AP10 Advanced Materials and Nanotechnology

Supported graphene films
(nanoelectronic and sensoristic applications)

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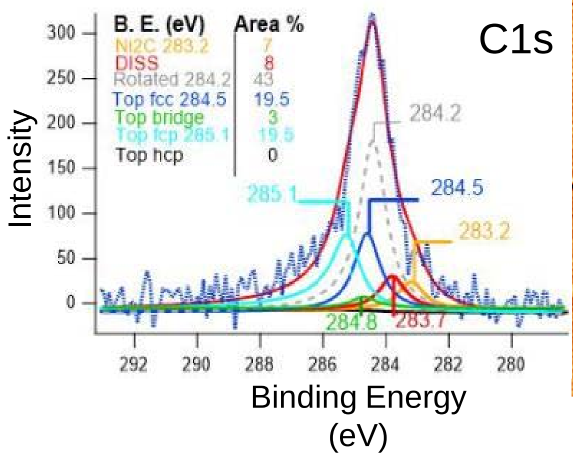
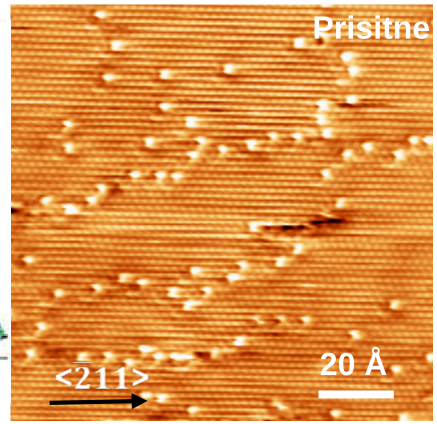
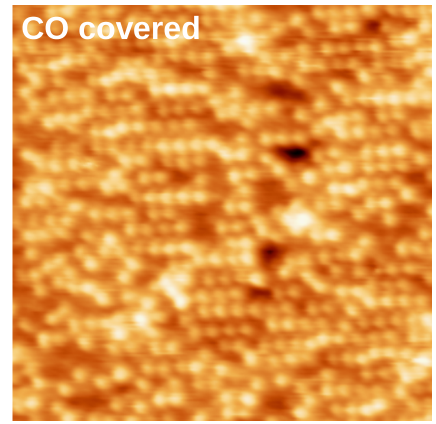
Engineering, ICT and Technologies for Energy and Trasportation Department

1) Graphene/Ni(111), pristine, defected, N-doped:

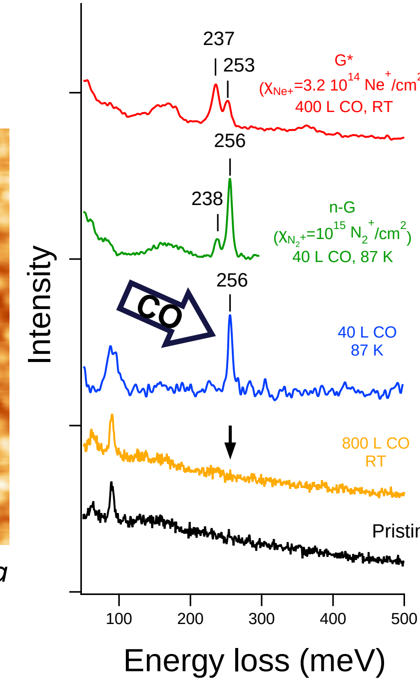
- Synthesis by C2H4 dehydrogenation in UHV
- Characterization and reactivity towards CO





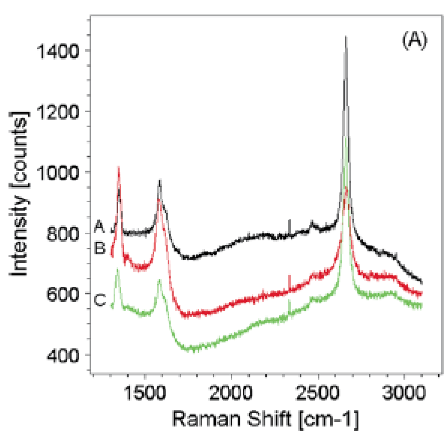


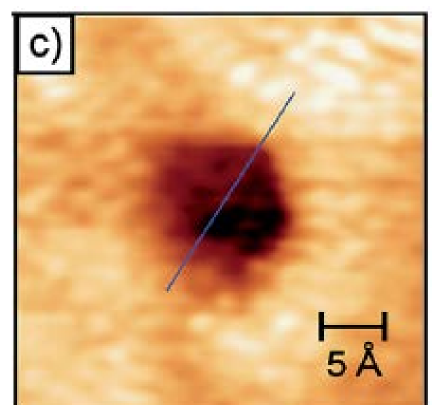
Firb2012: Futuro in ricerca

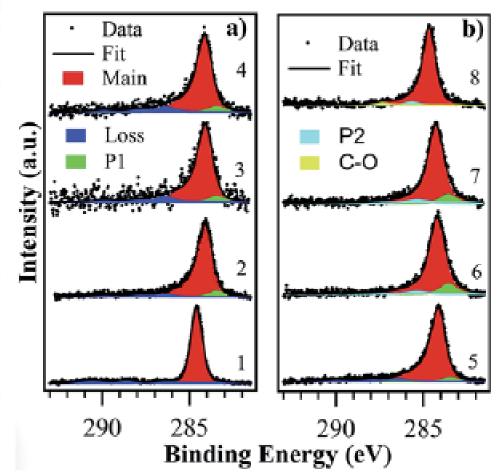


2) Graphene/Cu

- Synthesis by C60 SuMBD at 35eV
- Cage opening and formation of defected but homogeneous single layer graphene







AP10 Advanced Materials and Nanotechnology

SiC as material for nanomedicine

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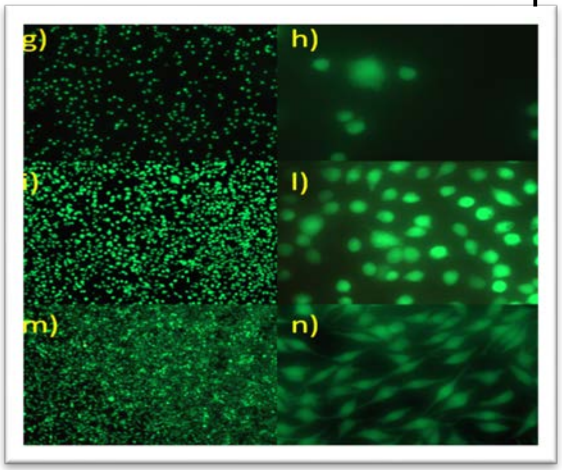
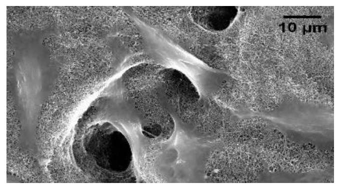
1) SiC/SiO_2 NWs as promising biomimetic biomaterial for implantable prosthetic devices.
Core/shell NWs may be suitable for tissue regeneration.

Cells adhesion and proliferation on NWs

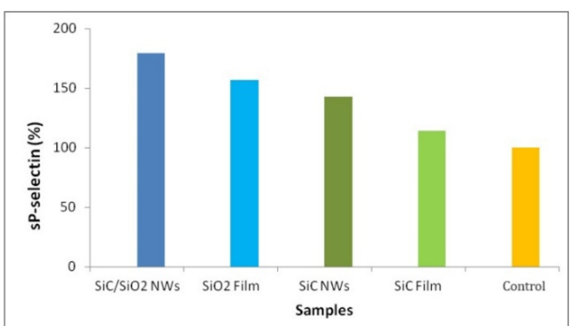


L929 cells (96h culture)



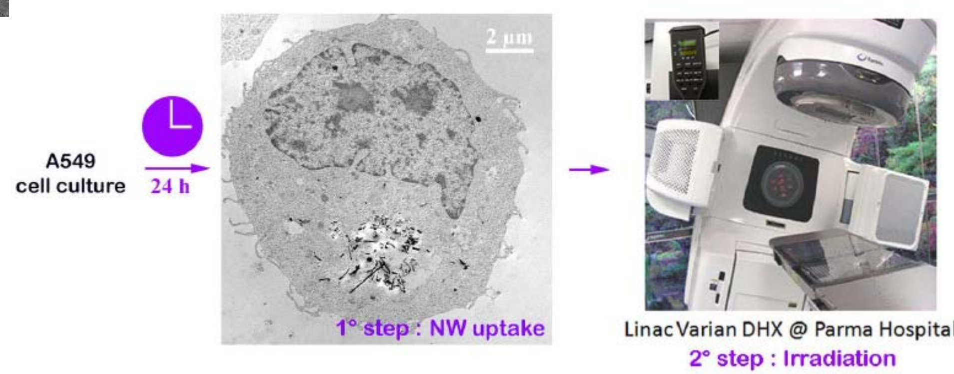
Project funded by the Swiss foundation ITI

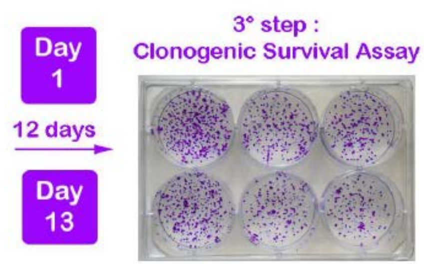
A549 cells: viability after 24, 48 and 96 hours. Cells appear elongated and spread, as typical of healthy cells.

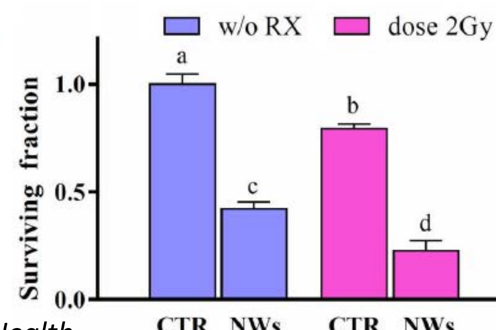


2) X-Ray induced photodynamic therapy for deep solid tumours treatments

H2TPACPP-functionalised nanowires and radiation on A549 cells.







Project funded by US National Institute of Health

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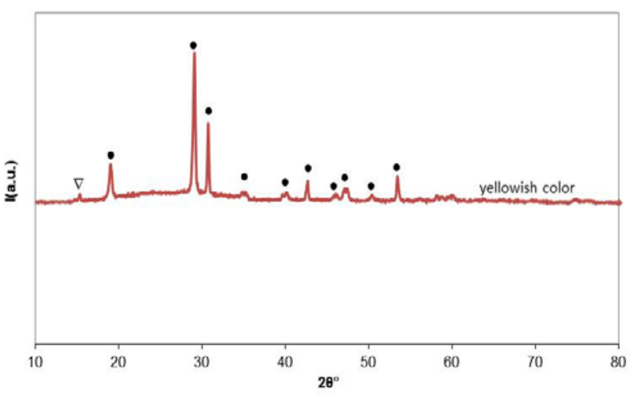
Nanomaterials for energy applications

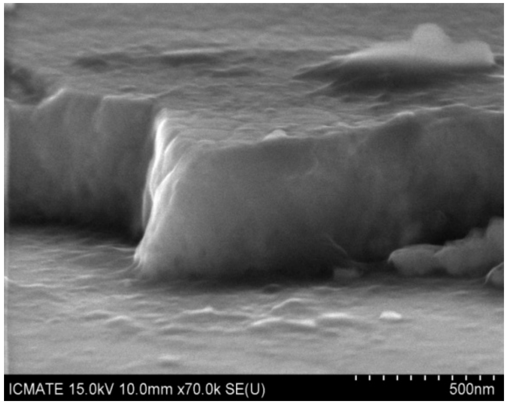
I-ZEB project (Terzo Accordo–Quadro CNR-Regione Lombardia 2017-2018, n° 19366/RCC, 10/01/2017) IFP value of research project 186 keuro (funding 50%)

IFP activity: development of advanced semiconductor materials (thin films, textured coatings) for low power electronics with a focus on renewable energy.

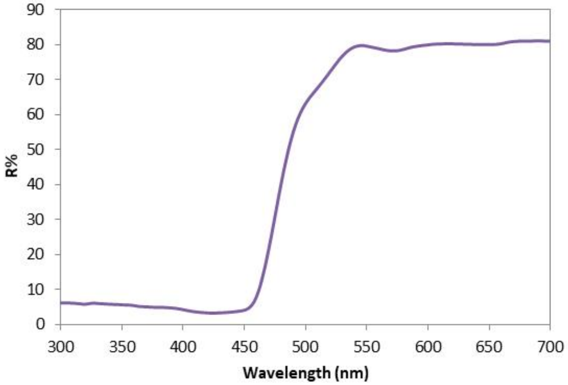
Status of task: development of inorganic photocatalysts → bismuth vanadate coatings ($BiVO_4$) were produced by plasma sputtering deposition technology using a Ar/O_2 mixture.
Targets: V and Bi_2O_3, Substrates: Si, glass, Al, Ti, FTO. Coating thickness range 400 - 600 nm. Deposition temperature: RT, post-annealing at 400°C for 2 hours.
To identify a suitable stoichiometry of coatings the power supplied to Bi_2O_3 target was changed in the range 15-30 W. The correct stoichiometry was found at 20 W, EDS measurements (in collaboration with ICMATE Milano) showed an atomic % for Bi, V and O of 16.9, 16.7 and 66.3, respectively (≈1:1:4).



X-ray diffraction (XRD) shows a $BiVO_4$ monoclinic phase



SEM (ICMATE Milano Lab.)The coating shows a dense, uniform and smooth structure.



UV-Vis diffuse reflectance spectra: energy gap estimated 2.46 eV, according to the literature values.

