NATIONAL RESEARCH COUNCIL OF ITALY

President: Prof. Luigi Nicolais

CNR

- *It acts as a knowledge hub fostering competences through a widespread network at national and international level.*

- *CNR human resources consist of 8000 employees of whom 6000 carry out research activities.*

- *The ongoing reorganization process will lead to the aggregation of competences fostering the realization of a platforms in a specific areas of strategic interest.*

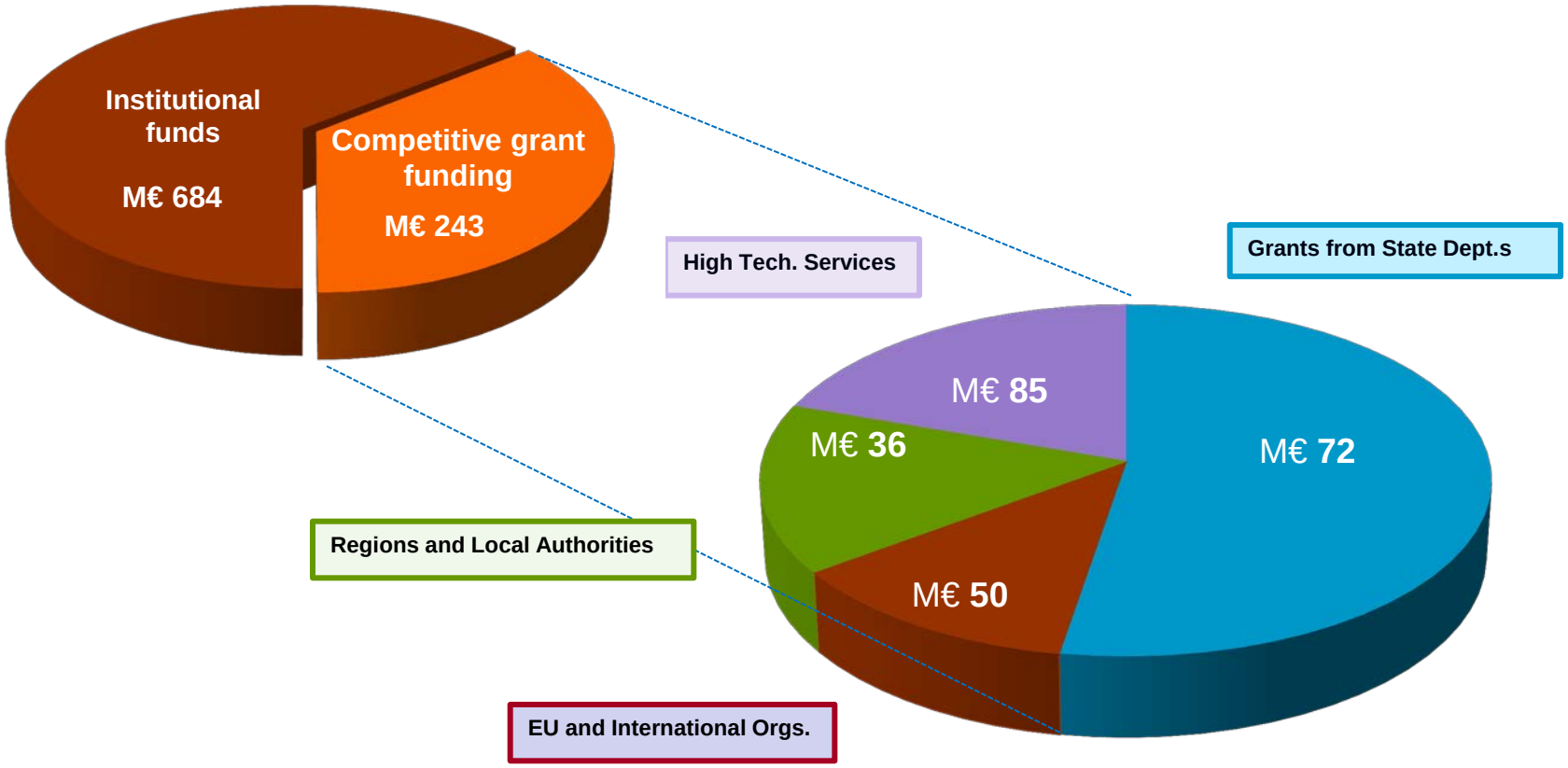
CNR

- **7 Macro-Areas (Departments):**
  - Earth system Sciences - Environmental Technologies
  - Bio-Agrifood Sciences
  - Biomedical Sciences
  - Engineering - ICT - Energy and Transport Technologies
  - Human and Social Sciences - Cultural Heritage
  - Physical Sciences - Technologies of the Matter
  - Chemistry - Materials Technologies

- **109 Research Institutes performing research activities and developing capabilities**
- **20 Research Centers**

CNR

FINANCIAL RESOURCES 2012



Scimago Istitution Ranking 2011

SIR World Report 2011
http://www.scimagoir.com

WR	RR	CR	Organization	Sector	Country	Region	Output	IC(%)	Q1(%)	NI	Spe	Exc
1	1	1	Chinese Academy of Sciences	GO	CHN	AS	144,269	21.5	40.5	0.9	0.6	11.3
2	1	1	Centre National de la Recherche Scientifique	GO	FRA	WE	130,977	49.0	61.9	1.4	0.5	18.7
3	1	1	Russian Academy of Sciences	GO	RUS	EE	88,907	35.0	24.2	0.5	0.7	5.9
4	1	1	Harvard University	HE	USA	NA	69,995	34.4	79.0	2.4	0.5	35.7
5	2	1	Max Planck Gesellschaft	GO	DEU	WE	49,987	65.0	72.2	1.8	0.7	29.3
6	2	1	University of Tokyo	HE	JPN	AS	48,947	26.3	56.7	1.2	0.5	17.9
7	2	2	National Institutes of Health United States	HL	USA	NA	46,819	35.3	84.3	2.3	0.7	40.1
8	3	1	University of Toronto	HE	CAN	NA	45,771	41.1	65.7	1.8	0.4	24.3
9	3	1	Consejo Superior de Investigaciones Cientificas	GO	ESP	WE	42,087	49.4	68.8	1.4	0.6	21.9
10	4	3	Johns Hopkins University	HE	USA	NA	41,399	29.8	74.5	2.1	0.6	30.1
11	3	2	Tsinghua University	HE	CHN	AS	41,197	18.6	26.8	0.8	0.7	6.6
12	5	4	University of Michigan, Ann Arbor	HE	USA	NA	41,059	25.3	70.3	2.0	0.4	25.6
13	1	1	Universidade de Sao Paulo	HE	BRA	LA	40,196	24.8	39.4	0.8	0.5	9.9
14	4	3	Zhejiang University	HE	CHN	AS	40,140	15.7	28.6	0.7	0.6	7.4
15	6	5	University of Washington	HE	USA	NA	39,428	26.2	71.7	2.1	0.4	28.6
16	7	6	Partners HealthCare System	HL	USA	NA	38,096	28.5	80.7	2.6	0.7	36.5
17	8	7	University of California, Los Angeles	HE	USA	NA	37,994	29.3	70.7	2.1	0.4	28.9
18	4	1	Consiglio Nazionale delle Ricerche	GO	ITA	WE	37,928	42.5	63.8	1.3	0.6	17.7
19	9	8	Stanford University	HE	USA	NA	37,885	29.5	69.8	2.3	0.4	29.1
20	10	9	Veterans Affairs Medical Centers	HL	USA	NA	36,902	16.3	77.8	2.0	0.7	30.6

DEPARTMENTS

- **7 DEPARTMENTS**
  - EARTH SYSTEM SCIENCES - ENVIRONMENTAL TECHNOLOGIES
  - BIO-AGRIFOOD SCIENCES
  - BIOMEDICAL SCIENCES
  - ENGINEERING - ICT - ENERGY AND TRANSPORT TECHNOLOGIES
  - HUMAN AND SOCIAL SCIENCES - CULTURAL HERITAGE
  - PHYSICAL SCIENCES - TECHNOLOGIES OF THE MATTER
  - **CHEMISTRY - MATERIALS TECHNOLOGIES**

RESEARCH INFRASTUCTURE

Integrated approach for the development of advanced structure and systems

Luigi Ambrosio

Department of Chemical Science & Materials Technology

National Research Council

P.Le A. Moro, 7 – 00185 Roma

luigi.ambrosio@cnr.it

Department of
CHEMICAL SCIENCE and
MATERIALS TECHNOLOGY

INSTITUTES

MOLECULAR SCIENCE & TECHNOLOGY
MILANO, Padova, Perugia

CHEMISTRY & MOLECULAR RECOGNITION
MILANO, Roma

MACROMOLECULES
MILANO, Genova, Biella

CHEMISTRY OF ORGANOMETALLIC COMPOUNDS
FIRENZE, Bari, Pisa

NANOSTRUCTURED MATERIALS
ROMA, Bologna ,Palermo

CHEMICAL METHODOLOGY
ROMA

CHEMISTRY & POLYMER TECHNOLOGY
NAPOLI , Catania

COMPOSITE & BIOMEDICAL MATERIALS
NAPOLI, Pisa

BIOMOLECULAR CHEMISTRY
NAPOLI, Sassari, Catania, Roma, Padova

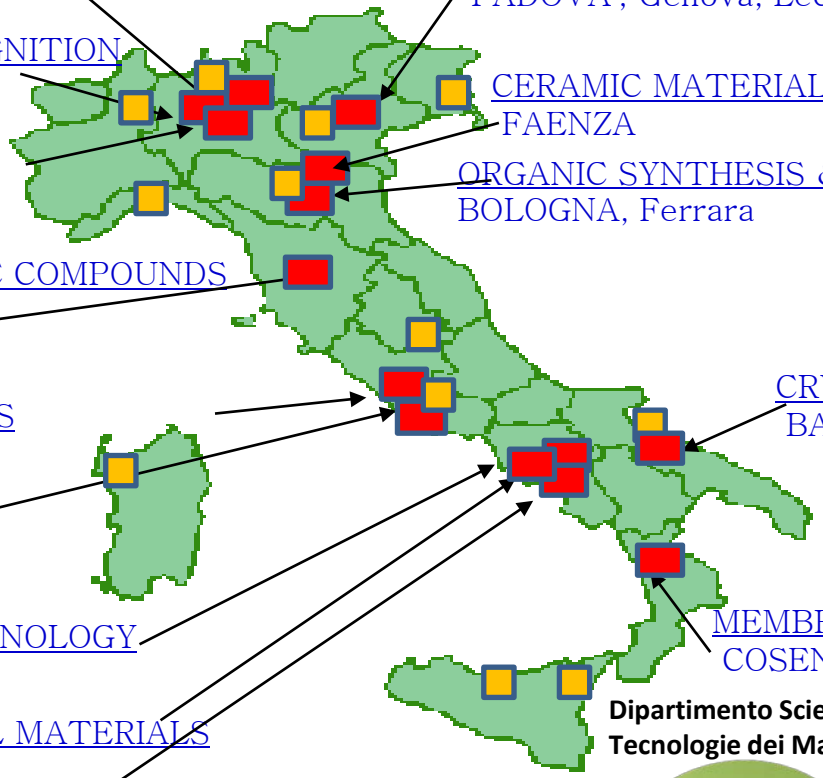
ENERGY & INTERPHASES
PADOVA , Genova, Lecco, Milano, Pavia

