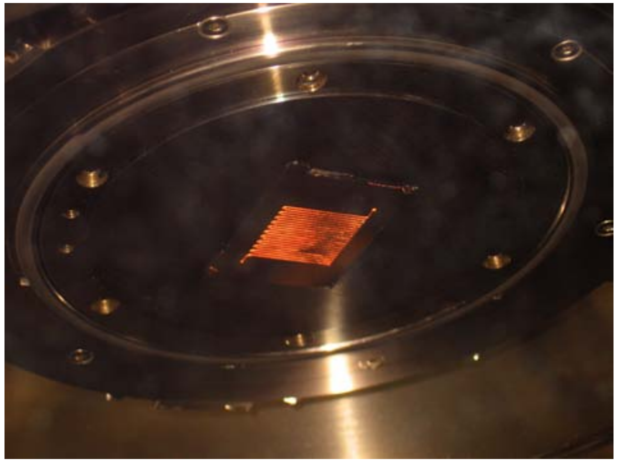
Hot Embossing

HOT EMBOSSING

Jenoptik Jena Mikrotechnik - HEX01

Hot embossing of polymers is the cutting edge technology for the manufacturing of smart micro-components. Our equipment is the HEX01 hot embossing solution from JENOPTIK Mikrotechnik designed for applications in the emerging fields of micro-optics, microfluidics, smart materials and electronics subcomponents. It ensures highly precise moulding of any structures in polymers, especially microstructures with aggressive aspect ratio (up to 150:1). This is the easiest way to replicate a nanostructured and expensive mould into a more useful and cheaper polymeric material.

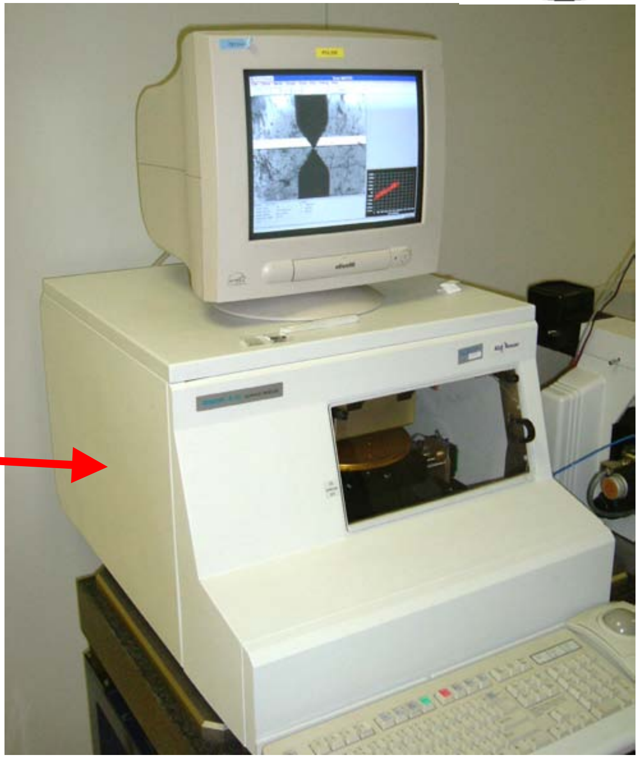
Nano-embossing can rapidly pattern large areas with feature sizes that previously required far slower and more costly electron-beam or ion-beam patterning. These technologies now may pattern the nano-scale features on the master die. The master die then replicates the features onto whole wafers, if only a single level of patterning is needed, or at chip size when several layers with an accurate overlay are required.



CHARACTERIZATION FACILITIES

Structural Characterizations

X Ray Diffractometer (BB grazing angle and μbeam)
Micro-Raman Spectrometer
μFT-IR Spectrometer
Micro-Photolum. Spectrometer (vis and UV excit.)
Optical, AFM and STM microscopies
Profilometer
SNOM
FESEM + EDX analysis
Contact angle



The profiler is a computerized, highly sensitive surface profiler that measures roughness, waviness, step height, and other surface characteristics in a variety of applications over a full 205 mm scan.
The built-in PC computing power offers precise, automatic measurement capability with the convenience and ease of use of Microsoft windows-based software control and data analysis.

- Vertical range = 160 μm and 1 Å vertical data resolution.
- Measurement 205 mm (8 in.) substrates.

Optical Characterizations

UV-Vis Spectrometer
Photothermal deflection Spectrometer (PDS)

Electrical Caracterizations

Set-up for conductivity measurement vs temperature
Set-up for I-V and C-V measurements
Set-up for photoelectric characterizations

CHARACTERIZATION FACILITIES

Structural Characterizations

X Ray Diffractometer (BB grazing angle and μbeam)
Micro-Raman Spectrometer
μFT-IR Spectrometer
Micro-Photolum. Spectrometer (vis and UV excit.)
Optical, AFM and STM **microscopies**
Profilometer
SNOM
FESEM + EDX analysis
Contact angle

- 5x, 10x, 20x and 100x optics
- up to 1000x real magnification (with CCD contribution)
- PC interfaced
- X-Y motorized stage for automated analysis (10 μm resolution)
- Z manual stage (0.1 μm resolution)

Optical Characterizations

UV-Vis Spectrometer
Photothermal deflection Spectrometer (PDS)

Electrical Caracterizations

Set-up for conductivity measurement vs temperature
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CHARACTERIZATION FACILITIES

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ZEISS SUPRA™ 40 Field Emission Scanning Electron Microscope (FESEM)

Performances:

- Nominal resolution: 1.5 nm at 10 KV and WD= 2mm
- Acceleration voltage: 0.1 - 30 KV
- Probe current: 4 pA-10 nA
- Magnification: 12 - 900,000 X
- Working distance: it ranges from 1 to 50 mm, depending on the operating conditions. The sample holder can host nine stubs. Each stub can contain samples of about 1 cm^2.

CHARACTERIZATION FACILITIES

Structural Characterizations

X Ray Diffractometer (BB grazing angle and µbeam)
Micro-Raman Spectrometer
µFT-IR Spectrometer
Micro-Photolum. Spectrometer (vis and UV excit.)
Optical, **AFM and STM microscopies**
Profilometer
SNOM
FESEM + EDX analysis
Contact angle

DME DS -200 system

- ✓ **Scanning area 200 µm x 200 µm**
- ✓ **vertical resolution <5 Å**
- ✓ **lateral resolution 3 Å**
- ✓ **contact and non contact mode and STM**

INFORMATION ON

- ✓ surface morphology
- ✓ high resolution defects profile

Optical Characterizations

UV-Vis Spectrometer
Photothermal deflection Spectrometer (PDS)

Electrical Caracterizations

Set-up for conductivity measurement vs temperature
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CHARACTERIZATION FACILITIES

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Micro-Raman Spectrometer

μFT-IR Spectrometer

Micro-Photolum. Spectrometer (vis and UV excit.)

Optical, AFM and STM microscopies

Profilometer

SNOM

FESEM + EDX analysis

Contact angle

The MicroRaman system is a Renishaw apparatus equipped with an Argon Laser with excitation at 514.5 nm.
The most important features are:

- Wavelengths range 400-1000 nm
- Spectral resolution 1 cm^-1
- Spatial resolution 1 μm (objective 100x)
- Depth 2 μm (objective 100x)
- Dimensions 650 mm x 400 mm x 650 mm
- Detector CCD camera
- Available power with line 514.5 nm up to 200mW

Recently the system was upgraded with the acquisition of an Hot Cell (up to 1500°C) with which is possible to measure in-situ annealing process. This powerful tecnique is used to study quality of materials growth with our systems with the great advantage to delete the contribute of the substrate where the film is growth.

INFORMATION ON

✓ material structure

✓ dopant concentration

Optical Characterizations

UV-Vis Spectrometer

Photothermal deflection Spectrometer (PDS)

Electrical Caracterizations

Set-up for conductivity measurement vs temperature

Set-up for I-V and C-V measurements

Set-up for photoelectric characterizations

CHARACTERIZATION FACILITIES

Structural Characterizations

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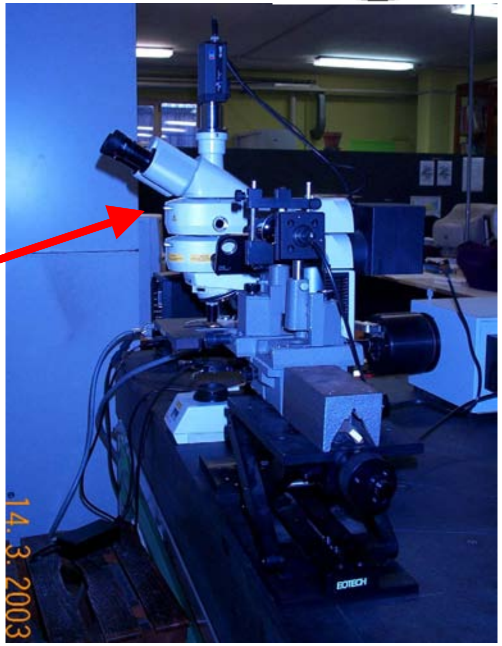


Optical Characterizations

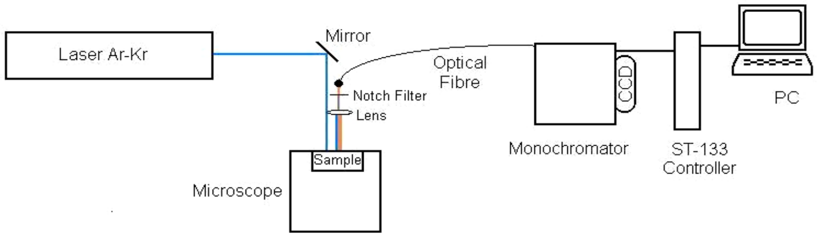
UV-Vis Spectrometer
Photothermal deflection Spectrometer (PDS)

INFORMATION ON

- ✓ material impurities
- ✓ dopant identification
- ✓ defects
- ✓ recombination centers on surface and in bulk

Electrical Caracterizations

Set-up for conductivity measurement vs temperature
Set-up for I-V and C-V measurements
Set-up for photoelectric characterizations



CHARACTERIZATION FACILITIES

Structural Characterizations

- X Ray Diffractometer (BB grazing angle and μbeam)
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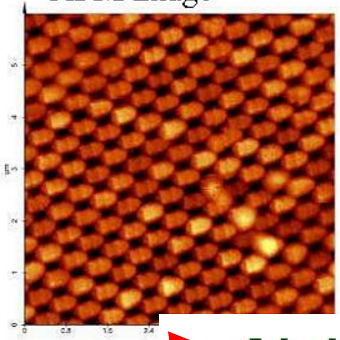
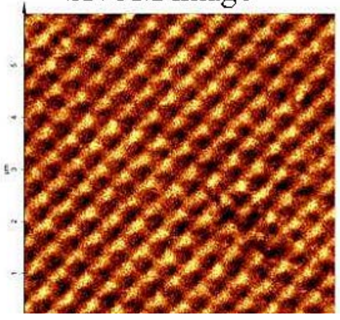
- **SNOM**
- FESEM + EDX analysis
- Contact angle

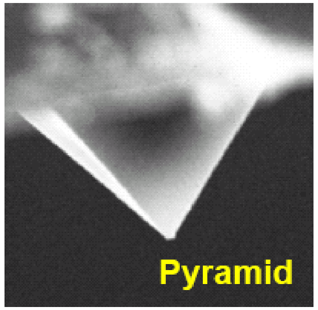
AFM image

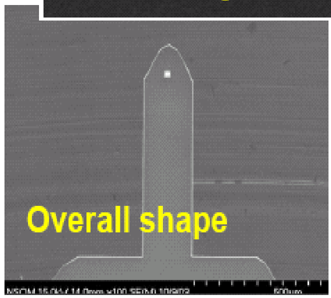


SNOM image



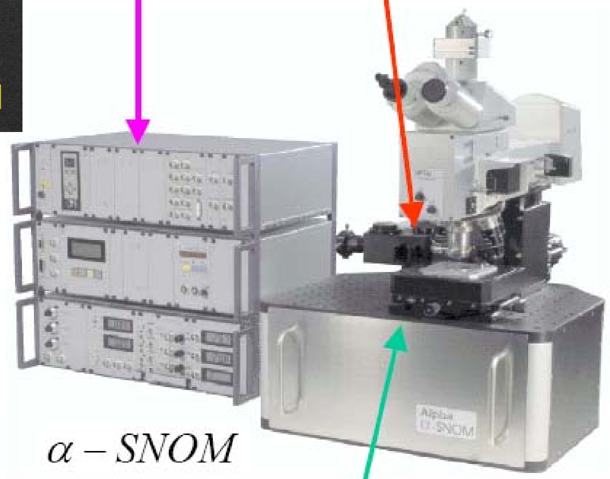
Alpha-SNOM





Nanoprobe

SNOM modules



$\alpha - SNOM$

Piezo stage

Optical Characterizations

- UV-Vis Spectrometer
- Photothermal deflection Spectrometer (PDS)

Electrical Caracterizations

- Set-up for conductivity measurement vs temper
- Set-up for I-V and C-V measurements
- Set-up for photoelectric characterizations

To overcome diffraction limit imposed by conventional optical microscopy

CHARACTERIZATION FACILITIES

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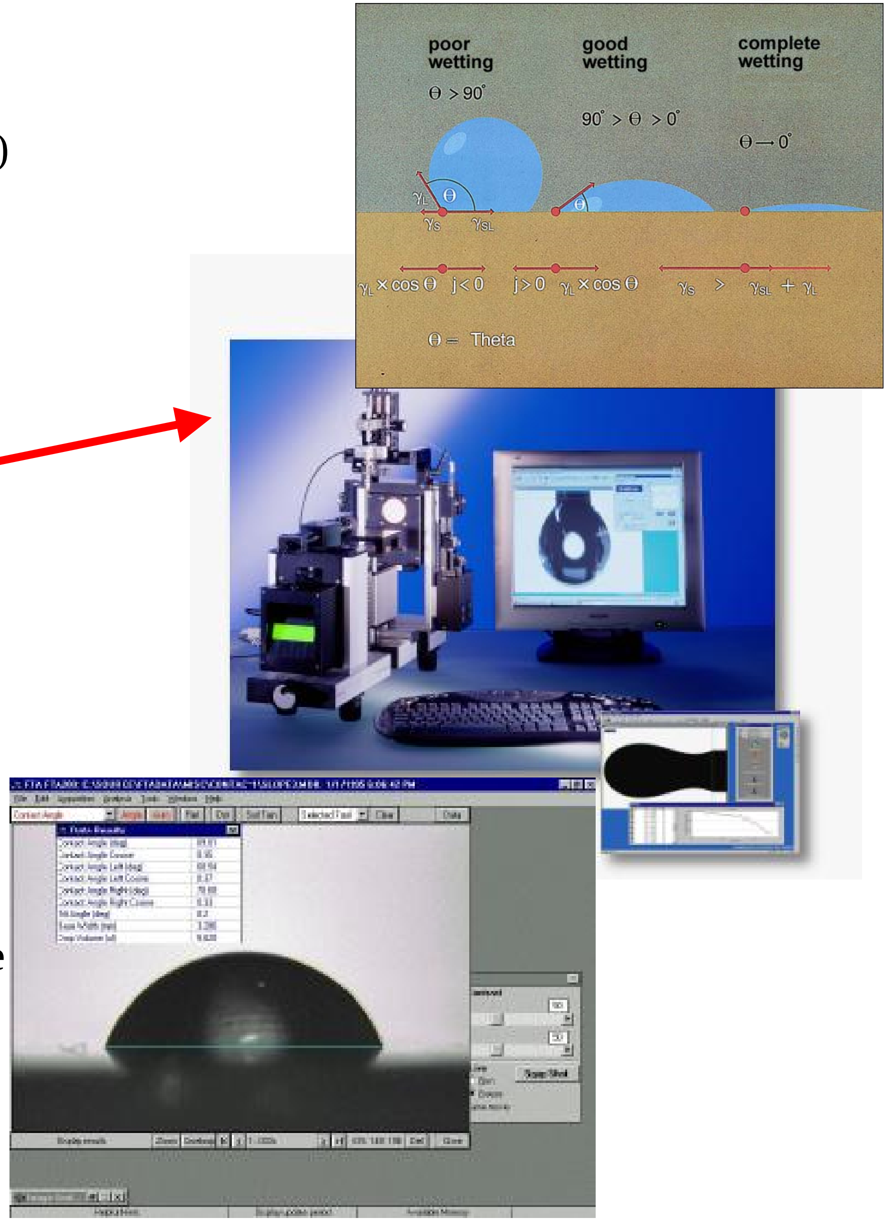

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Photothermal deflection Spectrometer (PDS)

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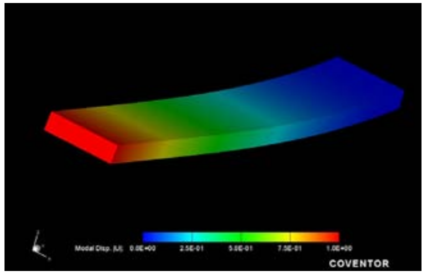
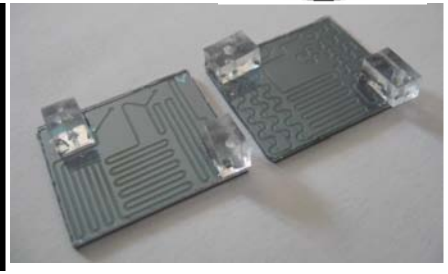
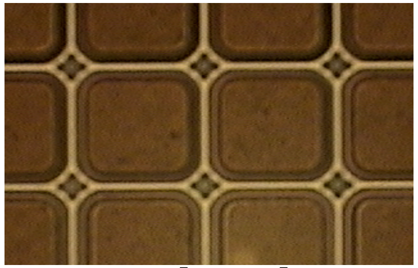
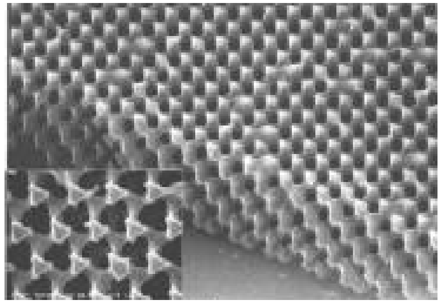
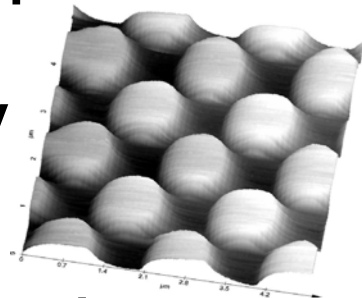
RESEARCH LINES

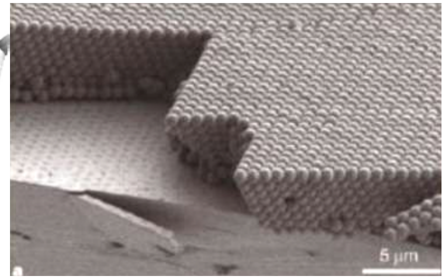


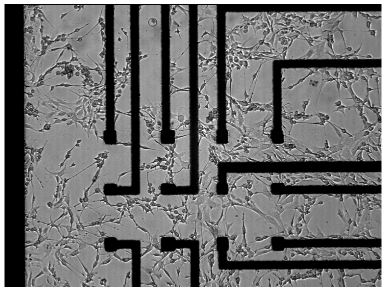


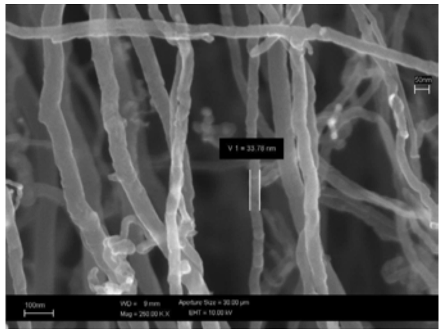












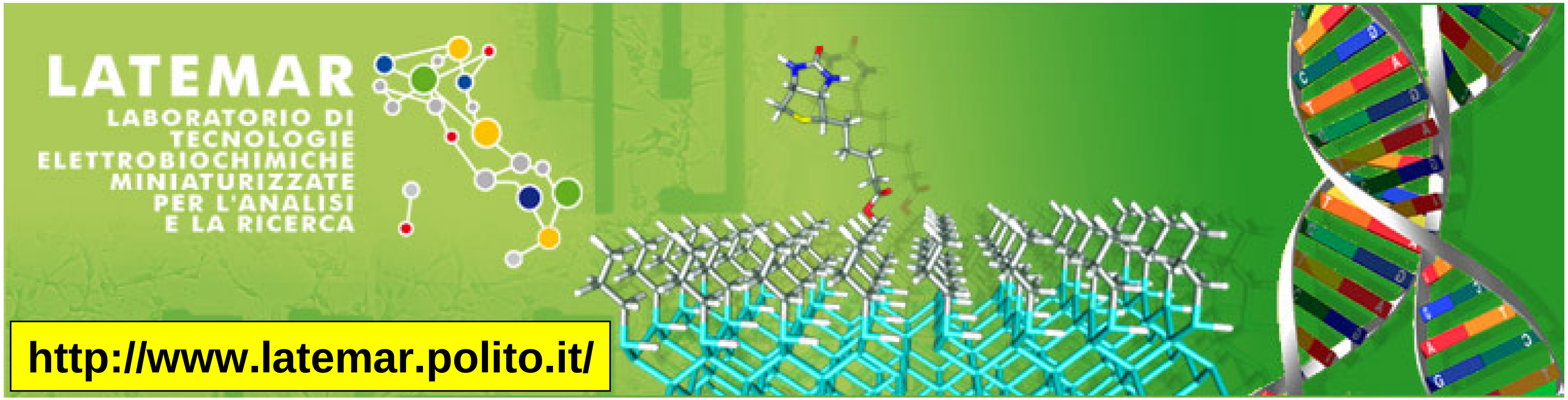
- **Micro e Nanotechnologies for:**
  - **biotech applications**
  - **photonic structures**
  - **microfluidics**
  - **vacuum technologies**
  - **sensor development**
  - **high temp/power electronics**
  - **environmental monitoring & energy production**
- **Micro & Nanoscale characterizations**
- **Surfaces and biointerfaces technology**
- **Nano-bio-photonics**
- **Development of Nano-lithographies**
- **Nano-imaging and nanoparticles applications**
- **Ab-initio and FEM simulations**
- **Carbon NanoTubes technology**
- **Spintronics**
- **Laser marking & machining**

LATEMAR

FOCUS ON BIO → LATEMAR

MICRO – TECHNOLOGY | AND / OR | NANO - TECHNOLOGY | + | BIOLOGICAL GENOMIC PROTEOMIC Applications

LAboratorio di Tecnologie Elettrobiochimiche Miniaturizzate per l'Analisi e la Ricerca (LATEMAR)



WHAT IS LATEMAR ?

