



Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Frascati

NEXT – NanosciencE eXperiment for Technology

"What Next at LNF: scienze dei materiali"

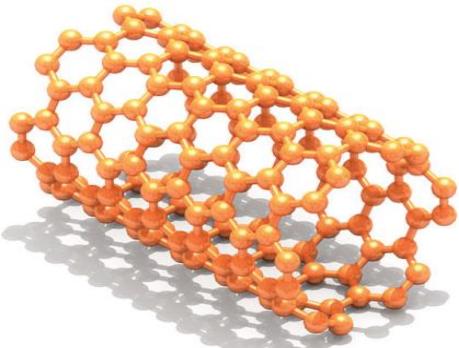
LNF – 26 Febbraio 2015

**Roberto Baldini Stefano Bellucci (Responsabile) Silvia Bistarelli
Cristina Cairone Antonino Cataldo Matteo Mastrucci Federico Micciulla
Ilaria Tabacchioni**

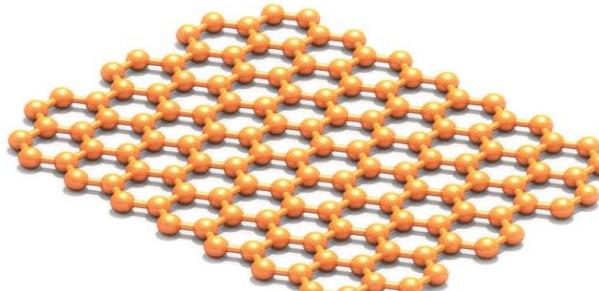
A 360° Sulle NanoTecnologie



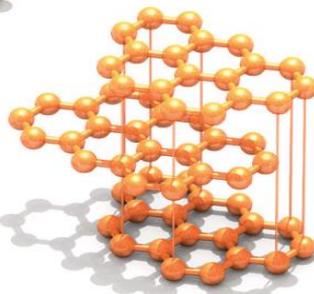
Famiglia del Carbonio



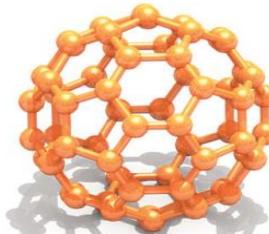
Nanotubo



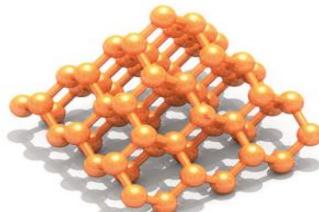
Grafene



Grafite



Fullerene



Diamante



Carbon-based units?



Scarica ad Arco

Parametri di sintesi:

Diametro anodo: 10 mm

Diametro catodo: 6 mm

Distanza

anodo-catodo: ~ 2 mm

Pressione

di vuoto: ~ 2×10^{-4} mbar

Gas utilizzato: He

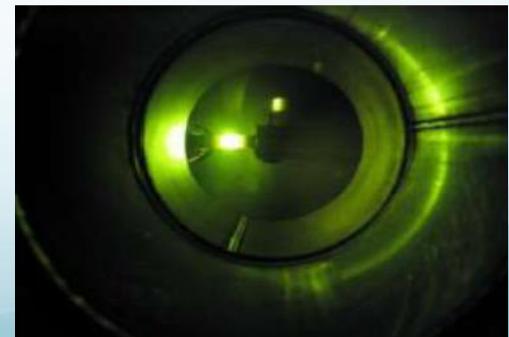
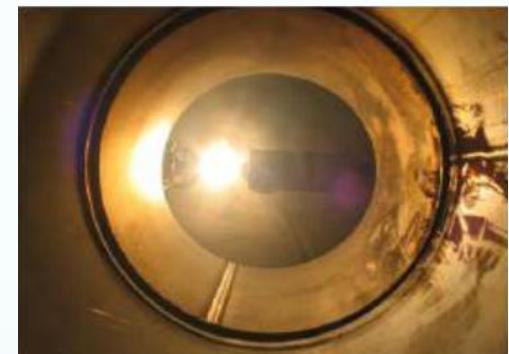
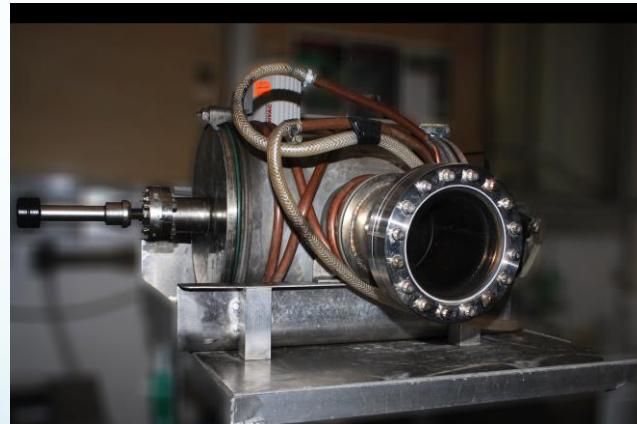
Corrente: 90 A