CERAMIC MATERIALS SCIENCE & E TECHNOLOGY
FAENZA

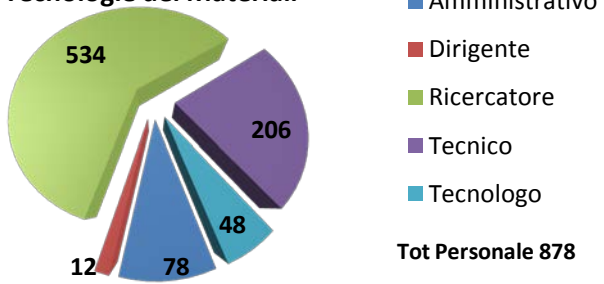
ORGANIC SYNTHESIS & PHOTOREACTIVITY
BOLOGNA, Ferrara

CRYSTALLOGRAPHY
BARI , Roma, Trieste

MEMBRANE TECHNOLOGY
COSENZA, Padova



Dipartimento Scienze Chimiche e Tecnologie dei Materiali



Tot Personale 878

http://www.dsctm.cnr.it/ direttore.dsctm@cnr.it

RESEARCH PLATFORMS

SUISTANABLE CHEMISTRY

- Enzymatic reactions
- Hydrogen generation and storage
-Carbon Capture and Sequestration
-Energy from renewable sources
-Biorefinery
-Chemical processes with low environmental impact
- Modelling

ADVANCED MATERIALS KEY ENABLING TECNOLOGIES

- Nanostructures
- Polymers & Composites
- Ceramics & Composites
- Metals & Composites
- Biodegradable Materials
- Multifunctional Biomaterials
- Coatings & Adhesive
- Nanostructured Membranes
- Optoelectronic& Photonics
- Sensors
- Rapid Prototyping

NANOMEDICINE

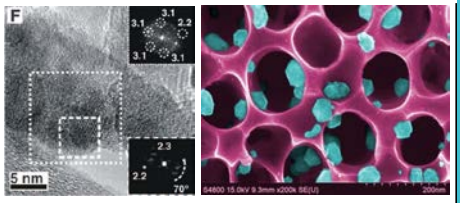
- Tissue Engineering
- Natural biopharmaceutical molecules
- Drug delivery
- Drug discovery
- Nanoparticles
- Biosensors
- Nutraceutics
- Teradiagnostic
- Modelling

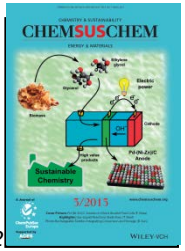
Health | **Energy** | **Transports** | **Cultural Heritage** | **Made in Italy** | **Building** | **Industrial Processes** | **Advanced Manufacturing**

SUSTAINABLE CHEMISTRY

Main Activities - Results

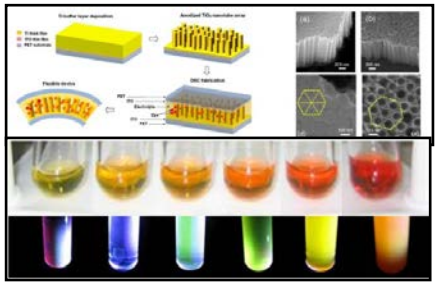
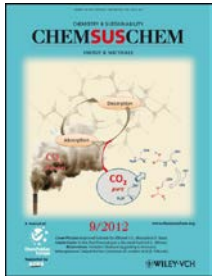
- *New sustainable chemical processes with high efficiency and selectivity.*
- *Electro/photocatalysis for applications in the energy sector*
- *Hydrogen chemistry and technology: production, storage and employment in fuel cells.*

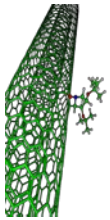




Science 2012 *CNR patents, 2006 - 2012*

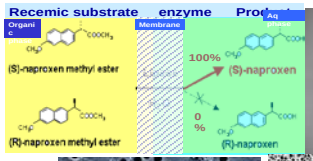
- *Organic and organometallic compounds for third generation photovoltaics*
- *Technologies for C1-chemistry: CO_2 exploitation and confinement (CCS)*
- *Organic, inorganic and hybrid polymeric materials with functional properties*

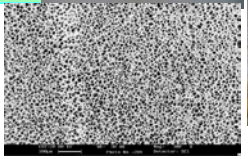


CNR patent, 2011

- *Functional nanostructure membranes*
- *Protein based thermoplastic products*
- *Packaging*



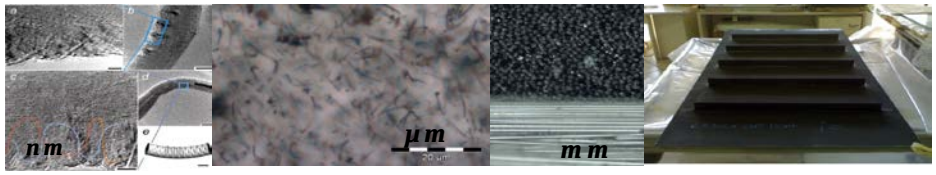




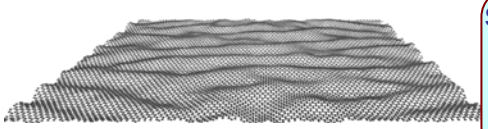

ADVANCED MATERIALS & ENABLING TECHNOLGY

Main Activities - Results

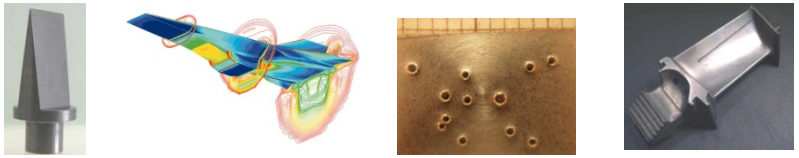
- *Multi scale polymer nano-composite*



- *Graphene based materials*

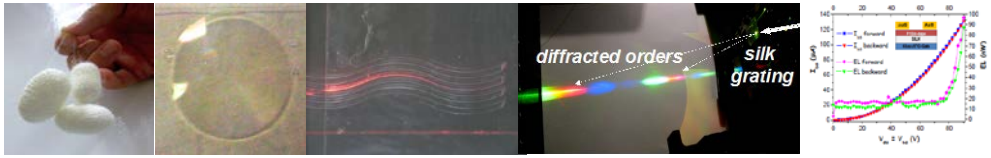


- *Ceramics and metals for extreme conditions*



- *Materials technology for cultural heritage*

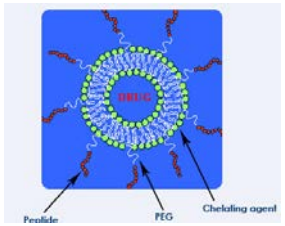
- *Silk fibroin in optoelectronics devices: Transistors & light emitting transistors*

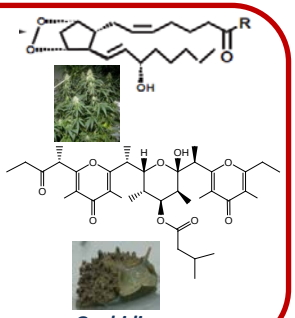


NANOMEDICINE

Main Activities - Results

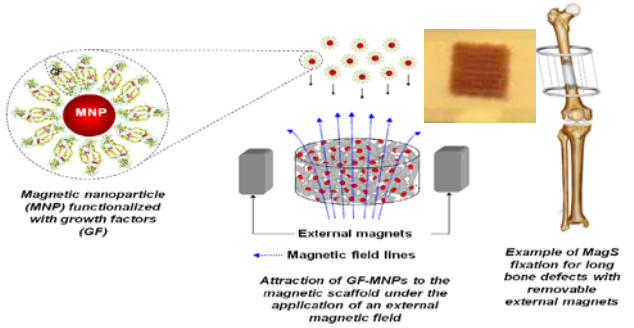
- *Development of new drugs and diagnostics on molecular basis.*
- *Protein expression, Structural and Computational Biology, Cellular Biology, HTS technologies.*
- *Isolation and characterization of new molecules from natural substances for health, cosmetics and pharmaceuticals.*



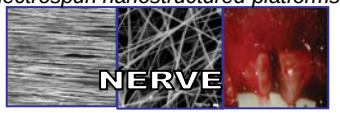


Onchidium sp.

