Micro e nano-materiali per l'industria dei trasporti

Livio Battezzati

11 Luglio 2013, Unione Industriale, Torino

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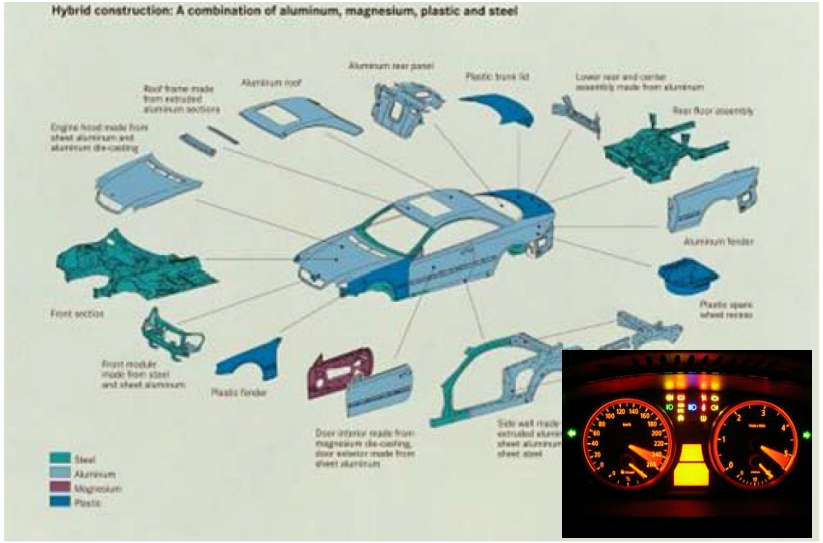
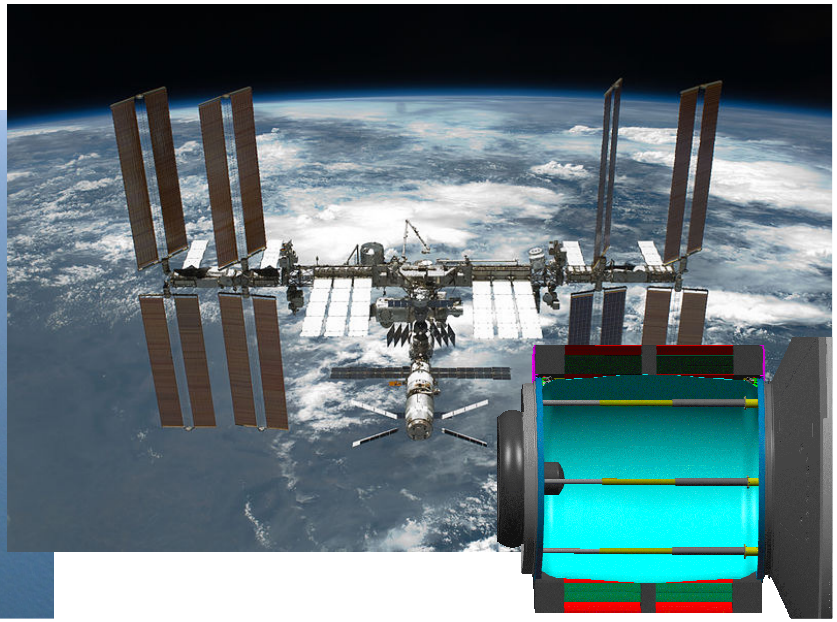
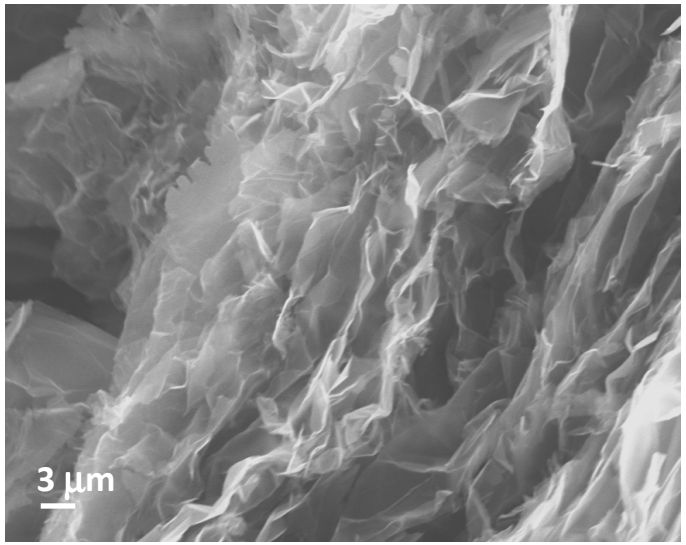
Centre of Excellence

- esperienze acquisite
- attività in corso su temi specifici
- progetti da sviluppare

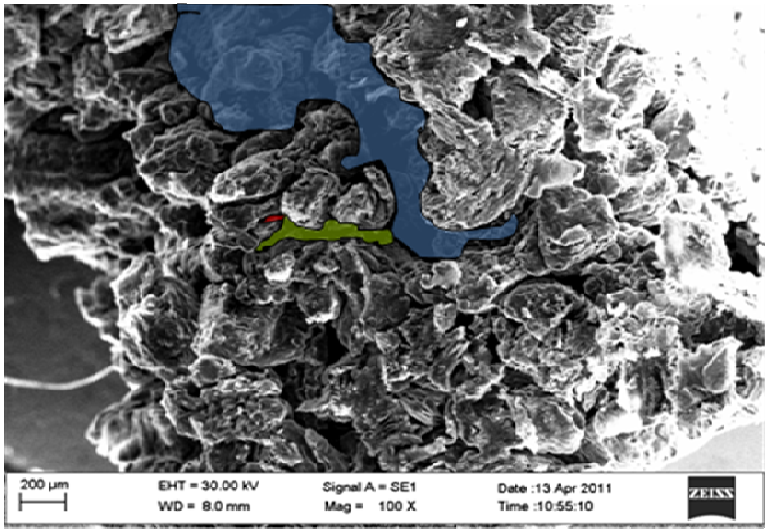




Sistemi e Tecnologie per l'EsPlorazione Spaziale, STEPS fase 1 (2010-2012) fase 2 (2013-2014)
Materiali ablativi



SEM image of a carbon-based polymer composite foam



SEM image showing a hierarchiacal porosity: large porosity (blue) and smaller interconnected pores (green, red).