Istituto di Fisica del Plasma "Piero Caldirola" Consiglio Nazionale delle Ricerche

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Nanomaterials for Energy Applications: development of advanced semiconductor materials

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Photograph of $BiVO_4$ coatings as a function of the power supplied to Bi_2O_3 target. The deposition area is 2 cm x 7 cm.

15 W **20 W** **25 W** **30 W**

In progress → $BiVO_4$ *photocurrent measurements*
→ $BiVO_4/WO_3$ *heterojunction produced by plasma*
→ $BiVO_4/WO_3$ *heterojunction characterization*

Nanomaterials for industrial devices and processes

Greencoat project 2017 (industrial task Prot. 751, 20-4-2017), IFP value of research project 10 keuro.

IFP activity: Plasma deposition of top-coatings on metal substrates to increase the surface hardness and corrosion resistance.

Status of task: organosilicon monomers (SiOxCyHz) are good process precursors for the deposition of protective coatings both anti-corrosion and anti-scratch on metal substrates. By a Plasma Enhanced Chemical Vapour Deposition (PECVD) process, it is possible to produce on the metal surface an optically transparent layer of a few nanometers of thickness with the desired characteristics. For this research activity, an appropriate layer was produced using hexamethyldisiloxane as monomer with dilution in oxygen. The deposited coating on the metal surface showed a high chemical stability, properties of water repellency and surface hardness.

Ellegi project 2017 (industrial task Prot. 1469, 26-07-2017), IFP value of research project 12 keuro.

IFP activity: Plasma deposition of hexamethyldisiloxane-based coatings to facilitate the sliding of plastic components on conveyor belts.

Status of task: for this research activity, an appropriate layer was produced using hexamethyldisiloxane as monomer with dilution in oxygen. The deposited coating on the surface of plastic components showed a good property of sliding.

Topic sterilization/decontamination of materials by plasma methods

The plasma can be used as an efficient tool to sterilize and decontaminate surfaces without damaging them, or can be used to produce surfaces with bactericidal activity.

- Task sterilization/decontamination → low or high pressure plasmas produce oxidative sterilization/decontamination at low temperature to be used for example for medical devices and surgical instruments. On this topic, IFP obtained a *project (industrial task Kenosistec Prot. 63, 22-01-2018, value of the project ~10 keuro)*

  IFP activity: study of low pressure plasma processes to sterilize and decontaminate inorganic compounds inoculated with different microorganisms.

  Status of task: plasma processes are in progress on Bacillus stearothermophilus, Staphylococcus aureus and Candida.

- Task surfaces with bactericidal activity → studying the natural bactericidal activity (due to nano-texture) of the surface of some insects, the plasma has been used to treat the surface of different materials in order to mimic this nano-texture. Plasma treated surface inoculated with E. Coli and B. Cereus microorganisms confirmed the bactericidal mechanism.

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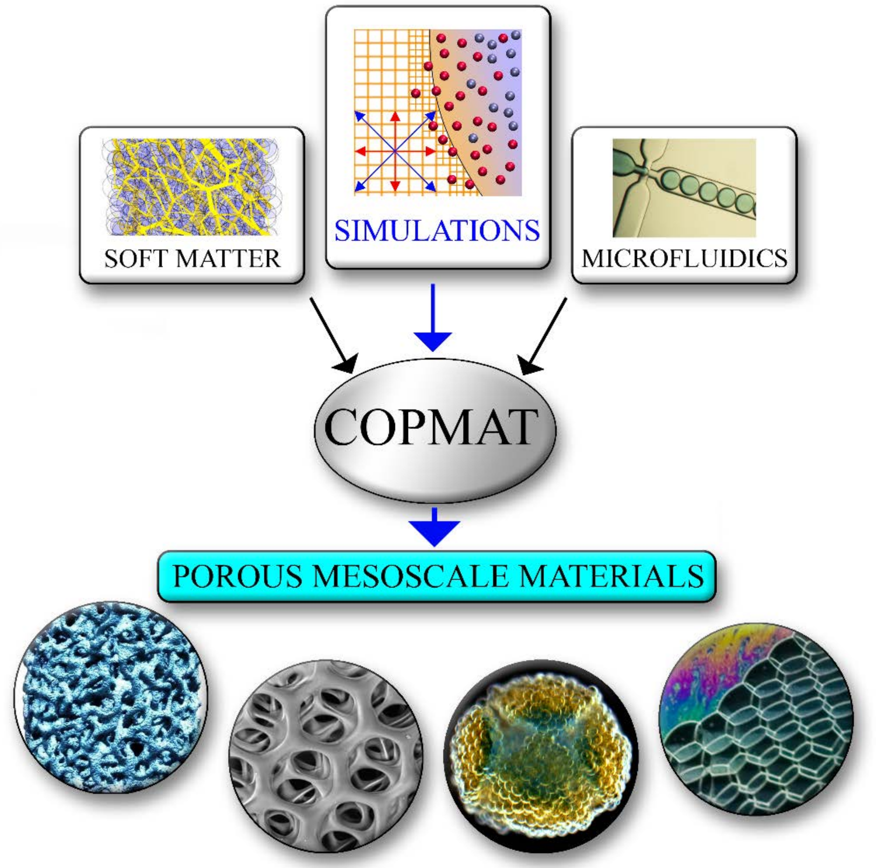
Istituto per le Applicazioni del Calcolo "M. Picone" - CNR

COPMAT

full-scale **CO**mputational design of **P**orous mesoscale **MAT**erials



European Research Council

2018-2022

Istituto per le Applicazioni del Calcolo "M. Picone"

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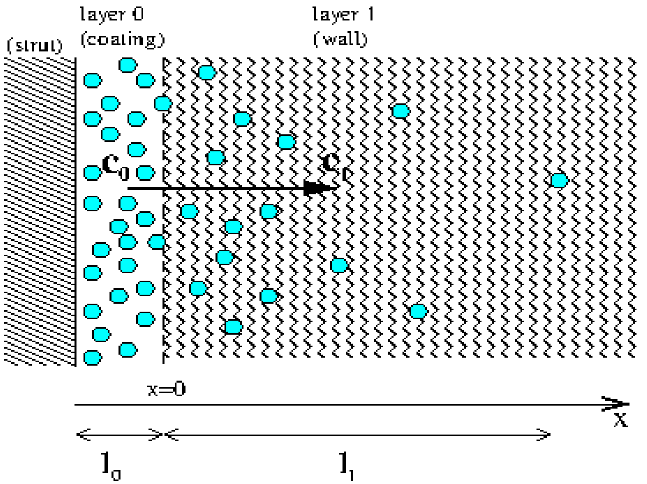
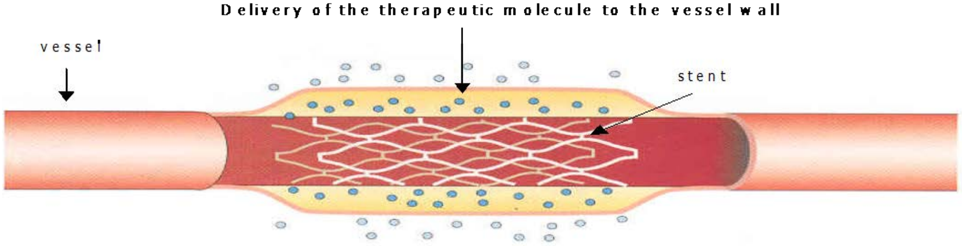
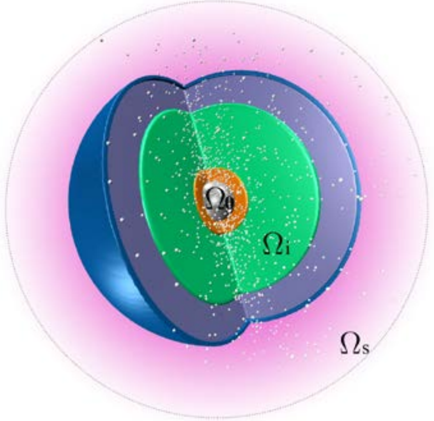
Diffusion problems from a polymeric platform for drug delivery



Drug-eluting stent

A coupled two-layer model for drug releasing systems





Drug release from a composite spherical nano-capsule

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Nanomaterials for solid oxide fuel cells

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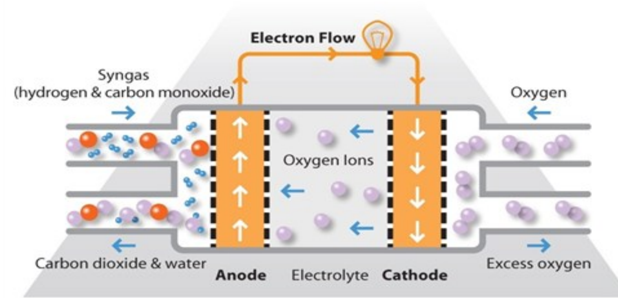
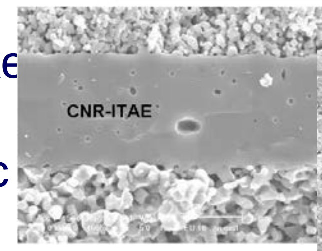
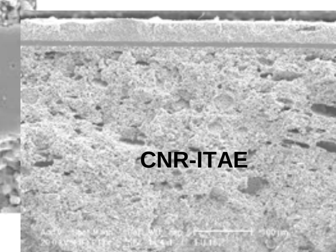
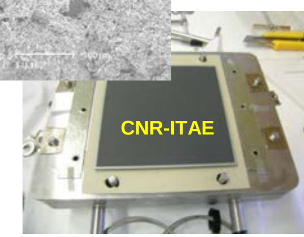
Objective:

- **SOFCs** are based on *ceramic materials* and operate at high temperatures between 800-1000°C.
- The challenges in this sector are regarding the *reduction of the operation temperature* and the direct utilization of hydrocarbons.
- This will allow to decrease degradation and make the device cost–effective by system simplification (reduced fuel processing) and use of cheap ferritic steel interconnectors.









Approach:

- The approach is to develop ceramic electrolytes for intermediate temperature operation based on ceria and gallates, use a multifunctional electrocatalytic layer at the anode to favour internal fuel processing and tailor the composition of the perovskite cathodes to speed-up the oxygen reduction process

Scientific Impact/Results:

- The new materials and cell architectures have been validated for the direct oxidation of hydrocarbons such as methane, ethanol, bio-gas, propane, reformed diesel etc. in systems up to 2 kW power

• Tecnologie ad alta Efficienza per la Sostenibilità Energetica ed ambientale On-board (TESEO) Progetto PON2_00153_2939517.
• Intermediate temperature solid oxide fuel cells fed by bio-fuels (BIOITSOFC) prot. 2010KHLKFC. (*PRIN)*

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Nanomaterials for low temperature fuel cells

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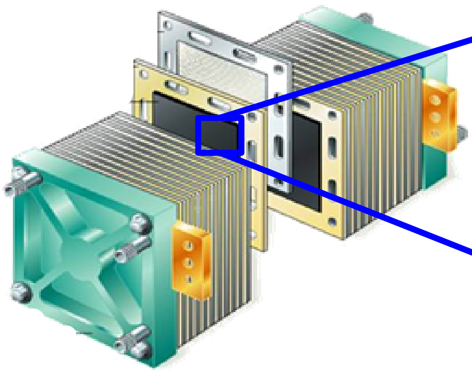
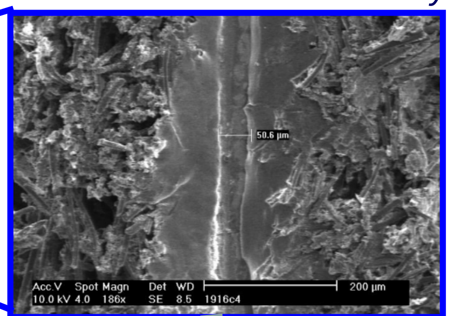


Membrane electrode assembly



Cathode

Anode

PEMFC

$$H_2 + {}^1/_2 O_2 \rightarrow H_2O$$

DMFC

$$CH_3OH + {}^3/_2\, O_2 \rightarrow CO_2 + 2\, H_2O$$

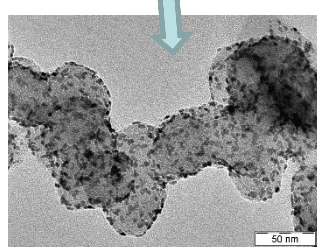
- Catalysts for the cathode of PEMFC/DMFC:

  Pt/C, PtMe/C (Me: Ni, Co, Fe)

- Catalysts for the anode of PEMFC/DMFC:

  Pt/C, PtRu/C

C (Ketjenblack, Vulcan, Acetylenblack, carbon nanofibers/nanotubes...)



- **Synthesis procedure:** sulphite complex route
- **Characterized by:**
  - Employment of sulphites as complexing agents
  - Low crystallite sizes (2-4 nm)
  - Great metallic dispersion (even at high loadings, *i.e.* 80 wt.%)

European Projects

- Improved Durability and Cost-Effective Components for New Generation Direct Methanol Fuel Cells.
- Improved Lifetime of Automotive Application Fuel Cells with ultra low Pt-loading.