LAboratorio di **T**ecnologie **E**lettrobiochimiche **M**iniaturizzate per l'**A**nalisi e la **R**icerca **(LATEMAR)**

Centre of Excellence funded by MIUR (through FIRB 2003-2004 grants) for public and private research structures operating in strategic fields for the Nation

DIFFUSED LABORATORY

merges and coordinates Centres of Excellence in the basic research related to the development of micro and nanotechnologies and biotech together with R&D centres of extremely qualified Companies

<u>Coordination of the Laboratory</u> → Politecnico di Torino

LATEMAR

AIM AND STRATEGY OF THE LABORATORY

biotech
genomics
proteomics

micro and nanotechnologies

Devices for diagnostics and therapeutics in biomedical, pharmacological, agriculture and food science fields, in particular in strongly innovative areas like DNA, RNA, proteins, biological molecules and cells analysis

Development of highly integrated systems to perform quickly and automatically several complex biochemical analysis

medium and long term unitary strategy

integration of different disciplines and competences

LATEMAR

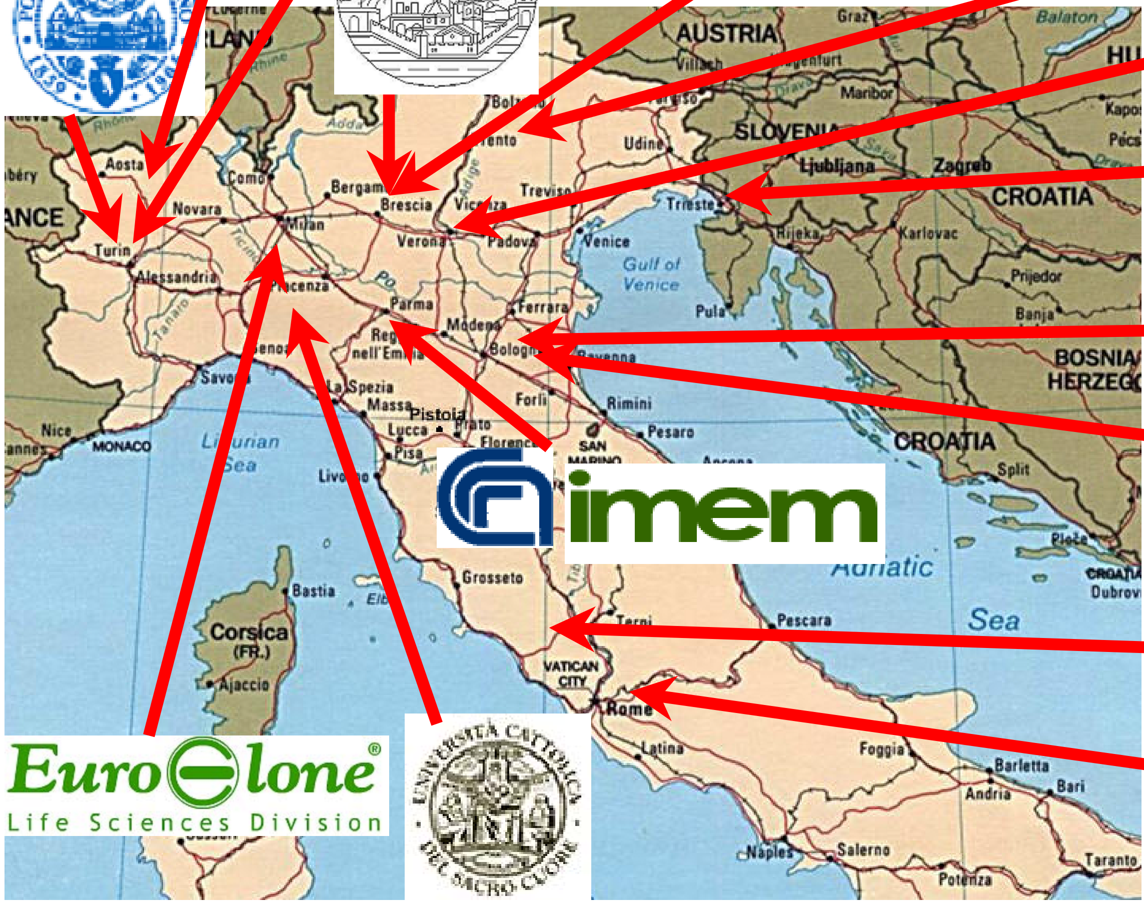
LATEMAR – THE 15 PARTNERS

olivetti

ENVIRONMENT PARK
PARCO SCIENTIFICO TECNOLOGICO PER L'AMBIENTE

Biodiversity
diagnostica molecolare, ricerca applicata, genomica, proteomica

ITC
ISTITUTO TRENTINO DI CULTURA



imem

Euro Clone
Life Sciences Division

UNIVERSITAS STUDIORUM BRIXIAE

UNIVERSITÀ CATTOLICA DEL SACRO CUORE

POLITECNICO DI TORINO 1859 1906

UNIVERSITÀ DEGLI STUDI DI VERONA

TeleThon

ALMA MATER STUDIORUM A.D. 1088

CYANAGEN
Reagents for Genomics and Proteomics

UNIVERSITÀ DEGLI STUDI DELLA Tuscia

TECNO BIOMEDICA

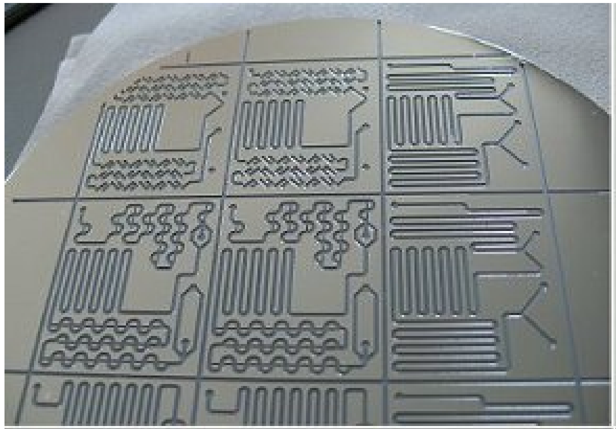
DEVELOPMENT OF Si-based LAB-ON-A-CHIP FOR THE DNA ANALYSIS

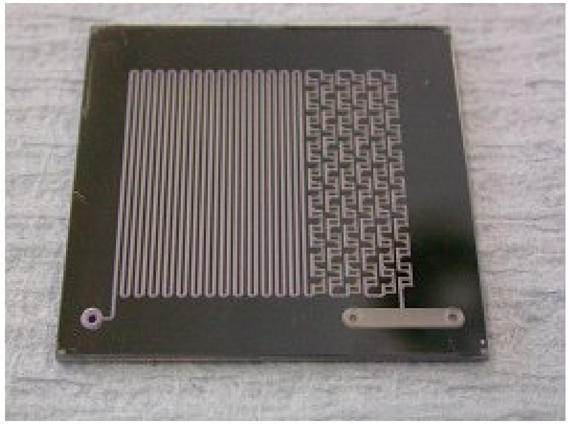
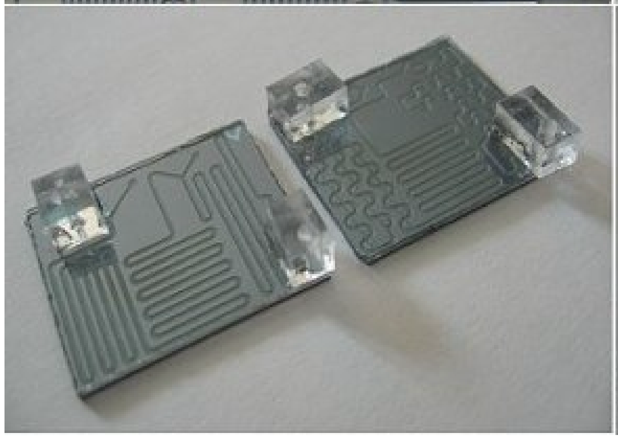
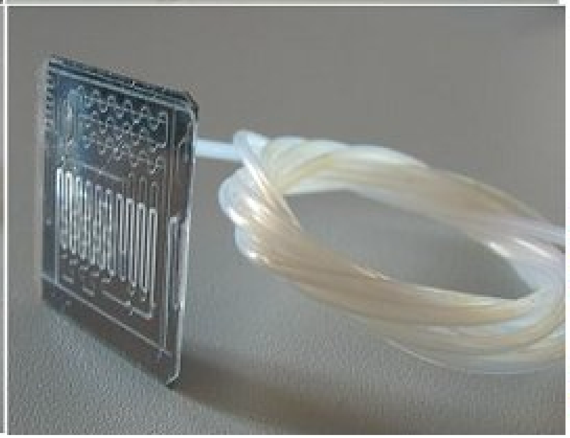
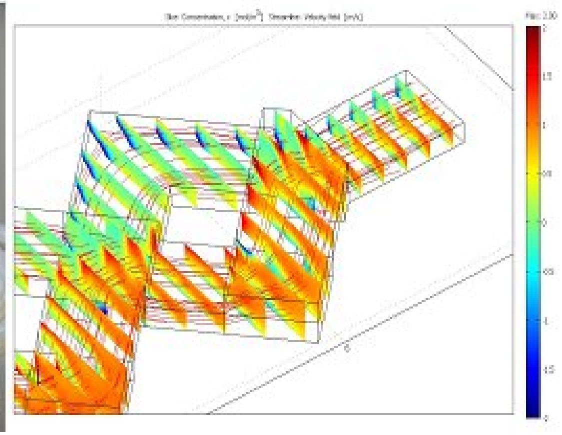
LATEMAR

"Lab-on-Chip" for SNPs detection

probes

biological sample → DNA Extraction → DNA Amplification (PCR) → Denaturation and hybridization on DNA microarrays → Detection

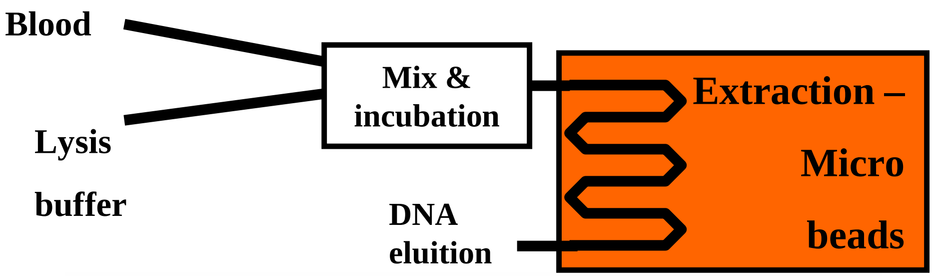


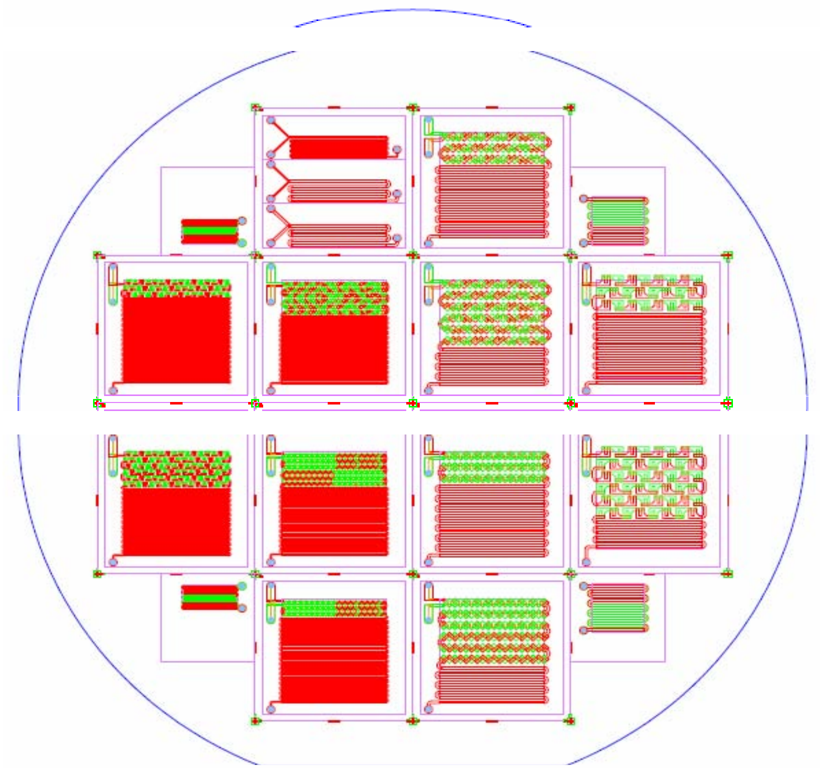





DEVELOPMENT OF Si-based LAB-ON-A-CHIP FOR THE DNA ANALYSIS

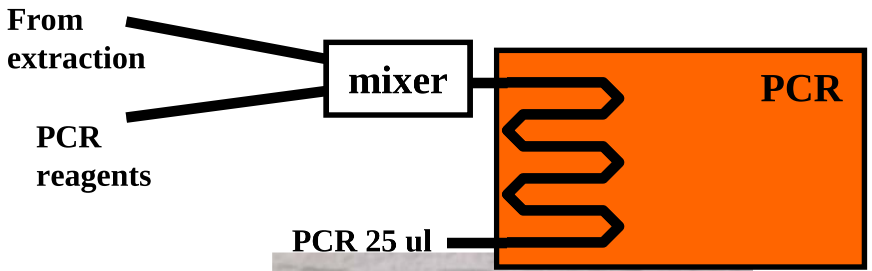
LATEMAR

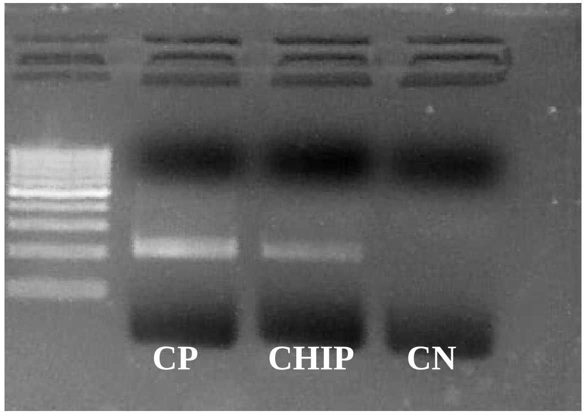
Extraction Module



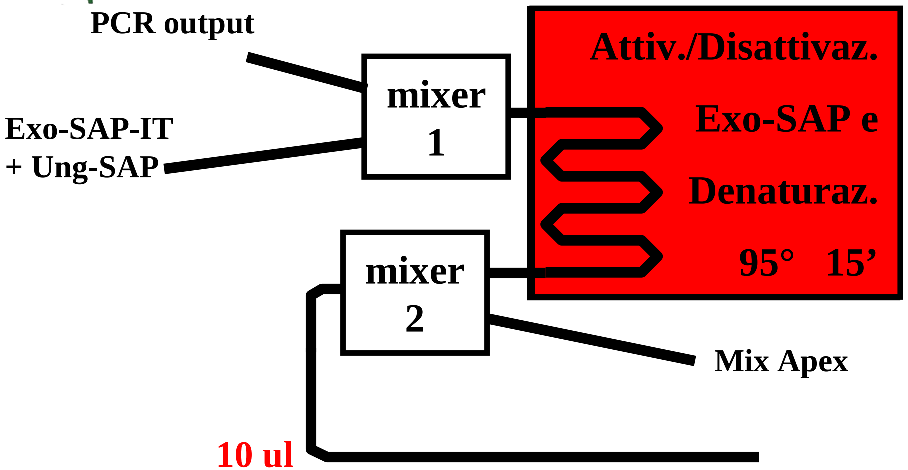


PCR Module

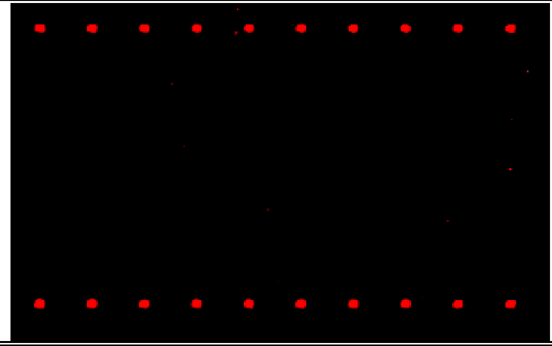


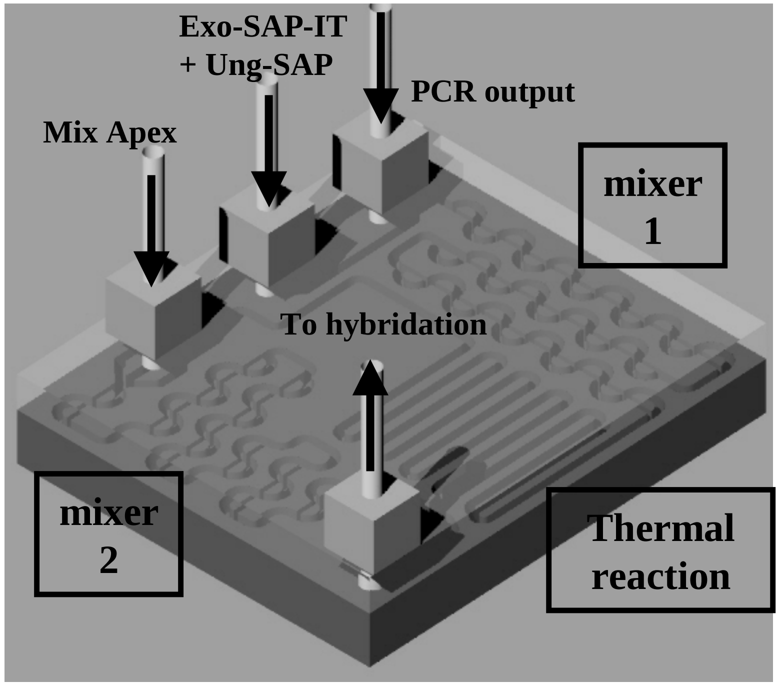


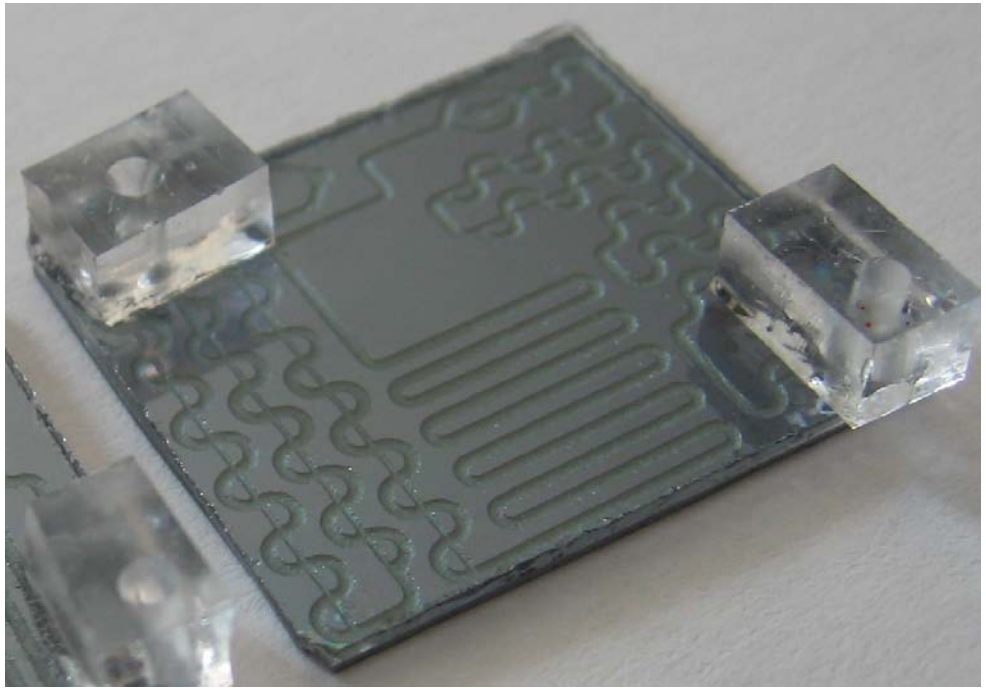
DEVELOPMENT OF Si-based LAB-ON-A-CHIP FOR THE DNA ANALYSIS



Hybridization/Detection Module

Frammentazione in chip + reazione APEX in chip (Esperimento C–Vetrino 1)	





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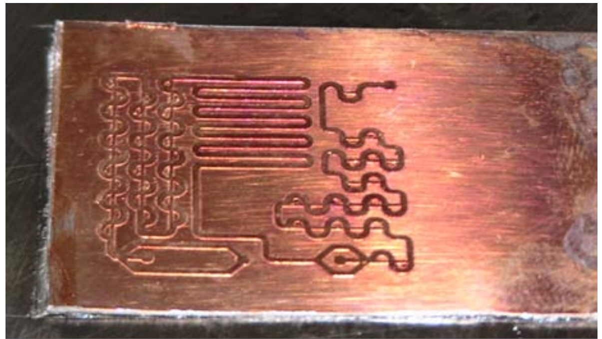
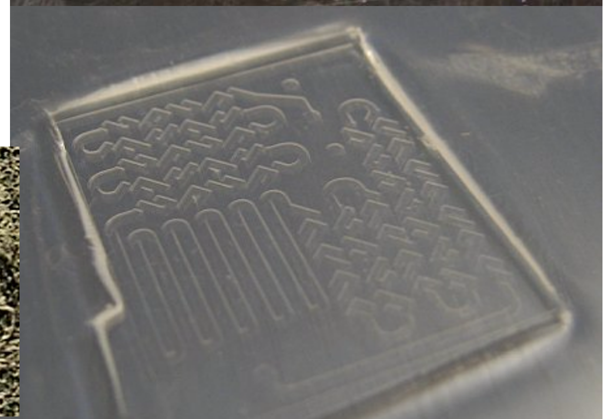
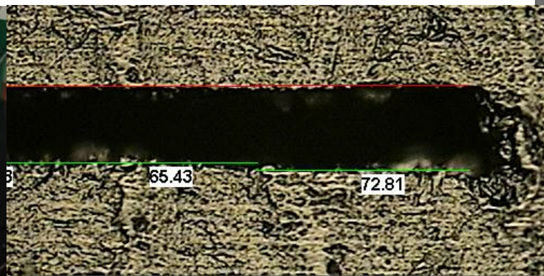
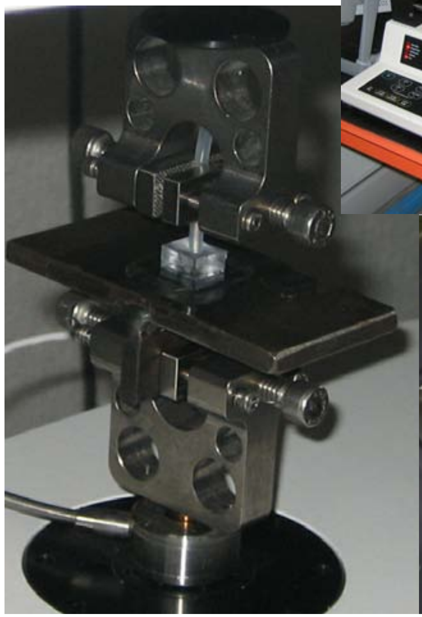
DEVELOPMENT OF POLYMERIC LAB-ON-A-CHIP FOR THE DNA ANALYSIS