Voltaggio: ~ 20 V

Pressione

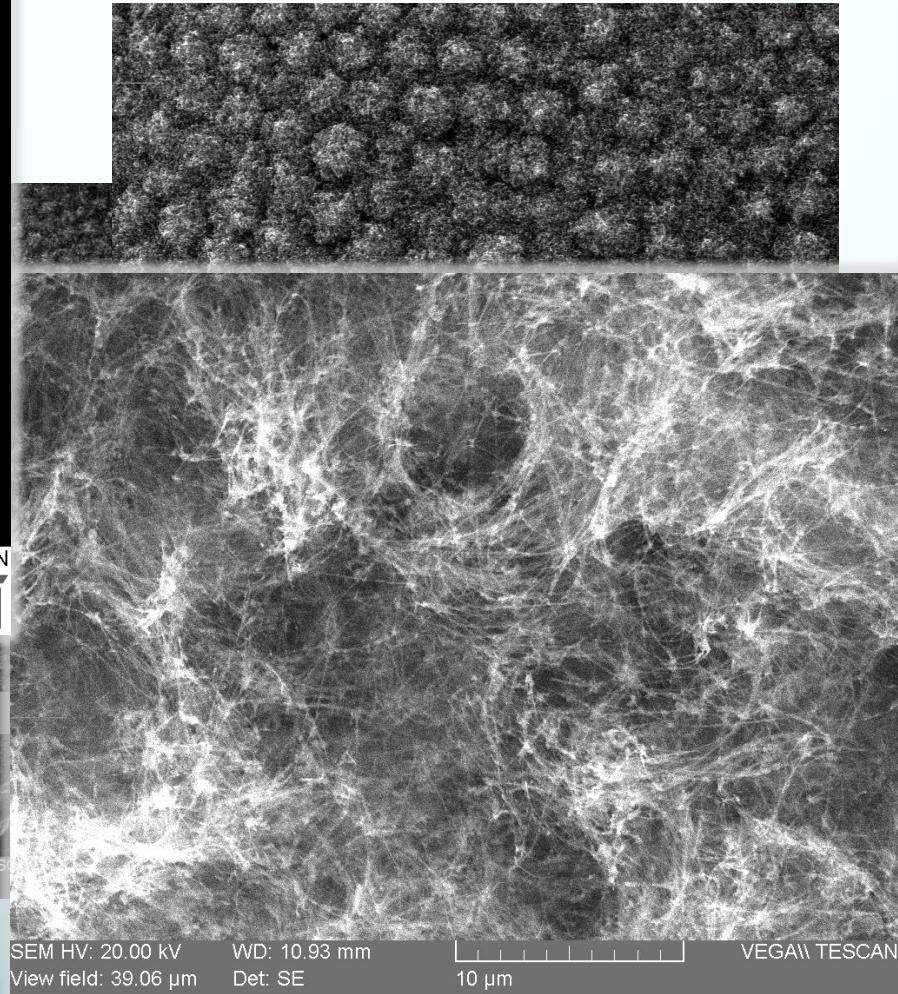
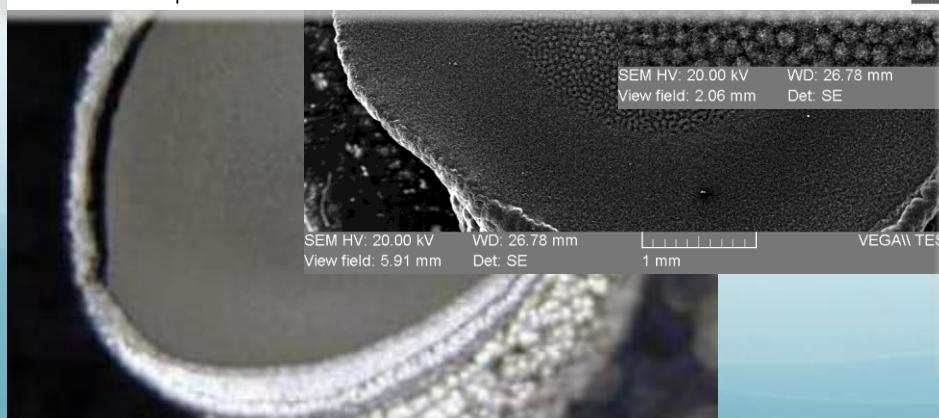
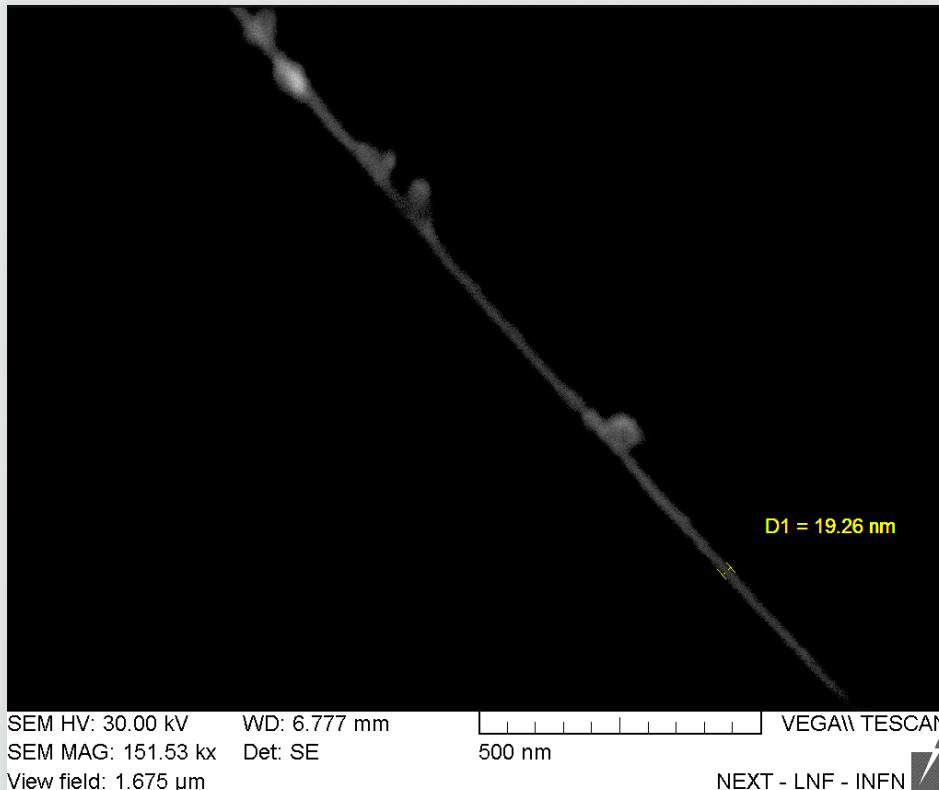
di esercizio: 600 mbar