DURAMET Methanol fuel Cells

IMPACT

AP10 Advanced Materials and Nanotechnology

ADVANCED MATERIALS FOR HYDROGEN GENERATION BY PEM ELECTROLYSIS

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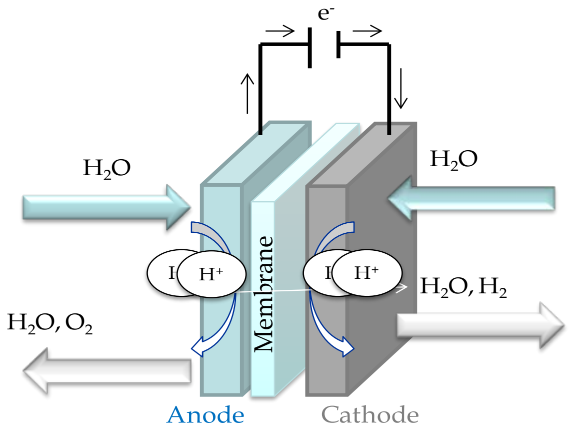
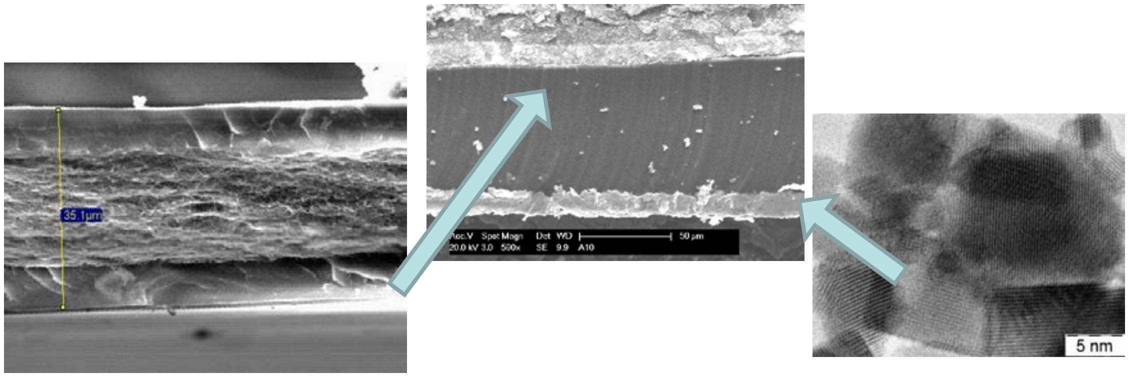
Next generation water electrolysers must achieve a good dynamic behaviour (rapid start-up, fast response, wider load and temperature ranges) to provide proper grid-balancing services and thus address the increase of intermittent renewables interfaced to the grid.

Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers in combination with renewable power sources are developed at ITAE. The aim is to contribute to the road-map addressing the achievement of a wide scale decentralised hydrogen production infrastructure.





EU Projects

HORIZON 2020 PROGRAMME

SEVENTH FRAMEWORK PROGRAMME

Electrohypem

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

HPEM2GAS

http://electrohypem.eu

http://www.hpem2gas.eu

AP10 Advanced Materials and Nanotechnology

Hydrogen Storage Advanced Materials

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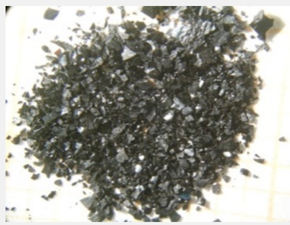
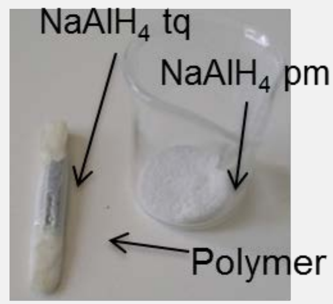
AIM: The main focus is the development of new materials for Solid State H_2 storage, having low cost, simple synthesis, no sensitivity to air, H_2 storage value comparable to commercial material in non drastic T and P conditions

Materials

Polymers functionalisation



Composite materials based on metal oxides grown onto polymer matrix

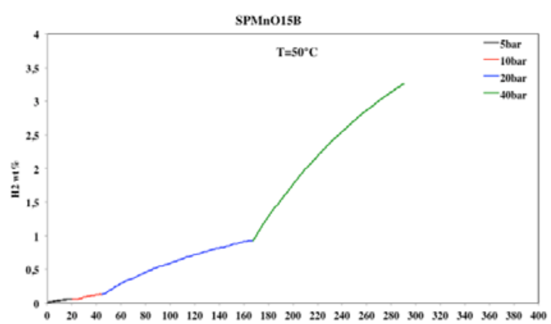


Metallic Alanates covered with polymers

Study on natural volcanic materials

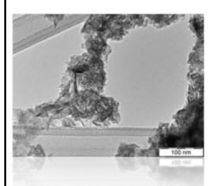
Activated carbons from natural wastes (banana peels, etc.)

Characterisation by Sievert method



Volumetric analyses revealed a good H_2 sorption (~3wt%) value in particular at non drastic conditions (40bar 50° C)

INNOVATIVE MATERIALS AND SYSTEMS FOR H2 STORAGE



SPMnO material

Prototypes Development

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Advanced Materials for electrochemical devices and purification systems

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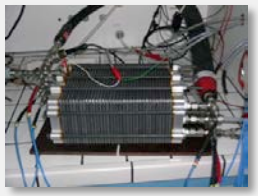
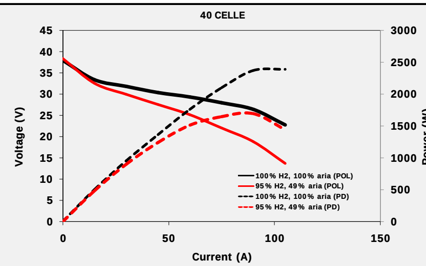
1. Membranes for electrochemical systems (PEFC, AMFC, EHC, VRFB, Super-Cap)

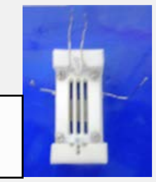
PEFC:
Nafion composite (ZrO_2, YSZ, TiO_2)
s-PEEK; s-PSF
Biopolymeris (chitosan, Nanocellulose)





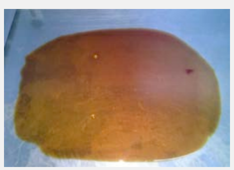
95%RH Fuel – 49%RH aria	
Current	75A
Potential 120°C in H_2	22 V
Rated Power a 120°C in H_2	1650 W

AMFC:
Polysulphone PSF-Q



Anionic conductivity(Cl^-): 3mS/cm

VRFB: s-PEEK composite with $SiO\text{-}NH_2$



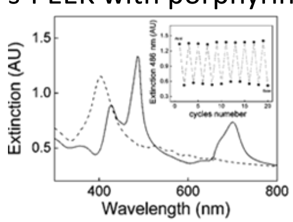
- ✓ Charge/discharge efficency of 96% against 85% for N115
- ✓ Selectivity to ions V^{4+} di $49 \cdot 10^6$ $S \cdot s \cdot cm^{-3}$ against $6 \cdot 10^6$ $S \cdot s \cdot cm^{-3}$

Super-Cap: s-PEEK

- ✓ Specific capacity (123F/g) higher than reference porous separator
- ✓ Stability of 20000 cycles at 2A/g

2. Membranes for pH and metals optical sensors

Composite Nafion and s-PEEK with porphyrins

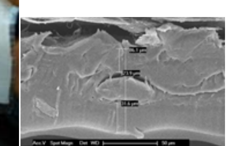


3. Membranes for waste water purification systems

- ➢ PSF
- ➢ PVDF
- ➢ PP
- ➢ PEEK

4. Membranes for Liquid Desiccant and dehumidification systems

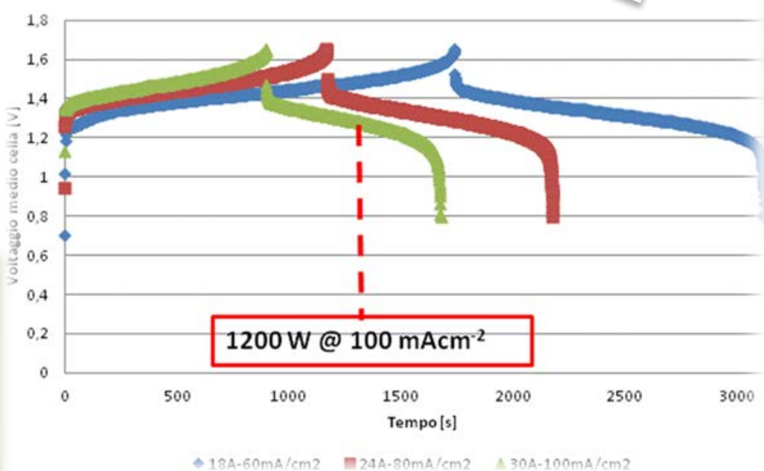
Asymmetric membranes based on: PP, PVDF, PSF, PVA



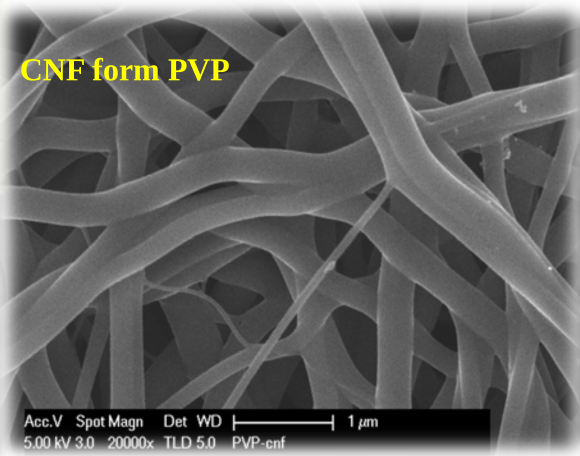
Vanadium Redox Flow Battery (VRFB) Activity

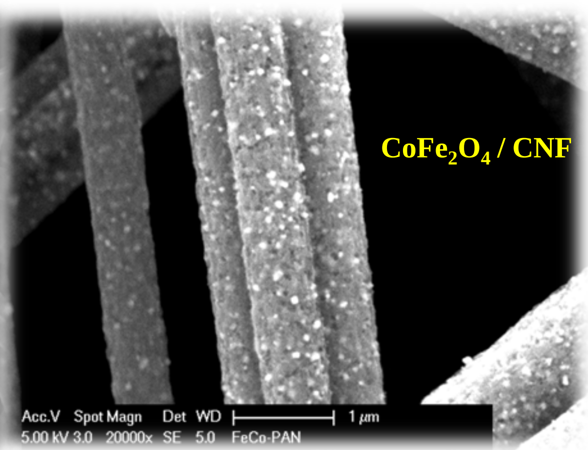
Materials and Stack Design Optimization to improve electrochemical parameters and reduce technology costs

- Electrode materials synthesis by electrospinning tecnique
- Electrochemical characterizations from single cell up to kW stack
- Stack design and development
- Electrochemical model development
- Cell and stack fluid dynamic studies



1 kW VRFB Stack





Nanomaterials for metal-air batteries

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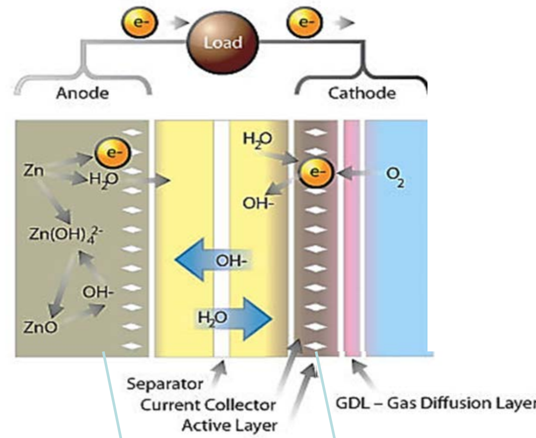
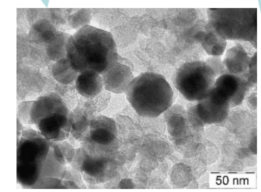
- Based on the electrochemical reaction of a metal (Fe, negative electrode) with oxygen from atmospheric air (positive electrode)



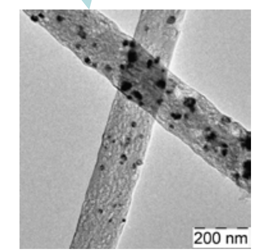
$$O_2 + 2Fe + 2H_2O \underset{charge}{\overset{discharge}{\rightleftarrows}} 2Fe(OH)_2$$

$$3Fe(OH)_2 + \tfrac{1}{2}O_2 \underset{charge}{\overset{discharge}{\rightleftarrows}} Fe_3O_4 + 3H_2O$$

- Materials for the positive electrode (air):
  - **Noble metal catalysts: Pd/C** (sulphite complex route)
  - **Cost-effective materials: Perovskites** ($La_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_3$)



- Materials for the negative electrode (Fe):
  - **Fe_2O_3/C + sulphide additives** (synthesized by several methods: colloidal routes, both organic and inorganic, salt fusion method).



- Alternative supports (more resistant to corrosion):
  - **Carbon nanofibers (CNFs)**
  - **Ti-suboxide**

EU Project

NECOBAUT

SEVENTH FRAMEWORK PROGRAMME

AP10 Advanced Materials and Nanotechnology

Nanomaterials for Supercapacitors

Consiglio Nazionale delle Ricerche
Engineering, ICT and Technologies for Energy and Trasportation Department

1. Development of Electrode materials

- Mesoporous carbon
- Carbon xerogels
- Graphene
- Manganese oxides

Well developed porosity
High charge/discharge rate
Appreciable cycling stability

2. Development of Electrolytes

- Neutral aqueous
- Solid Polymer

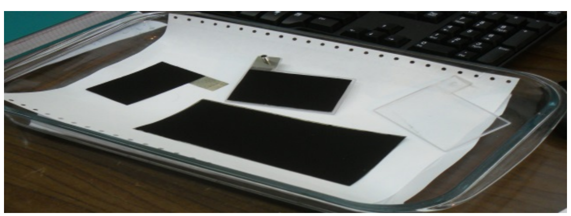
Inexpensive
Easily handling
Environmental friends but…..
…Low operating voltages

How working voltage window can be increased ?