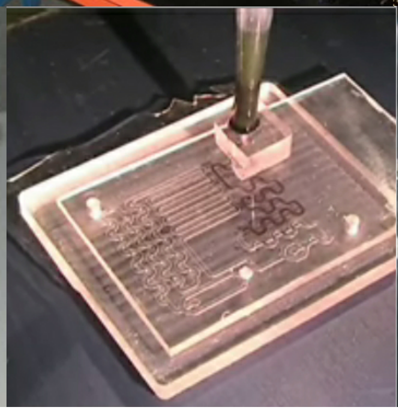
- SU-8 LITHOGRAPHY
- COPPER ELECTROPLATING (both on Cu seed-layer and on Cu or Al bulk plates)
- HOT EMBOSSING on COC, PMMA, PC, PEHD, PS or PDMS casting in situ
- BONDING (thermoplastic, plasma activation, stick & stamp)
- DICING
- INTERCONNECTIONS fabrication & test

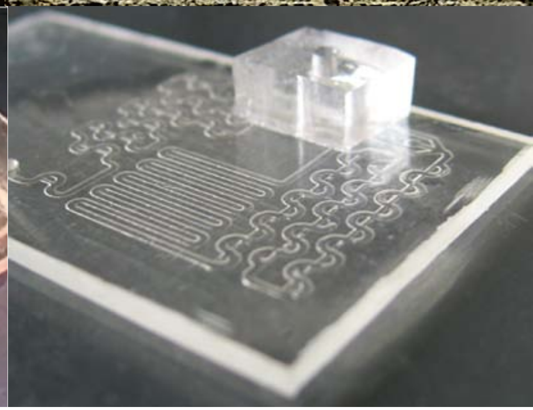


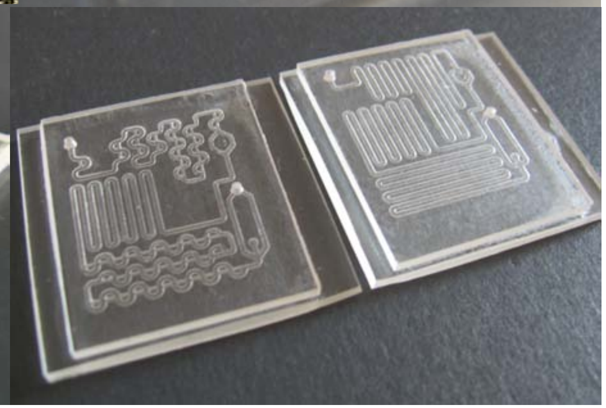












DEVELOPMENT OF CANTILEVERS ARRAYS FOR GENOMIC AND PROTEOMIC DETECTION

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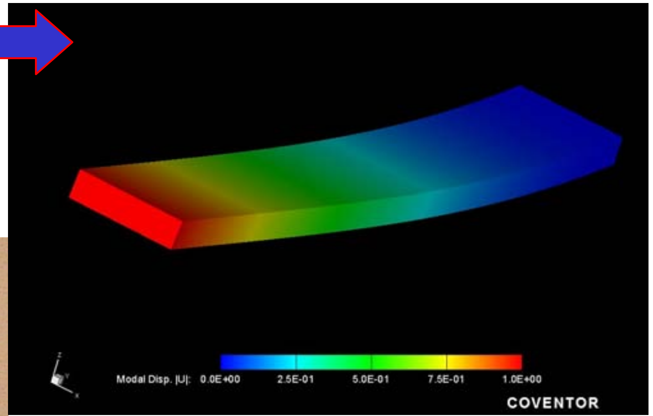
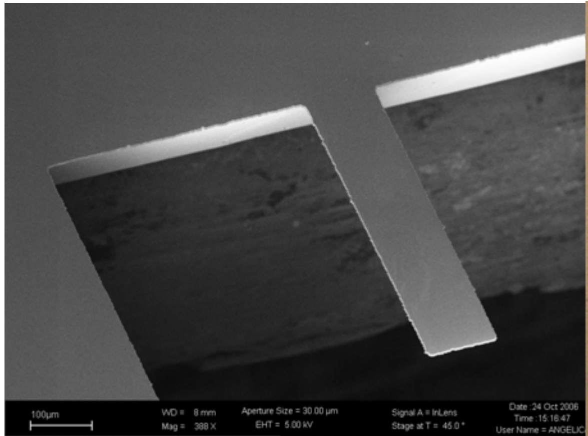
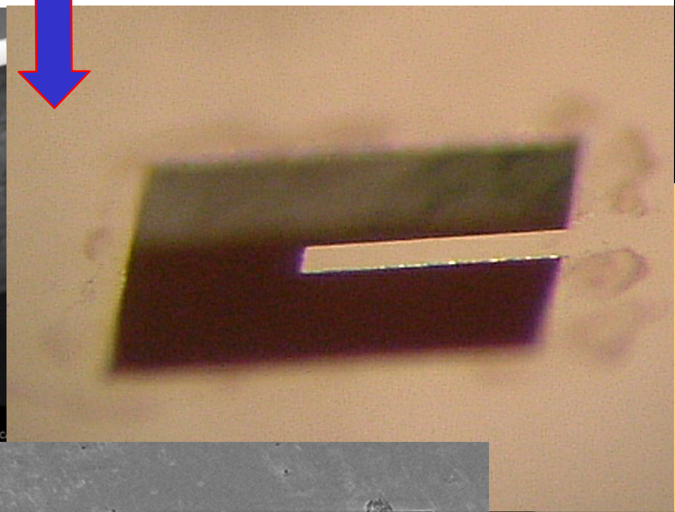
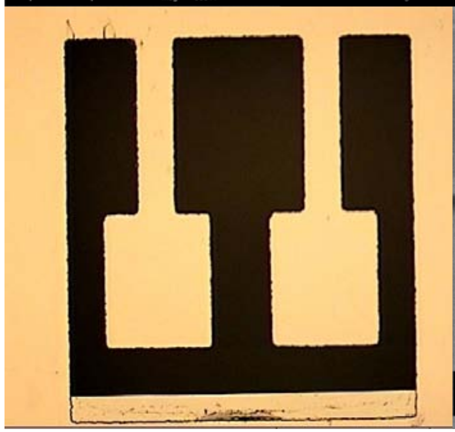
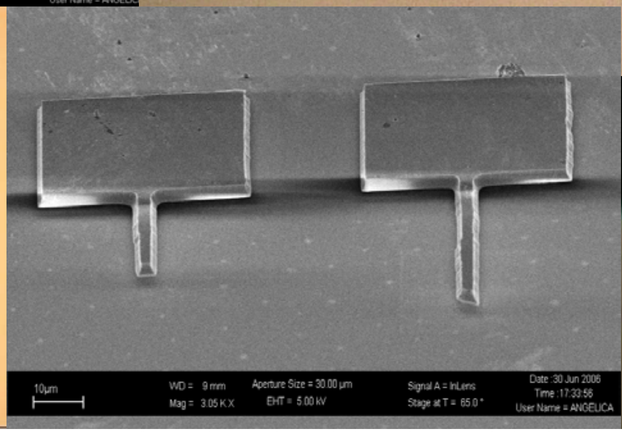
- ✓ Design and Simulation of cantilevers with FemLab and CoventorWare
- ✓ Set-up of different technological processes and realization of cantilevers and arrays of cantilevers (through Bulk and Surface Micromachining)

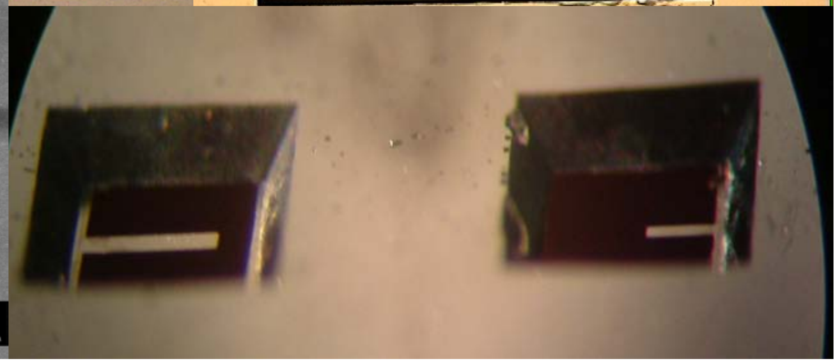








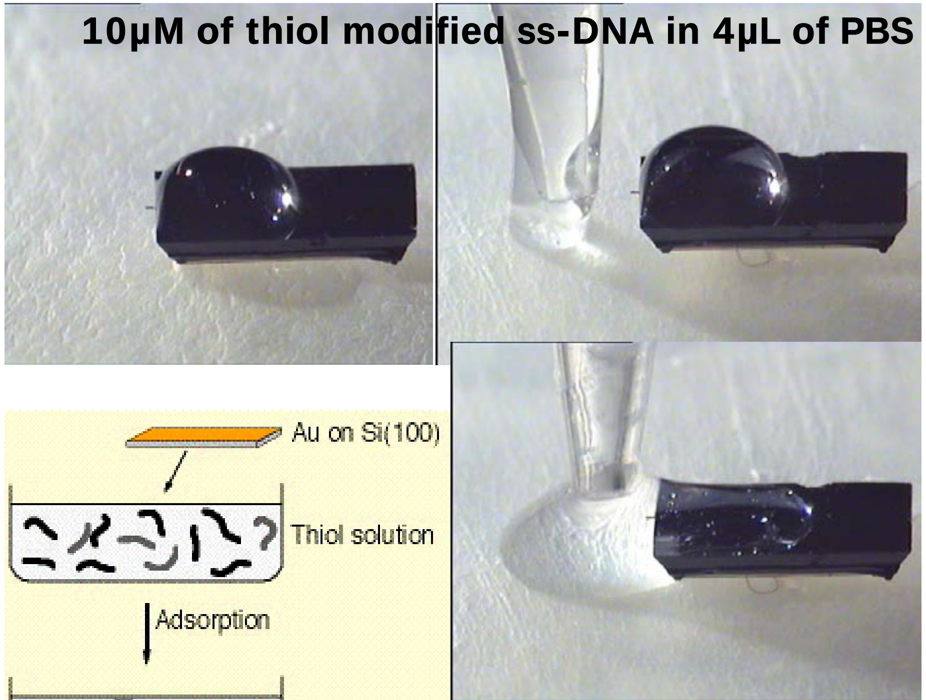


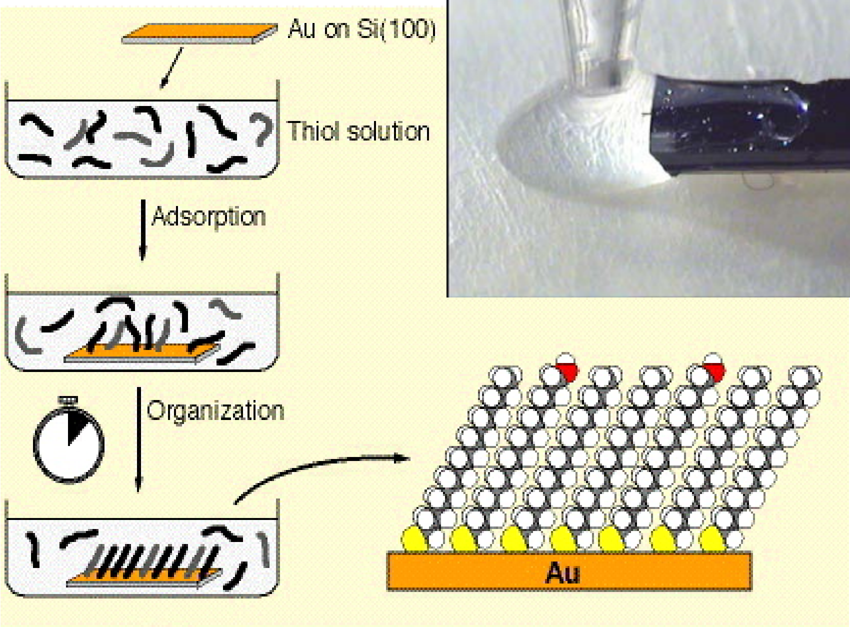


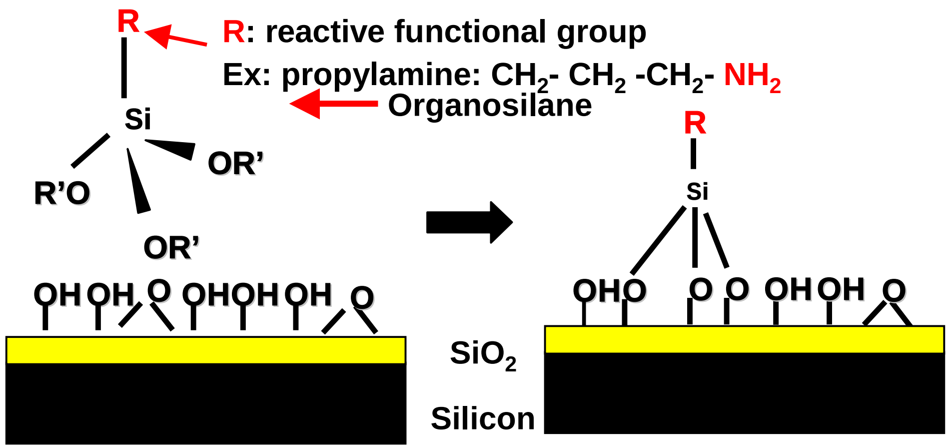
DEVELOPMENT OF CANTILEVERS ARRAYS FOR GENOMIC AND PROTEOMIC DETECTION

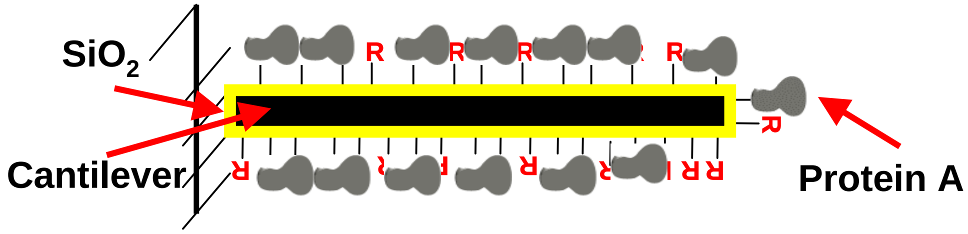
LATEMAR

✓ **Functionalization of cantilevers through silanization of silicon oxide covered surfaces or gold / thiols interfaces**





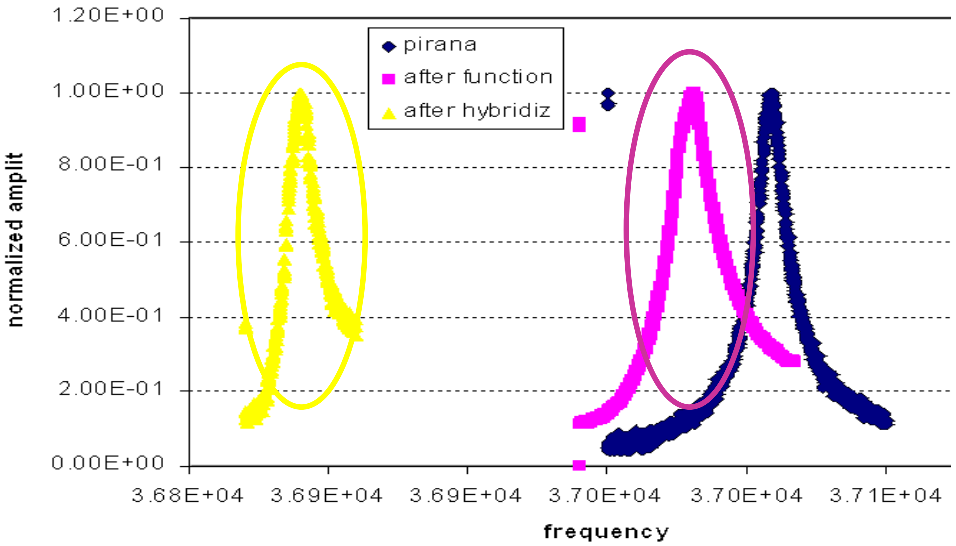


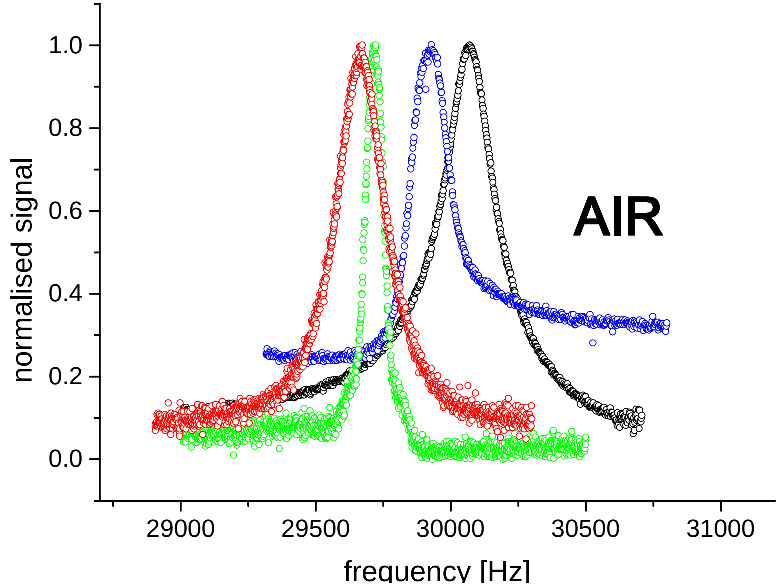


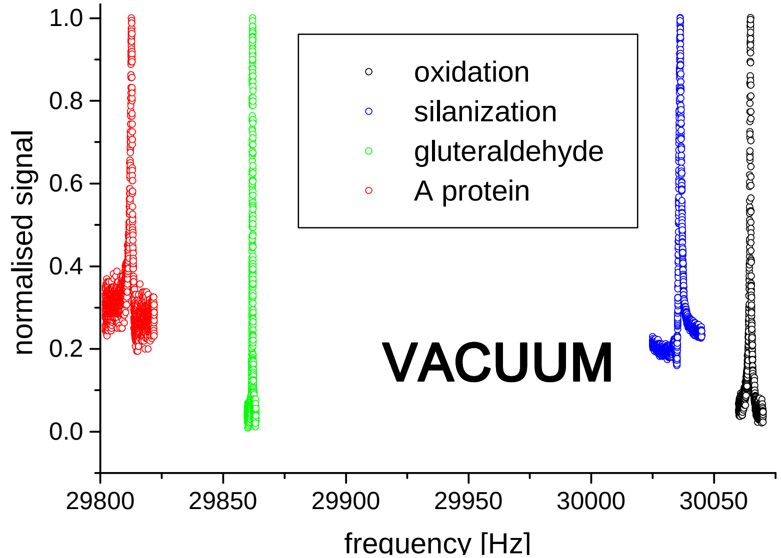
DEVELOPMENT OF CANTILEVERS ARRAYS FOR GENOMIC AND PROTEOMIC DETECTION

LATEMAR

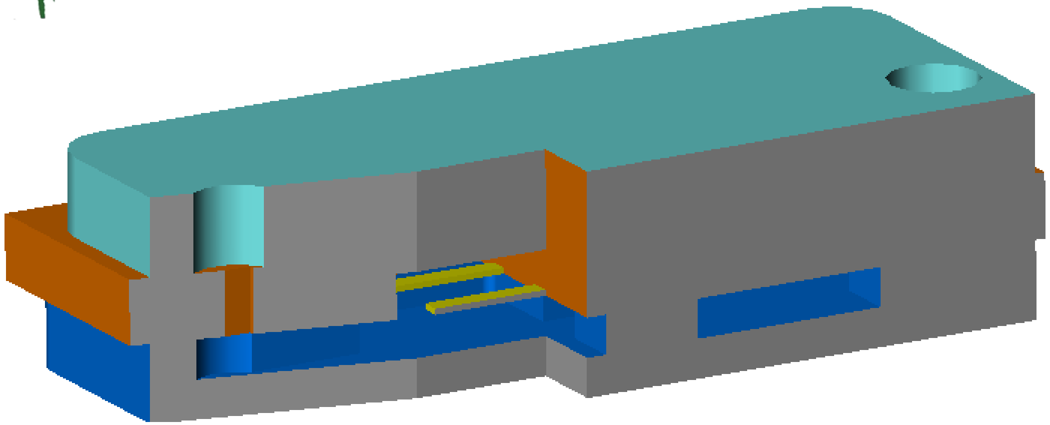
- ✓ **Micromechanical characterization of cantilevers (verification and extraction of mechanical properties)**