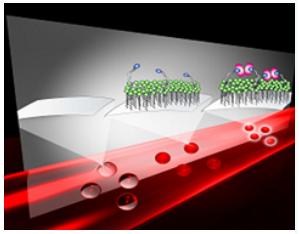
- *Magnetic nano-composite scaffolds*
- *Electrospun nanostructured platforms.*
- *Hydrogels for Protein release for central nervous pathology*

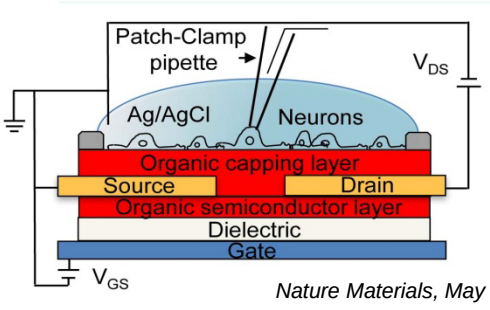


Electrospun nanostructured platforms



- *Biosensors*
- *Bio-electronics platforms* - Transparent Organic Cell Stimulating and Sensing Transistors *for neural cells*

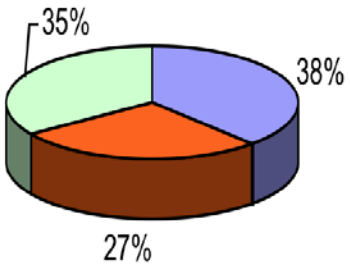




Nature Materials, May 2013

PATENTS & SPIN-OFF

54 Patents



- Health
- Sustainability
- Materials & Enabling Technologies

Punto quantico
Qmaterials and design

Organic Spintronics

SCRIBA NANOTECNOLOGIE

LIPINUTRAGEN
EQUILIBRIO DI MEMBRANA = EQUILIBRIO DI VITA

MEDITEKNOLOGY

ETC

HYPUCEM

ACADEMICA LIFE SCIENCE

optoXsmart
OPTOELECTRONIC AND SMART SYSTEMS

APM Advanced Polymer Materials Inc.
Provides Novel Polymers & Technologies for Your Innovative R&D

INTERNATIONAL COOPERATION

ROLE IN EUROPEAN STRATEGY

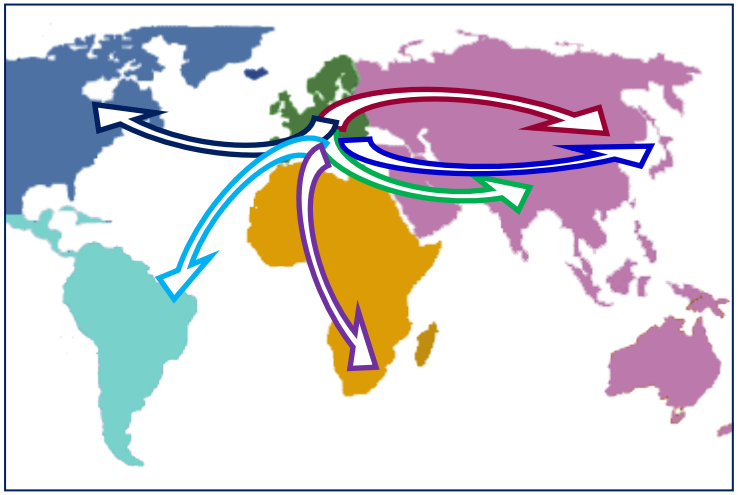
Member of High Level Group
Key Enabling Technologies (KETs)

Tenders – *Methodology, work plan and roadmap for cross-cutting KETs activities in Horizon 2020.*

NANOREG – Coord. Ministry of Infrastructure and the Environment - The Netherland
A common European approach to the regulatory testing of nanomaterials.

INTERNATIONAL AGREEMENTS

- **Advanced Materials & Silk Platform**
- **Nanostructures**
- **Biomaterials for Health – Advanced Materials - Education**
- **Advanced Materials - Education**
- **Green Chemistry – Biotechnology**
- **Advanced Materials - Membranes**

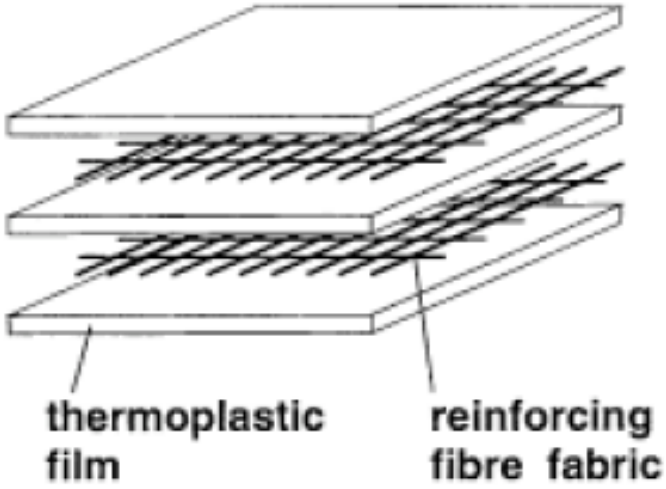


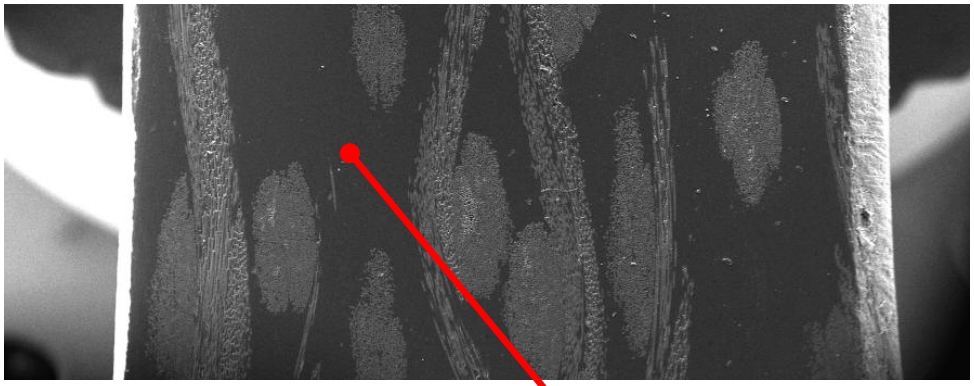
COMPOSITE MATERIALS

BIOMATERIALS

COMPOSITE MATERIALS

Fiber reinforced nanocomposites





Polymers

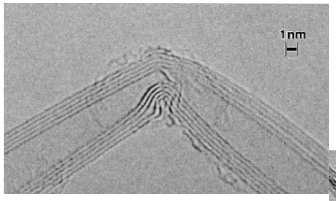
- Polyolefins: PP
- Thermoplastic polyurethanes (TPU)
- Polyesters: PET
- Biopolymers: PCL (natural fibers)
- Engineering thermopl: PES, PEN, PEEK

Nanocomposites

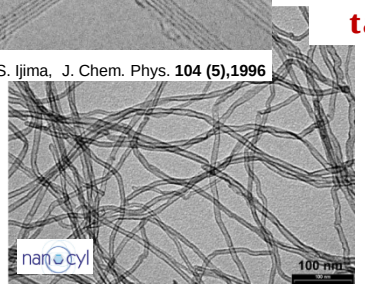
- CNT
- Clay
- Silica
- Graphene

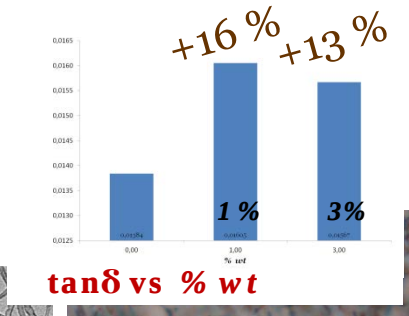
Multi scale composites enhancing damping features

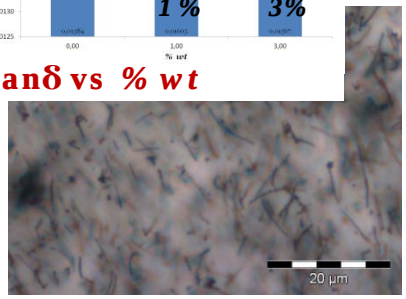
The activities were performed in the framework of the project "ARCA " granted to IMAST Scarl by Italian Ministry M.I.U.R.

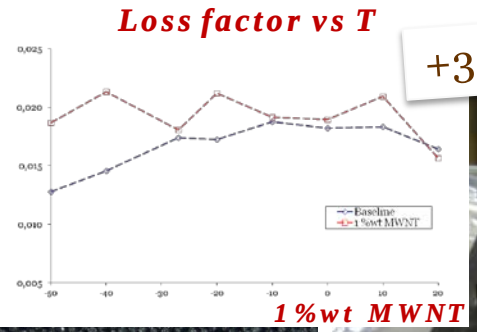


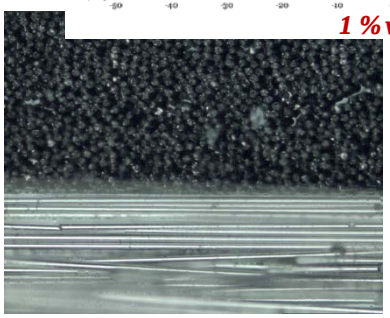
Cfr. S. Ijima, J. Chem. Phys. **104 (5),1996**

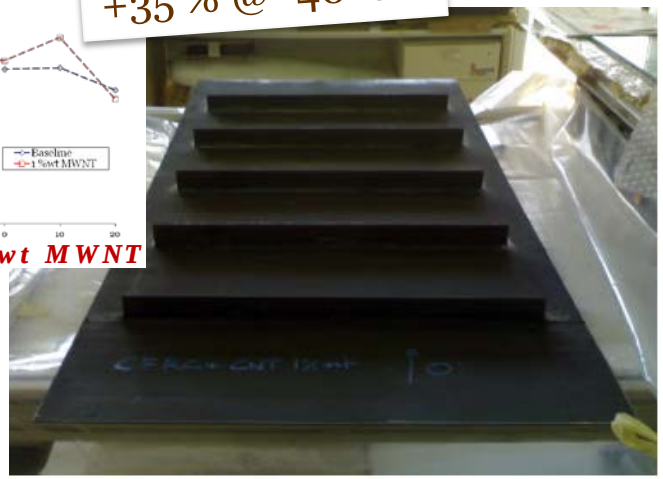












A. Martone, C. Formicola, M. Giordano, M. Zarrelli. "*Reinforcement Efficiency of Multi-Walled Carbon Nanotube/epoxy nanocomposite*" – Composite Science and Technology, Volume 70, Issue 7, pp. 1154-1160 (2010) DOI: 10.1016/j.compscitech.2010.03.001

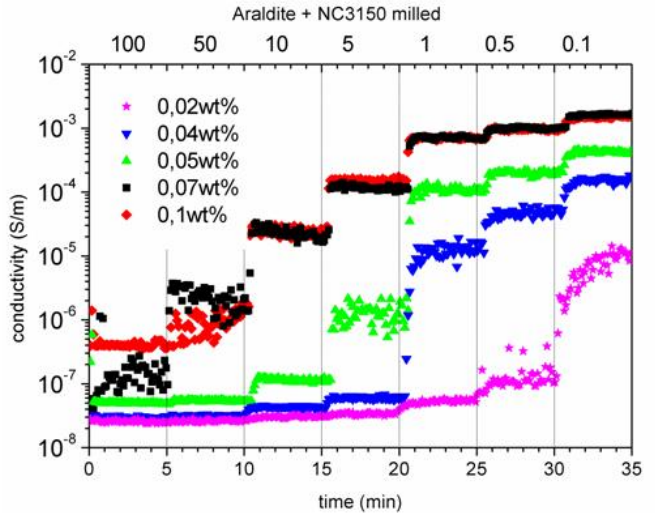
A. Martone, G. Faiella, V. Antonucci, M. Giordano, M. Zarrelli. "*The effect of the aspect ratio of carbon nanotubes on their effective reinforcement modulus in an epoxy matrix*" - Composites Science and Technology (2011) DOI: 10.1016/j.compscitech.2011.04.002