Neutral aqueous Electrolytes

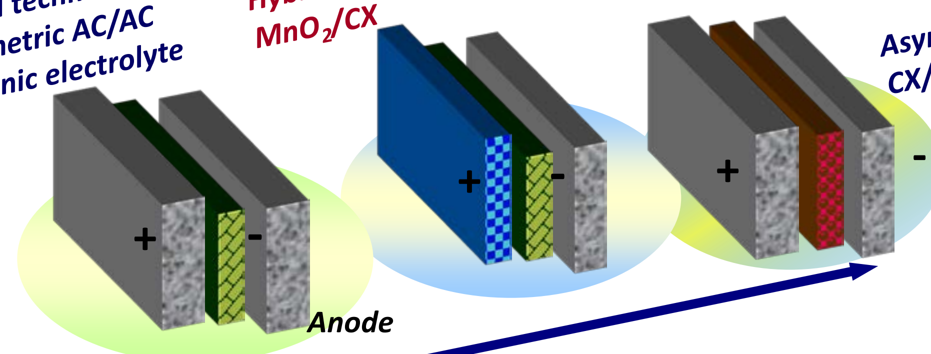
3. Development of Electrodes

- Casting/Coating technology



4. Configuration of supercapacitors

Hybrid or asymmetric configuration



5. Prototype of Supercapacitors

1.5 F
5.5 V

12 F - 5 V

50 F - 1.5 V

20 F - 3 V

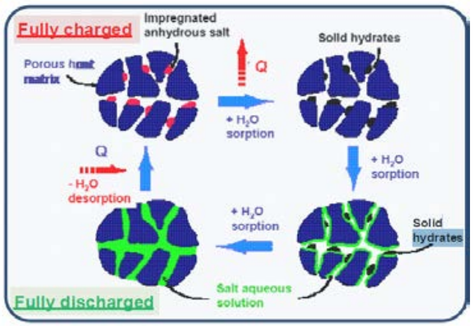
AP10 Advanced Materials and Nanotechnology

Consiglio Nazionale delle Ricerche
Engineering, ICT and Technologies for Energy and Trasportation Department

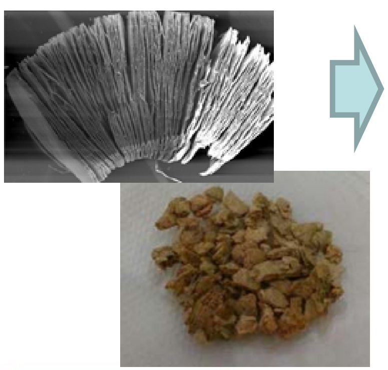
Development and Validation of an Innovative Solar Compact Selective-Water-Sorbent-Based Heating System — SWS-HEATING

Aim:

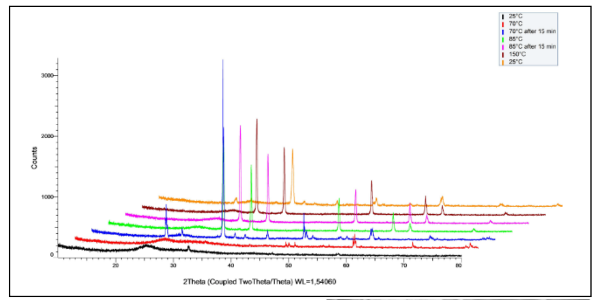
The SWS-Heating project will develop an innovative seasonal thermal energy storage unit based on a *novel composite sorbent material* and creative multi-modular configuration.

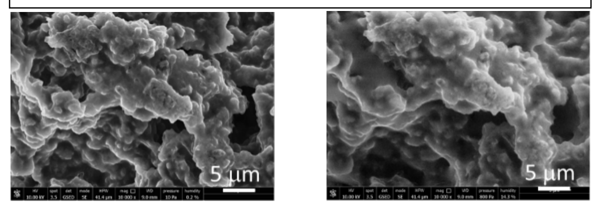


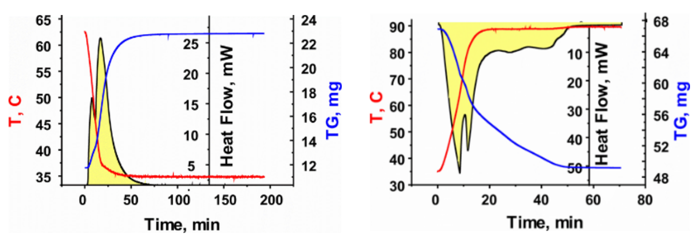
Composite sorbent concept



Vermiculite-LiCl synthesized







Morphological, structural and thermal characterization of ad/desorbed material

Next steps:

- *Synthesis optimization*
- *Cycling stability analysis*
- *Scale-up of the production*
- *Full-scale sorption storage testing*

The SWS-Heating project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 764025.

AP10 Advanced Materials and Nanotechnology

Activated Bio-Char

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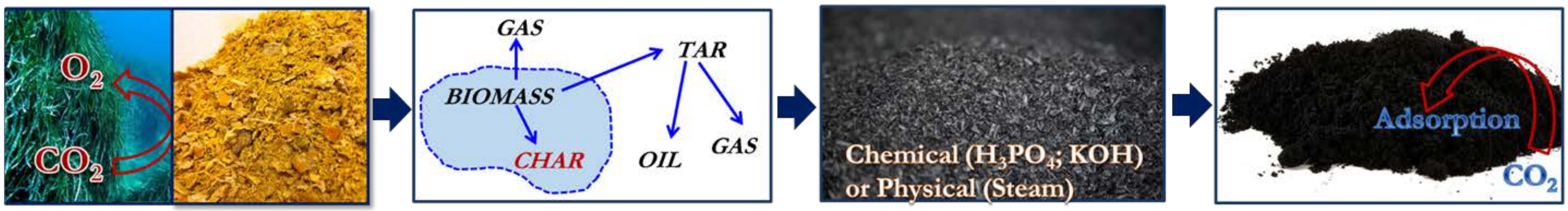
Engineering, ICT and Technologies for Energy and Trasportation Department

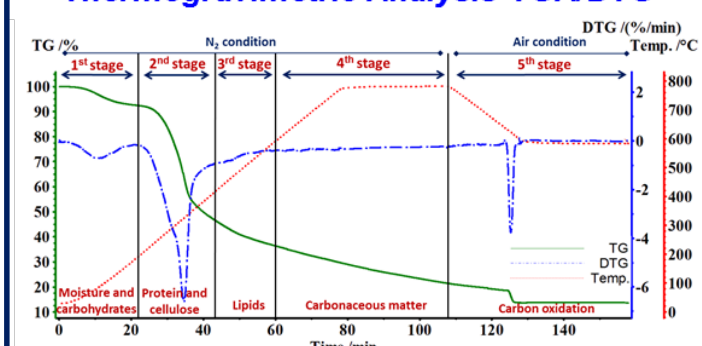
Biomass — Carbonization — Bio-Char Activation — Porous Bio-Char



Pyrolysis of local residual biomass to produce activated carbon (bio-char) with a high surface area and remarkable CO_2 adsorption properties

Beached seaweed (Posidonia Oceanica)

Thermogravimetric Analysis TGA/DTG



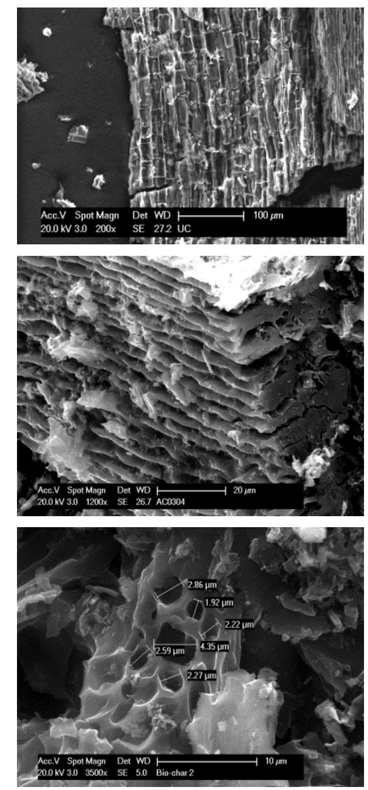
Elemental Analysis (wt%)

	C	H	N	O	O/C
Biomass (Posidonia Oc.)	40.3	5.7	1.1	25.6	0.64
Activated Bio-Char	92.7	2.1	0.6	4.6	0.05

Bio-char Adsorption-Desorption measurements

Surface Area m^2/g	2938
Adsorbed CO_2 mmol/g	4.8
Pore volume cm^3/g	0.91
Horvath Kawazoe Median pore width nm	1.16

SEM Analysis



AP10 Advanced Materials and Nanotechnology

Nanohybrid materials for the production of DME via CO_2 hydrogenation

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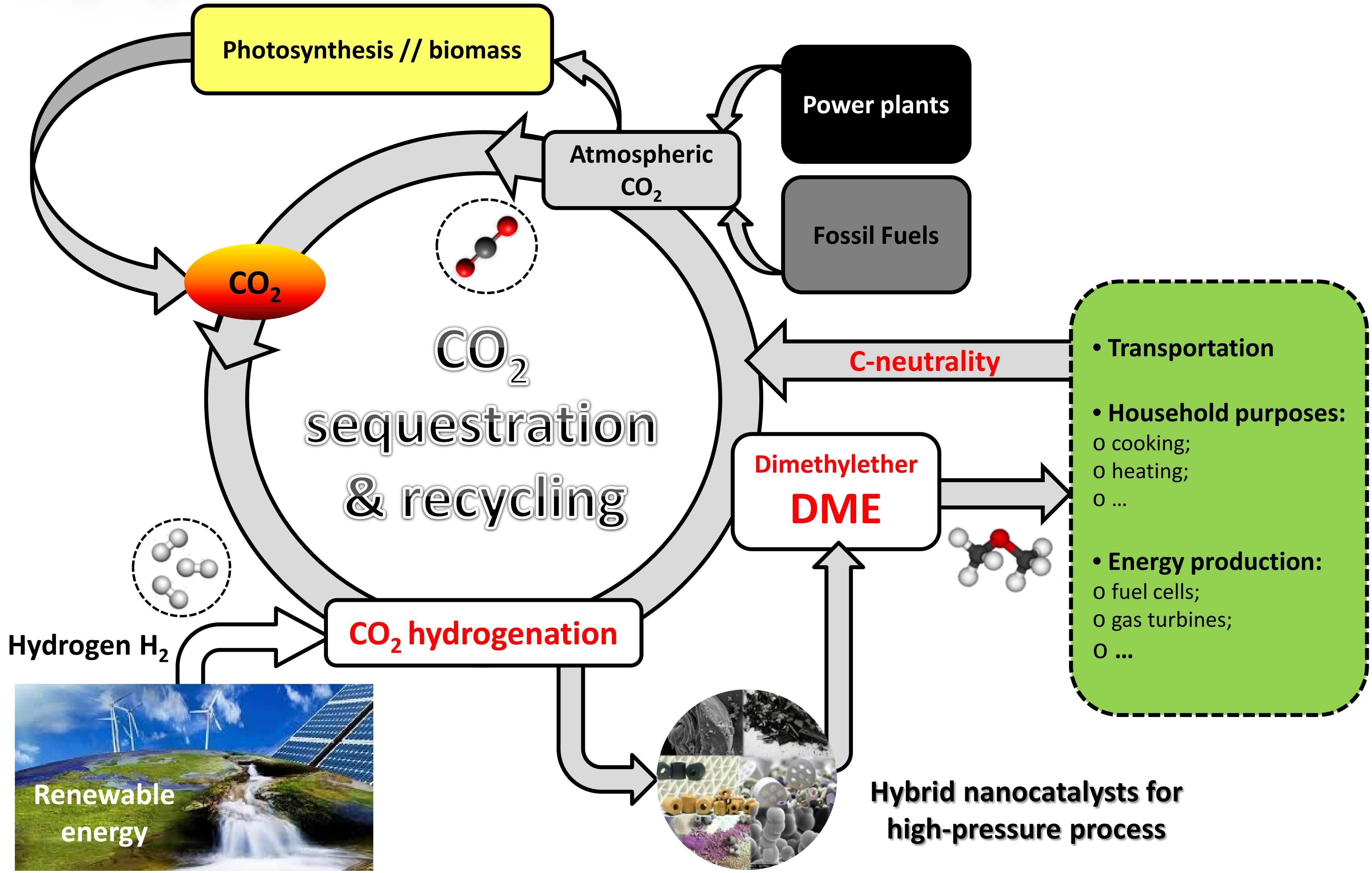

AP10 Advanced Materials and Nanotechnology

Structured catalysts with enhanced transport and surface to volume ratio properties for the development of intensified reactors for catalytic conversion of CO_2 into usable fuels and chemicals (methanation case)

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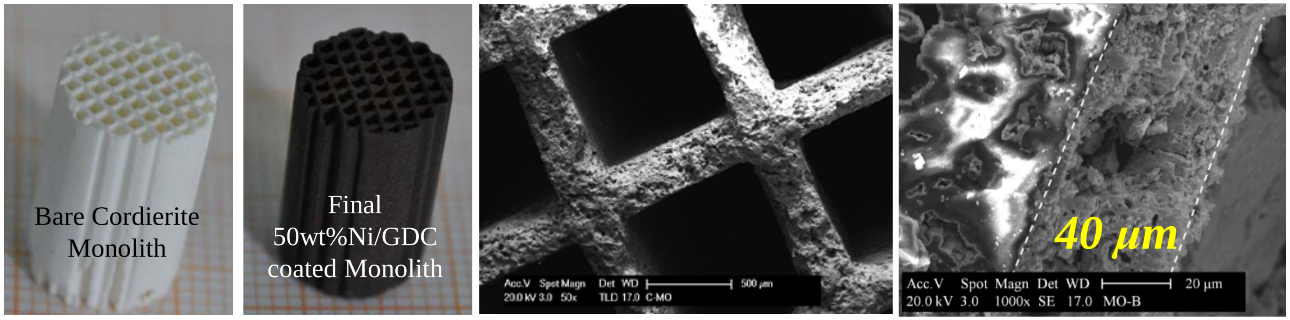