Contatti: D. Scarano, F. Cesano, A. Zecchina

air/propane flame test

Carbon-carbon conductive and piezoresistive composites

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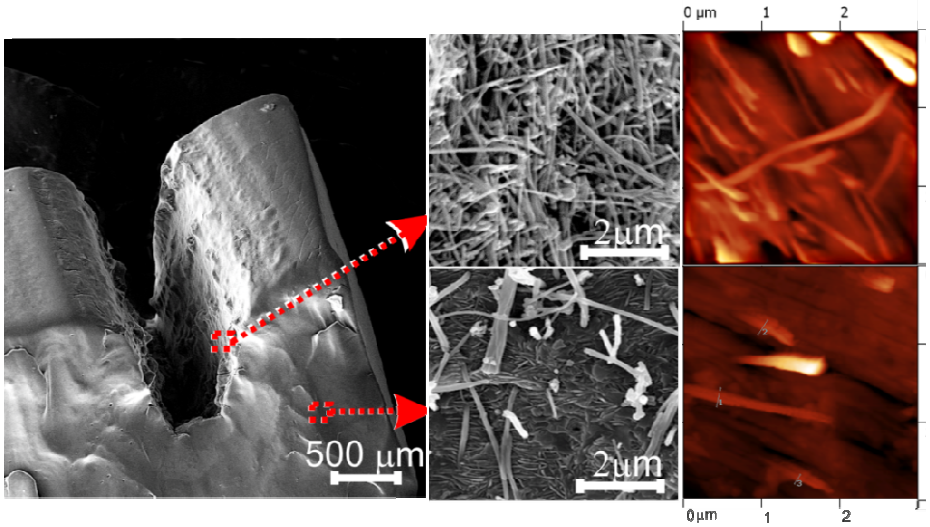
1D and/or 2D Carbon-based composites

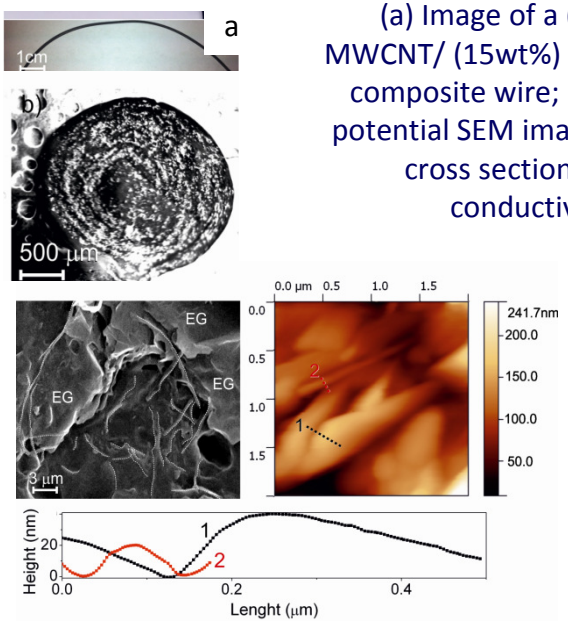
*…conductive **tracks** on polymers obtained by laser irradiation on non-conductive MWCNT/Polyethylene composites.*



SEM lateral view of the v-shaped track after laser irradiation, high-resolution SEM and AFM images taken along the profile of the track (on the top right) and far from the laser track (on the bottom right)

F. Cesano, et al., Carbon 2013, doi: 10.1016/j.carbon.2013.04.066
S. Cravanzola, et al , Carbon 2013, doi: 10.1016/j.carbon.2013.05.064

*…conductive **wires**, 1.5 mm and 3 mm in diameters, obtained by melt blending raw materials: polypropylene (PP), exfoliated graphite (EG) and/or multiwalled carbon nanotubes (MWCNTs)*



(a) Image of a (2wt%) MWCNT/ (15wt%) EG /PP composite wire; (b) low potential SEM image of a cross section of the conductive wire

SEM and nc-AFM images of the conductive wire, showing the interconnections among graphite nanoplatetels (2D) and nanotubes (1D); on the bottom, height profiles along the selected lines

Porous carbon-oxide composites
(ZnO/C, SnO_2/C, TiO_2/C)

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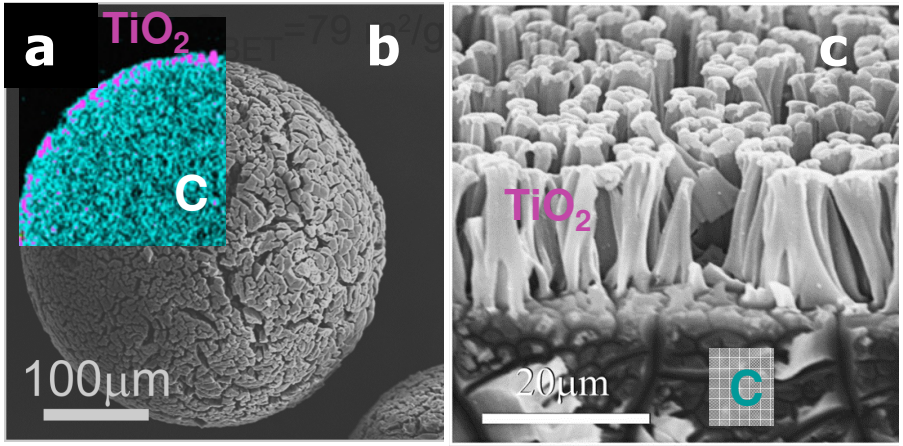
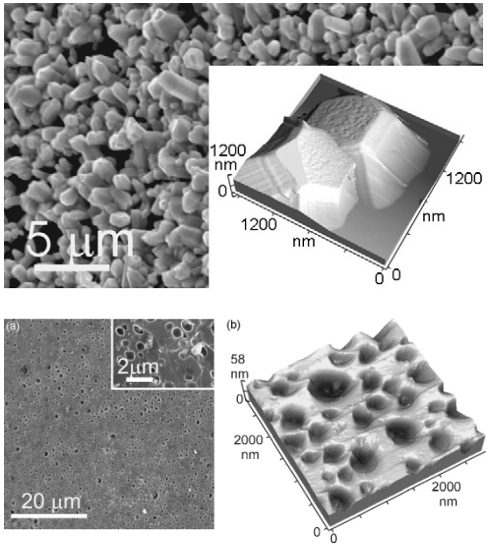
TiO_2/C