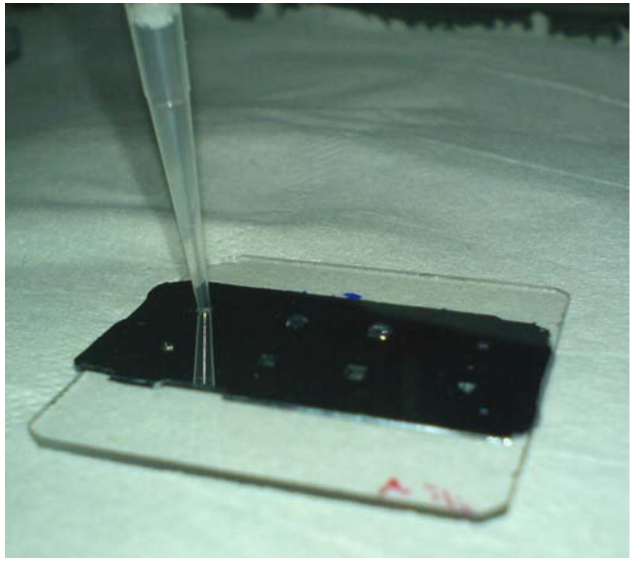


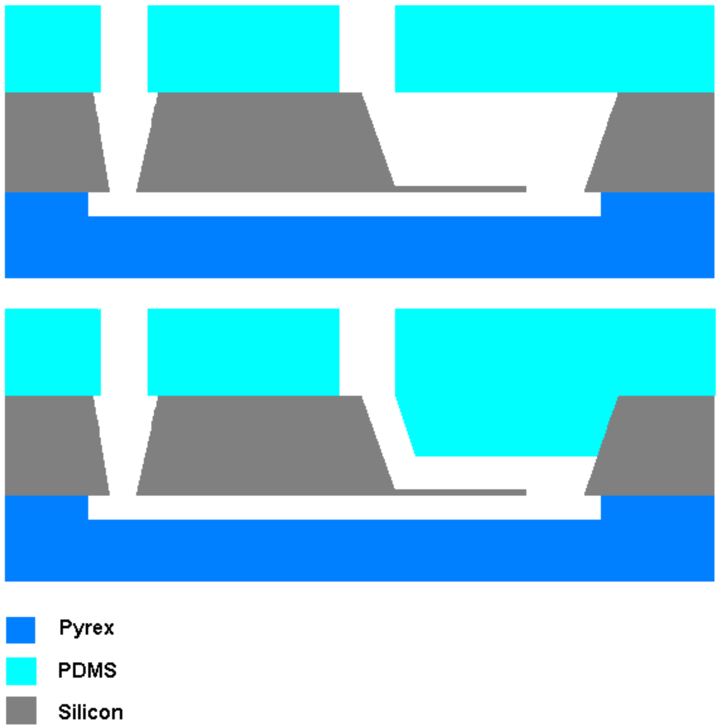


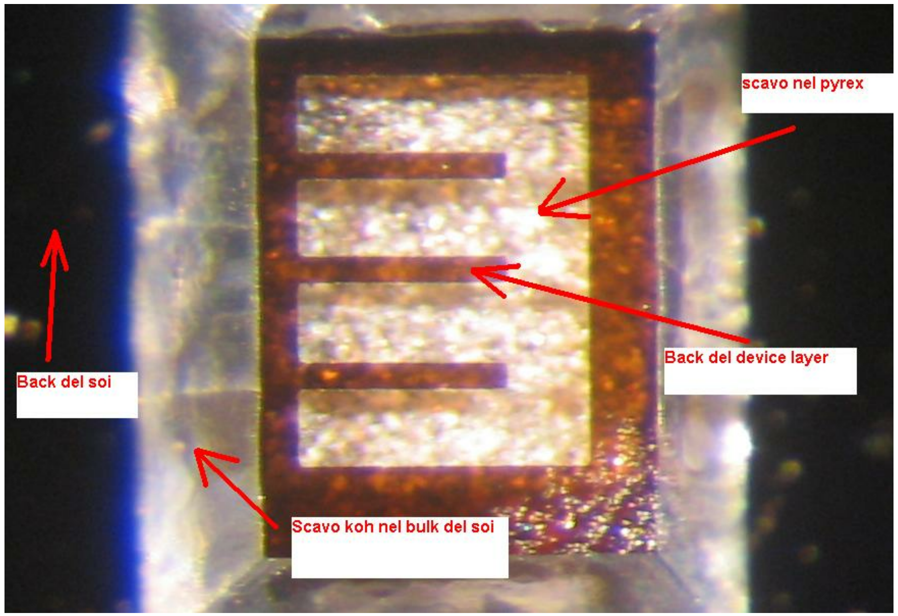


APPLIED MICROFLUIDICS → CANTARRAY based LAB-ON-CHIPs









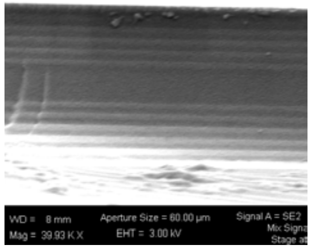
GENERAL AIM ➔ Improve Sensitivity and Resolution of visual detection techniques ➔ Detection and Identification of proteins and DNA without amplification

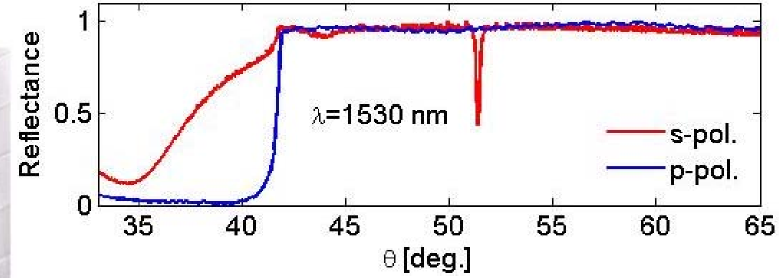
SOLUTION ➔ Nanofabrication techniques to produce “sensitive” materials + Advanced optical techniques applied to bio (BIOPHOTONICS)

HIGH SENSITIVITY AND RESOLUTION MICROSCOPIES AND SPECTROSCOPIES FOR BIO DETECTION

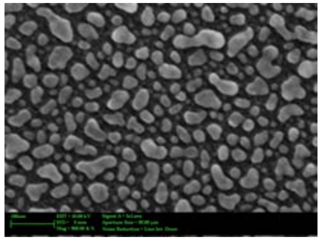
LATEMAR

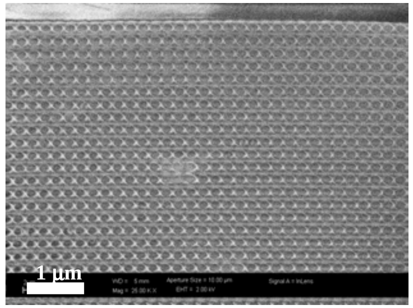
- **Planar multilayers for microcavities and 1D photonic crystals**

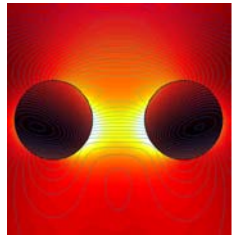


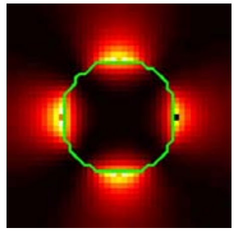


- **Nanostructures for Surface Enhanced Raman Scattering Spectroscopy (SERS)**

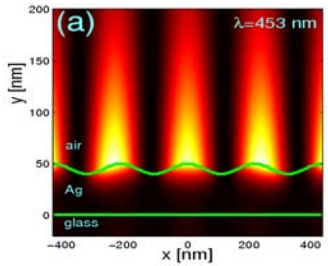




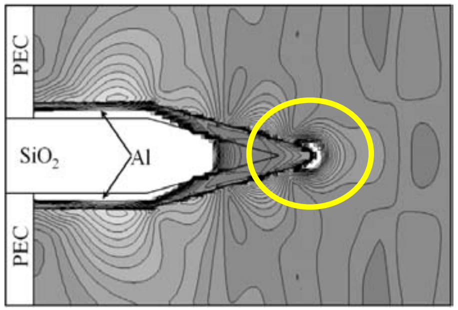




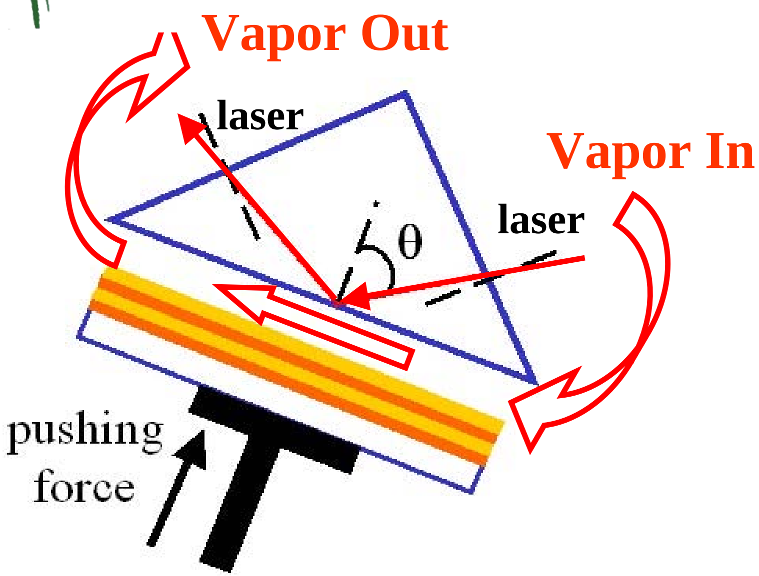
- **Surface Plasmon and Polaritons**



- **Near-field optical techniques for Raman spectroscopy**



SURFACE WAVES IN 1D PHOTONIC CRYSTALS FOR SENSING APPLICATIONS

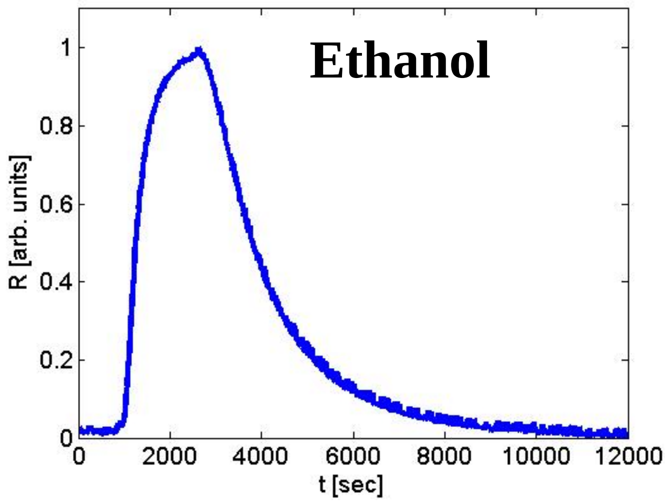


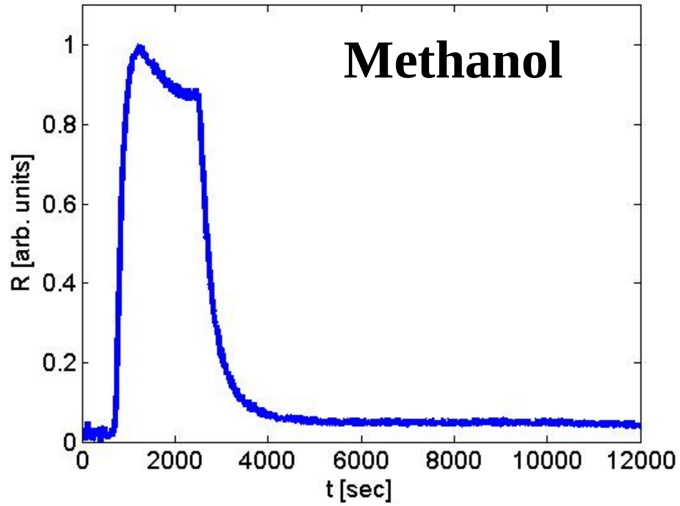
Multilayer exposed to organic vapors flow

Diffusion into the porous matrix

Real-time monitoring at λ_{RES} , θ_{RES}

Silicon Nitride or porous Silicon material



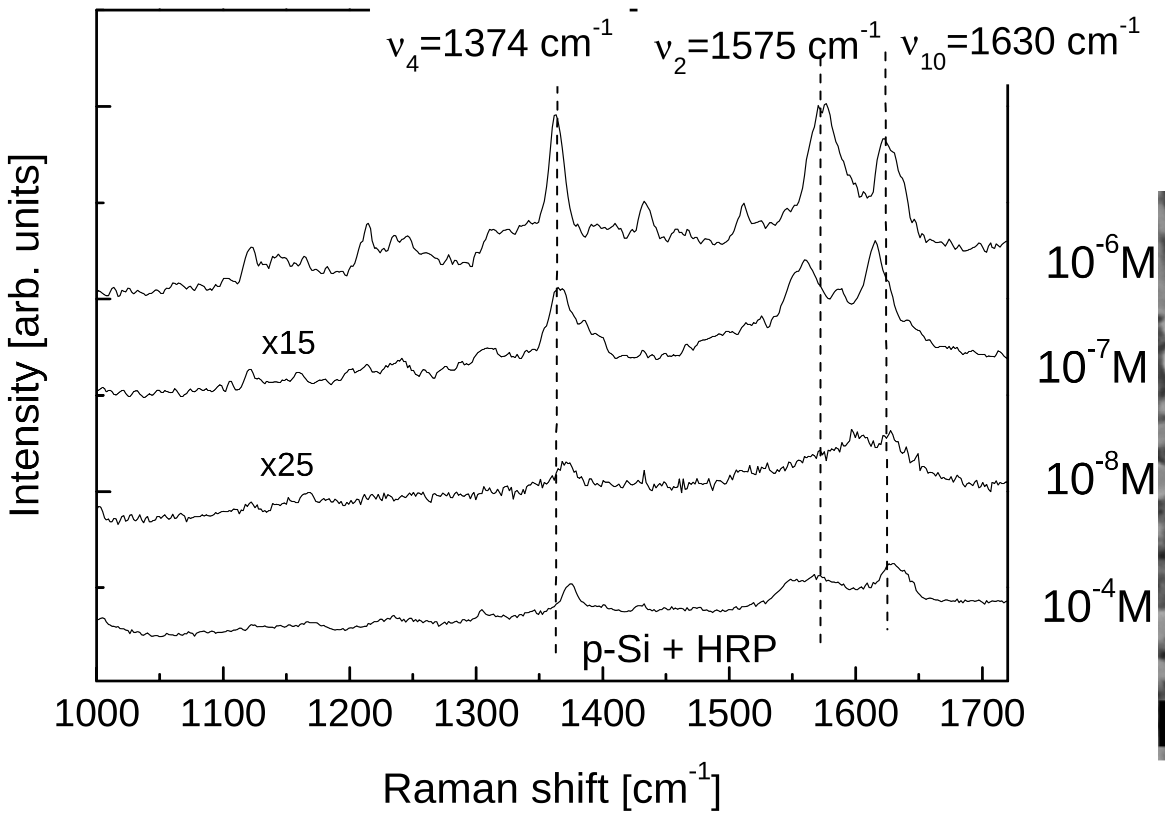


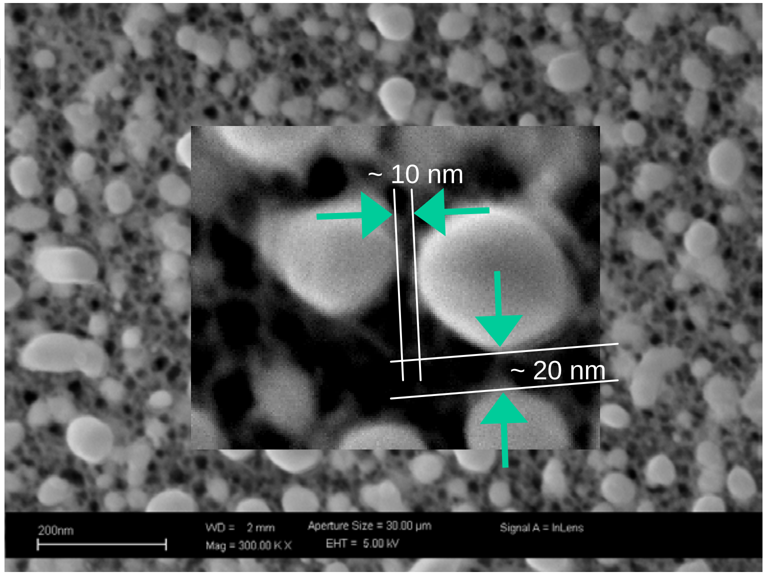
SERS SUBSTRATES FOR SENSITIVE BIO-DETECTION

LATEMAR

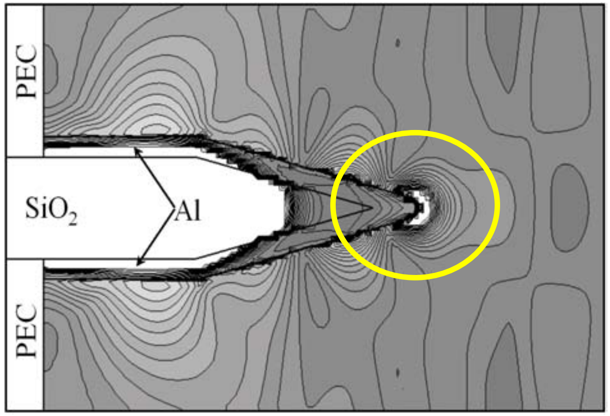
Micro-Raman/SERS spectroscopy of Horseradish Peroxidase (HRP) molecules on p-Si/Ag

10 μL of the analyte solution at several molar concentrations



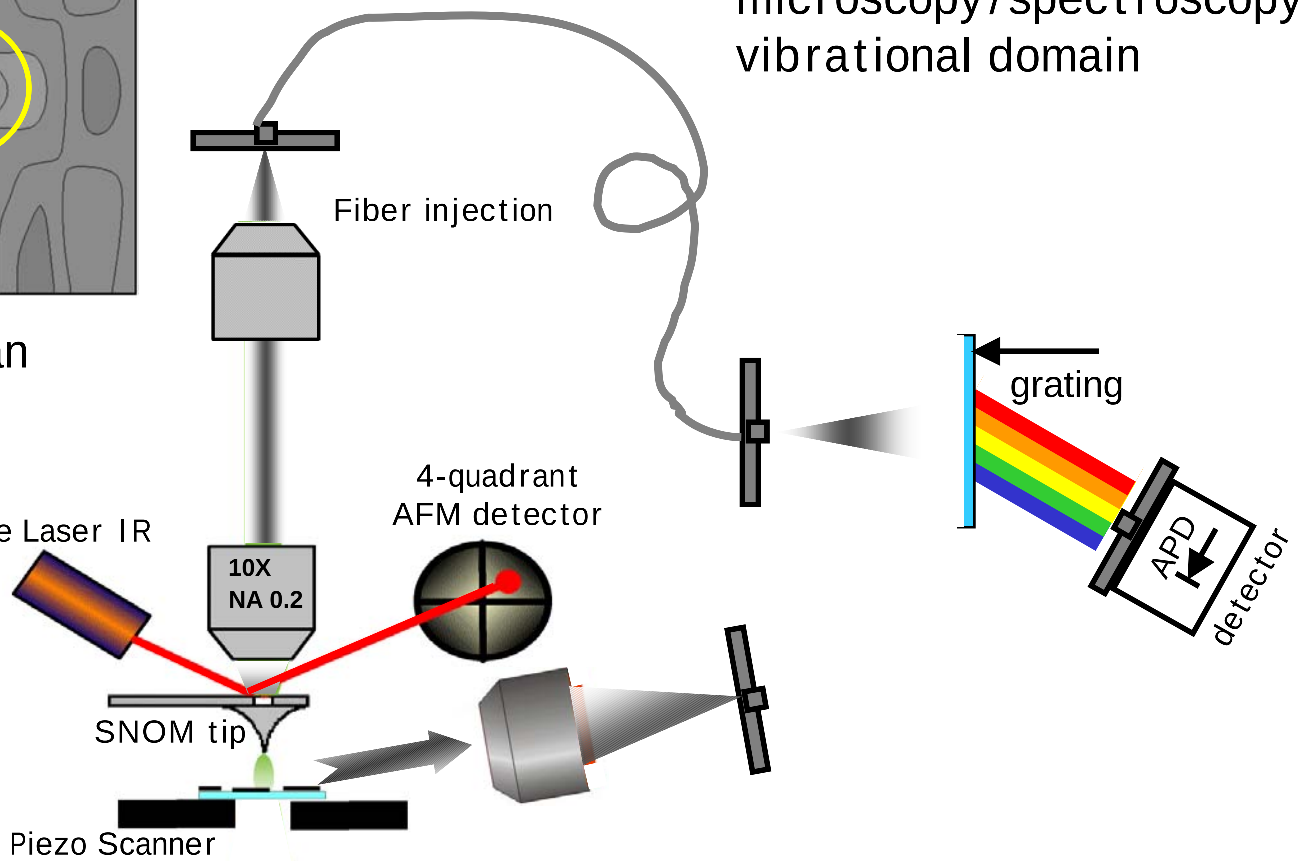


NEAR-FIELD MICROSCOPY FOR SUPER-RESOLVED RAMAN DETECTION

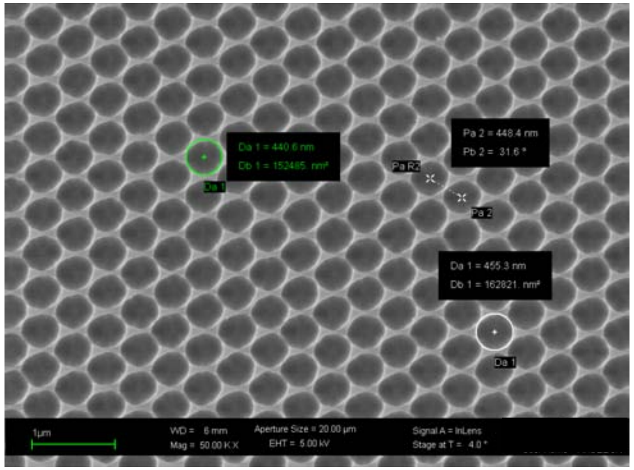


Tip Enhanced Raman Scattering (TERS)

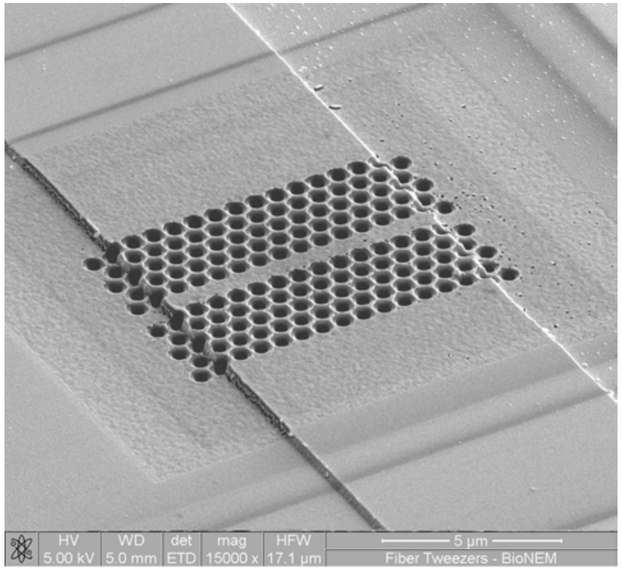
Scattering SNOM and collection-mode SNOM for microscopy/spectroscopy in vibrational domain



2D-PHOTONIC CRYSTALS

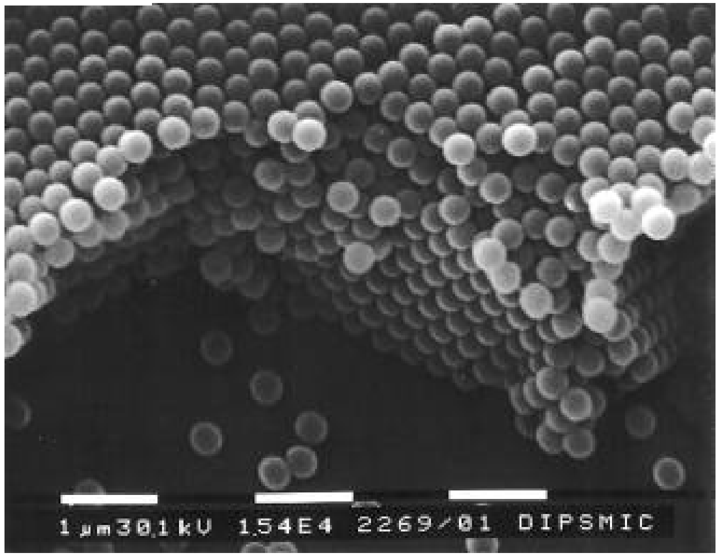


- Two-dimensional Silicon based structures
- Photonic waveguides
- Photonic structures in ridge waveguides