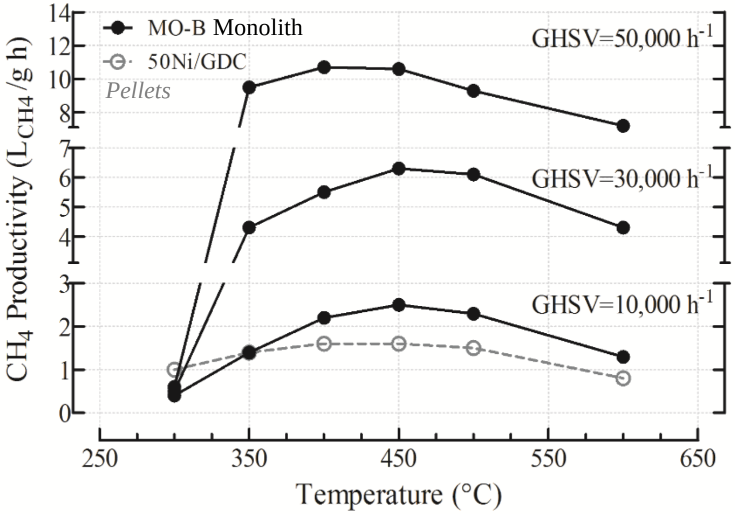
- Catalyst loading: 0.5 g/cm^3 (60% of packed bed)
- Well uniform and high-resistance coated layers
- Adhesion tests results, pointed out *good resistance* of the coated layers, with negligible weight loss (0.3-0.5%) after two sonication baths.

- Cordierite Structured support 500 CPSI

Channel Inner Size d_p (mm)	Wall thickness t (mm)	Bed density (kg/m^3)	Bed porosity (%)	Open frontal area ε	Geometric surface area GSA (cm^2/cm^3)
0.83	0.32	771	72.5	0.52	25.29

- MO-B catalyst allowed saving about 40-50% of catalyst employed in packed-bed system. **High surface-to-volume ratio** and **good interphase mass transfer** were able to ensure high methanation activity with low amount of catalytic phase.

- CH_4 productivity increased by increasing space velocity, reaching the maximum at 400°C and 50,000 h^{-1}: **10.7 L_{CH4}/g h**.



Conditions: $H_2/CO_2/N_2$ = 4/1/1 molar; GHSV = 10,000-50,000 h^{-1}; T = 300-600°C

Future perspective

- Advanced materials for catalytic conversion of CO_2 into usable fuels and chemicals are needed to scaling down the conventional processes for small-scale application and integration with distributed renewable energy production.

- New environmental friendly and competitive cost solutions for power plants and carbon-intensive industry, new markets and job creation for innovative industrial sectors

IMAMOTER
Institute for Agricultural and Earthmoving Machines
National Research Council of Italy

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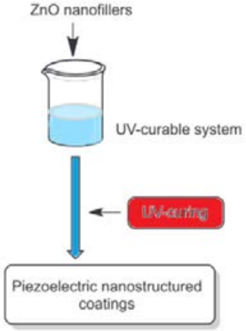
Engineering, ICT and Technologies for Energy and Trasportation Department

2.1 Advanced materials for industrial processes

❑Development of sustainable methods for machining **Ti alloys and Inconel** materials for aeronautic and aerospace applications: replacement of conventional lubrorefrigerants, with reduction of environmental impact.

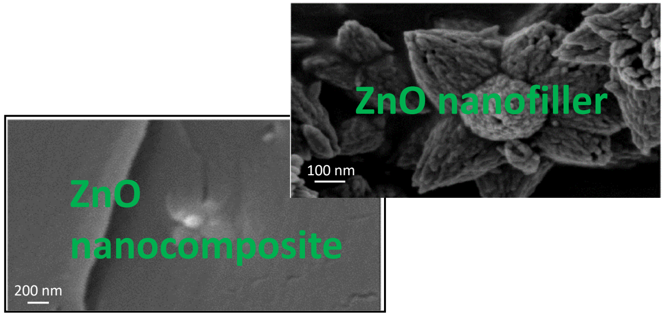
❑**Wear and friction** properties of materials for mechanical applications (main focus on **brake systems**): redesign of pads materials, for environmental impact reduction.

❑**Metal oxide nanomaterials** for gas sensing: early detection and monitoring of poisonous and hazardous chemicals, allow advancing on environmental security and healthcare.



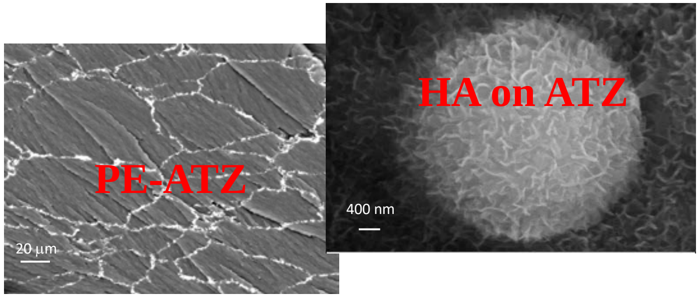
2.2 Enhanced materials and nanotechnologies for energy and environment

Oxidic nanostructures embedded into a polymer for flexible, versatile coatings of easy fabrication and low environmental impact for application in renewable/alternative energy technologies: use of wasted mechanical energy, energy consumption and carbon emissions reduction



2.3 Advanced materials and nanotechnologies for bio-medical use

Nanocomposite materials (oxide-polymer) for biomedical applications, endowed with reduced rigidity compared to metals and ceramics, with enhanced osseointegration properties with respect to polymers: cost reduction compared to commercially available materials.



Low-Dimensional materials: quantum and 2D

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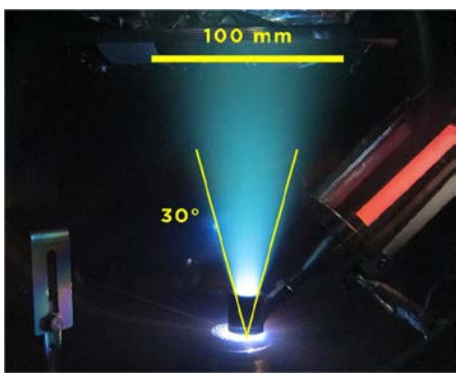
- advanced **synthesis**
- nanoscale **characterization**
- material **modelling**

→ control over the **fundamental quantum-mechanical properties** of materials

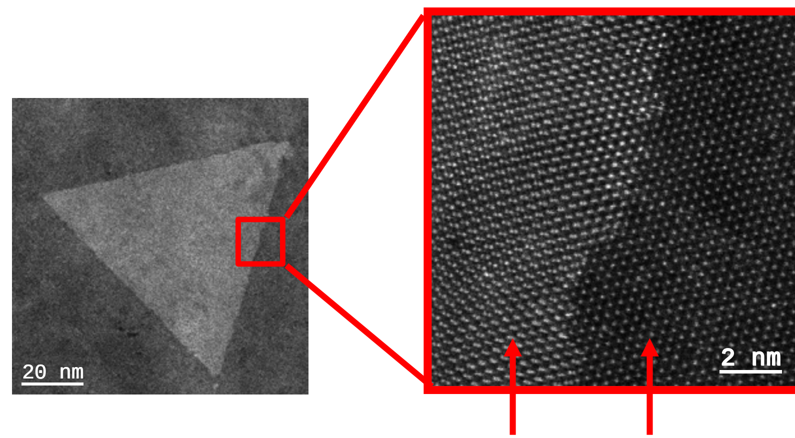
- **2D MoS_2:** promising candidate for **transistors, memory devices, photodetectors, solar cells, electrocatalysts for HER, lithium ion batteries.**

Synthesized by **Ion Jet Deposition (IJD)**



Advanced synthesis in vacuum: no need for post-deposition treatments

Synthesized by **Chemical Vapor Deposition (CVD)**



HR-TEM of MoS_2 flakes: bilayer monolayer

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AP10 Advanced Materials and Nanotechnology

Low-Dimensional materials: quantum and 2D

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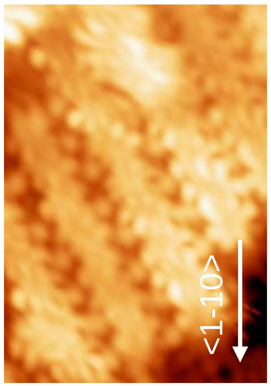
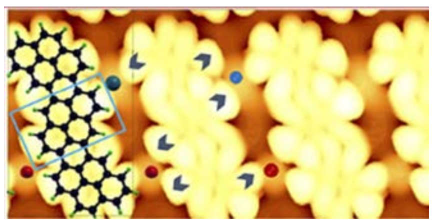
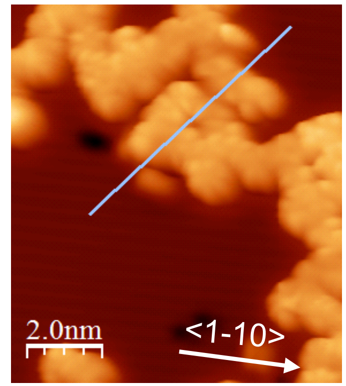
✧ **Graphene nanoribbons** and **C-based nanostructures:** suitably designed **precursor molecules** determine **different structures** and **different electronic properties**.



Graphene nanoribbons produced by surface assisted polymerization of di-bromopyerene

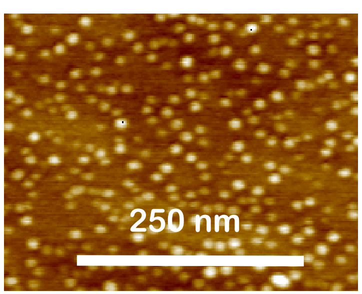




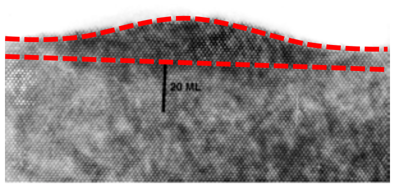
Corrugated C-nanostructures produced by surface assisted polymerization of Bromo-corannulene

✧ **Epitaxial semiconductor Quantum Dots**: 0-dymensional systems integrated into a semiconductor platform for the realization of electro-optical devices as **QD lasers**, **QD single photon emitters**, **QD sensors**.

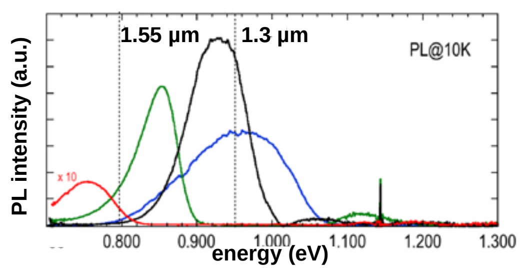
Molecular Beam Epitaxy of InGaAs-based nanoislands:



AFM: QD ensamble

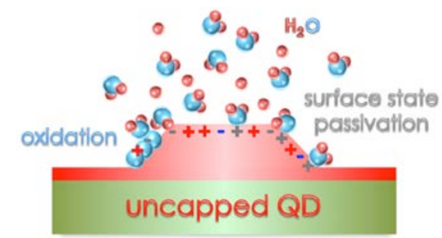


HR-TEM: single QD



optical emission at **telecom** wavelength: lasers / single-photon emitters

properties dependent on surface states: molecular sensor



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AP10 Advanced Materials and Nanotechnology

Electronic Materials

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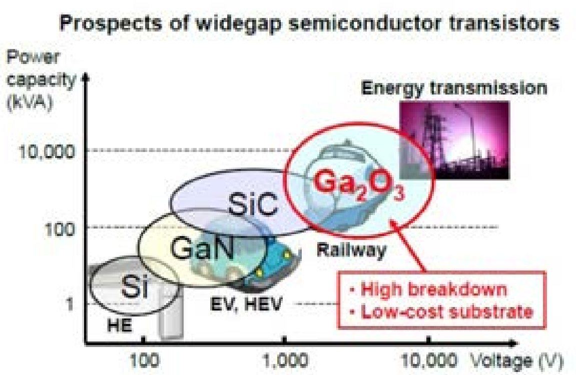
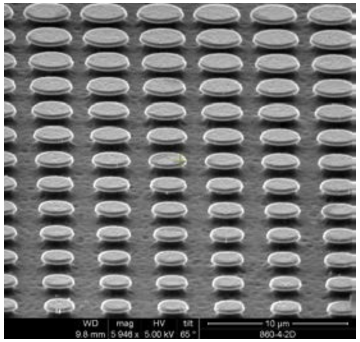
Engineering, ICT and Technologies for Energy and Trasportation Department

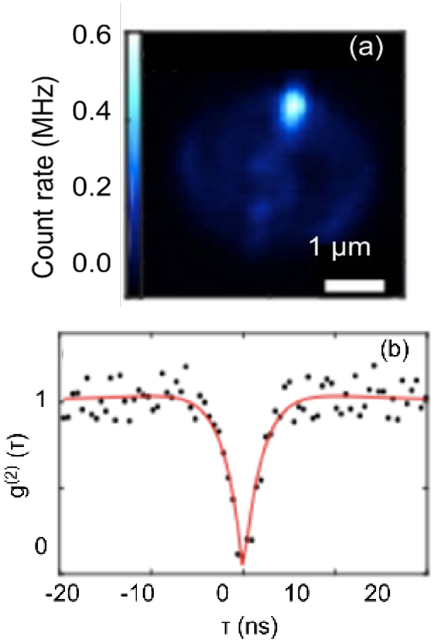
High band-gap semiconductor for high power electronics UV detection and quantum photonics