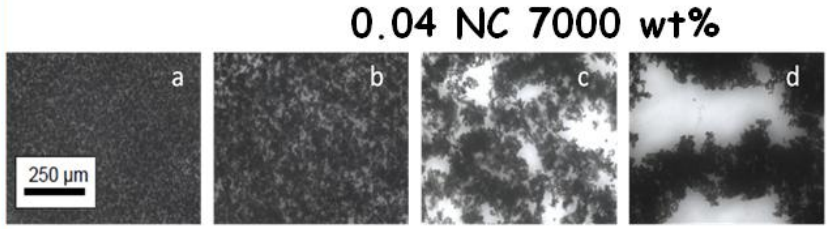
A. Martone, M. Giordano, V. Antonucci, M. Zarrelli, 2011. *Enhancing damping features of advanced polymer composites by micromechanical hybridization*. Composites Part A: Applied Science and Manufacturing 42, 1663-1672. doi:10.1016/j.compositesa.2011.07.019

CNT COMPOSITES WTH TUNED CONDUCTIVITY

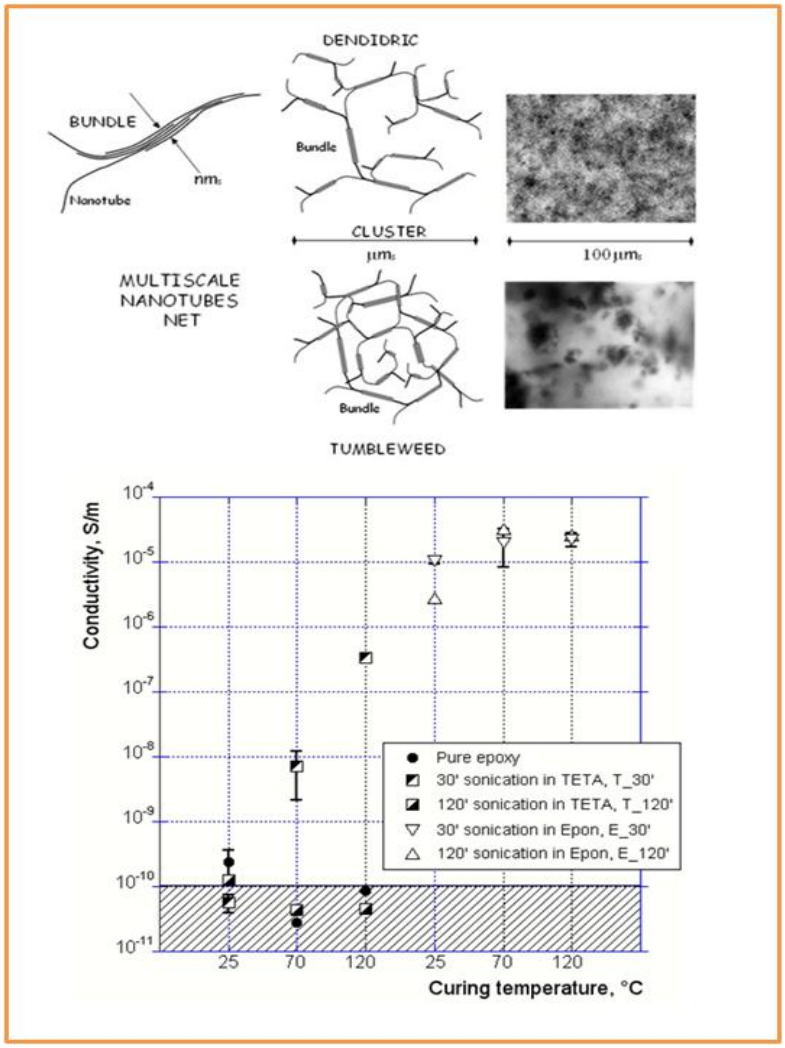
Conductive nanotube network is tuned to modulate the insulator to conductive transition at a fixed carbon nanotube concentration

By shear





By sonication

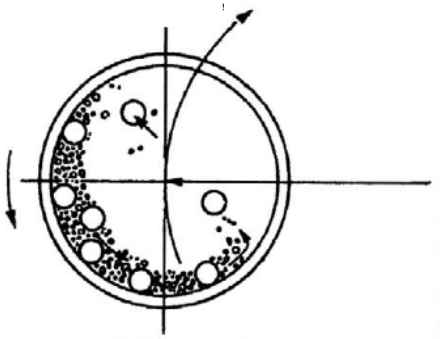


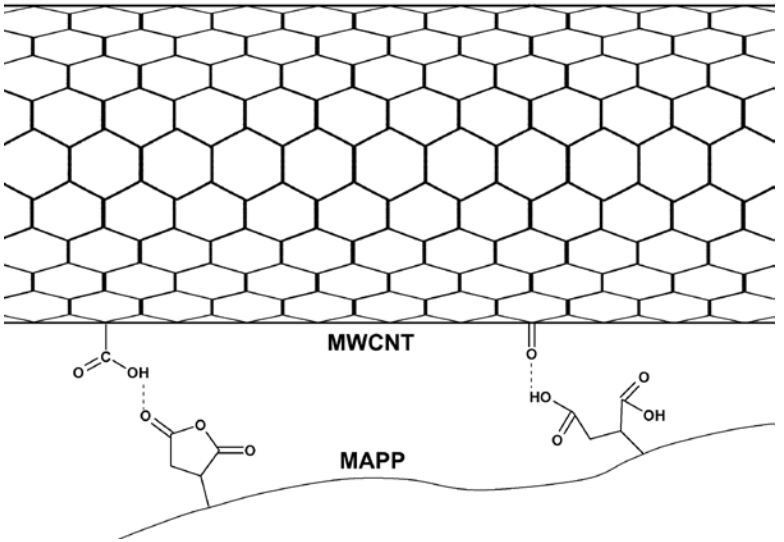
MULTI SCALE COMPOSITE: INTERFACES

A novel approach to functionalize CNT surface :

the solid state mechano-chemical treatment at room temperature.

The mechano-chemical methodology consists of mixing CNTs with suitable Precursor molecules and then proceeding the reaction through the high-energy ball impacts.

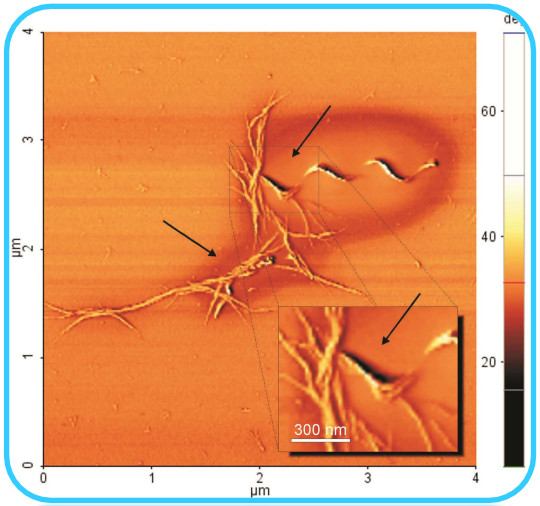


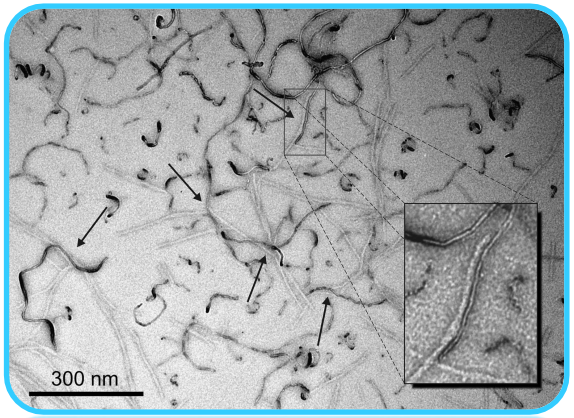


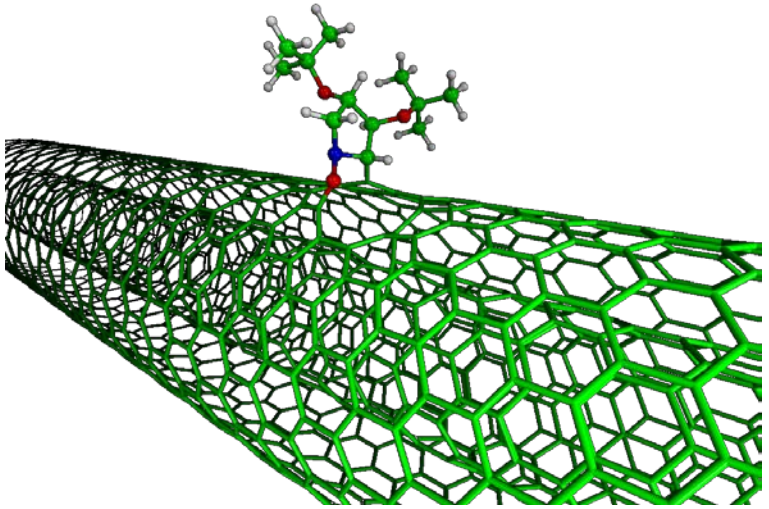
Scheme of the possible interactions between maleic anhydride groups of MAPP multi-wall carbon nanotubes