(a) X- Ray Tomography and (b) SEM images of a porous core-shell C/TiO_2 composite microsphere; (c) lateral-view SEM image of an array of TiO_2 pillars protruding from a C-monolith.

F. Cesano, et al,, Adv. Mater. 2008, 20, 3342–3348

ZnO/C



SEM and AFM images of ZnO–carbon composites

C

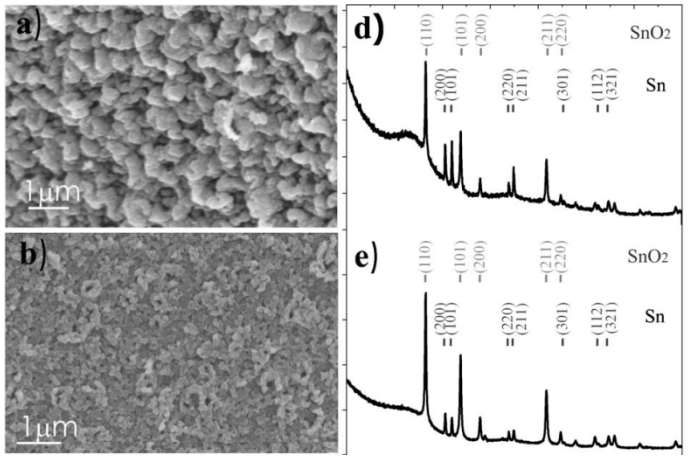
SEM and AFM images of imprinted carbon phase

F. Cesano, ***Journal of Photochemistry and Photobiology A: Chemistry*** *196 (2008) 143–153*

SnO_2/C

SEM images of SnO_2/Sn/Carbon-based porous composites: foams (a) and films (b), with the related XRD patterns (d, e).

Structure and optical/conductive properties make them suitable for capacitors (foams) and gas sensors (films)



M. Rahman et al., ***Catalysis Today*** *150 (2010) 84–90.*

Contatti: A. Damin, G. Spoto; F. Bonino, S. Bordiga; D. Scarano, F. Cesano, A. Zecchina,

Hybrid materials as anodes

Increase of electric conductivity of materials for power anodes based on TiO_2

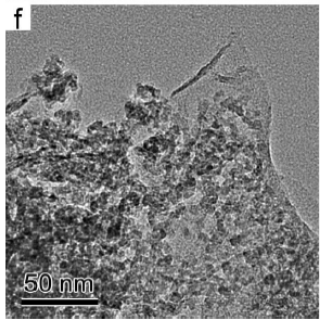
- State of the art

i)TiO2 + Grafene [1] hybrid materials

Self-Assembled TiO_2–Graphene Hybrid Nanostructures for Enhanced Li-Ion Insertion

Donghai Wang,† Daiwon Choi,† Juan Li,† Zhenguo Yang,† Zimin Nie,† Rong Kou,† Dehong Hu,† Chongmin Wang,† Laxmikant V. Saraf,† Jiguang Zhang,† Ilhan A. Aksay,‡,* and Jun Liu†,*

"The specific capacity was more than doubled at **high charge rates**, as compared with the pure TiO_2 phase"



Progress in the field can be achieved by:

1. Increase in conductivity of anodes by coupling TiO_2 with carbon based phases;
2. Hybrid TiO_2/*carbon based materials* (CBM) made via "*green*" synthesis;
3. Synthesis will NOT use expensive graphene made separately;
4. Applicatione to di TiO_2/CBM anodes in Li-batteries: catodes made of innovative materials such as nanostructured $LiFePO_4$.

Contatti: C. Minero

[1] ACS Nano, 2009, 3, 4, 907-914

Flame retardant nanocomposites

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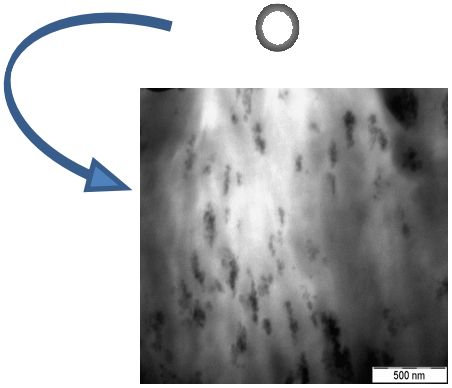
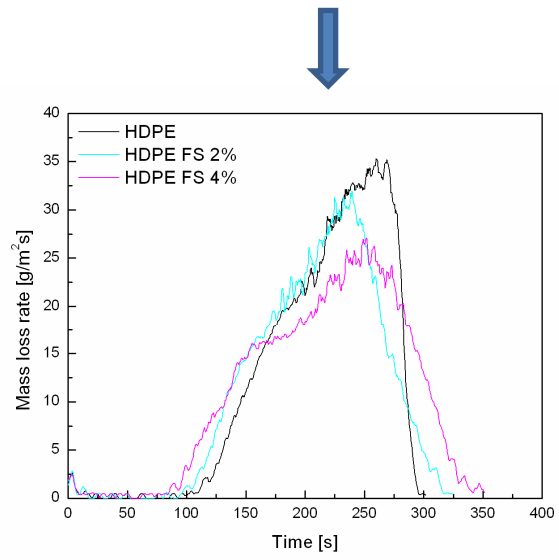
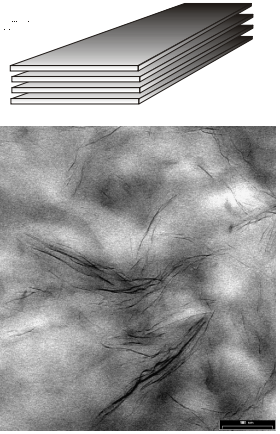
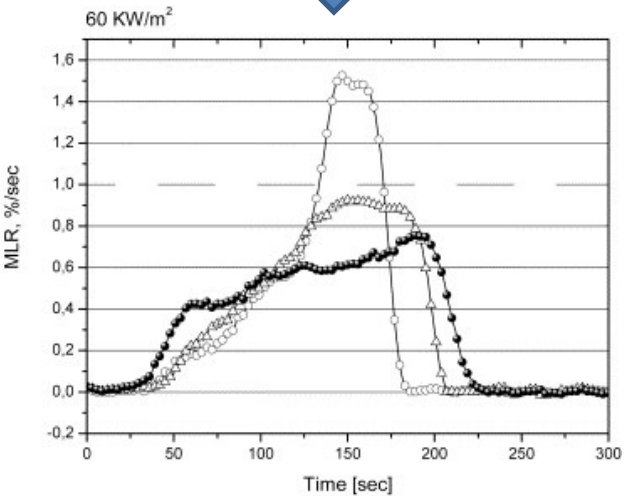
Nano-silica