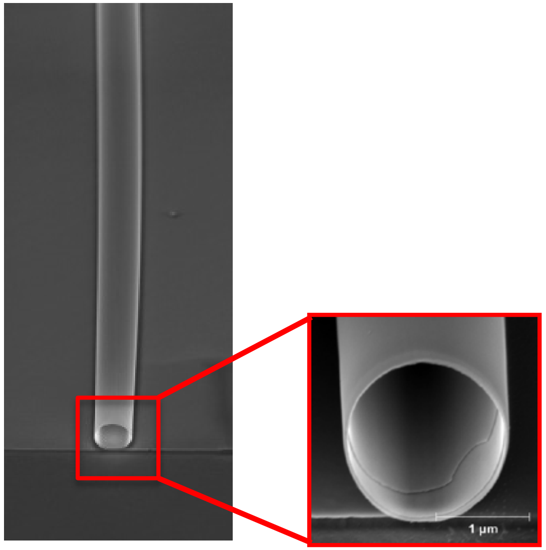
Ga2O3 as an emerging material for power devices
Development of e-Ga2O3 epitaxy by Vapor Phase Epitaxy
Material characterization (structural, optical, electrical)
Device prototyping (realized: UV-photodetector)

3C-SiC as an emerging material for quantum photonics
Single photon emission
Optical resonant microstructures





mm-long rolled-up semiconductor µicrotubes with nm-thin walls



applications as µfluidics channels for sensing, photonic integrated compononents, catalytic µicrotubular engines

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Electronic Materials

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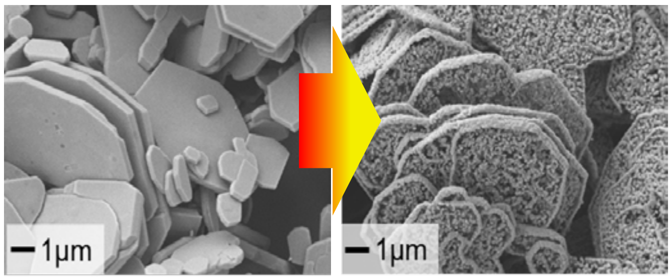
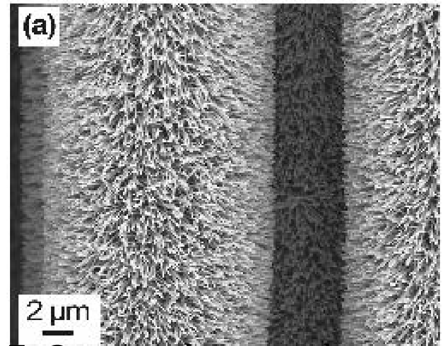
Metal oxide nanostructures

ZnS(en)$_{0.5}$ hybrid *Porous ZnO platelets*

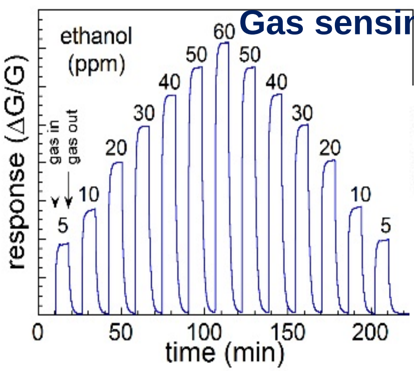


Mesoporous ZnO nanobelts and by thermal decomposition of ZnS(en)0.5 precursors

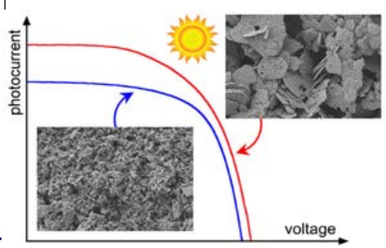


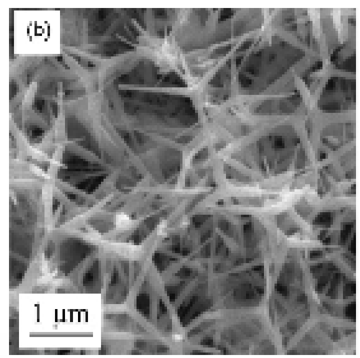
ZnO nanorods on a carbon fiber by wet chemistry

Gas sensing

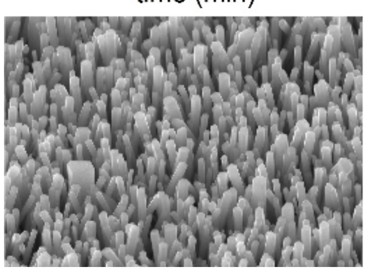


Solar cells

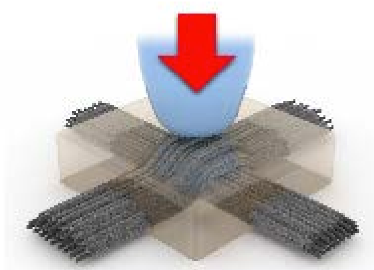




ZnO tetrapods by vapor phase

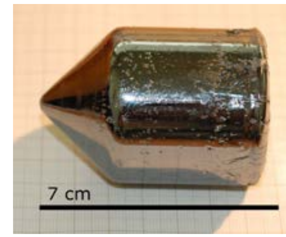


ZnO nanorods



ZnOnanorods-based piezosensor

CdZnTe-based X- and gamma-ray detectors

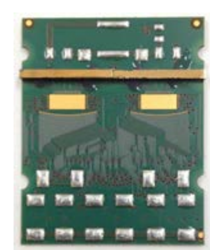


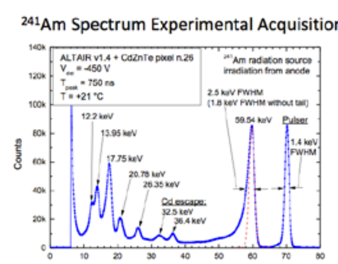
CdZnTe is the best material for room temperature operating, spectroscopic x- and gamma- ray detectors

XDRONE

Localization of nuclear materials

32000 pixels imaging detector





Linear array detectors for X-ray scanners

Advanced catalysts and materials for sustainable chemistry and energy

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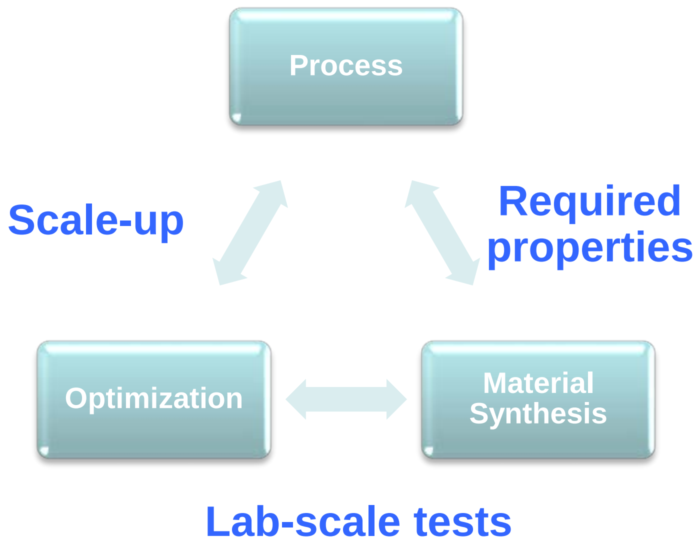

Development of novel and advanced materials/catalysts for process intensification and/or new alternative processes compared to traditional ones.

- Formulation of new materials with chemical and physical properties and functionalities tailored for specific applications
- Lowering costs and enhancing performances of currently used materials
- Development of properties of resistance to severe operating conditions
- Toxicity mitigation of common materials

AP10 Advanced Materials and Nanotechnology

Advanced catalysts and materials for sustainable chemistry and energy

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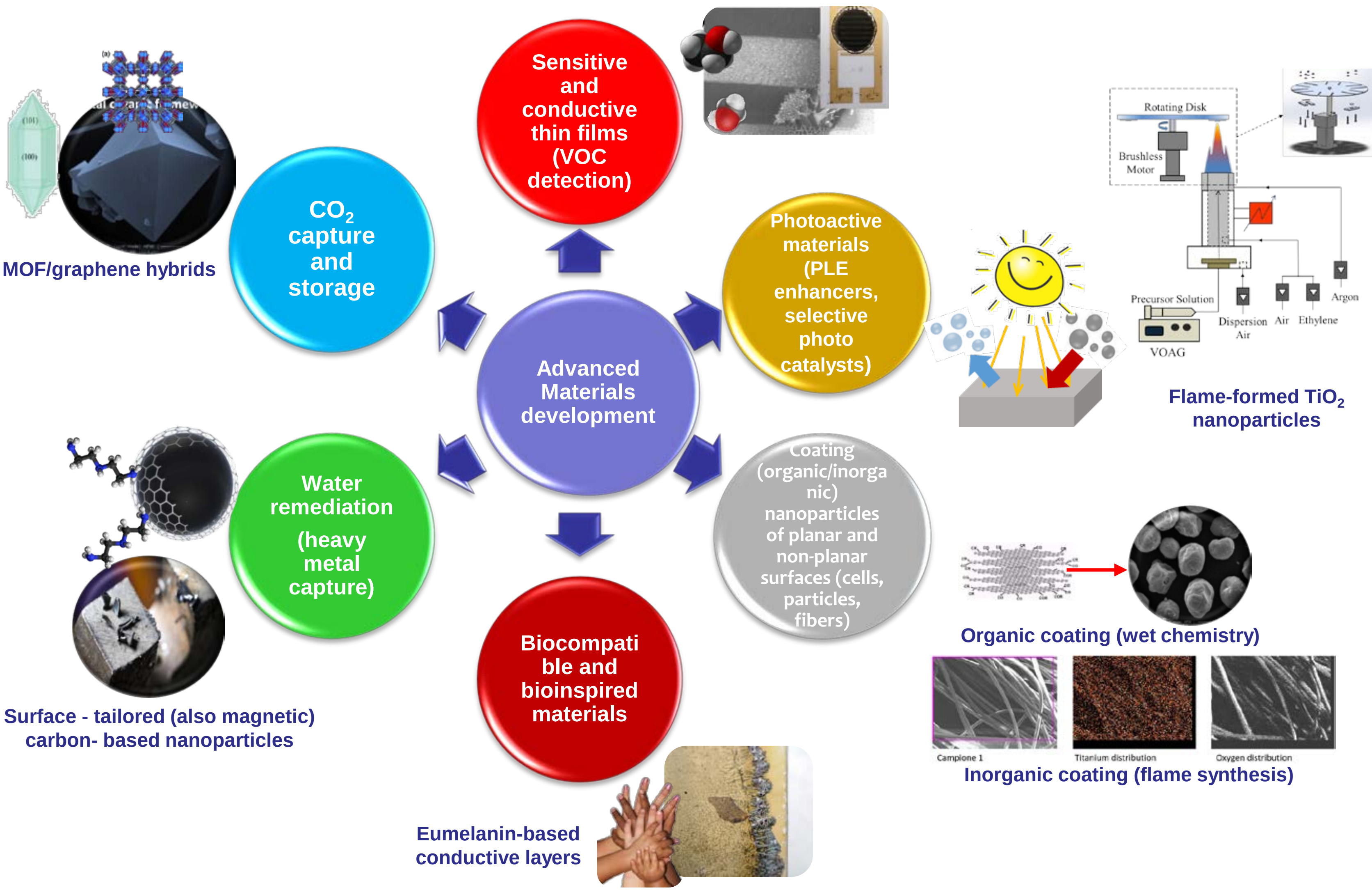
From combustion pollutants and raw materials and precursor to engineered materials



AP10 Advanced Materials and Nanotechnology

Advanced catalysts and materials for sustainable chemistry and energy

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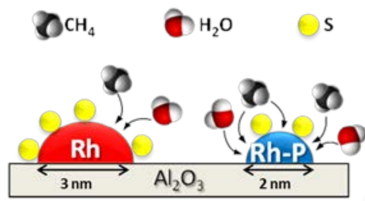
Heterogeneous Catalysis for Energy & Environment



Improved sulphur tolerance

Natural Gas and Bio-Gas Conversion

Power to Gas/ CO_2 valorization

Catalysts & process development

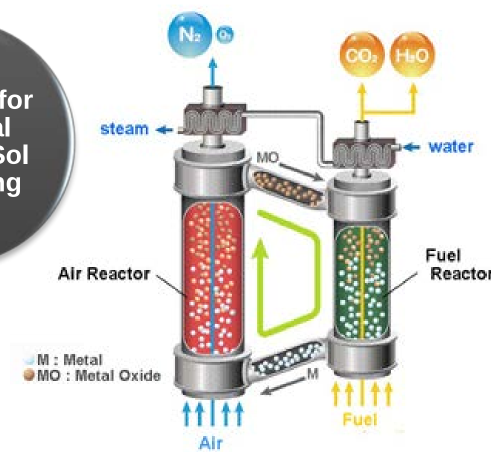
Catalytic Combustion

Radiant catalytic combustors

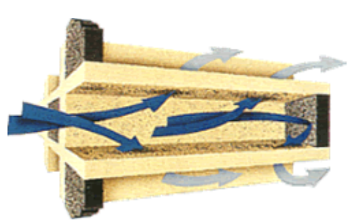
Pollution control

(NOx, VOC , soot, Hg)