Gel-functionalized Carbon Nanostructure Composite Materials

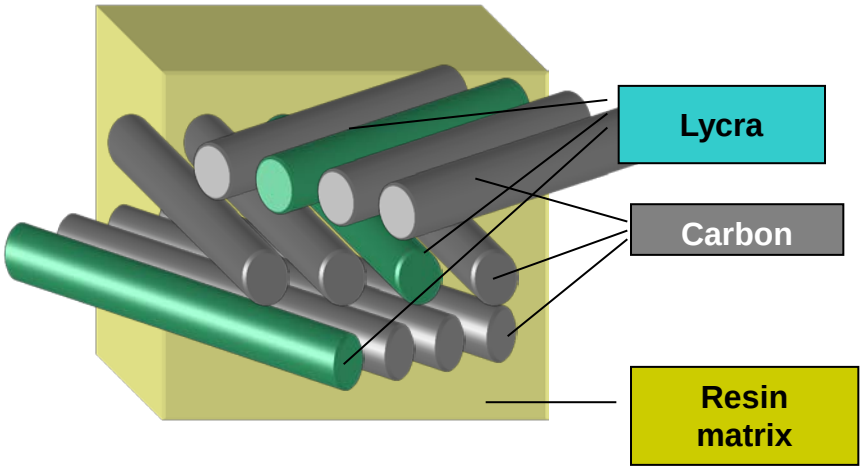
Soft Matter. (2011), 7, 10660-10665

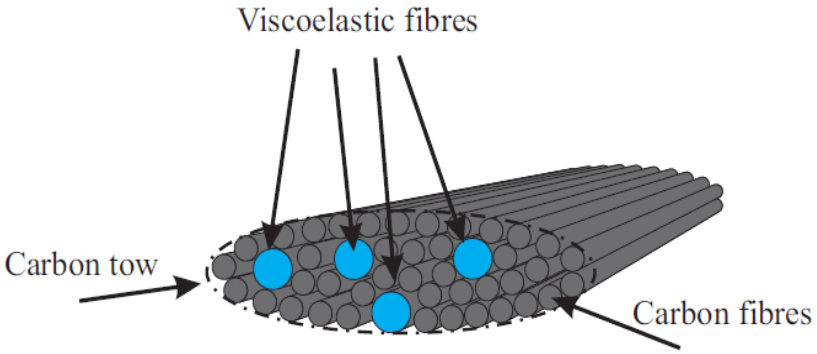


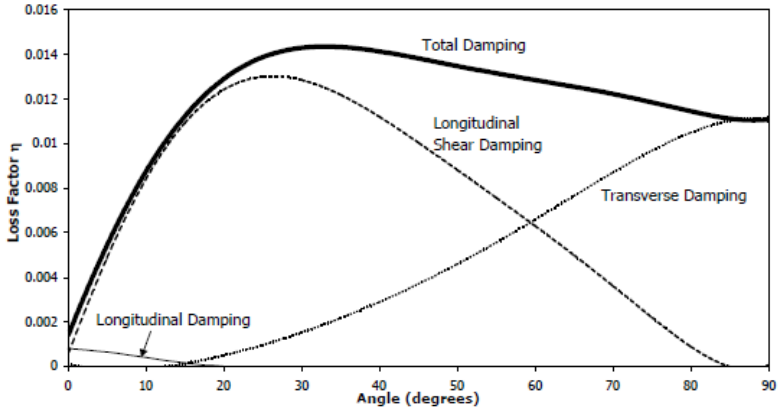




Hybrid Composite



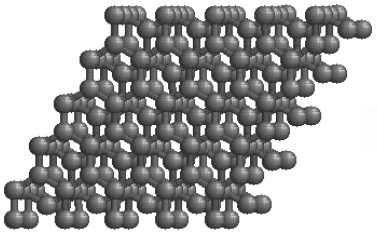




A possible strategy for improving material damping capacity is to use the distinguishing anisotropy behaviour of composites to define an hybrid architecture able to dissipate energy not mainly in interlaminar damping but capable to in elongational mode.

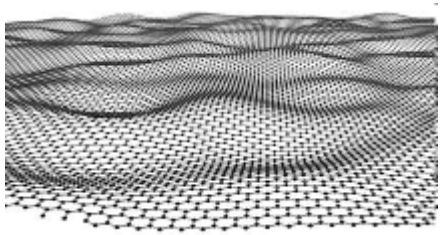
GRAPHENE TECHNOLGY PLATFORM

GRAPHITE



GRAPHENE

(NEWEST AND MOST STUDIED CARBON-BASED MATERIAL)

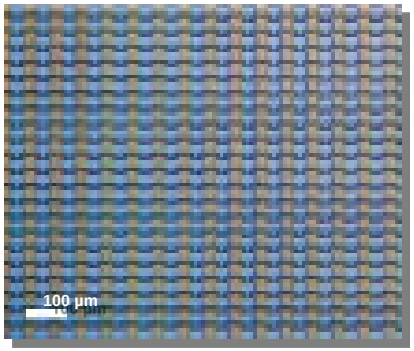


APPLICATIONS

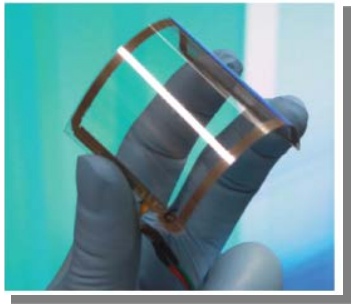
TRANSPARENT CONDUCTING DISPLAYS (ITO replacement)

ELECTRON ACCEPTOR (excellent charge mobility, very high surface area)

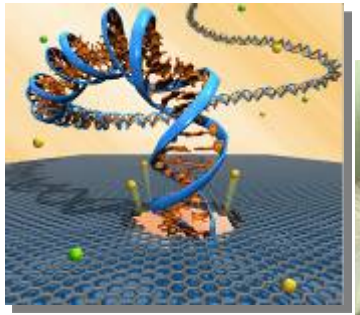
COATINGS (inert, high barrier to oxygen and moisture)



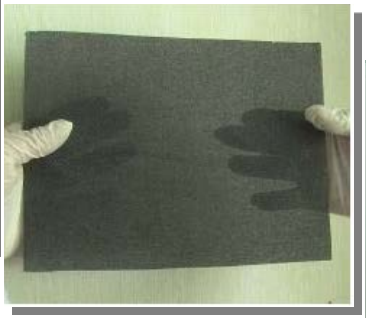
High-frequency electronics



Transparent displays and touch screens



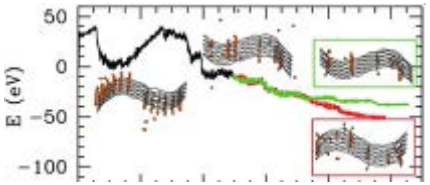
Biological sensing



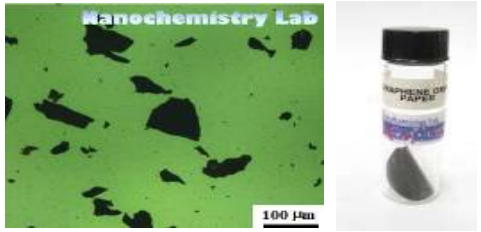
Smart materials

Electric charge and hydrogen storage

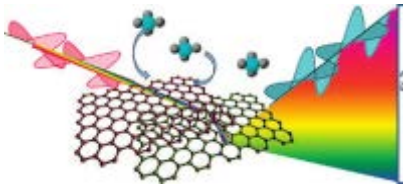
GRAPHENE RESEARCH HIGHLIGHTS



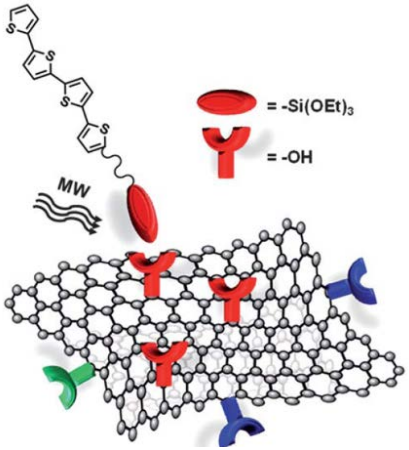
Hydrogen storage, charge transport
V. Pellegrini and M. Polini, CNR-NANO Pisa



Graphene – Organic Hybrid materials
V. Palermo, ISOF Bologna

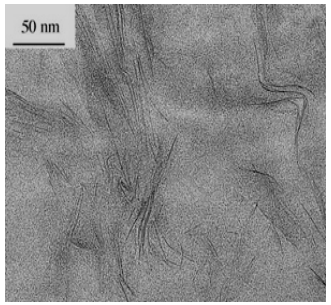


Real-Time Monitoring of graphene growth by Ellipsometry
G. Bruno – IMIP Bari



Chemical functionalization
M. Melucci, G. Giambastiani, ICCOM Florence

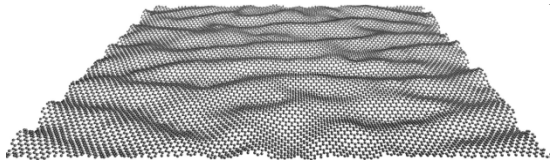
SPM and SEM characterization of epitaxial and CVD graphene
V. Morandi, F. Giannazzo
IMM Bologna + catania



Graphene-polymer nanocomposite
G.Carotenuto – IMCB-CNR

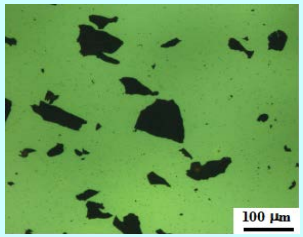
GRAPHENE NANO-TECHNOLGY PLATFORM

GRAPHENE



Nanochemistry Lab

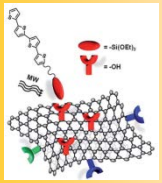
SINGLE SHEETS



SOLUTIONS

BULK MATERIALS

MAINSTREAM RESEARCH



EUROPEAN PROJECTS

GENIUS

GOSPEL

INDUSTRIAL COLLABORATIONS

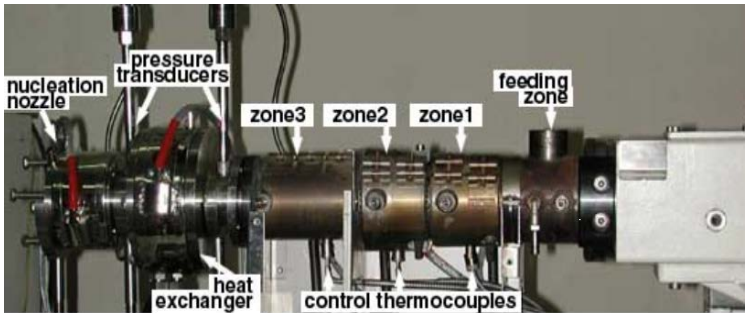
NOKIA

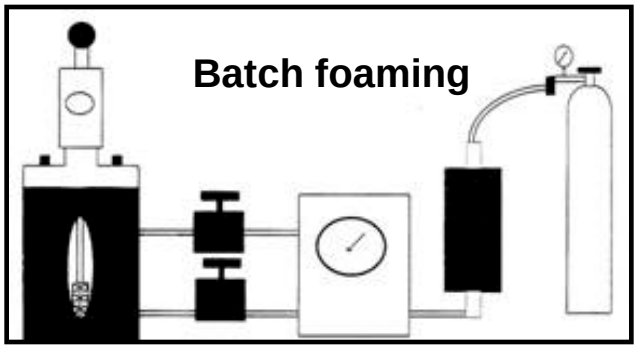
BASF
The Chemical Company

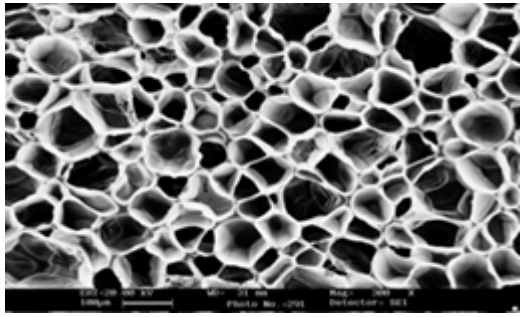
New Initiative:
FET FLAGSHIP
1 Billion €/10 years
GRAPHENE FLAGSHIP