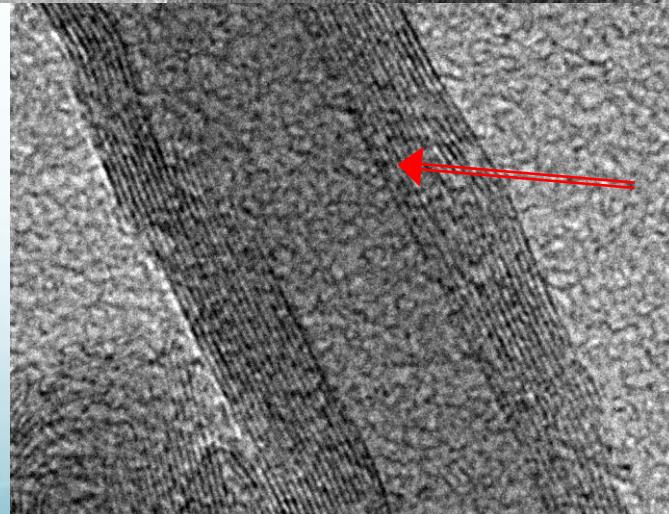
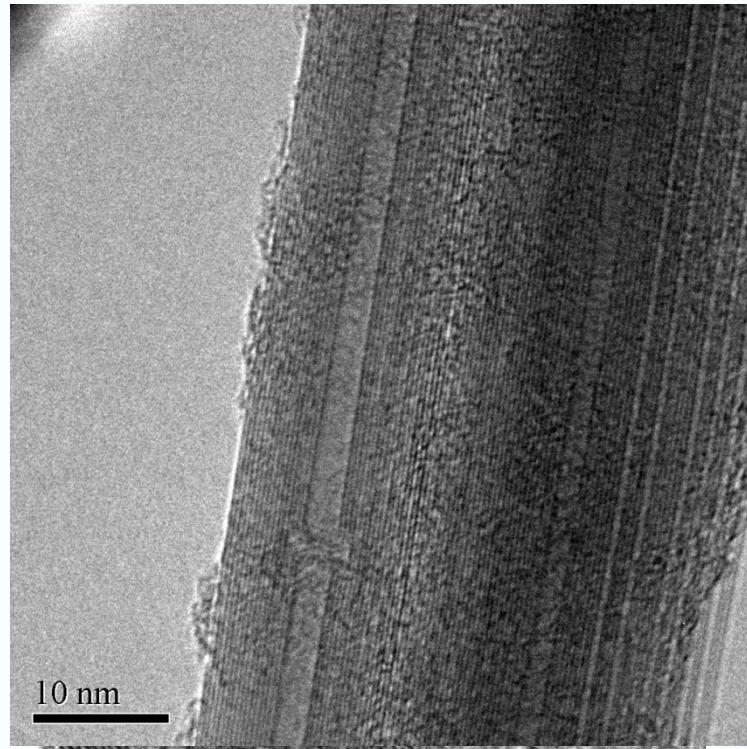
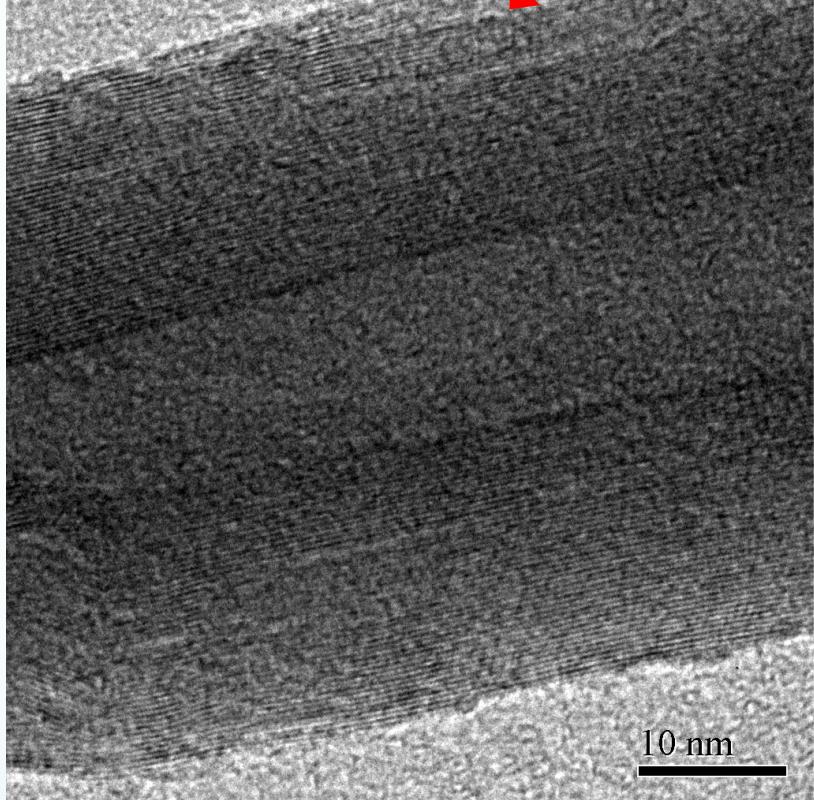
Durata: ~ 50 min.