Catalysts for Chemical Looping/Solar Splitting



Upgrading & Purification



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Magnetic materials and multiferroics

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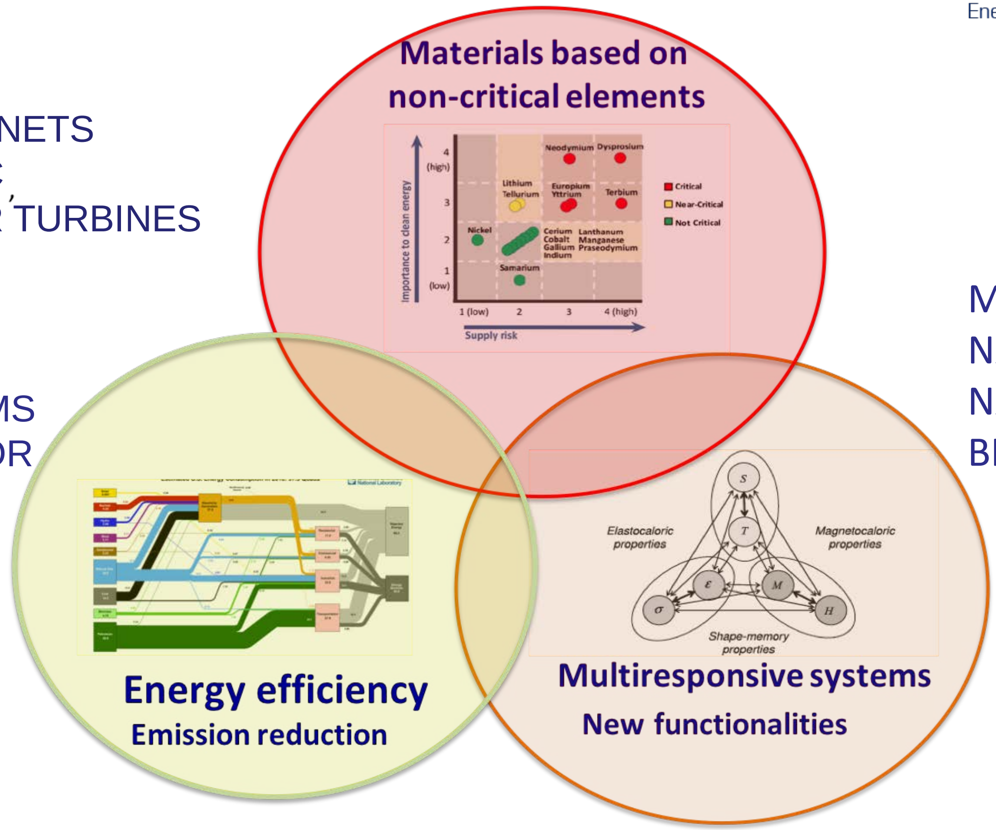
RE-FREE PERMANENT MAGNETS FOR HYBRID AND ELECTRIC MOTORS AND WIND POWER TURBINES

BULK MATERIALS, THIN FILMS AND NANOSTRUCTURES FOR SENSORS AND MEMORIES



MAGNETIC NANOPARTICLES AND NANOCOMPOSITES FOR BIOMEDICINE

MAGNETOCALORIC MATERIALS FOR RT MAGNETIC REFRIGERATION

MULTIFUNCTIONAL MATERIALS (e.g. MAGNETIC SHAPE MEMORY, MULTIFERROIC, MAGNETOPLASMONIC) FOR SENSORS, ACTUATORS, SMART APPLICATIONS

HORIZON 2020 AMPHIBIAN

Frimag Regione Emilia-Romagna

eit RawMaterials

MAGNETOMETRY.EU The European Magnetometry Network

AP10 Advanced Materials and Nanotechnology

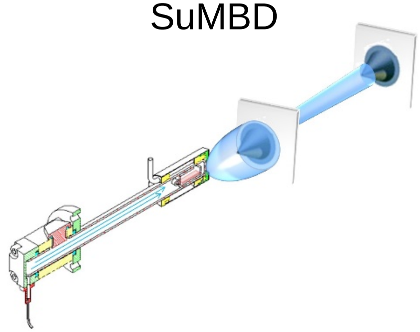
Organic & Hybrid materials

Consiglio Nazionale delle Ricerche
Engineering, ICT and Technologies for Energy and Trasportation Department

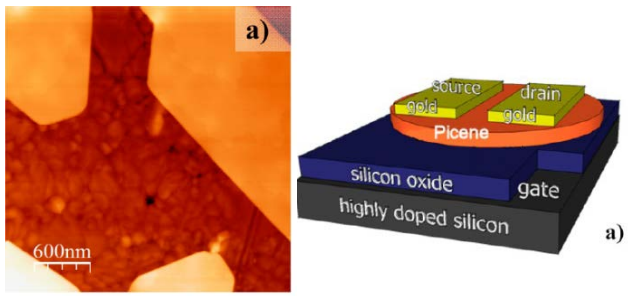
Organics

Semiconducting properties → **Electronic and optoelectronic devices**

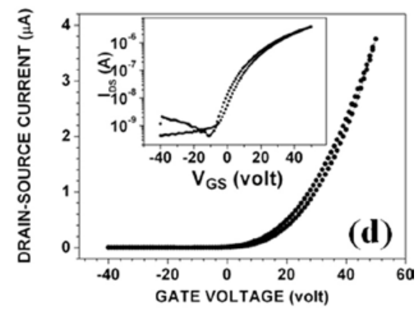
SuMBD



OFET Picene

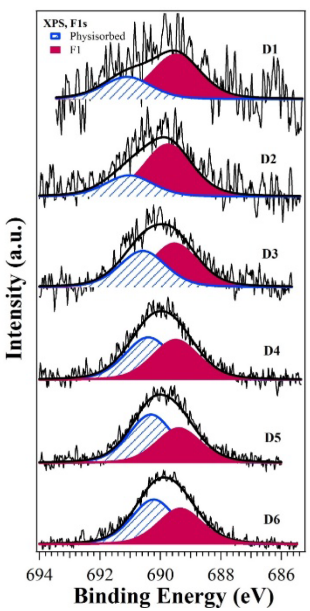


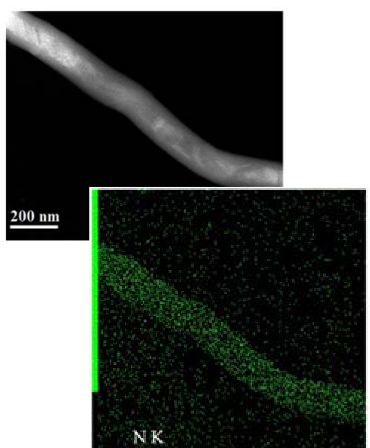
OTFT PDIF-CN2

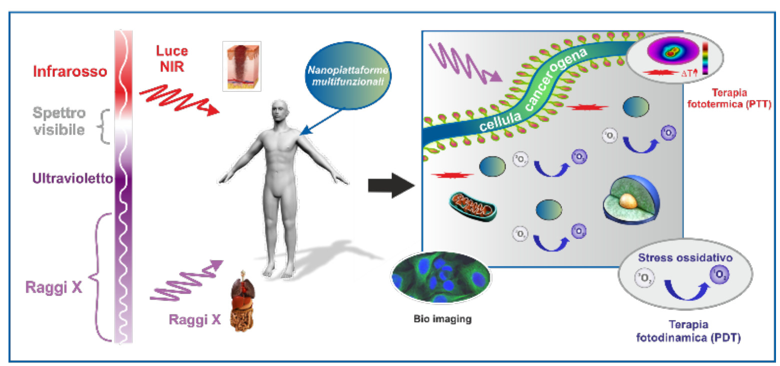


Acenes, phenacenes, perilenes thin film by Supersonic Molecular beams (SuMBD).
OFET, OTFT, LET

Inorganic surface functionalization → **Multifunctional materials, Biocompatible inorganics, Theranostics**



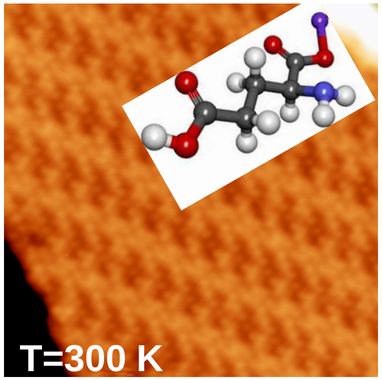




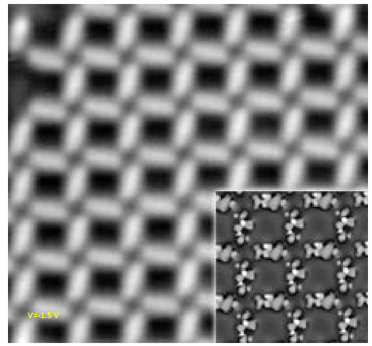
Nanowires direct functionalization by H_2TPP(F) SuMBD.
Multifunctional materials for X-ray/NIR PDT and imaging

AP10 Advanced Materials and Nanotechnology

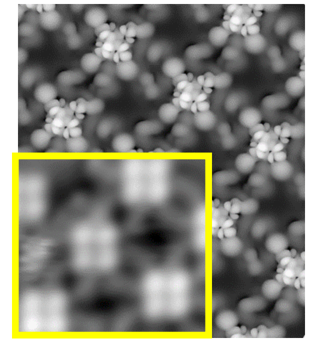
Organic & Hybrid materials



SQUARE ASSEMBLY



FLOWER ASSEMBLY

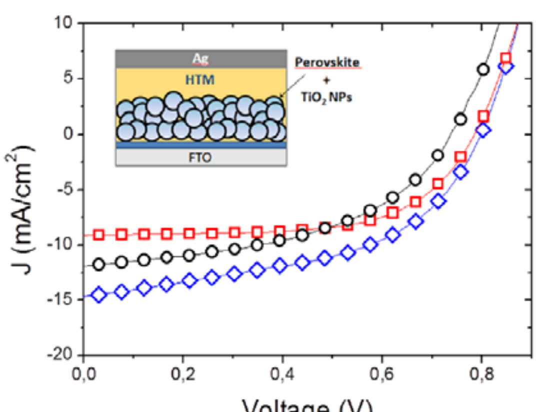


Aminoacid Glutamate self-assembly on Ag(100) surface.
Biosensing, biomedicals

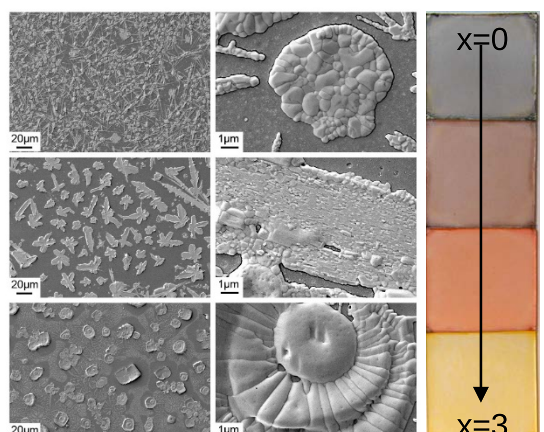
Hybrid materials

Organometal halide perovskites ➡ **Energetics and optoelectronics**

$CH_3NH_3PbI_{3-x}Cl_x$



$CH_3NH_3PbI_{3-x}Br_x$



Organometal halide perovskites by vacuum flash evaporation.
PV cells, LED, photodetectors

ITC
Contact: sergio.bobbo@itc.cnr.it

AP10 Advanced Materials and Nanotechnology

NANOFLUIDS

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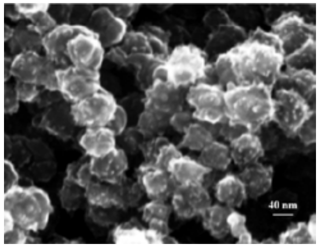
WHAT ARE NANOFLUIDS?