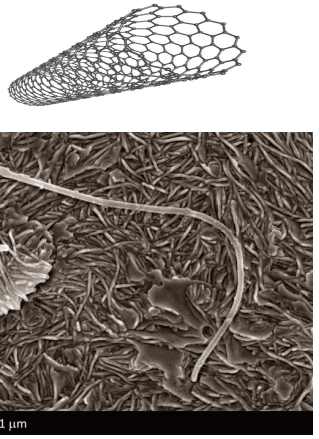


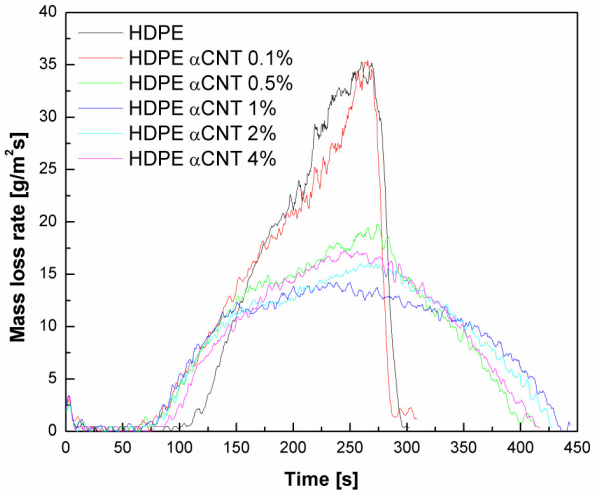
Nano-fillosilicates





Carbon nanotubes



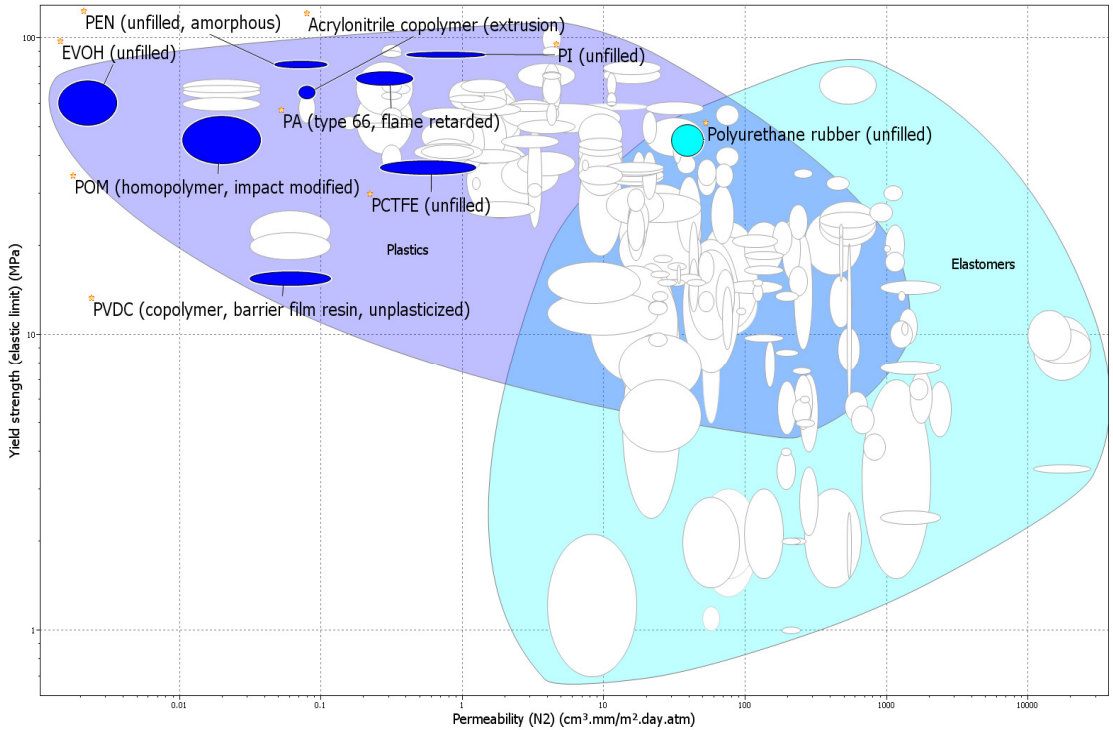


Flattening of HRR → efficient flame retardation.