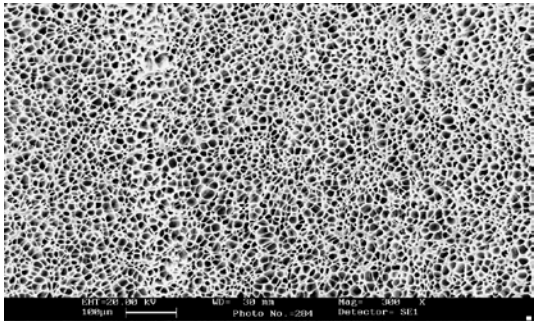
- **Coordination of two EU projects on graphene-organic hybrids (1 Marie Curie ITN + 1 ESF EUROCORES)**
- **CNR is one of the official Partner of the GRAPHENE FLAGSHIP initiative**

THERMOPLASTIC FOAMS









<u>Process-properties:</u> rheology, gas solubility and diffusivity, modelling

Materials

Neat matrices

Commodity: PE, EVA, PS

Thermoplastic polyurethanes (TPU)

Polyesters: PET, PEN, PLA, PCL

Biopolymers: Zein, Collagen

Engineering: PES, PC, PPSU, PEI

Nanocomposites

EVA: clay

PP: clay

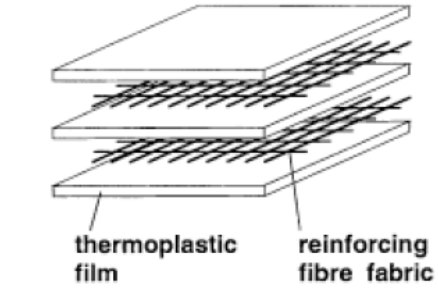
TPU: MWCNT

PET: MWCNT, Clay

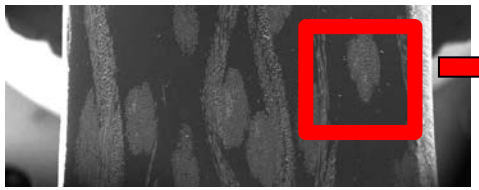
PEN: SiO_2, Expanded Graphite, clay (MMT)

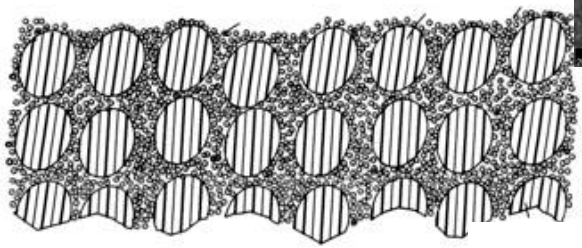
PES: SiO_2, Expanded Graphite

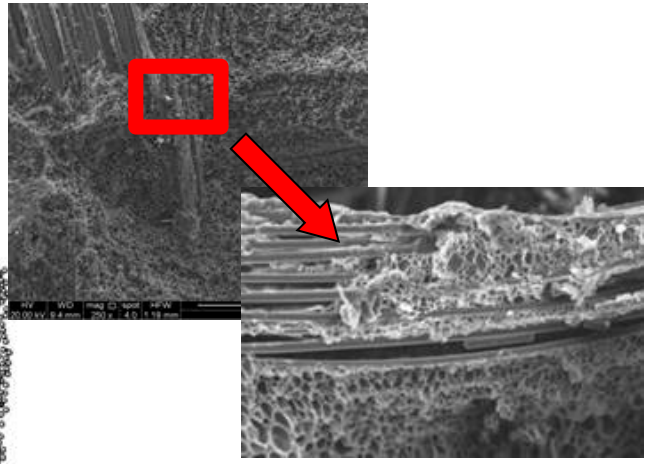
Multifunctional lightweight materials having porous and reinforcement phases hierarchically organized from nano to micro scale



Controlled generation of microcellular structure into the polymeric matrix and between fibers through Graphite nanoparticles

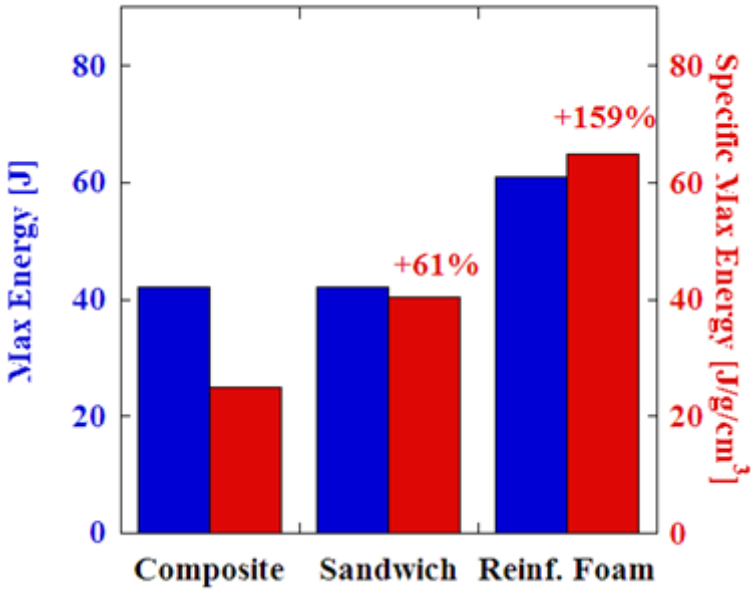




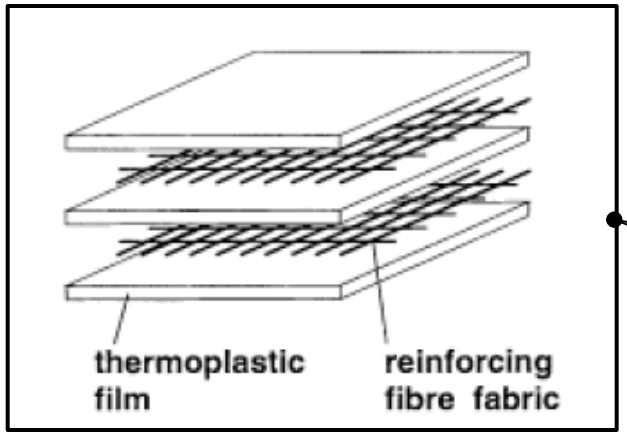


LARGE AMOUNT OF IMPACT ENERGY:

- **Deformation mechanism involving both the foamed matrix (combination of compression and shear) and the glass fiber fabric layers**
- **plastic deformation of the foamed matrix in a large area around the falling weight**

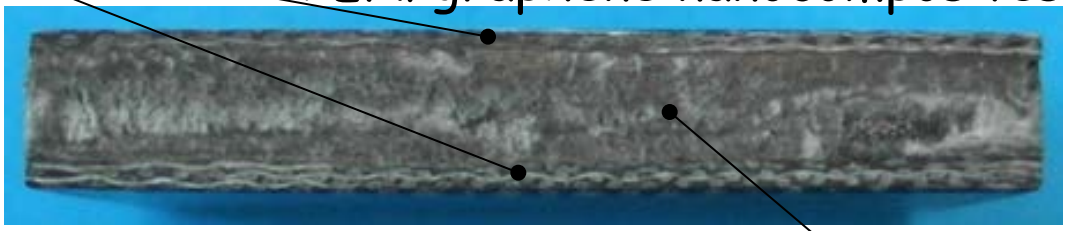


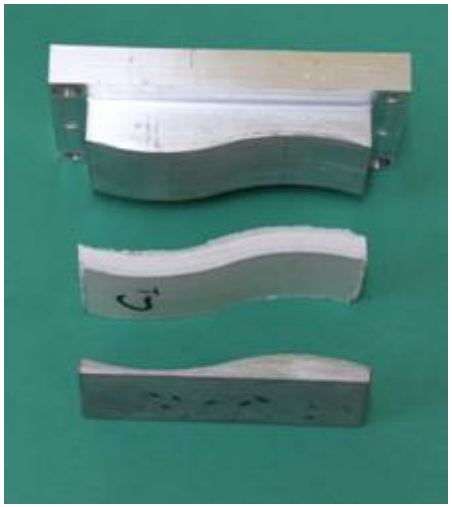
Sandwich structures: in situ foaming



Thermoplastic nanocomposite skins

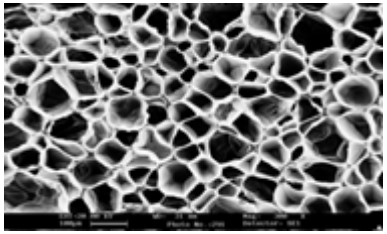
PEN/graphene nanocomposites





In situ foaming

Nanocomposite foamed core



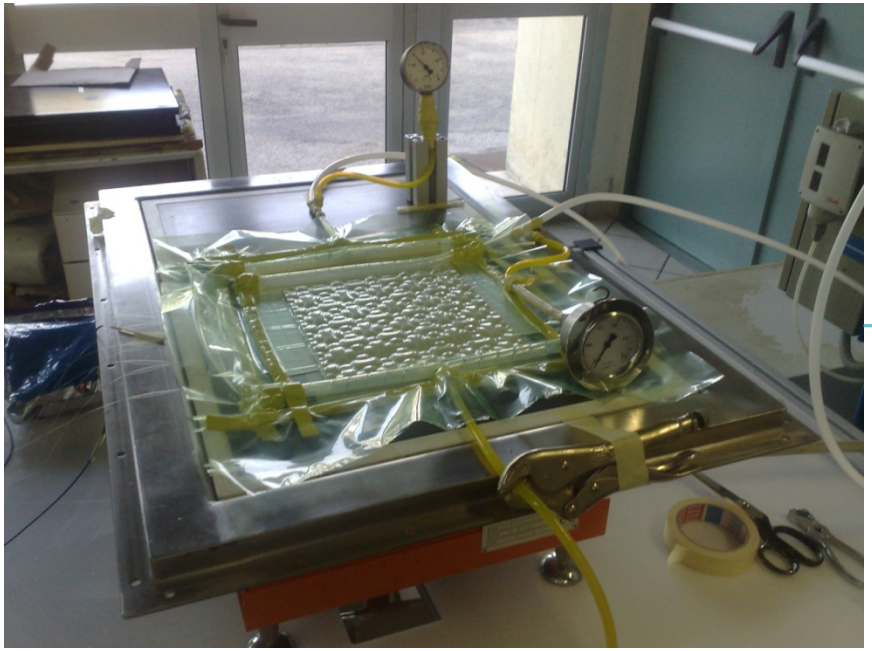
Complex structures and shapes can be obtained by combining foaming of the core and skin consolidation directly in the mold