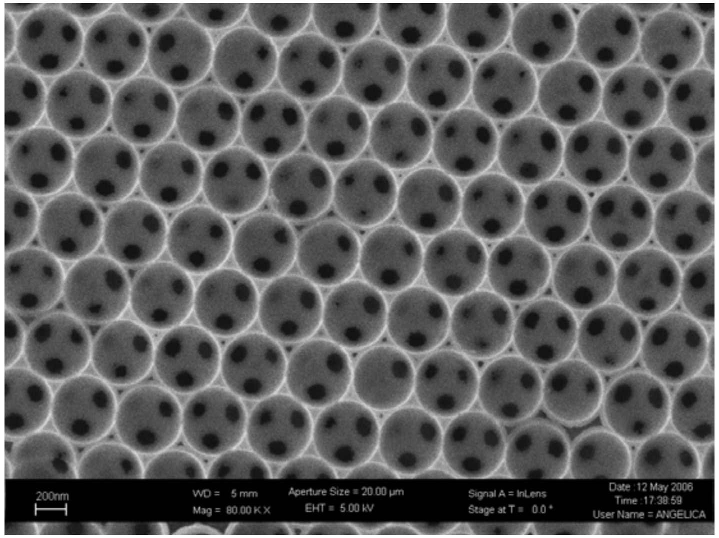
Collab. With Univ. of Catanzaro

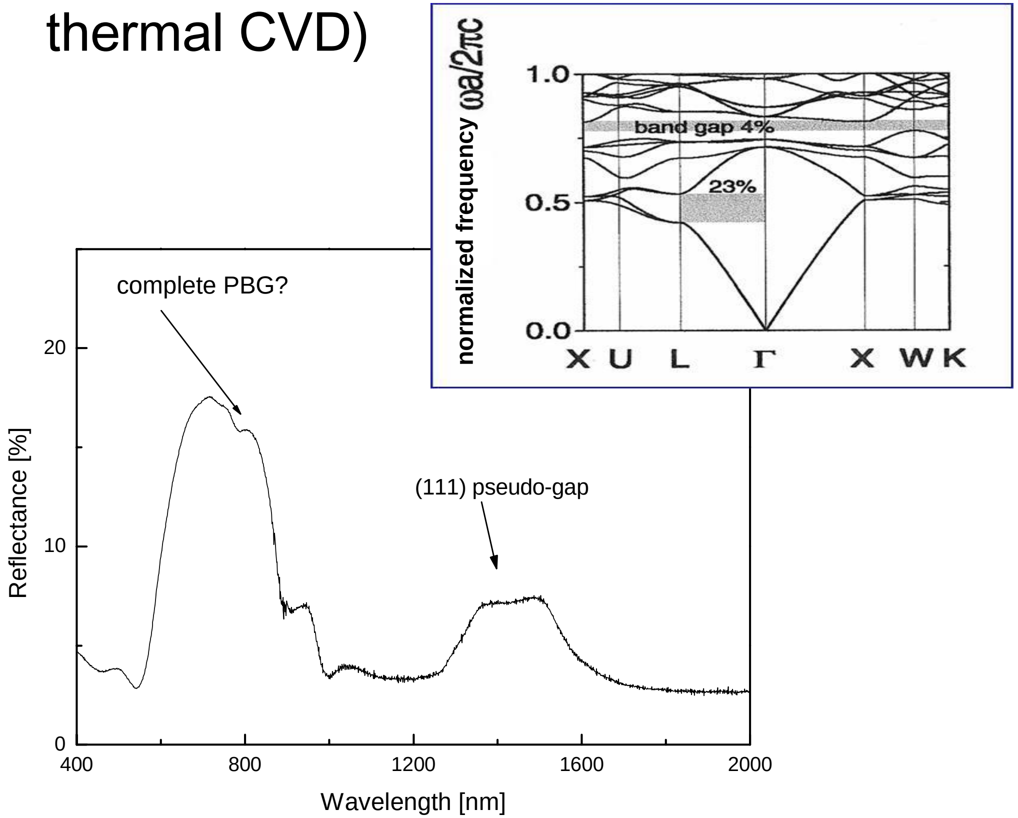
3D-PHOTONIC CRYSTALS: DIRECT & INVERTED OPALS



Polystyrene and silica nanospheres self-assembled in fcc structures (artificial direct opals)

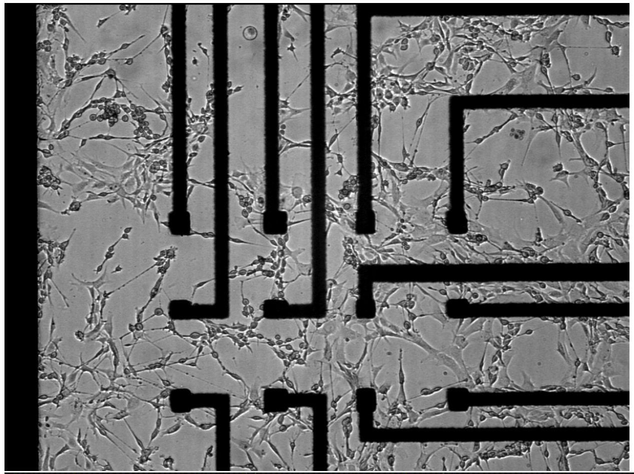
Inverted opals (Si infiltration by thermal CVD)

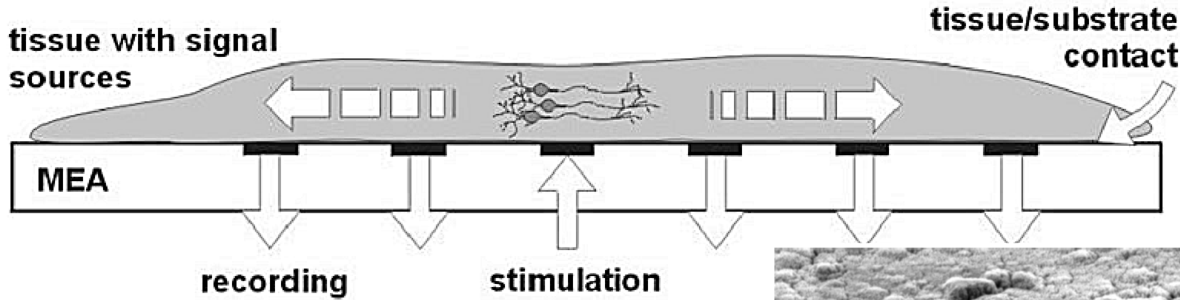


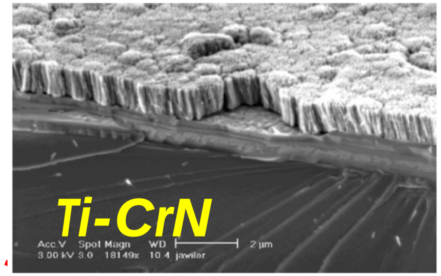


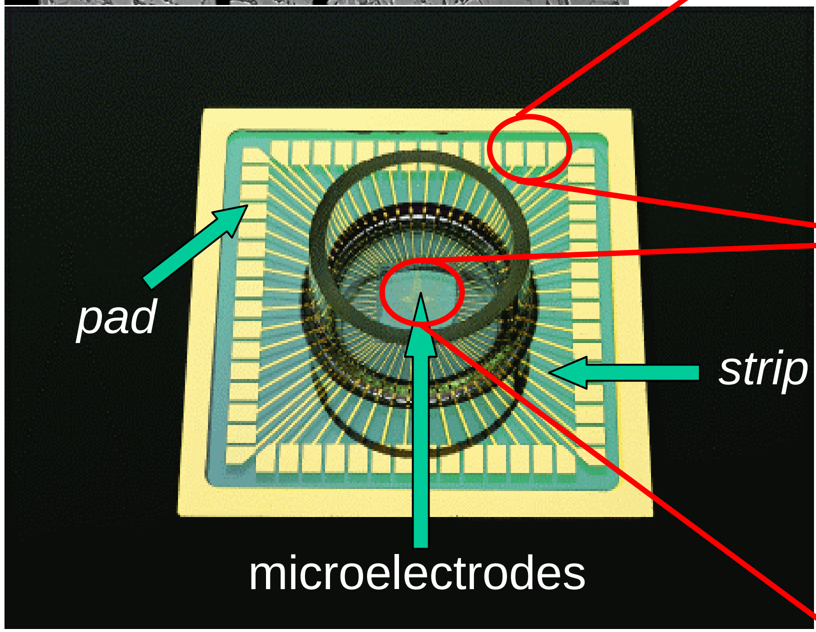
MULTIELECTRODE ARRAYS → MEA

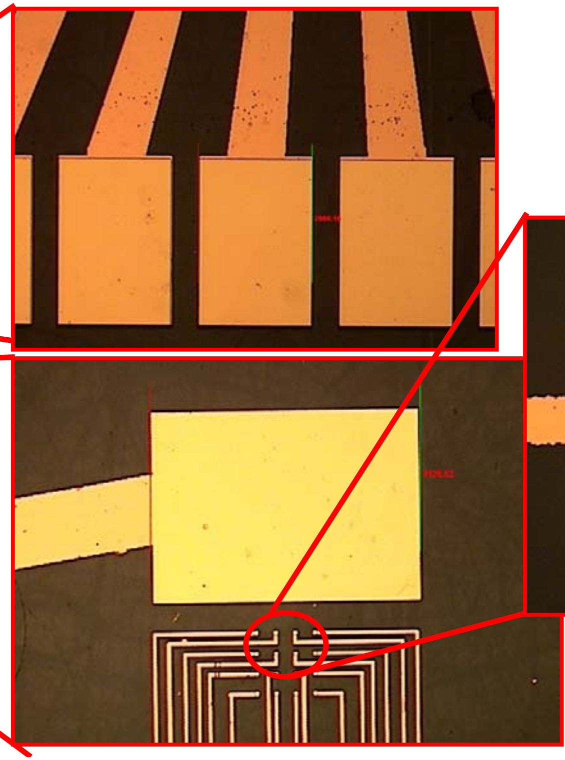
Matrix of microelectrodes → **Excitation and simultaneous multi-point monitoring of electrical activity of neuronal cells**

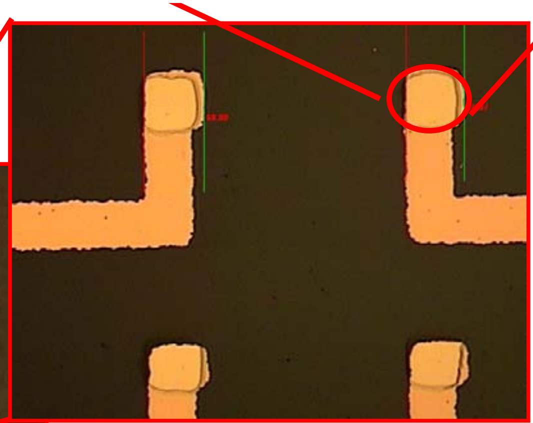




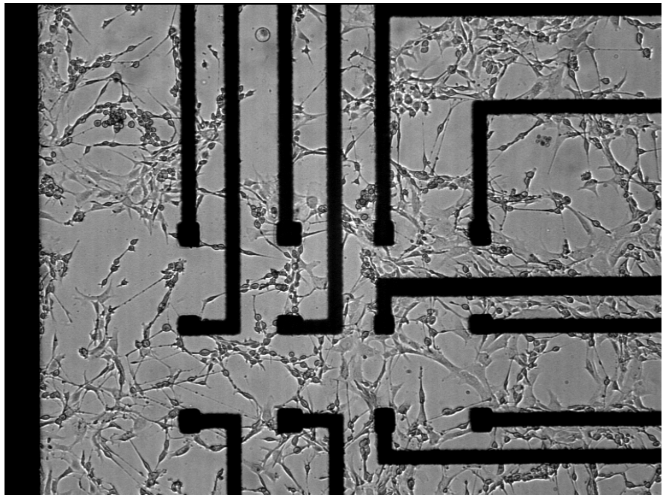


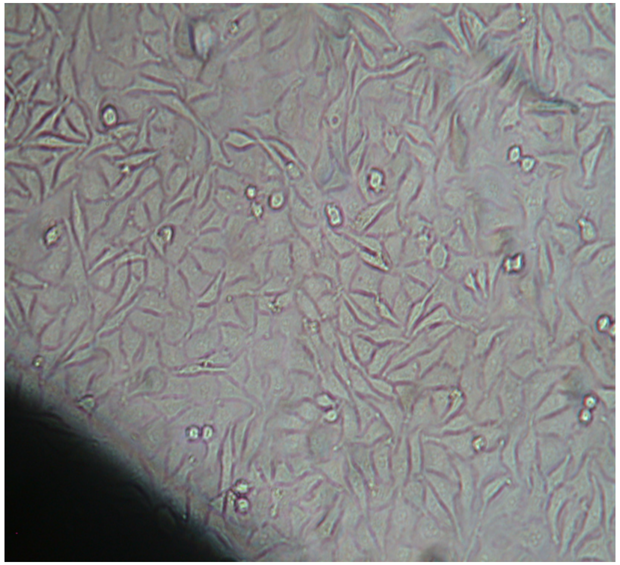


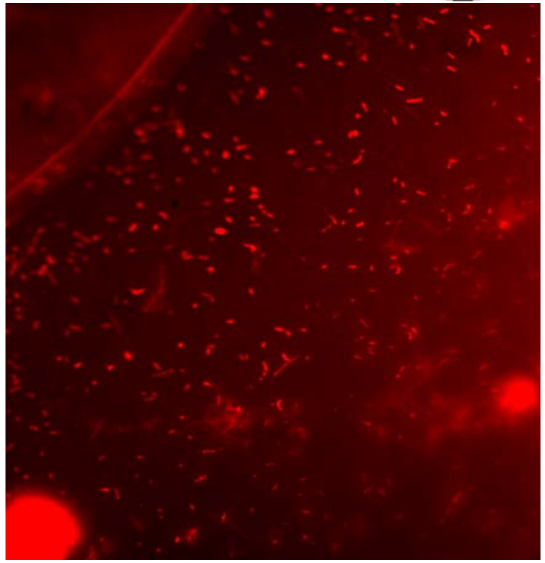


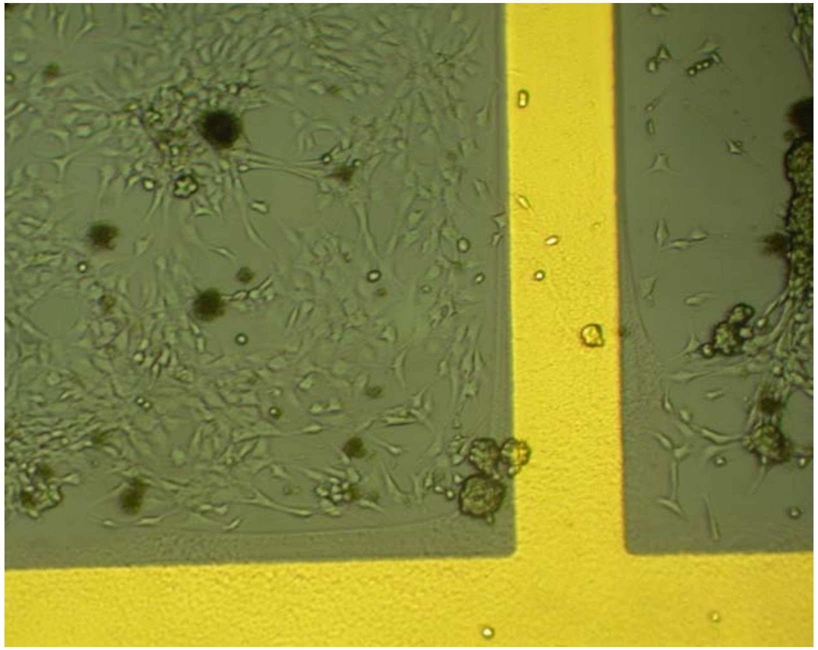


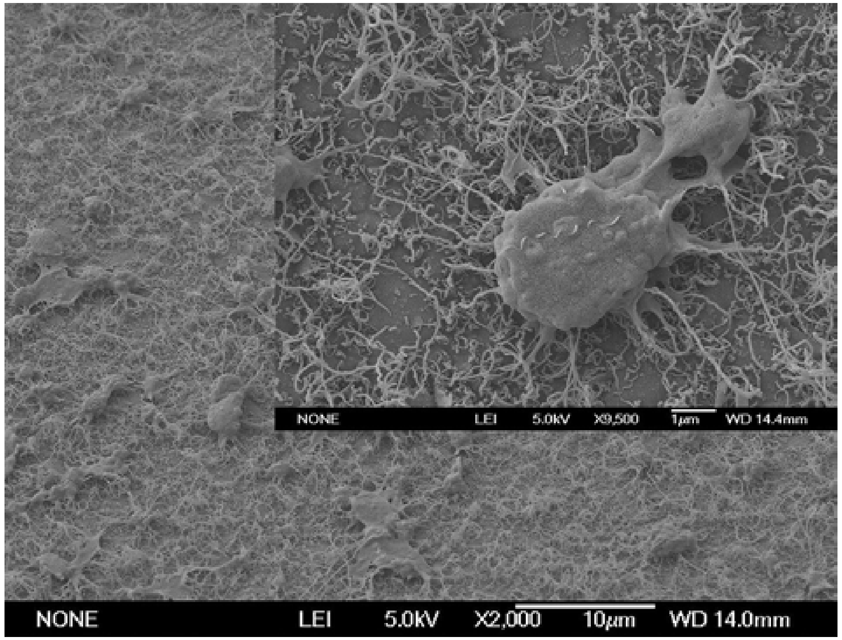
SURFACES AND BIOINTERFACES TECHNOLOGY











PLASMA ASSISTED SURFACE MODIFICATIONS

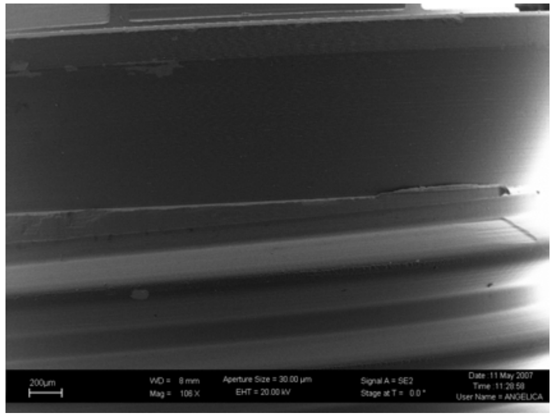
Surface modifications for dental prostheses and implants

Partners

- *University of Turin, Dept. of Biomedical Sciences and Human Oncology*

Objectives

- improve the performance of dental prostheses
- barrier diffusion on metal implants (Ti, CrCo, ...)
- accelerate ostheointegration of implants



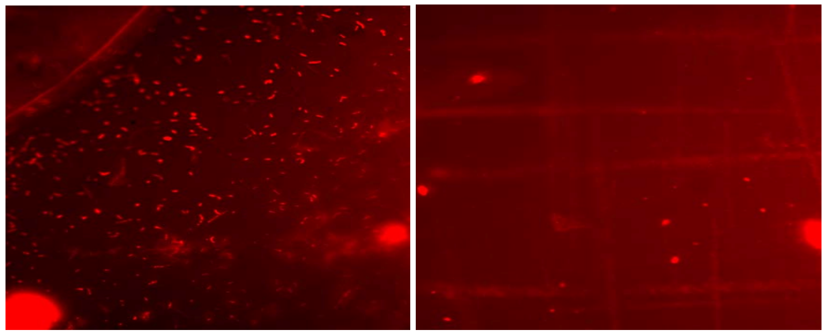
a-SiO_x coated Ti implant

Methods

- plasma-assisted thin film growth (PECVD, PVD)
- plasma-assisted surface modification
- surface characterisation (SEM, EDX, AFM)

Results

- improvement of biocompatibility of composite materilas
- reduced bacterial adhesion on composite and ceramics



Bacterial adhesion on vergin (left) and a-SiO_x coated (right) dental material

PLASMA ASSISTED SURFACE MODIFICATIONS

Diffusion barrier coatings for food packaging

Partners

- *Politechnic of Turin, Dept. of Material Science and Chemical Eng.*

Objectives

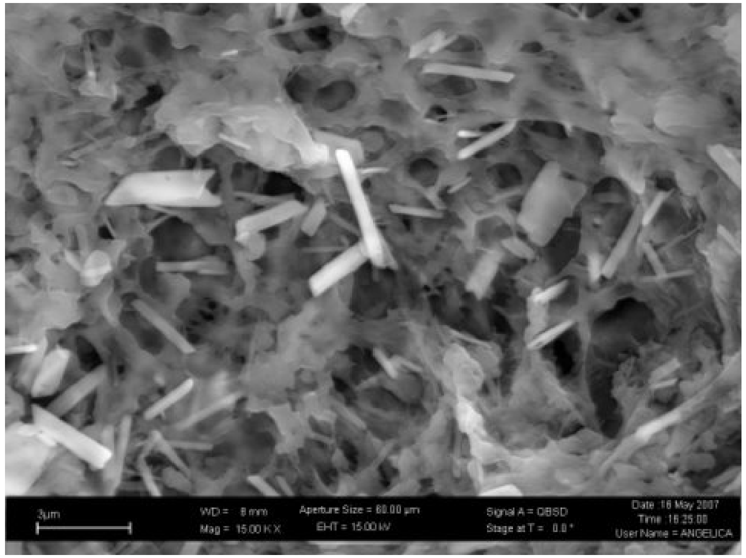
- improve protection againts O_2/CO_2/H_2O diffusion in food packaging

Methods

- plasma-assisted thin film growth (PECVD, PVD)
- plasma-assisted surface modification (etching)
- surface characterisation(SEM, AFM)

Results

- a-SiO_x thin films for diffusion barrier
- characterisation of nanofilled PA6 films



SEM image of PA6 film with embedded nanostructures

PLASMA ASSISTED SURFACE MODIFICATIONS

Protective coatings for textile applications

Partners

- *LameLedal s.p.a.*

Objectives

- protection of metallic yarns during aggressive textile treatments

Methods

- plasma-assited coating deposition (CVD, PVD)
- chemical etching tests
- surface characterisations