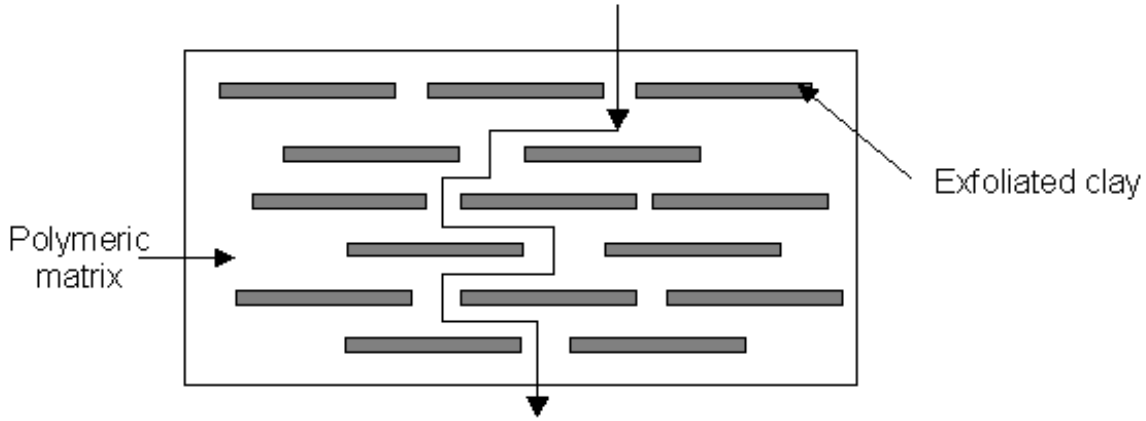
Contatti: M. Zanetti

Inflatable structures

Polymer for low permeability/high strength filled with phillosilicates or graphene



"Tortuous path" of a gas atom or molecule in a exfoliated nanocomposite



Contatti: G. Ricchiardi

Thermoelectric materials:
energy harvesting in transportation

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Systems and components for energy harvesting and energetic efficiency

Progetto Automotive DRAPO'

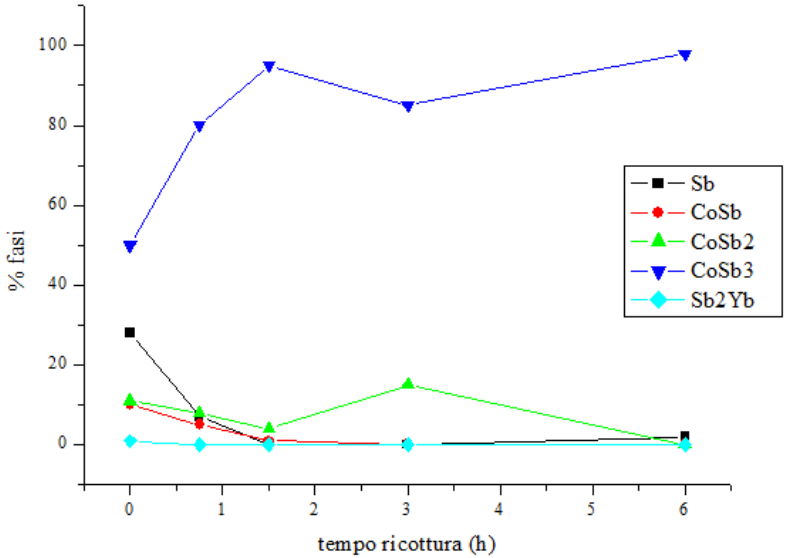
Efficiency increase of $CoSb_3$, Zn_4Sb_3

$$ZT = \frac{\alpha^2 \sigma}{k} T$$

- Stoichiometric monophasic system
- High grain boundaries density
- Single/double/multi-doping
- Supersaturation by non equilibrium techniques (ball milling, melt-spinning)

Environment friendly TE materials: Mg_2Si

Stability of TE modules in service: thermal diffusion at interfaces



Contatti: A. Castellero

MRI and space-related magnetic shields

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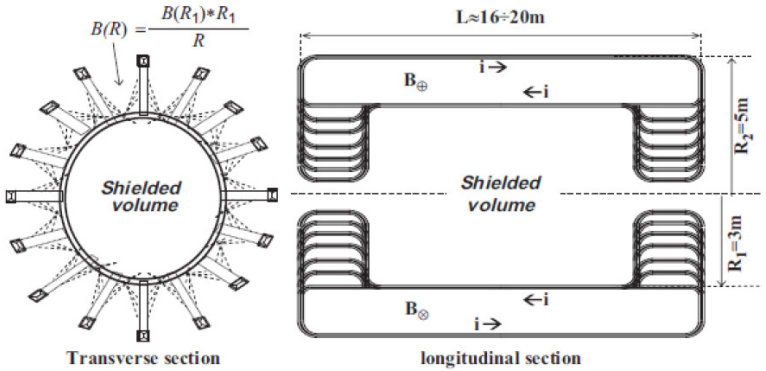
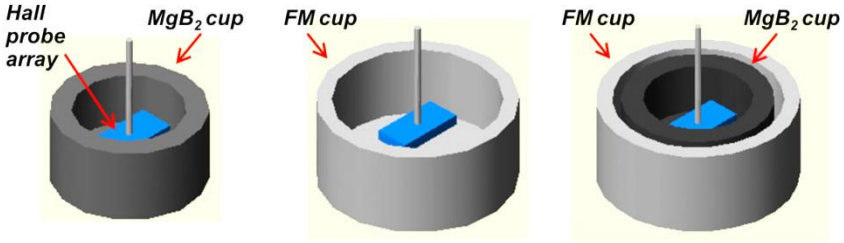
Magnetic shielding from cosmic rays for interplanetary missions (superconducting coils to induce a toroidal field)