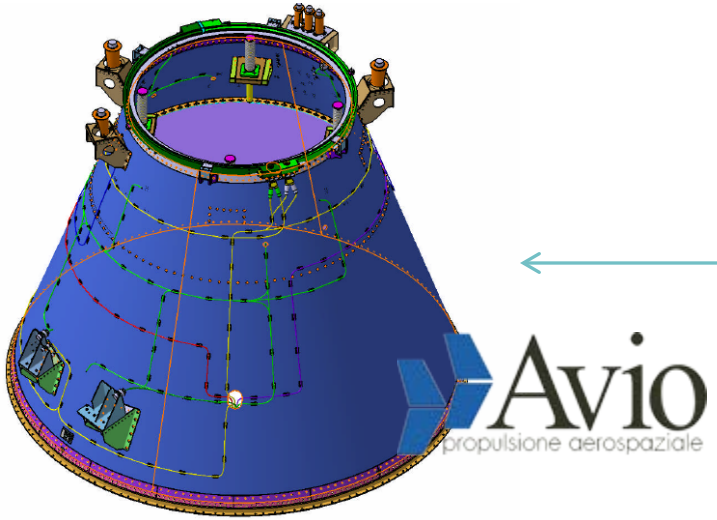
In house technology

"Out of autoclave" manufacturing technology development

Pulse Infusion

Resin infusion by pulsed rubbery mold





Optimization for the manufacturing of phenolic cone

REGIONAL DISTRICT

DAC - Technology Aerospace District

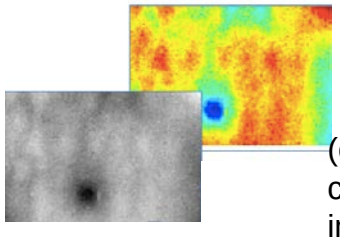
formed in the 2012 with participation of 30 government and private subjects:
- 8 major aerospace companies;
- 11 SME (among which 8 consortium grouping 124 high tech companies),
- 11 Government Research Organization (including 5 Universities).

CNR will be involved in several R&D strategic projects for the commercial aviation

- Technologies & Processes for composite materials

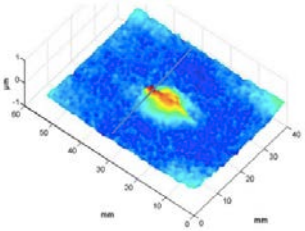
(es. CFRP component)

- Non Destructive Inspection and Testing



(es. impact damage in carbon fiber composite panel detected by optical interferometric method)

- New methods for stress analysis for complex structures and advanced materials

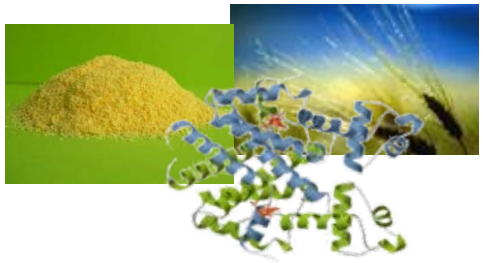


(es. Full-field stress in a composite component map in presence of delamination.

BIOMATERIALS

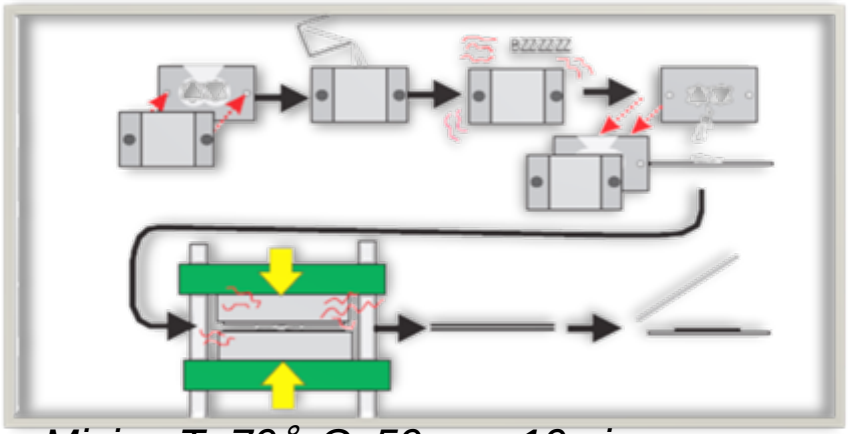
Thermoplastic zein-lignin structures

Natural source, maize: zein



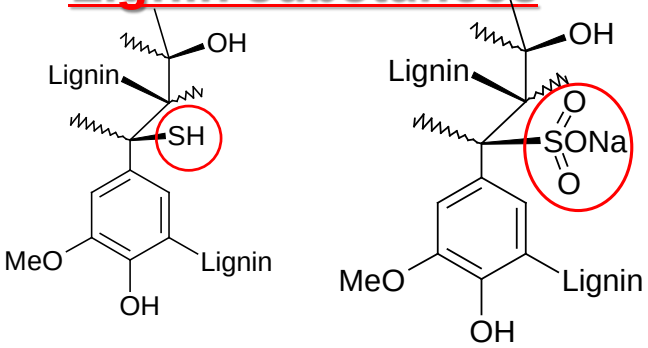
+ PEG400 (plasticizer)

Process

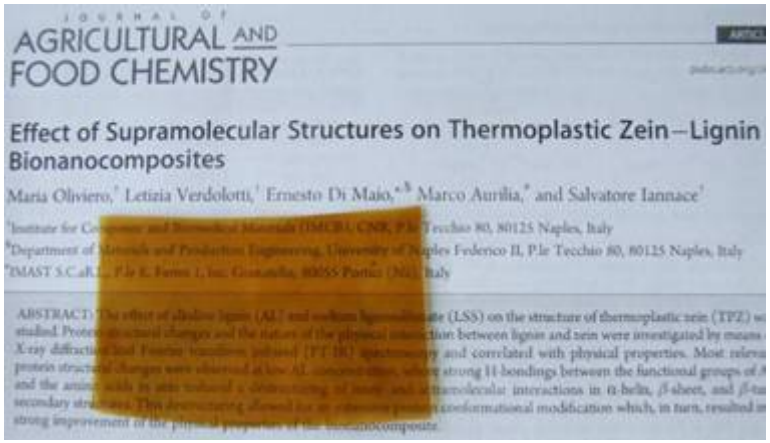


Mixing:T=70° C, 50rpm, 10min
Compression moulding: T=70° C, P=50bar

Lignin substances



PEG (%wt on zein+PEG)	25
Lignin substances (%wt on zein+PEG)	1-3-10



JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY

Effect of Supramolecular Structures on Thermoplastic Zein–Lignin Bionanocomposites

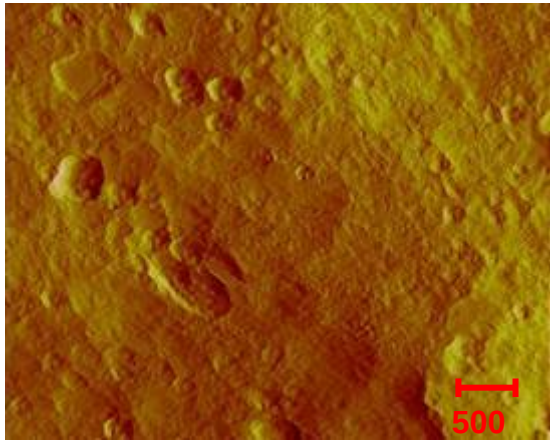
Maria Oliviero,† Letizia Verdolotti,† Ernesto Di Maio,*,‡ Marco Aurilia,† and Salvatore Iannace†

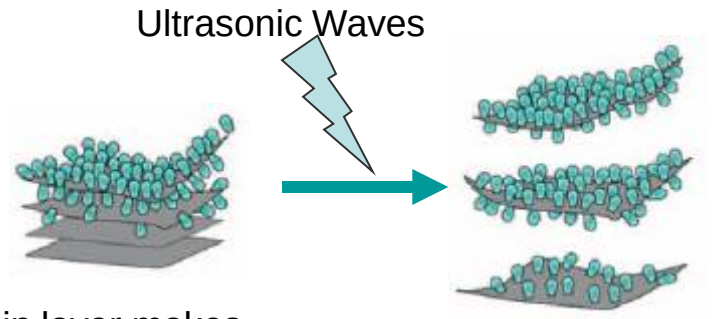
†Institute for Composite and Biomedical Materials (IMCB), CNR, P.le Tecchio 80, 80125 Naples, Italy
‡Department of Materials and Production Engineering, University of Naples Federico II, P.le Tecchio 80, 80125 Naples, Italy
§IMAST S.C.a.R.L., P.le E. Fermi 1, loc. Granatello, 80055 Portici (NA), Italy

ABSTRACT: The effect of alkaline lignin (AL) and sodium lignosulfonate (LSS) on the structure of thermoplastic zein (TPZ) w
studied. Protein structural changes and the nature of the physical interaction between lignin and zein were investigated by means
X-ray diffraction and Fourier transform infrared (FT-IR) spectroscopy and correlated with physical properties. Most relev
protein structural changes were observed at low AL concentration, where strong H-bondings between the functional groups of
and the amino acids in zein weakened a destructuring of inter- and intramolecular interactions in α-helix, β-sheet, and β-tu
secondary structures. This destructuring allowed for an extensive protein conformational modification which, in turn, resulted in
strong improvement of the physical properties of the biocomposite.