Results

- protection layers and structures

PLASMA DRIVEN CATALYSIS OF TOXIC EFFLUENTS

Partners

- *Politechnic of Turin, Dept. of Material Science and Chemical Eng.*
- *MI s.a.s*

Objectives

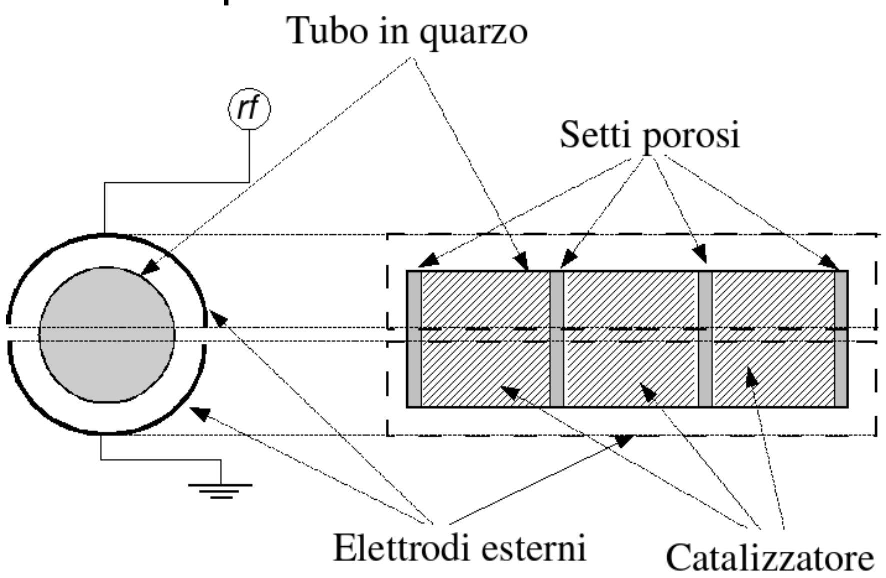
- Reduction of toxic emission from some industrial processes

Methods

- plasma-driven catalysis (PDC)
- measurment of pollutant concentration (IR cell)

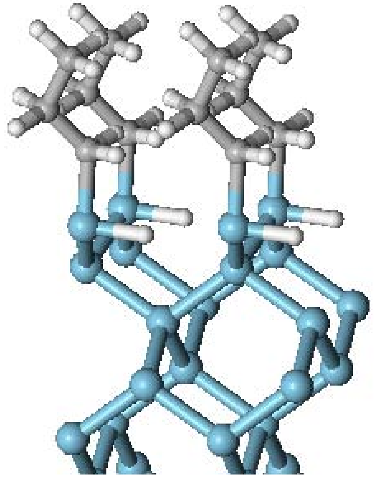
Results

- reduction of toluene by PDC



Example of PDC reactor

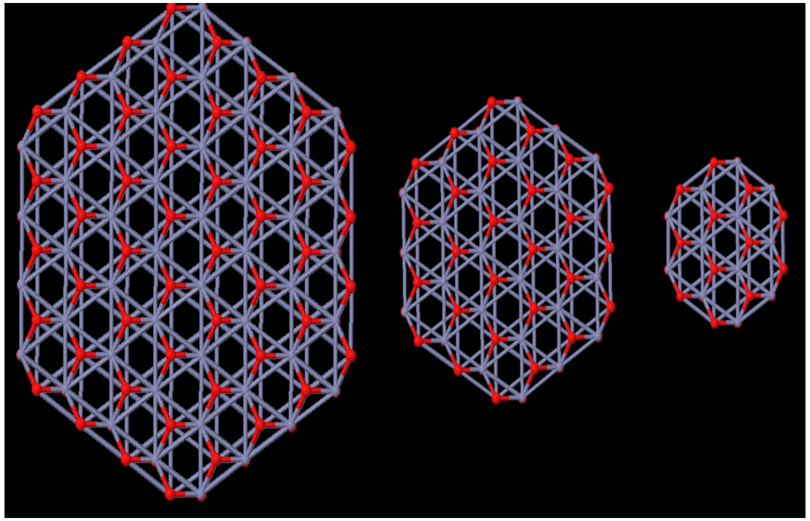
ATOMISTIC SIMULATIONS OF SURFACES AND NANOSTRUCTURES



Structural and mechanical properties of functionalized surfaces:

- Alkyl terminated Si(001).

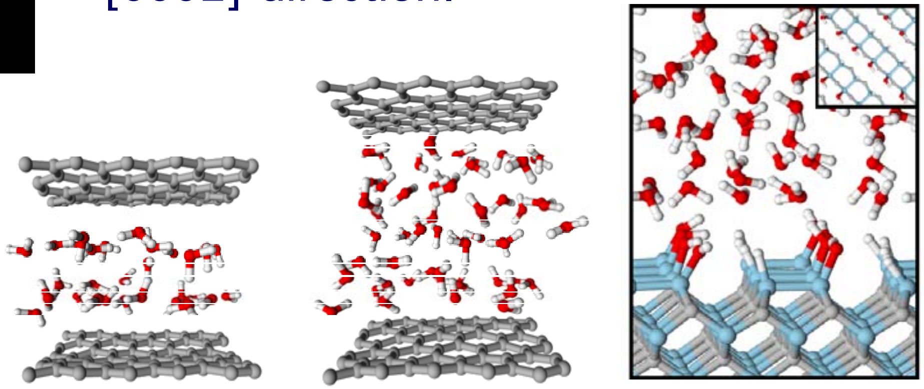
- Thiol functionalized Au(111).



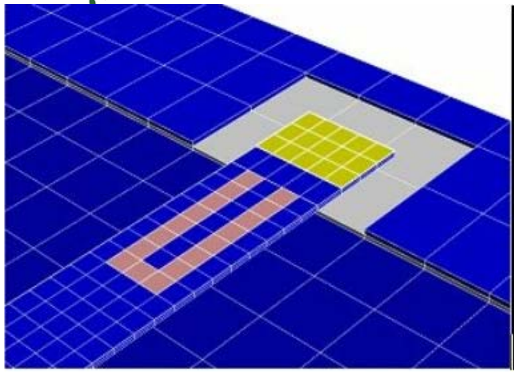
Structural and Electronic properties of nanowires (InN, ZnO, CdSe) for photovoltaics applications.

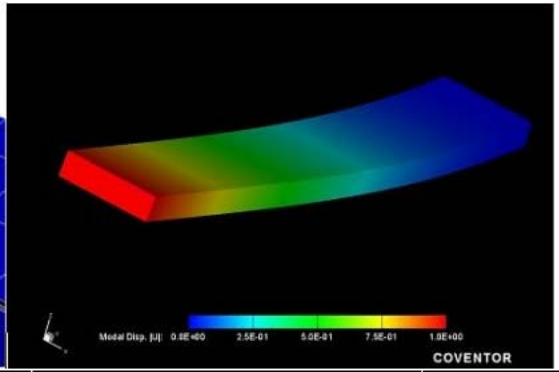
Section of nanowires grown in the [0001] direction.

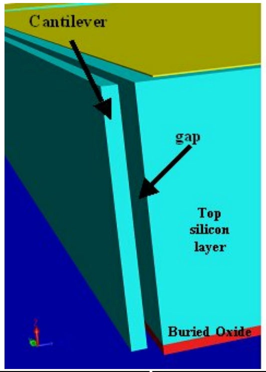
Molecular Dynamics simulations of Solid/liquid interfaces.

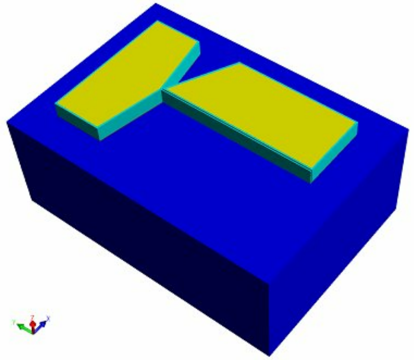


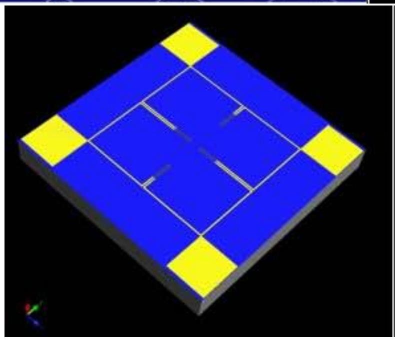
FEM AND FVM SIMULATIONS

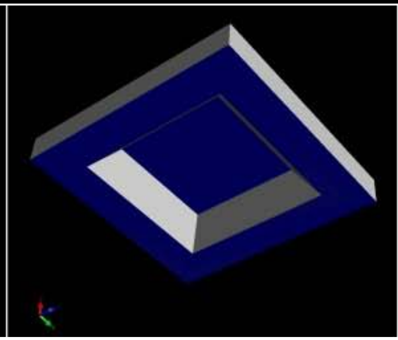


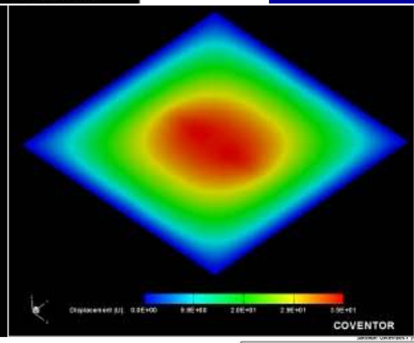


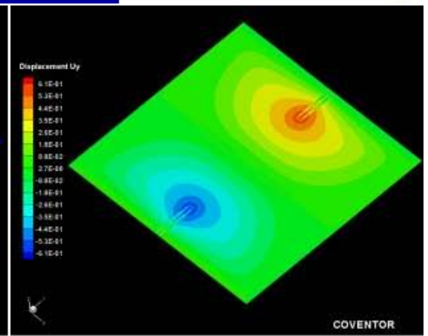


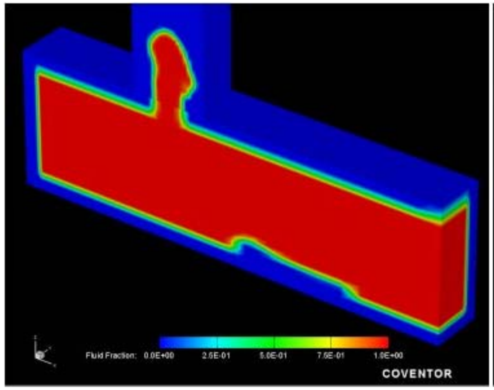


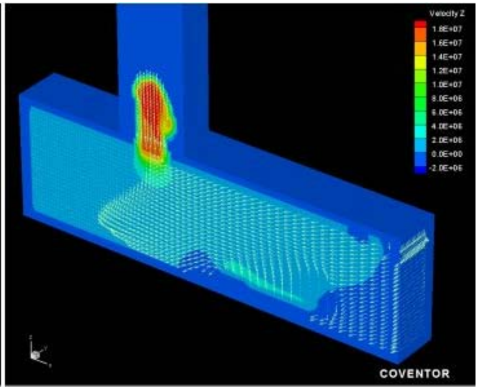


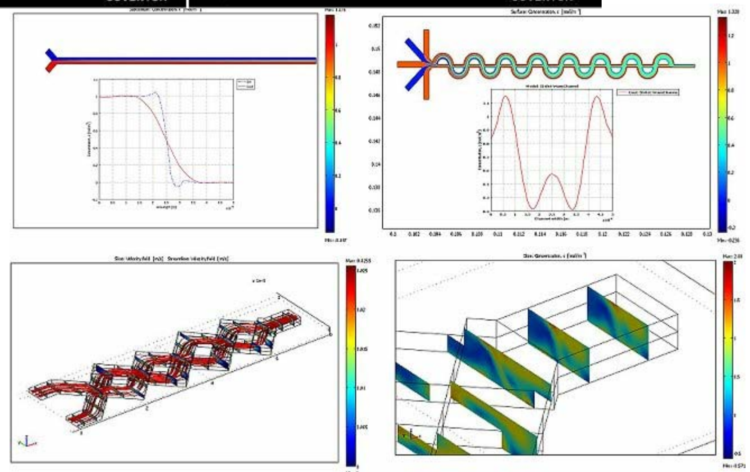




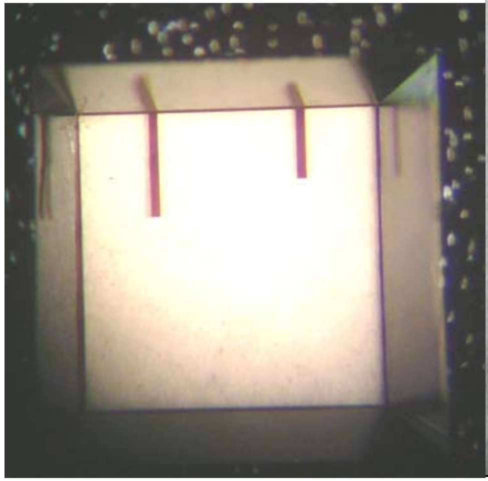


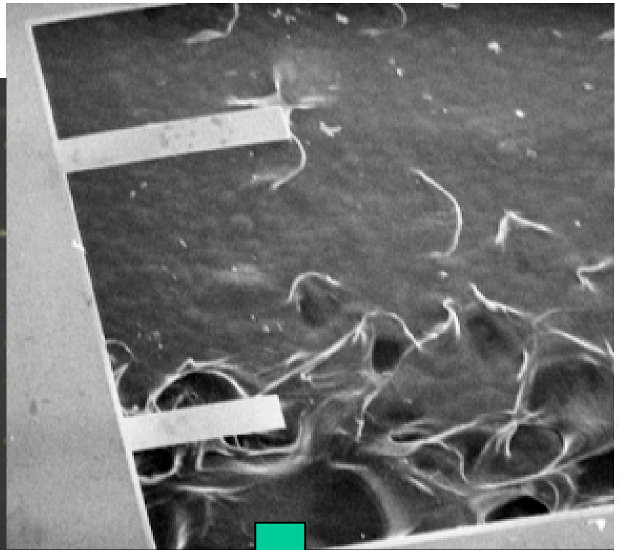




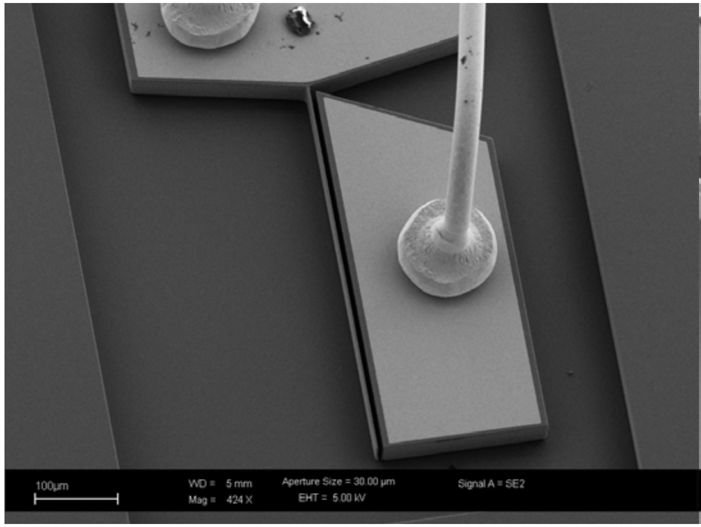


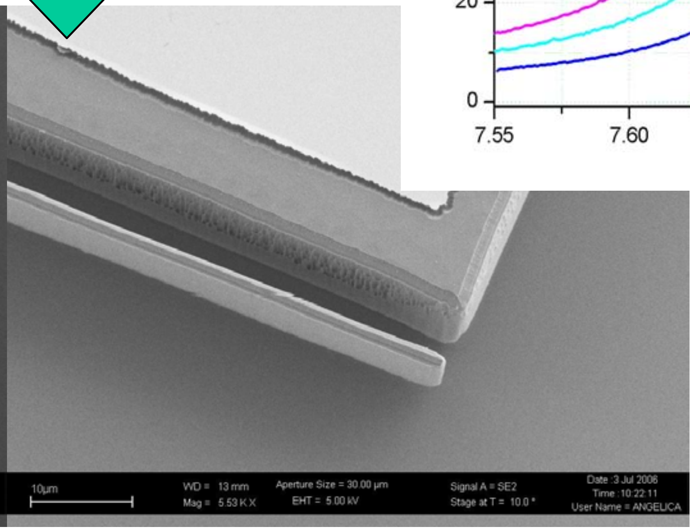
CANTILEVER BASED PRESSURE SENSOR FOR VACUUM APPLICATIONS

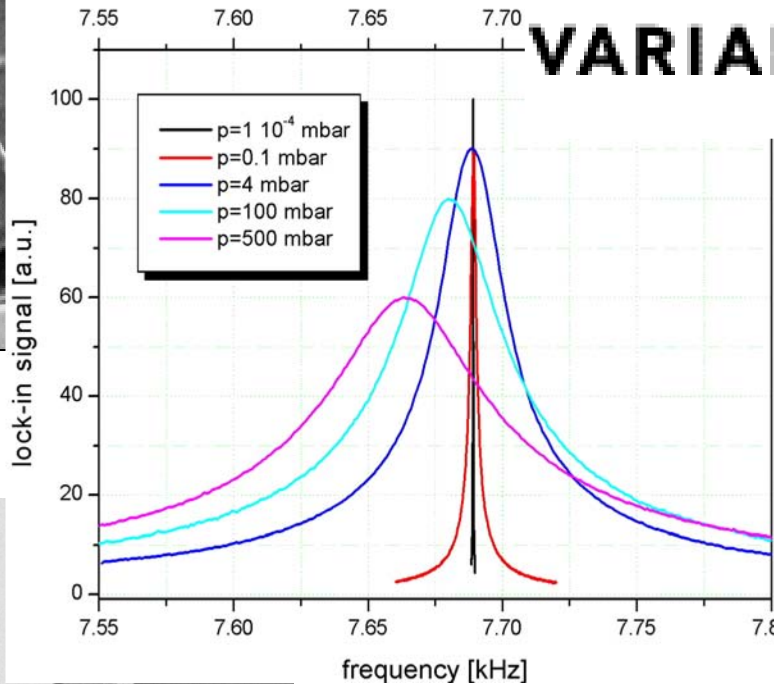




Electrostatic actuation &
capacitive readout integration





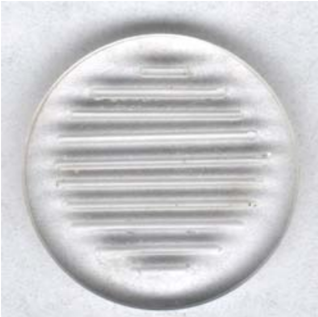


olivetti i-Jet

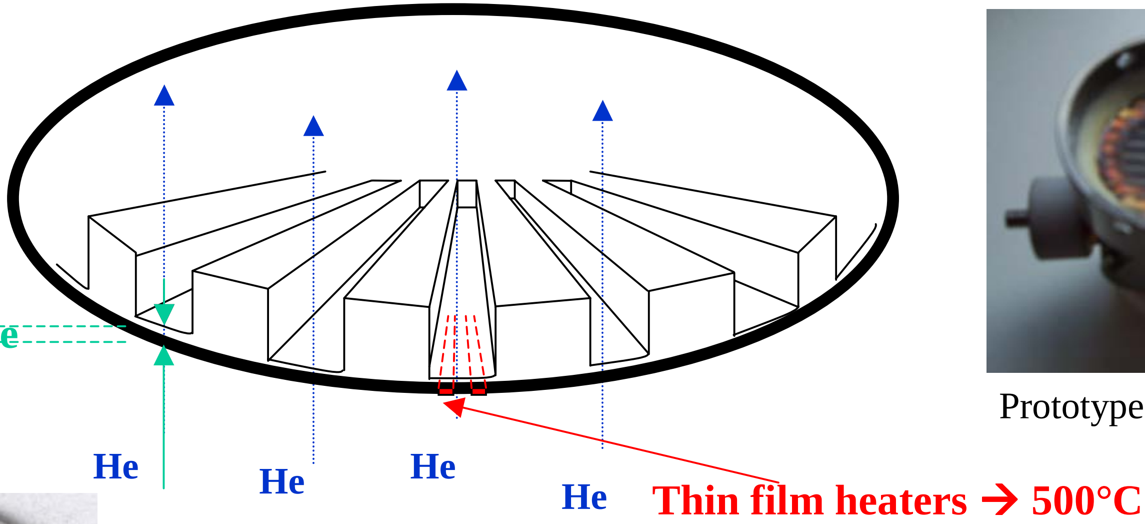
VARIAN

Fused Silica structured membranes for Helium leak-detection

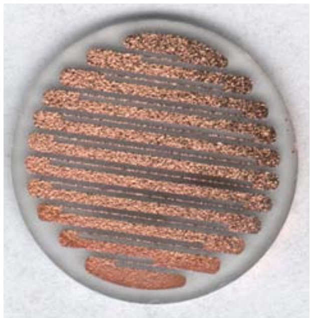
Quartz disk: D = 1”; Th = 3 mm



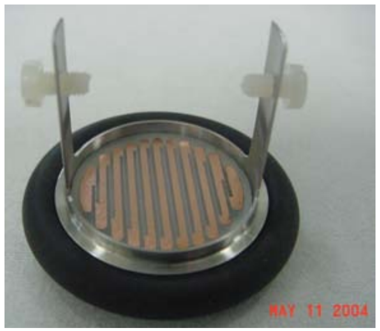
Micromachined quartz by powder blasting



Prototype final assembly



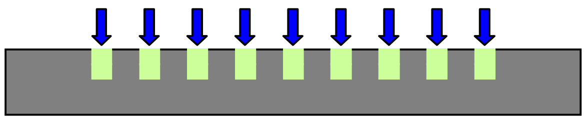
Heater integration by thin/thick film techniques