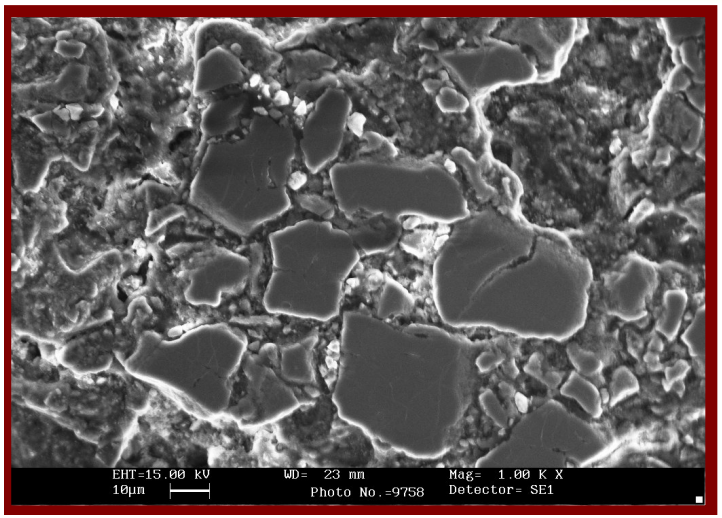


Magnetic shield for stray magnetic fields

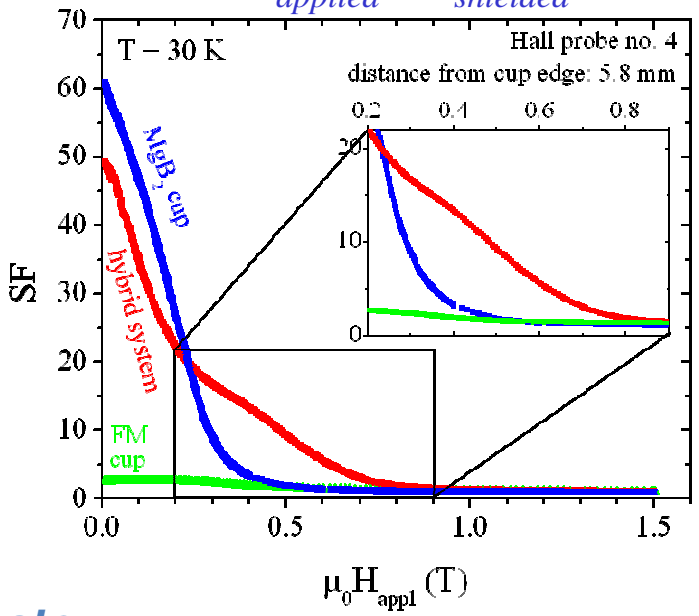
Figure 1-2 Active magnetic system concept, assuming a 6m diameter cylindrical habitat, the starting point of the CRYSMAS study (Spillantini, Acta Astronautica, 2010)

In collaboration with PoliTo:3 different shielding configurations



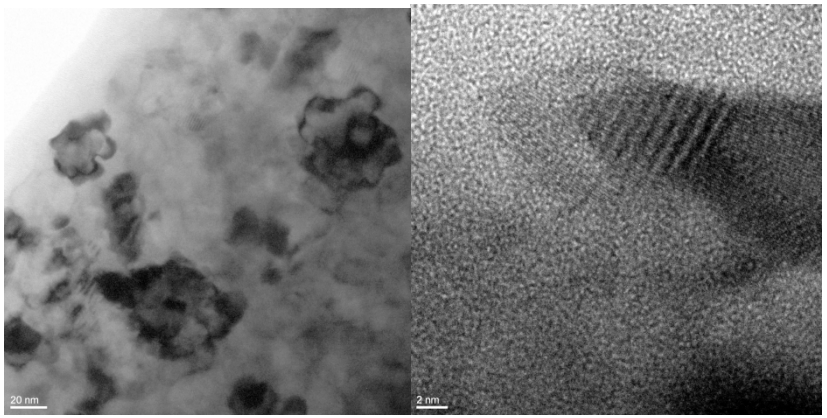


$SF = B_{applied} / B_{shielded}$

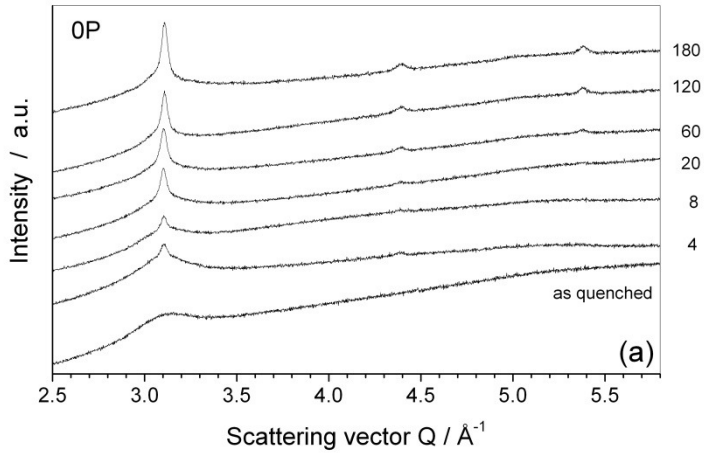


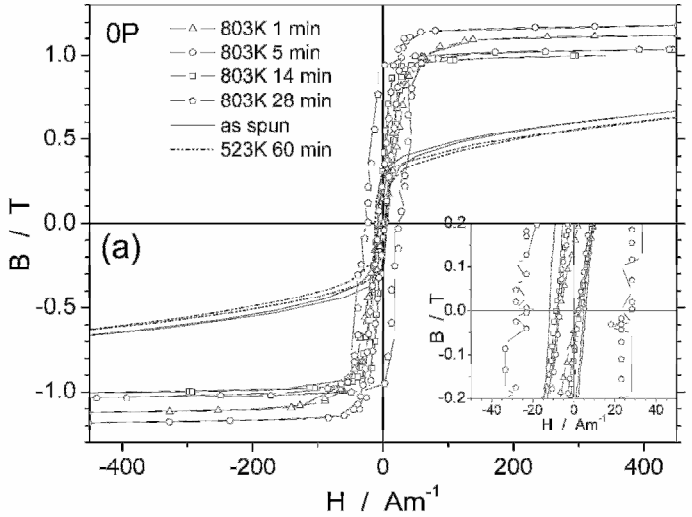
Contatti: M. Truccato

Nanostructured magnets



Improving magnetic properties of rapidly solidified ribbons and wire controlled amorphous to nano-crystalline transformation.