Thermoplastic zein/graphene bionanocomposites

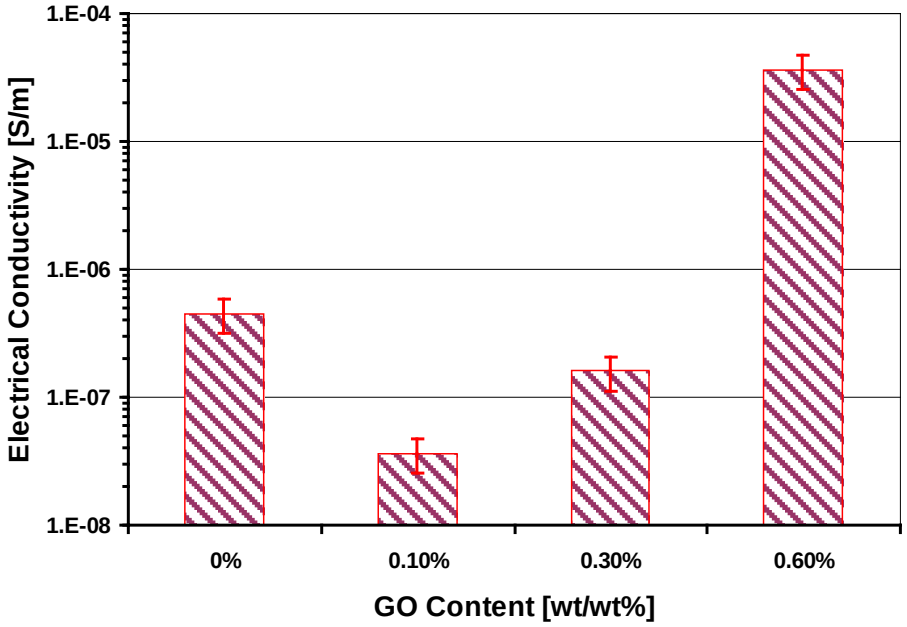
Controlling the electrical conductivity of proteins with graphene



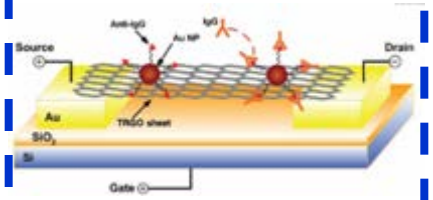


Protein layer makes the surface of graphite hydrophilic

Protein-coated sheets of graphene detach from graphite



Electroactive Polymers



Bio-sensors

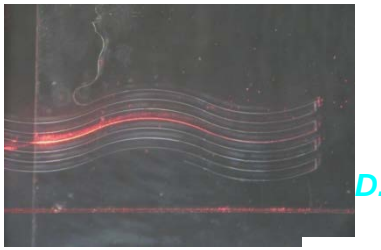
Smart Materials

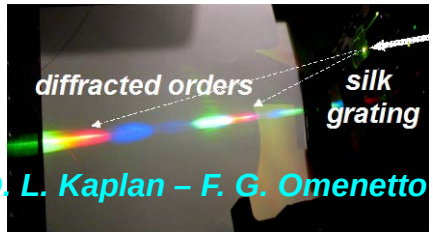
SILK TECHNOLGY PLATFORM

Silk for optical and photonic devices

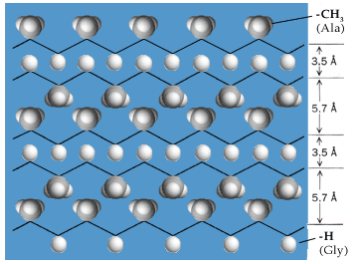
Integration of silk fibroin in optoelectronic devices: transistors e light emitting transistors

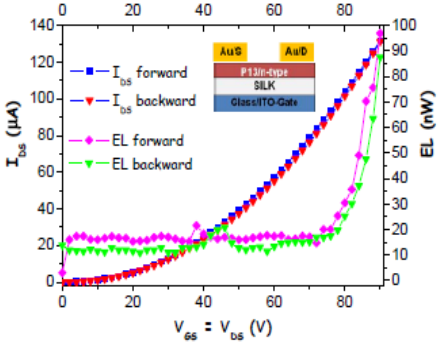
Printed silk waveguides





D. L. Kaplan – F. G. Omenetto

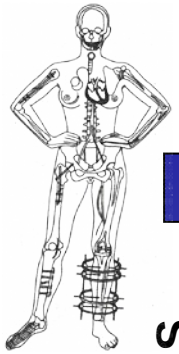




ISMN-CNR
Stazione Sperimentale Seta (MI)
Istituto di Bachicoltura (PD)

Evolution of Composite Biomaterials

Tissue Repair & Regeneration



BIOMATERIALS

REPAIR

REGENERATION

1985

1995

2003

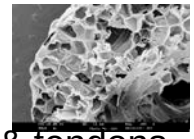
2005

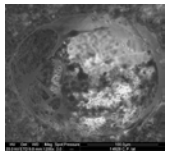
2008

2010

……2012

Ligament & tendons

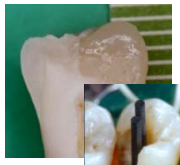




CaP scaffold

Hip

Tooth



restorative

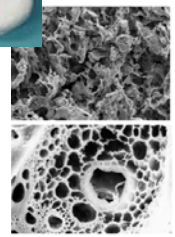
Ligament & tendons

Jaw

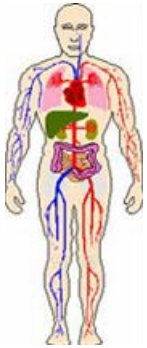
Disc Cage

Intervertebral Disc

Meniscus

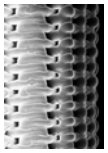


salt leaching
phase inversion

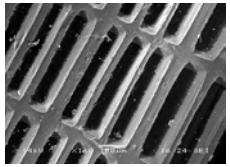


Multifunctionals
structures

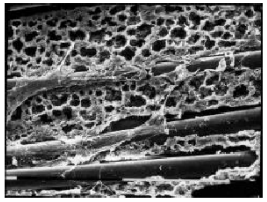
Rapid Prototyping

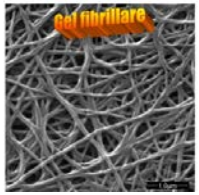


molecular imprintig



Filament winding





electrospinning

Custom-made Scaffold

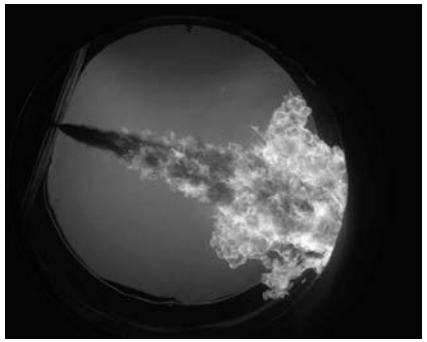
Structural metals and ceramics for severe conditions

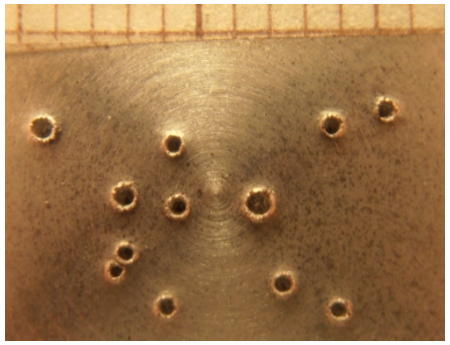
Structural metals for severe conditions

<u>New structural metallic materials for high temperatures</u>

- Mechanical and microstructure characterization

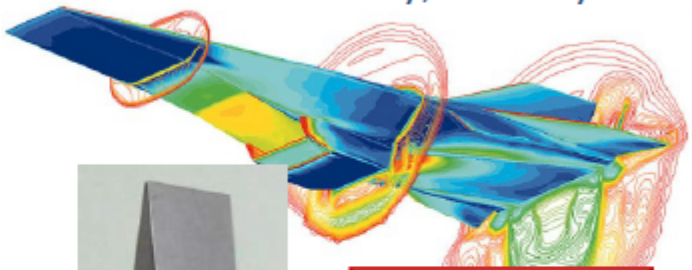
- Deformation and damage mechanisms, constitutive equations





Ultra High Temperature Ceramics for Aerospace

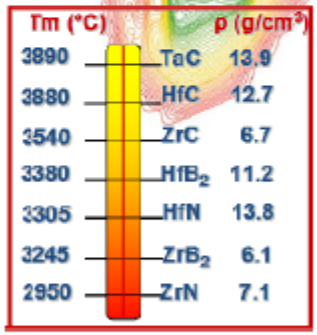
- Borides and carbides of early transition metals: ZrB_2, HfB_2, ZrC, HfC, TaC.
- Extremely high melting point, strength, high thermal and electrical conductivity, stability at T>1600°C in aggressive environment
- Applications: aerospace, nuclear plants



Prototypes produced at ISTEC-CNR

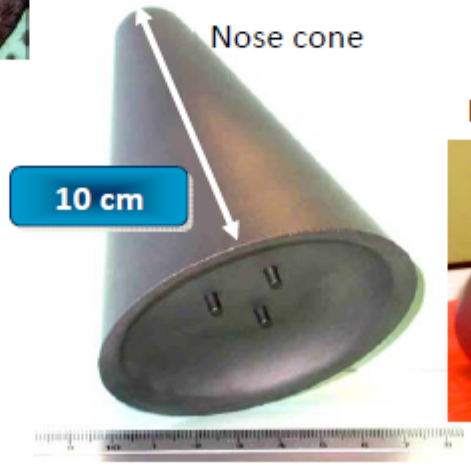
Mission BION_M1 (METEORIT experiment)

Sharp wedge
for lab arc-jet tests



Ceramic holder

Nose cone



Leading edge

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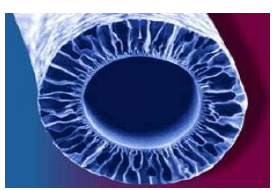
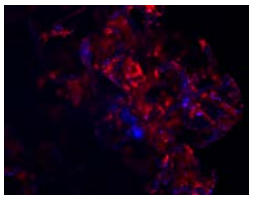
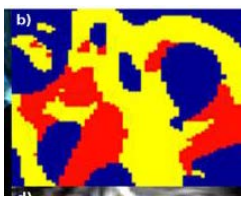
THANK YOU!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