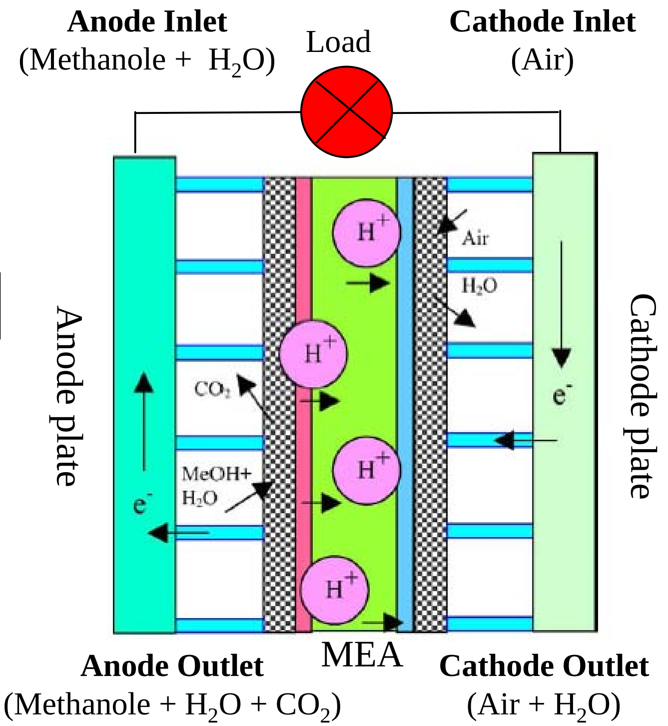
Device characterization

μDMFC FUEL CELLS

Si/Pyrex/PMMA Etching



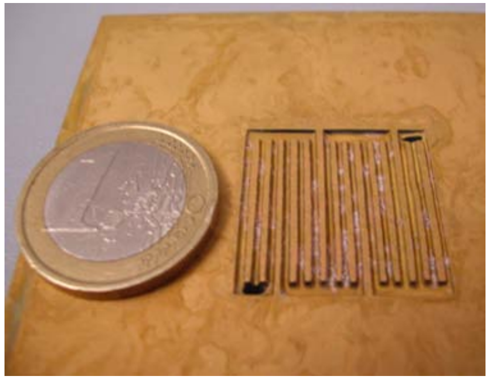
- RIE
- Powder blasting
- Or Hot Embossing for PMMA



(Schematic of Direct Methanol Fuel Cell)

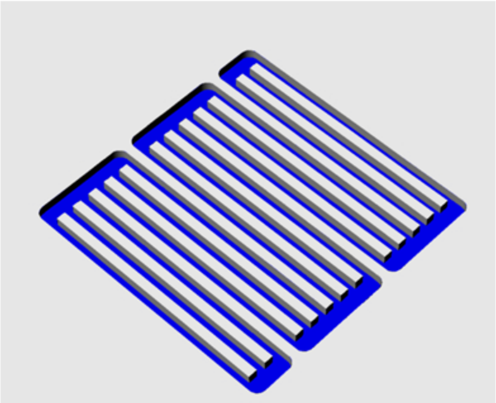
Useful for

Nafion and PEEK membranes

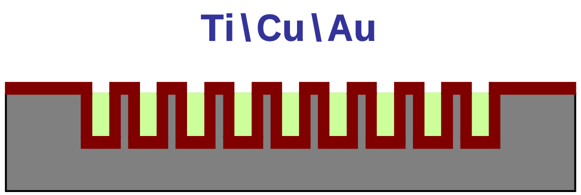


1€ coin for real comparison

(2W of power DMFC)



Bipolar plates channels fabrication



Bipolar plates metallization

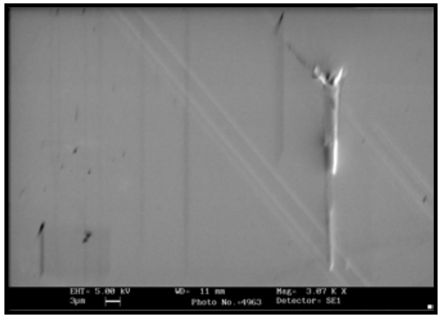
HIGH TEMPERATURE/POWER MICROELECTRONICS: SiC-BASED DIODES

International Rectifier → VISHAY

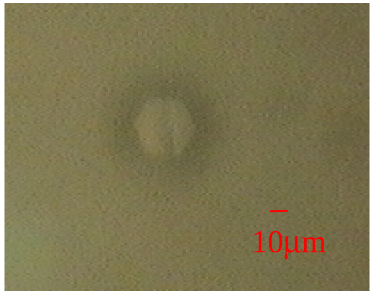
One of the world's **largest manufacturers** of discrete semiconductors and passive components

4H-Silicon Carbide wafers characterization *(Wafer supplier Cree Inc.)*

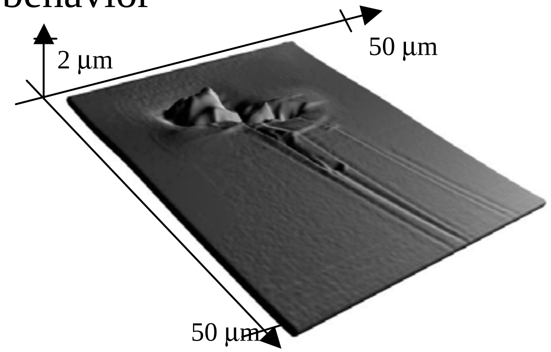
Detailed Structural and Morphological wafer surface characterization for defects identification and their influence in power electronics devices behavior



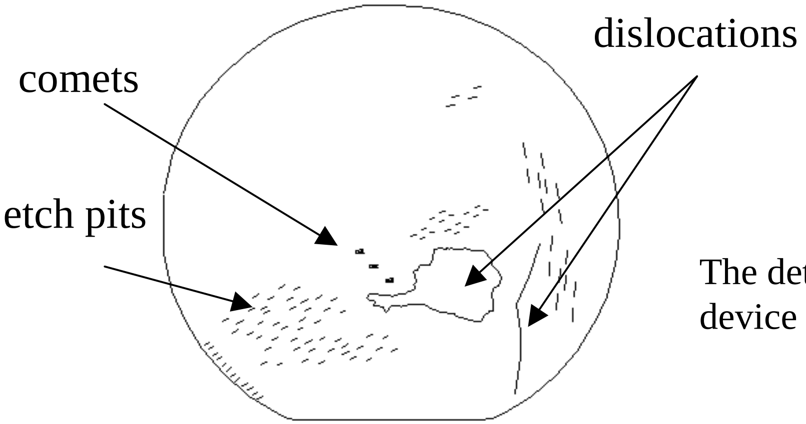
"Comet" Scanning electron microscopy



"Pipe" Optical microscopy



"Comet" Atomic Force microscopy



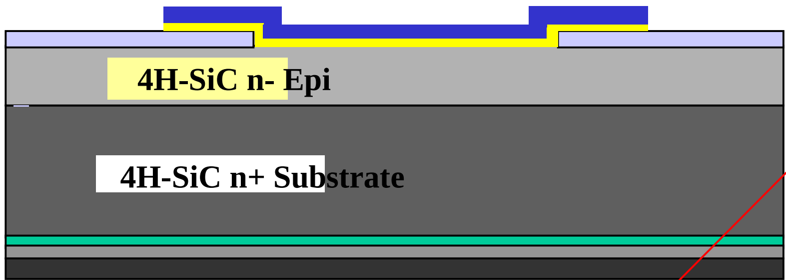
The detailed map is useful for defect to device behavior comparison.

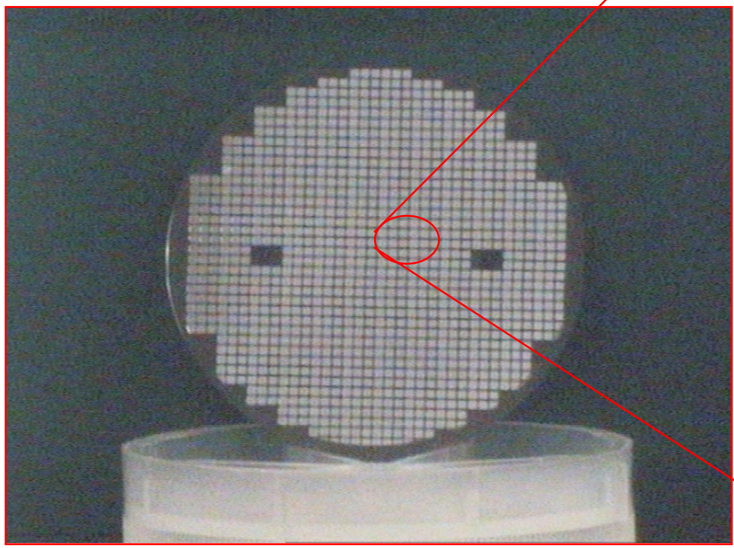
HIGH TEMPERATURE/POWER MICROELECTRONICS: SiC-BASED DIODES

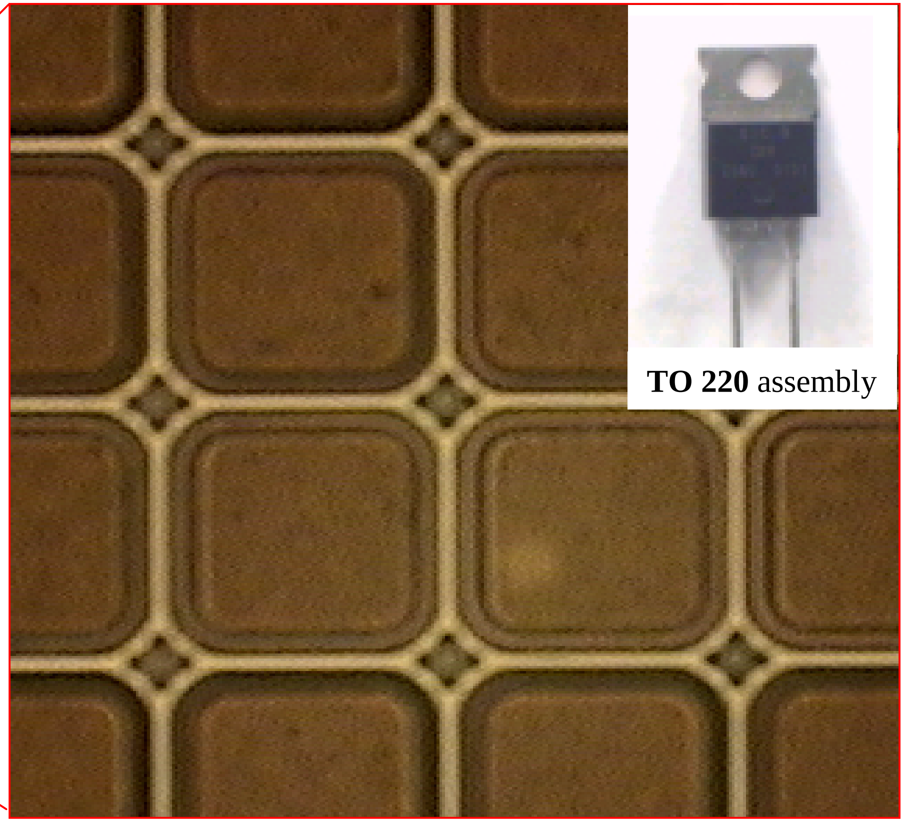
International Rectifier → VISHAY

One of the world's **largest manufacturers** of discrete semiconductors and passive components

4H-SiC Schottky diodes

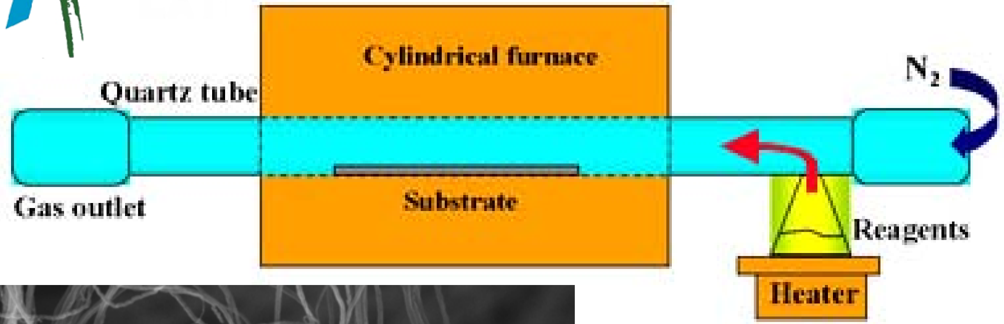


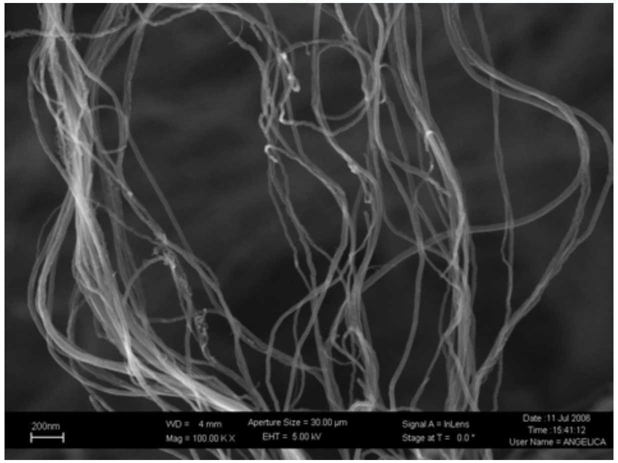


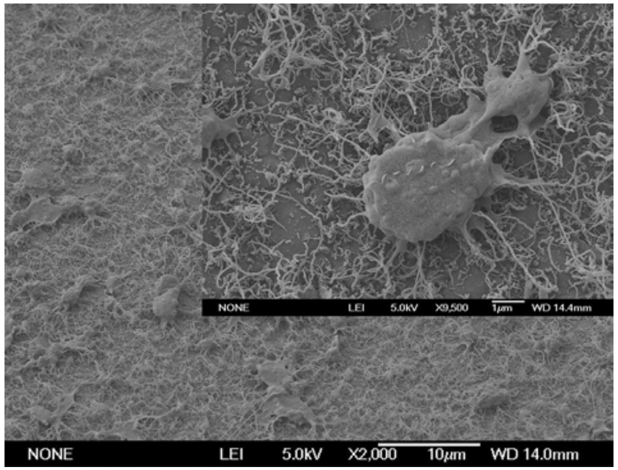


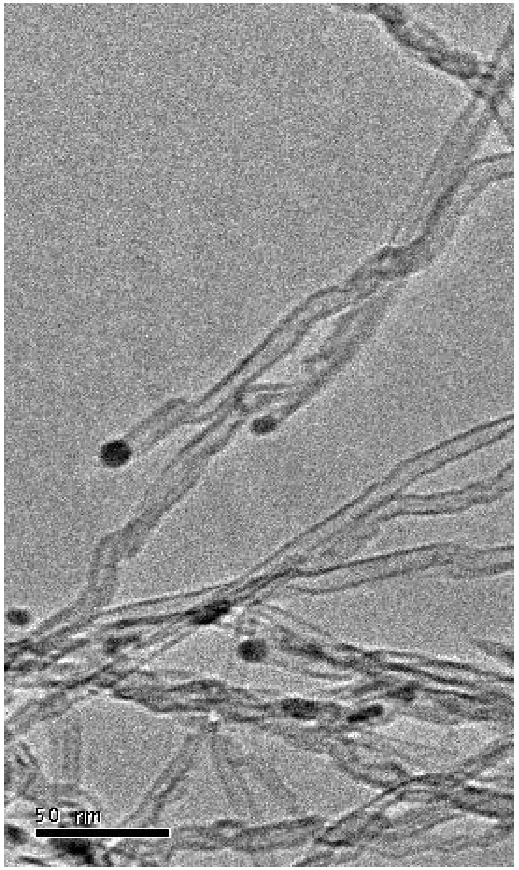
TO 220 assembly

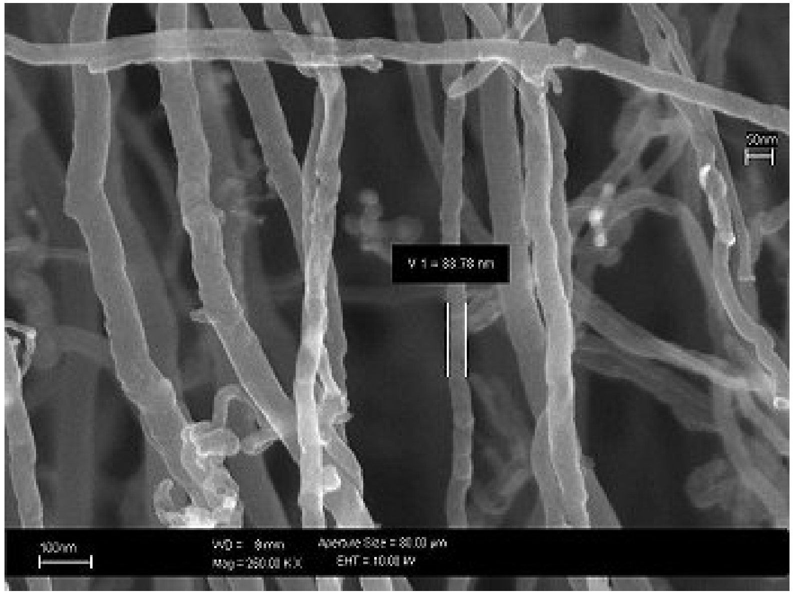
CARBON NANOTUBES

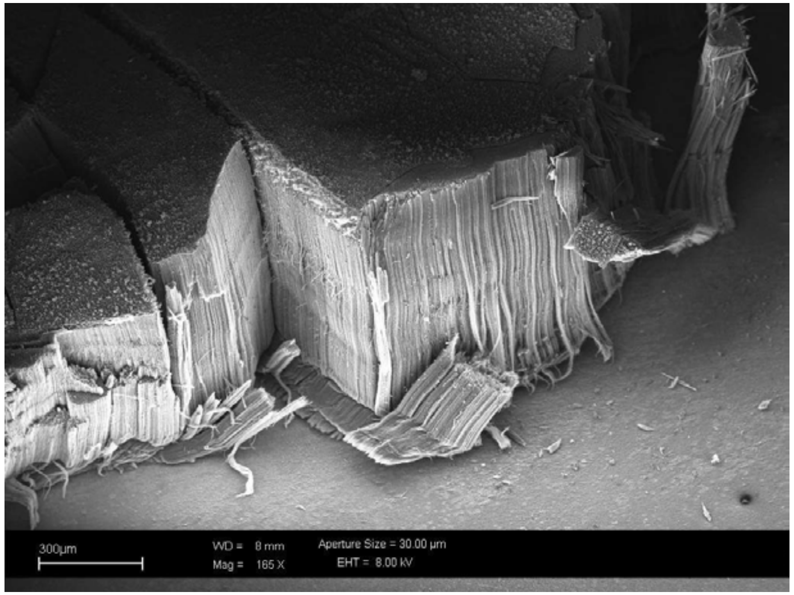






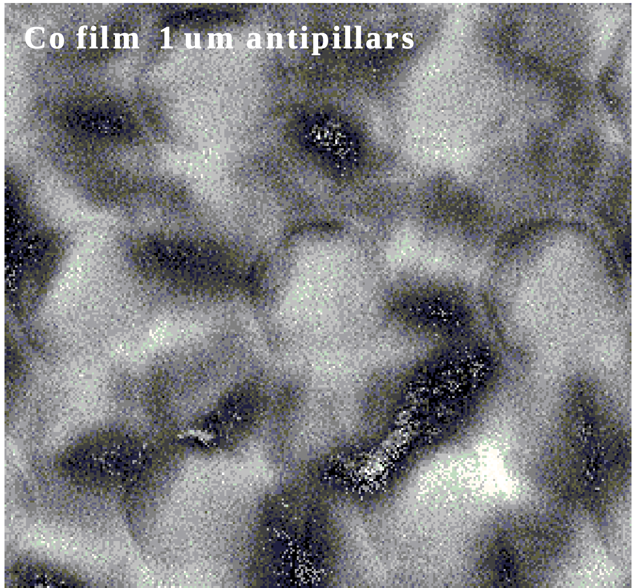


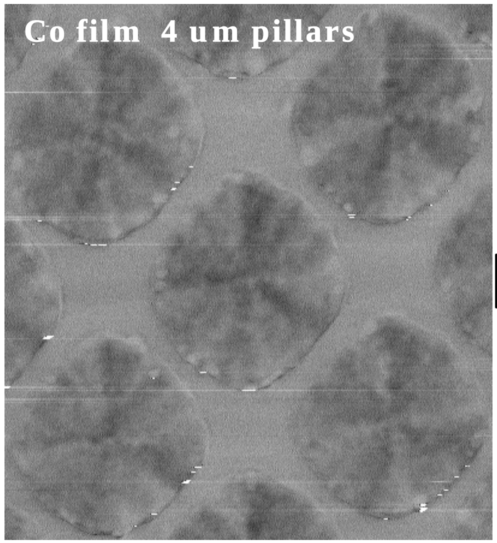


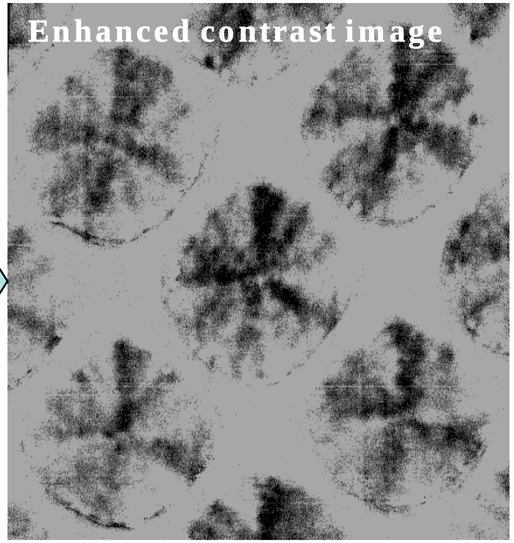


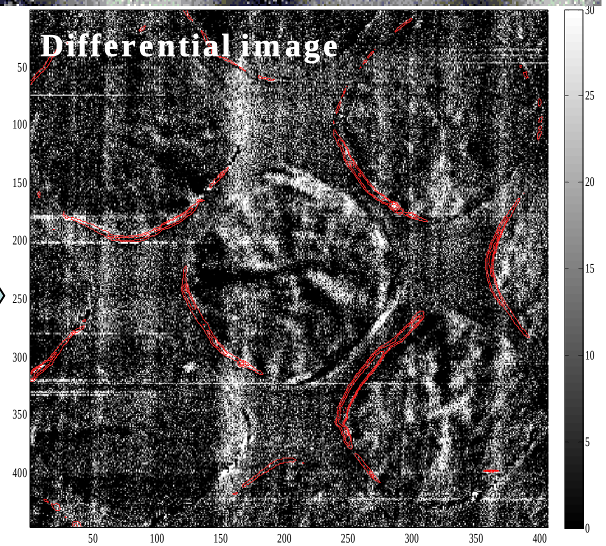
Patterned magnetic materials and multilayers

- Realization of micro and submicro patterns of pillars and antipillars (square and hex lattice) of Ni, Co, NdFeB and multilayered materials (both through optical lithography and EBL);
- AGFM/Kerr magnetic characterization;
- FESEM/AFM/MFM imaging;
- numerical contrast enhancement algorithms;
- magnetoresistive measurements.