- COLLOIDAL SUSPENSIONS OF NANOPARTICLES IN COMMON FLUIDS
  - BASE FLUIDS: water, oil, ethylene glycol, refrigerants
  - NANOPARTICLES: oxides (ceramics), metals, carbon nanotubes

NANOFLUIDS CHARACTERIZATION

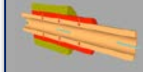
Heat Transfer Fluids

STABILITY

THERMAL CONDUCT. (l)

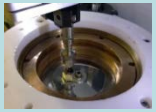
RHEOLOGY (m)

HEAT TRANSFER COEFFICIENT



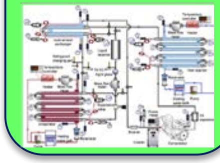
Lubricants

- HEAT TRANSFER
- TRIBOLOGY



Systems

- COP
- WEARING

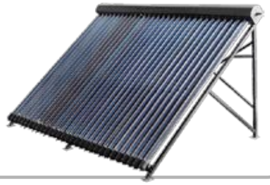


MAIN ACTIVITIES

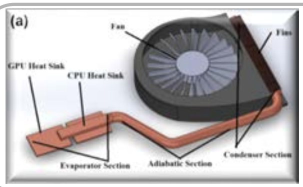
- THERMOPHYSICAL PROPERTIES MEASUREMENTS
  - colloidal suspension stability
  - transport properties (λ, μ, α)
- TRIBOLOGICAL PROPERTIES MEASUREMENTS
  - evaluation of anti-friction and anti-wear properties
- PERFORMANCE EVALUATION IN ENERGY SYSTEMS

POTENTIAL APPLICATIONS

- COOLING SOLAR COLLECTORS
  - flat plate
  - direct absorption (DAC)
  - evacuated tubular



- HVAC&R DEVICES
  - domestic refrigerators
  - residential air conditioning units
  - compressor lubrication



- HEAT PIPES
  - heat pipe for CPU cooling
  - screen mesh heat pipe
  - flat plate heat pipe

- PEM FUEL CELL COOLING SYSTEMS
  - domestic refrigerators
  - residential air conditioning units
  - compressor lubrication

AP10 Advanced Materials and Nanotechnology

Advanced Activity Measurement of Photocatalytic Materials

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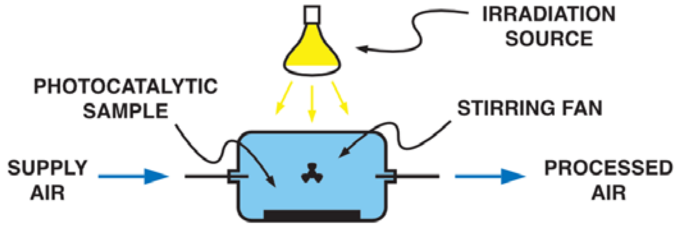
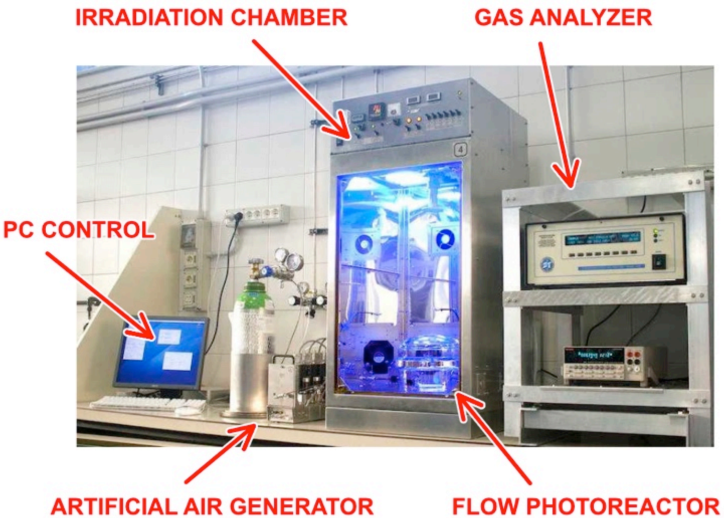
HETEROGENEOUS PHOTOCATALYSIS

CHEMICAL REACTIONS CATALYZED BY LIGHT AND (NANOCRYSTALLINE) SOLID PHOTOCATALYSTS

– Oxidation and reduction processes of organic and inorganic species in air and water

– Needs of specific instruments for the study of photocatalytic materials performance





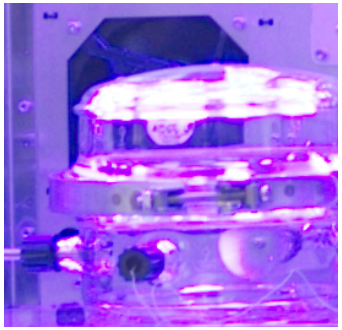
MAIN ACTIVITIES

DEVELOPMENT OF SPECIALIZED ANALYTICAL SYSTEMS FOR PHOTOCATALYTIC ACTIVITY MEASUREMENTS

– Advanced measurement of photocatalytic air depollution with a state-of-the-art, specifically developed analytical system

– Activity studies of nanostructured photocatalysts in air and water for special photocatalytic materials development

– Study of water-based photocatalytic oxidation processes of natural products



POSSIBLE APPLICATIONS

DEVELOPMENT OF HIGH EFFICIENCY PHOTOCATALYSTS OPERATING IN UV AND VISIBLE LIGHT

– Air and water depollution by special photocatalytic materials

– Photocatalysis-based advanced oxidation processes (AOP) for waste water treatments

– Water-based and solar driven chemical processes for sustainable chemistry

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IFAC

AP10 Advanced Materials and Nanotechnology

Materials for photonic sensing

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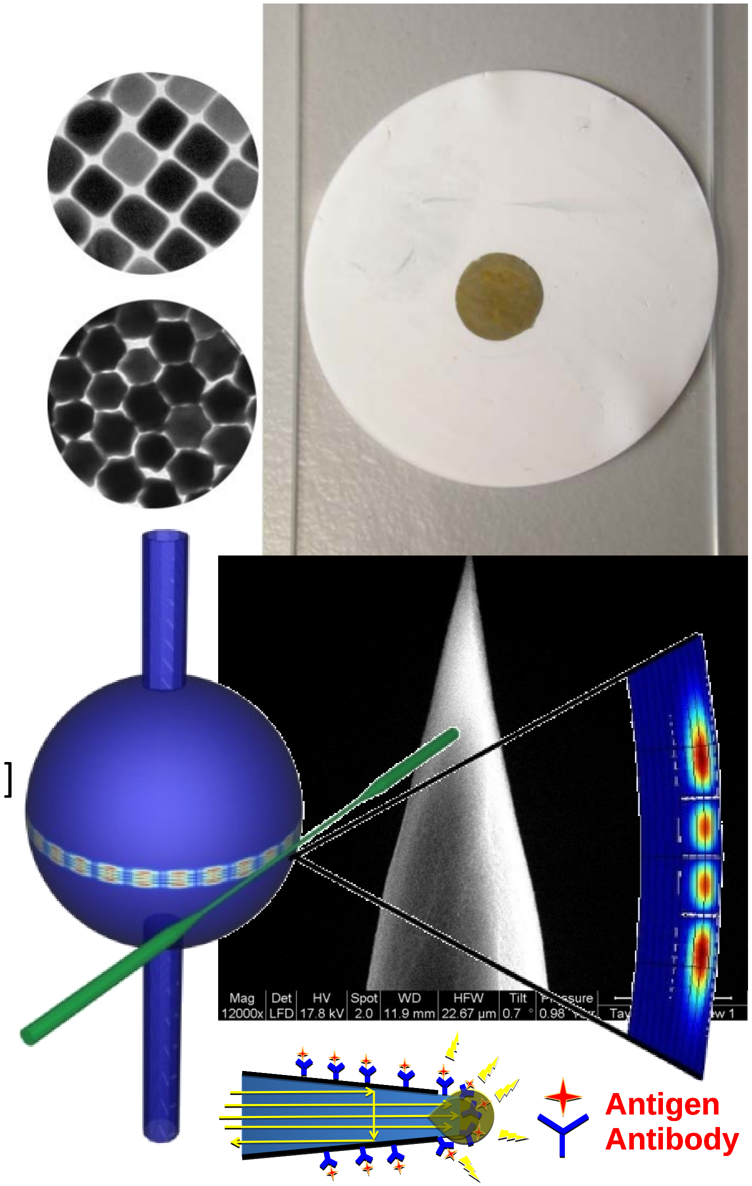
Plasmonic substrates for rapid surface enhanced Raman detection of proteins, hormones, DNAs, disease biomarkers in trace amounts in biological fluids.
[Coordinator: P. Matteini; Ref: *Sci. Rep.* **8** 1033 (2018)]

Photonic components, such as:

- Whispering gallery mode resonators as transducers for the detection of analytes of biomed interest [Coordinator: S. Pelli]
or broadband ultrasound [Coordinator: S. Soria]
- Optical fiber nanotips for intracellular sensing and monitoring of the effect of new drugs [Coordinator: S. Pelli, Ref: US PATENT pending]



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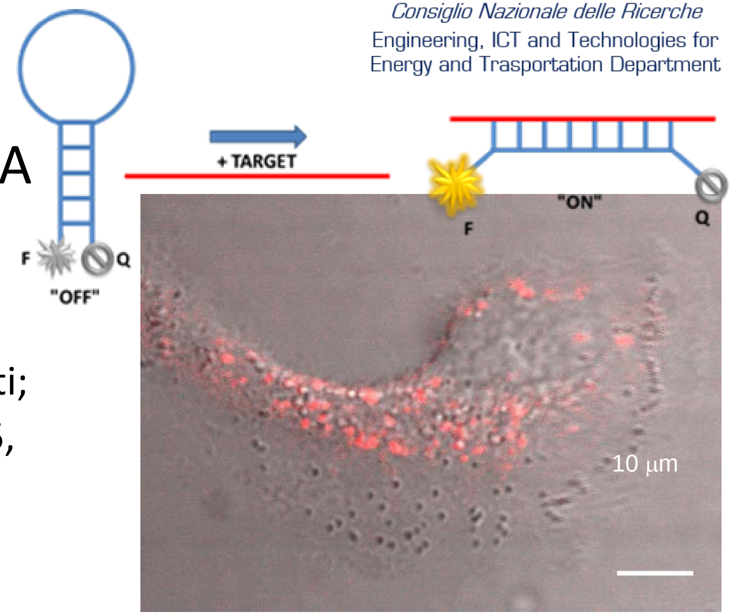
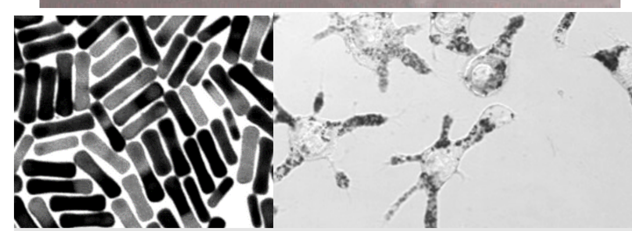
Materials for photonic theranostics

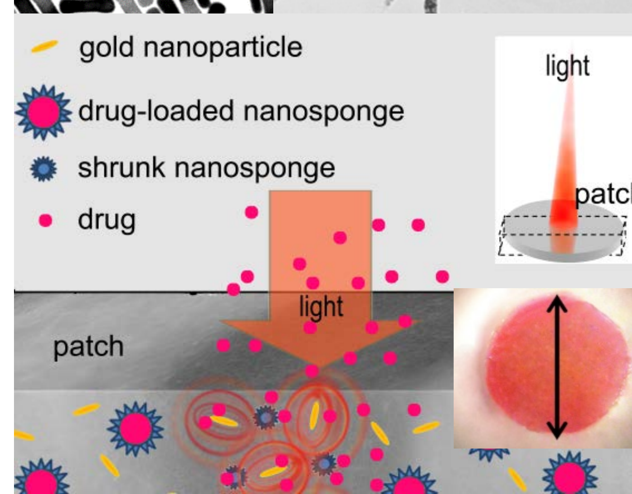
Consiglio Nazionale delle Ricerche
Engineering, ICT and Technologies for Energy and Trasportation Department



Hybrid particles for intracellular delivery of DNA probes, such as so-called molecular beacons, which acts as theranostic agents capable to sense and to silence m-RNA [Coordinator: A. Giannetti; Ref: *J. Contr. Release*, **280**, 76 (2018); *Biosens Bioelectron*, **88**, 15, (2017)]



Bionic contrast agents for photo-acoustics/ thermics in association with biomolecular ligands or cellular vehicles, i.e. autologous cells that constitutively migrate to a tumor microenvironment [Coordinator: F. Ratto; Ref: *Adv. Funct. Mater.* **26**, 7178 (2016)]



Optically responsive patches for welding of connective tissue and controlled drug release [Coordinator: P. Matteini; Ref: PATENT US2015086608]

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Tissue Engineering

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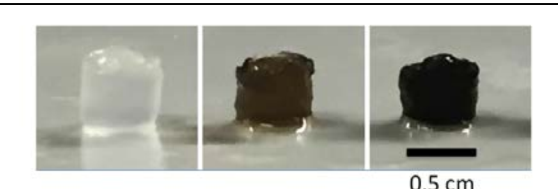
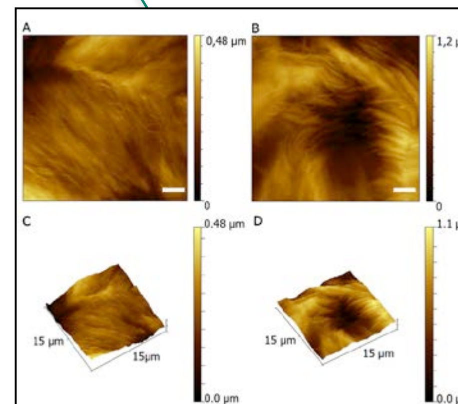
Graphene oxide/alginate hydrogel for articular cartilage regeneration



AFM images of biomimetic substrates functionalized with graphene's derived nanomaterials

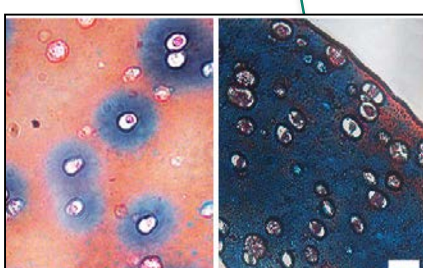


Biomimetic scaffolds design and development

Nanomaterials functionalization

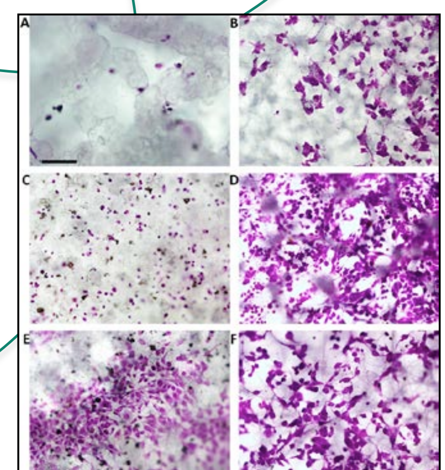
Cell Biology

Histological sections representing cartilage matrix deposition of human mesenchymal stem cells cultured within the materials



Alginate

Graphene oxide/ Alginate



Cell adhesion over scaffolds functionalized with graphene's derived nanomaterials for bone regeneration