Contatti: M. Baricco, L. Battezzati

Materials for additive manufacturing

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Superalloys and Ti-alloys are candidates for AM. Optimization of microstructure via phase fraction modelling.

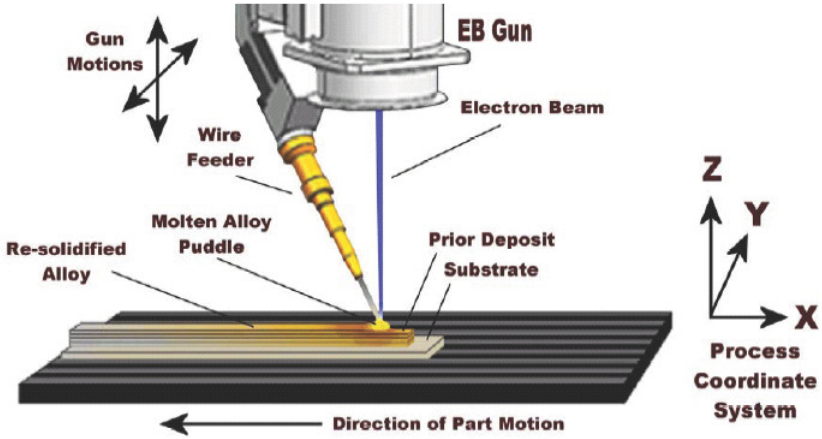
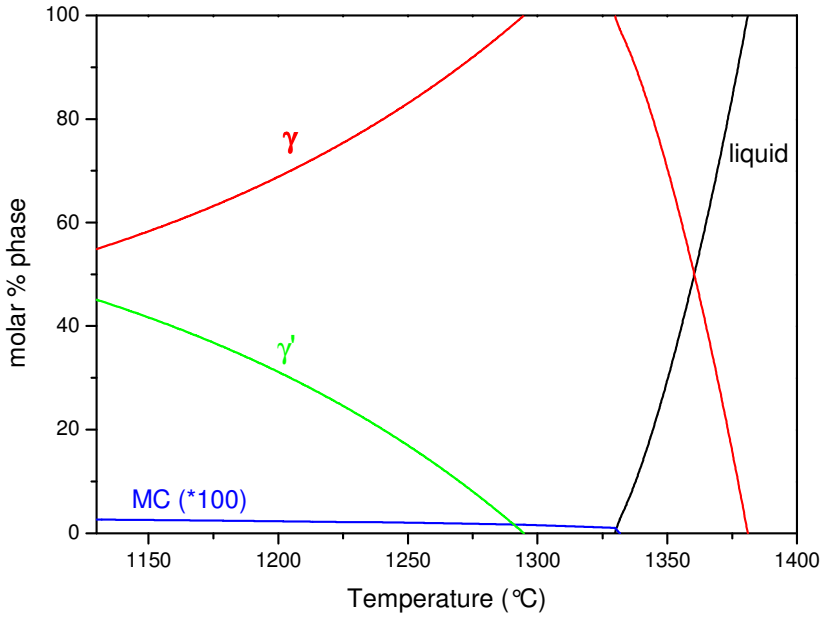
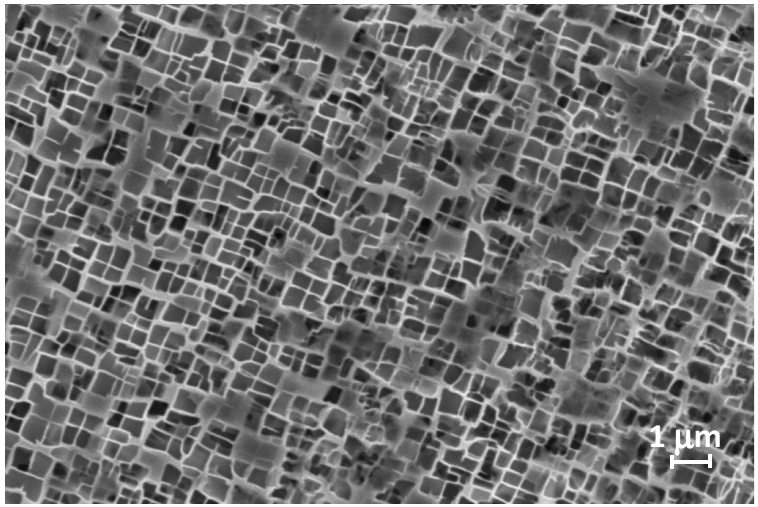


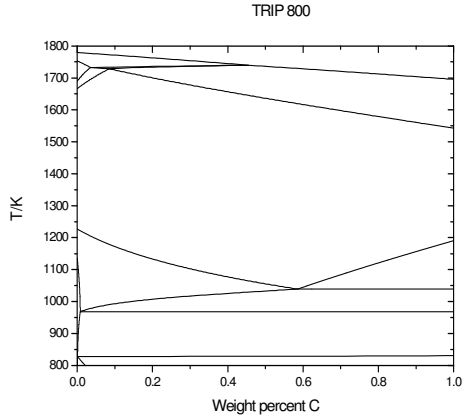
Figure 1: Schematic Diagram of the EBFFF Process