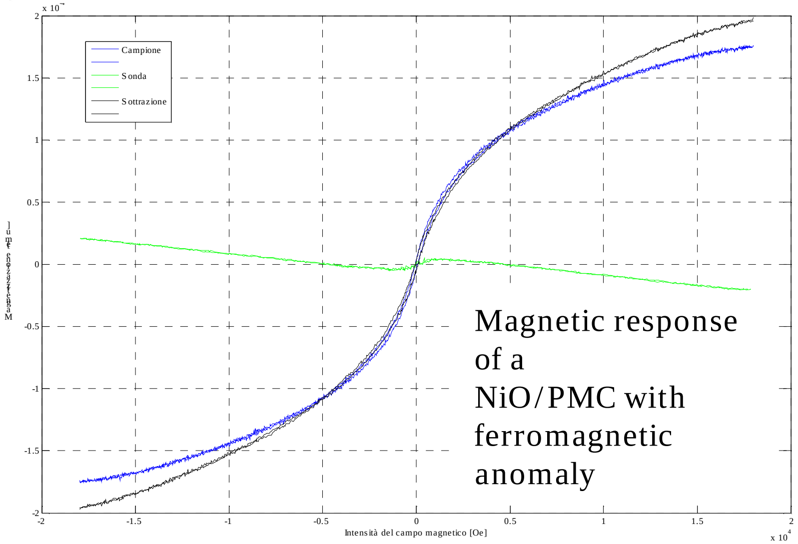




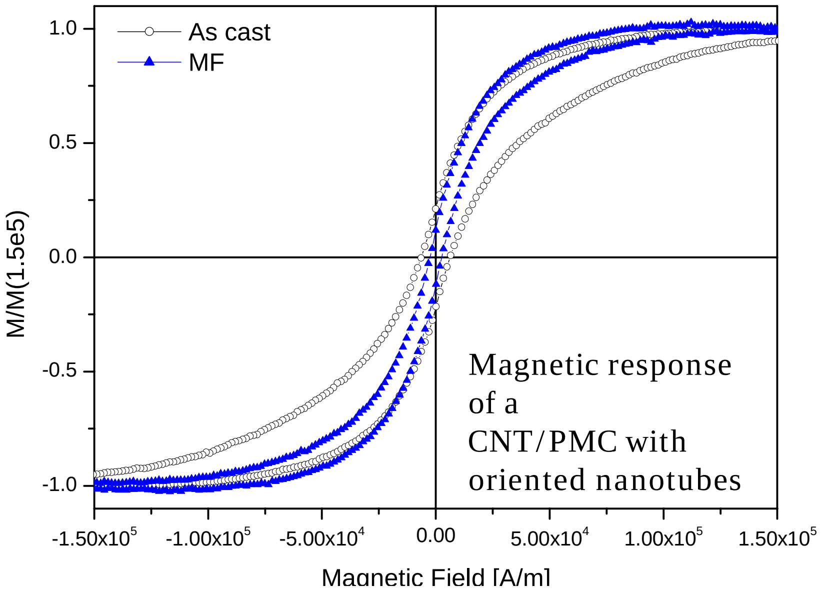


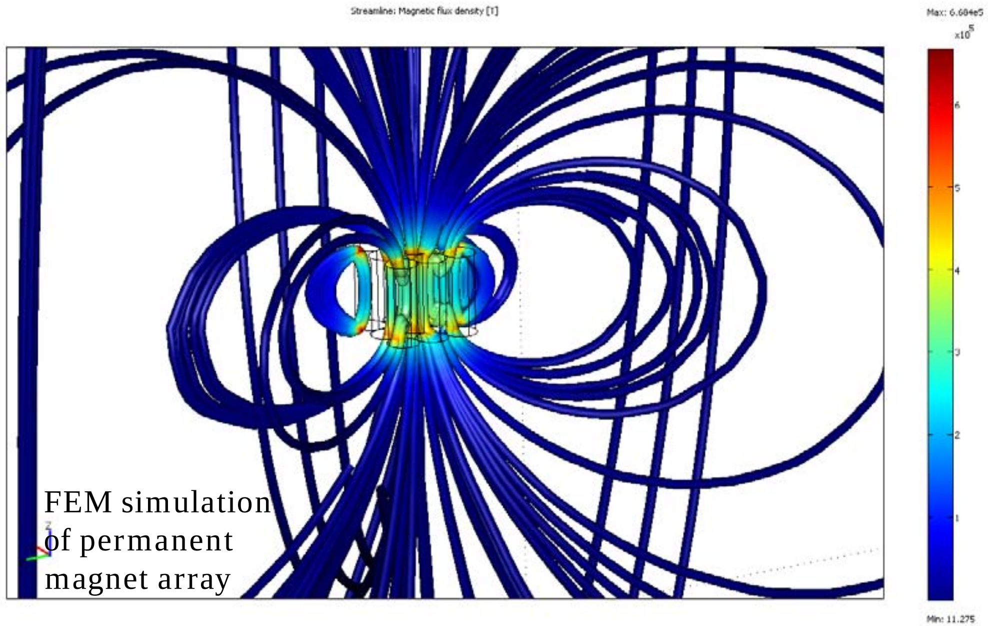


Other activities

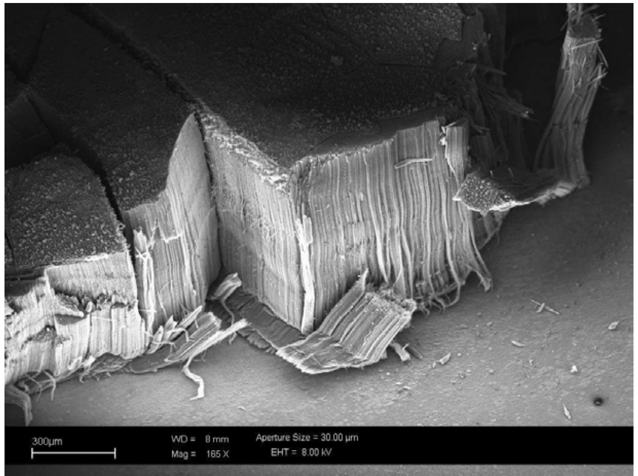


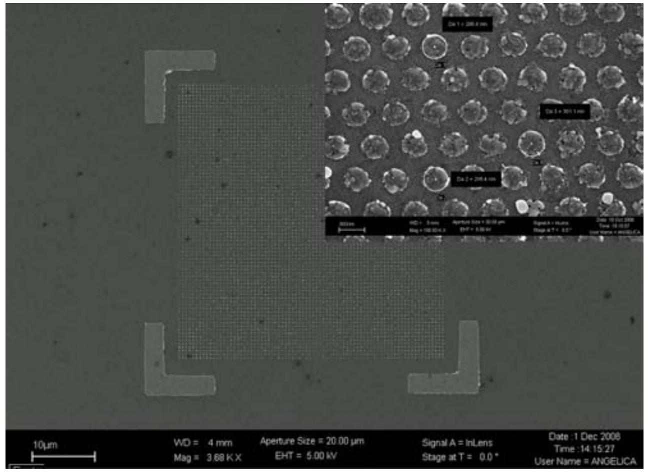
- Synthesis and characterization of polymeric matrix composite materials (PMCs) containing dispersed anti-ferromagnetic nanoparticles (NiO) or dispersed ferromagnetic carbon nanotubes;
- implementation of finite element method and genetic algorithm simulations of magnetic MEMS.

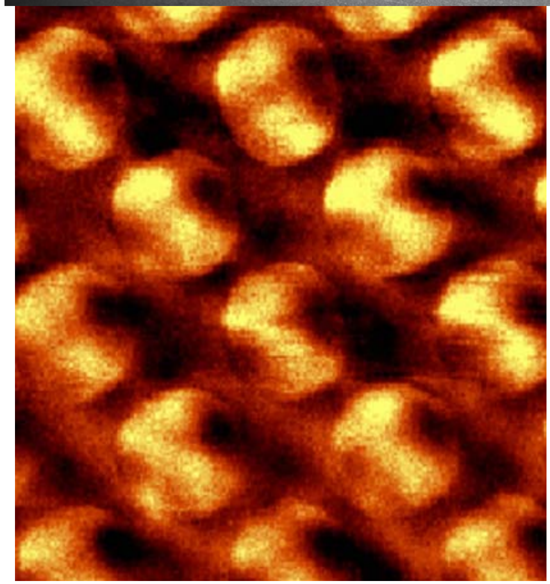


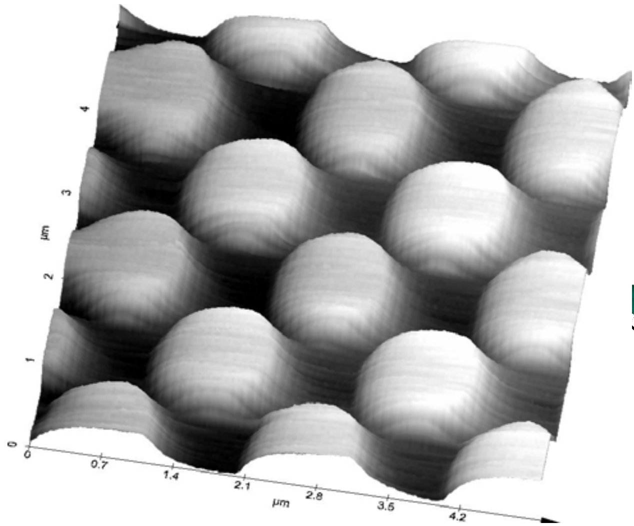


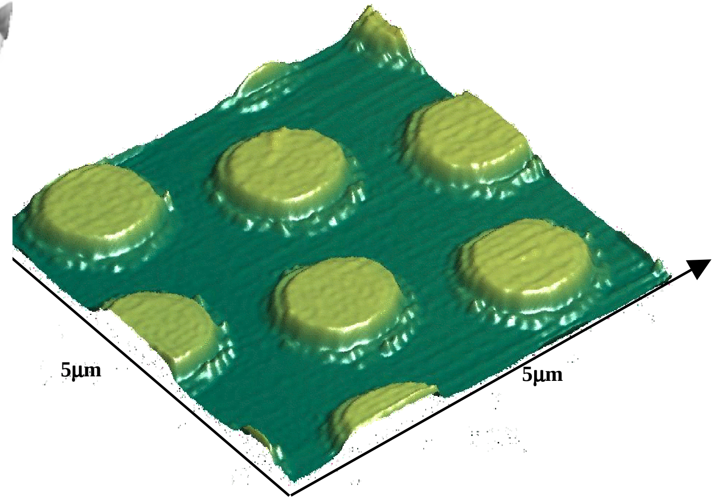
MICRO AND NANO SCALE CHARACTERIZATIONS











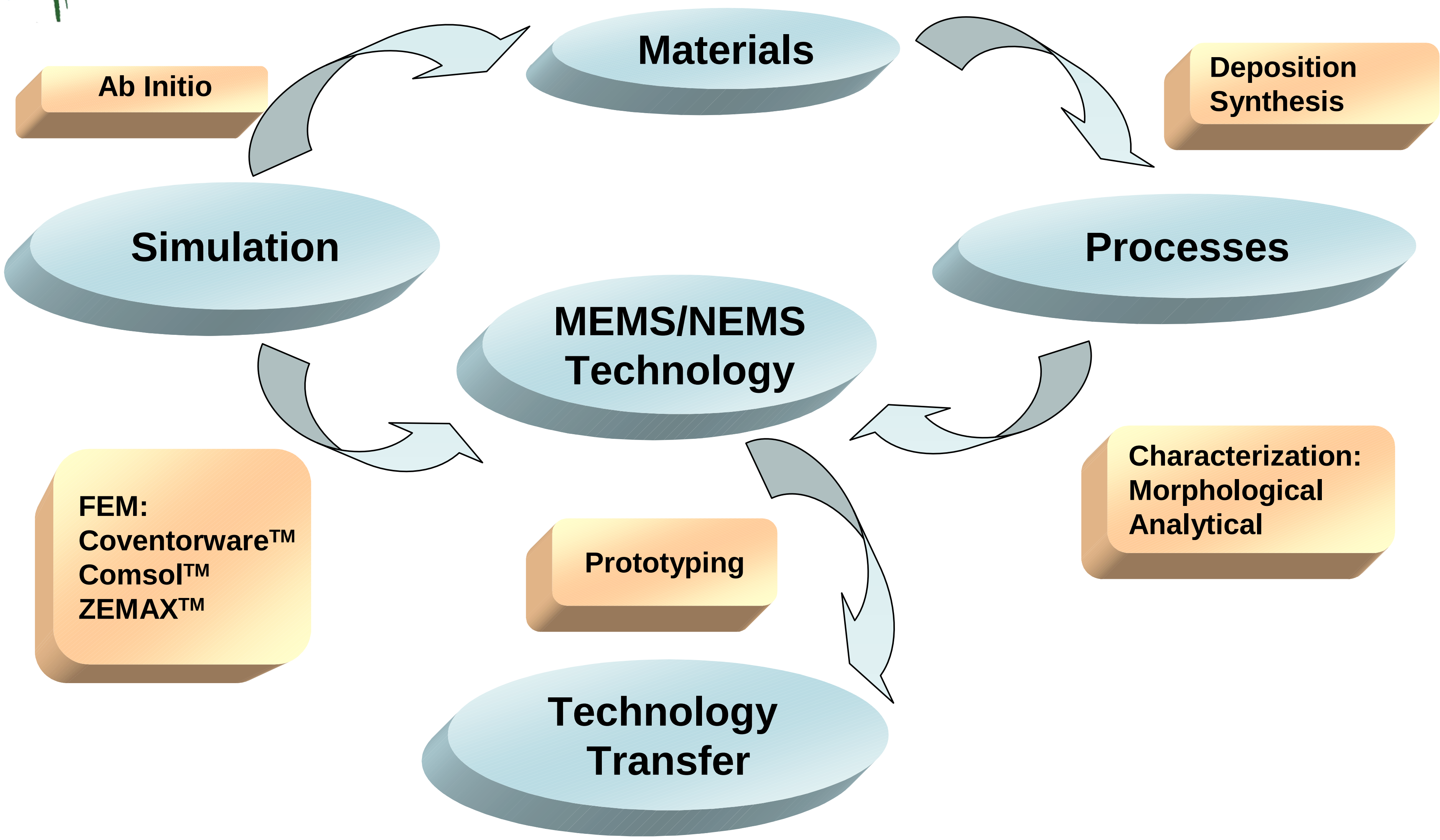
EDUCATION

http://www.master-nanotech.com/

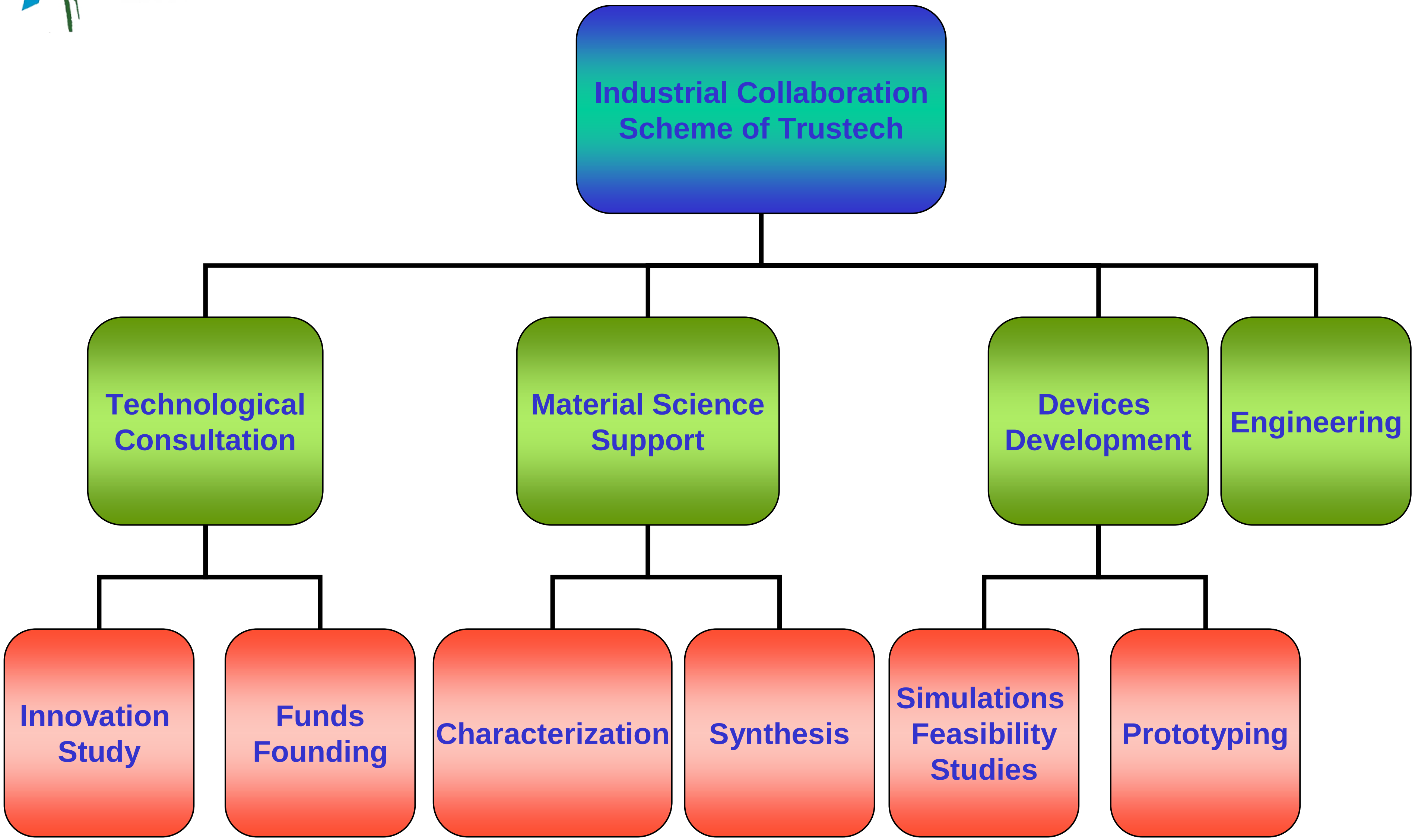
Didactic activities followed by the staff belonging to the Lab are set in the framework of the courses of different level present at the Polytechnic of Turin (degree courses, master courses, PhD courses). Among them we can cite: courses about basic Physics, Structure of Matter, Solid State Physics, Materials for Optics and Photonics, Physics of Surfaces, Physics of the Electronic Materials, Integrated Systems, Physics of the Processes for Microtechnologies, Devices & Technologies for Microsystems, Applications of Microsystems, Microsystems for medical applications.

Since september 2004, the staff of the Lab is managing a new Degree program "Nanotechnologies for ICT" in collaboration with the universities of Grenoble (INPG) and Lausanne (EPFL). Students are following courses in english, planned along three semesters in the three Institutes. The staff of the Lab gives lectures about Physics of Technological Processes, Microsystems Basics, CAD for Microelectronics, Design of Microsystems and CAD for MEMS.

TECHNOLOGICAL TRANSFER - TrusTech



TECHNOLOGICAL TRANSFER – TrusTech



MICROLA S.r.l.

Spin Off of Politecnico di Torino

microla
OPTOELECTRONICS

Products

QDPSSL (λ =1064nm)

- 10W
- 20W
- 40W

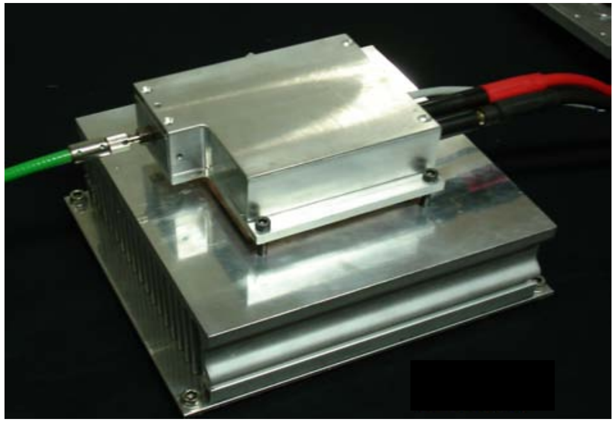
QDPSSL (λ = 532nm)

5W

MLP (λ = 640÷1064nm)

- Up to 100W

http://www.micro-la.com



Fibre coupled high power Diode Laser

End pumped Q-switched resonator

MICROLA S.r.l.

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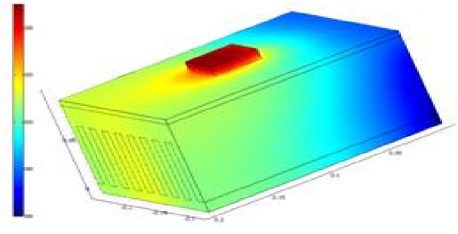
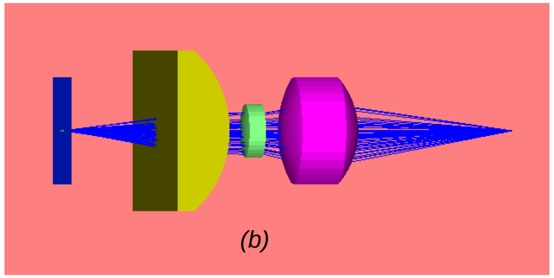
Laser Design and Characterization

- Thermo-fluidodinamic simulation and analysis (a)
- Design and simulation of optical systems (b)
- **Peak power pulse**
    - Ultrafast Photodiode “Photonic Solutions”
- **Beam shape**
    - -1.3 mm @ 20W



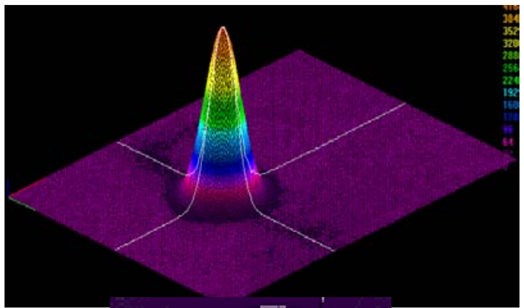
(a)

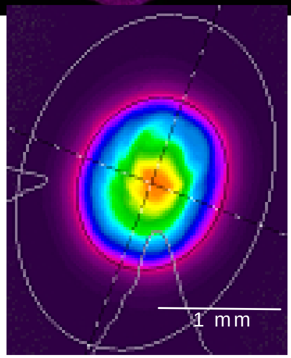
Comsol tool



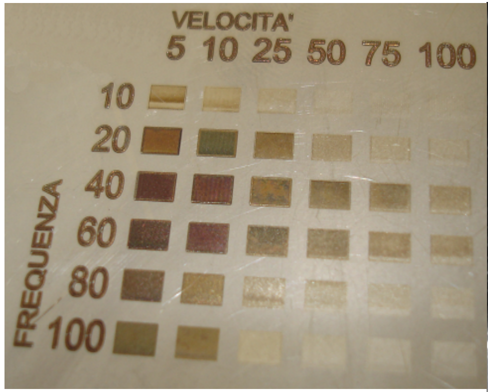
(b)

ZEEMAX tool





Processes characterization



HAZ Control