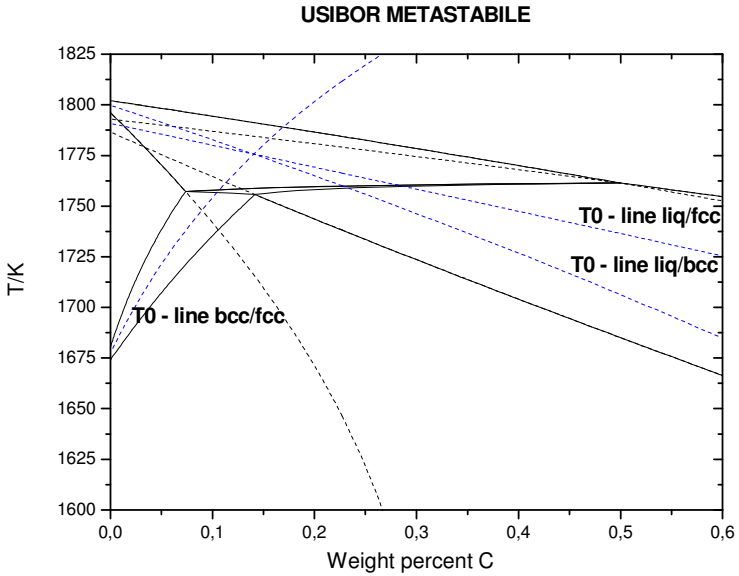




Contatti: L. Battezzati

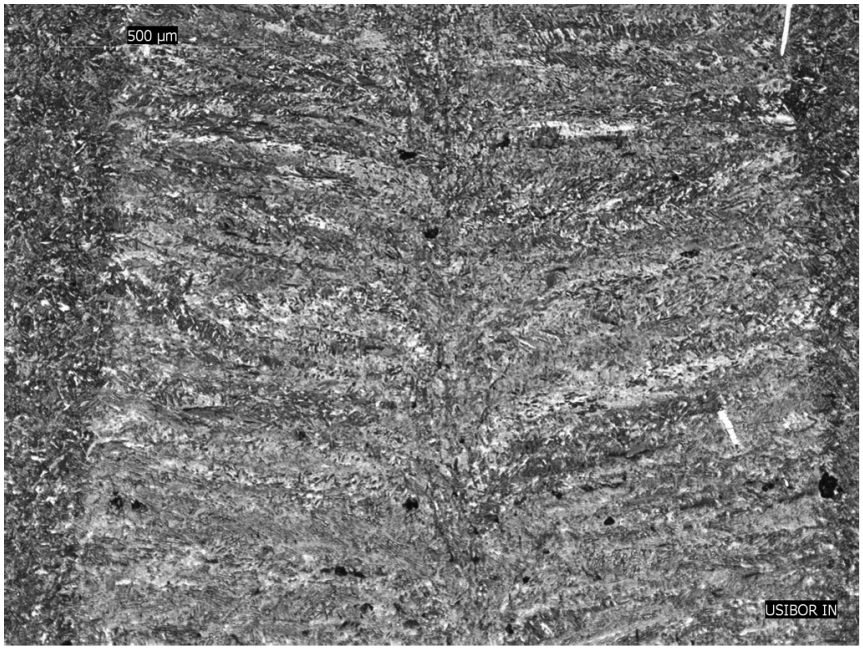
Welding of HS automotive steels





Laser weld of automotive steel: molten zone and HAZ.

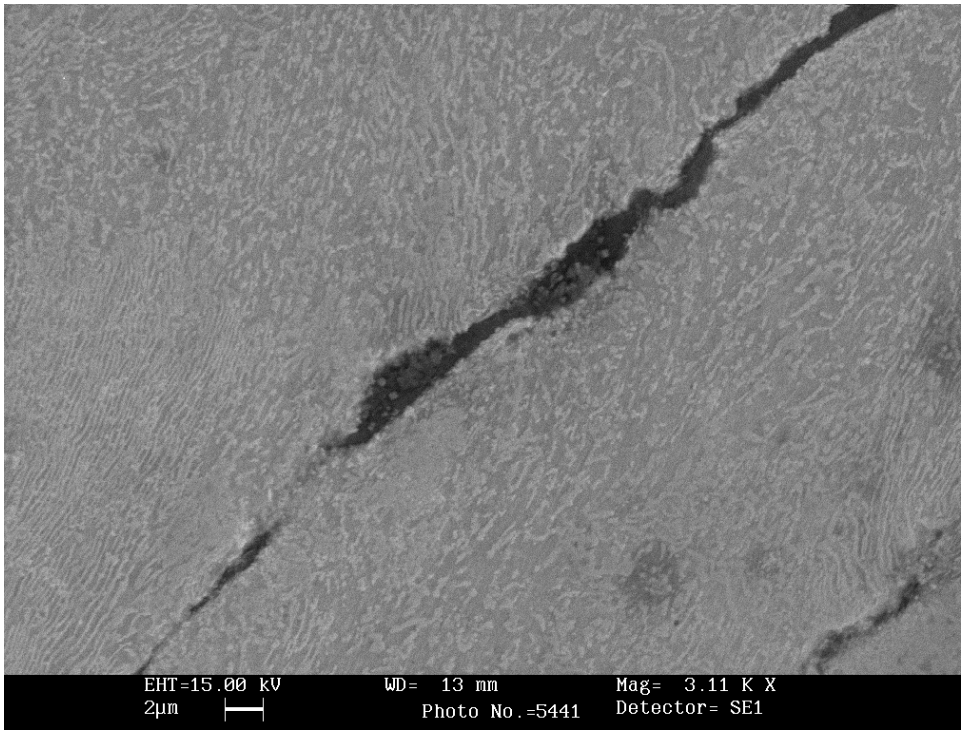
Modelling solidification microstructure using metastable phase diagrams



Wear in brake pads and discs

An example of service to industry: formulation and analysis of friction materials.

Wear debris acquire microstructure typical in processes of severe plastic deformation (ECAP, HPT, white layer formation…)



Contatti: P. Rizzi

Conclusions

- New projects on materials for application in transports
- Up to date research and training
- Relationship with other fields
- Critical mass needed for industrialization and competing with advanced countries
- Critical mass needed for large facilities

Ringraziamenti

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Compagnia di San Paolo

NANOCONTACT

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SMATF1

Progetto SISA

EU-7FP – AccMet

EU-7FP - VitriMetTech

SEVENTH FRAMEWORK PROGRAMME

PRIN vari

MESAP Mechatronics and Systems for Advanced Production

ESA-THERMOLAB

Progetto Automotive
DRAPO'
(Regione Piemonte)

	PROGRAMMA OPERATIVO REGIONALE *"Competitività regionale e occupazione"* **F.E.S.R. 2007/2013**	Asse 1 "Innovazione e transizione produttiva" Misura I.1.1 **"Piattaforme innovative"**