Caratterizzazione al SEM

presso il nostro laboratorio

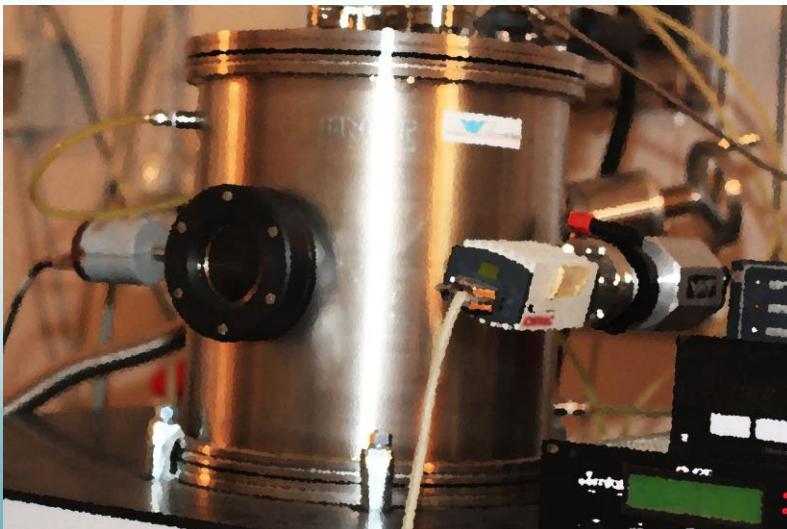




Immagini TEM

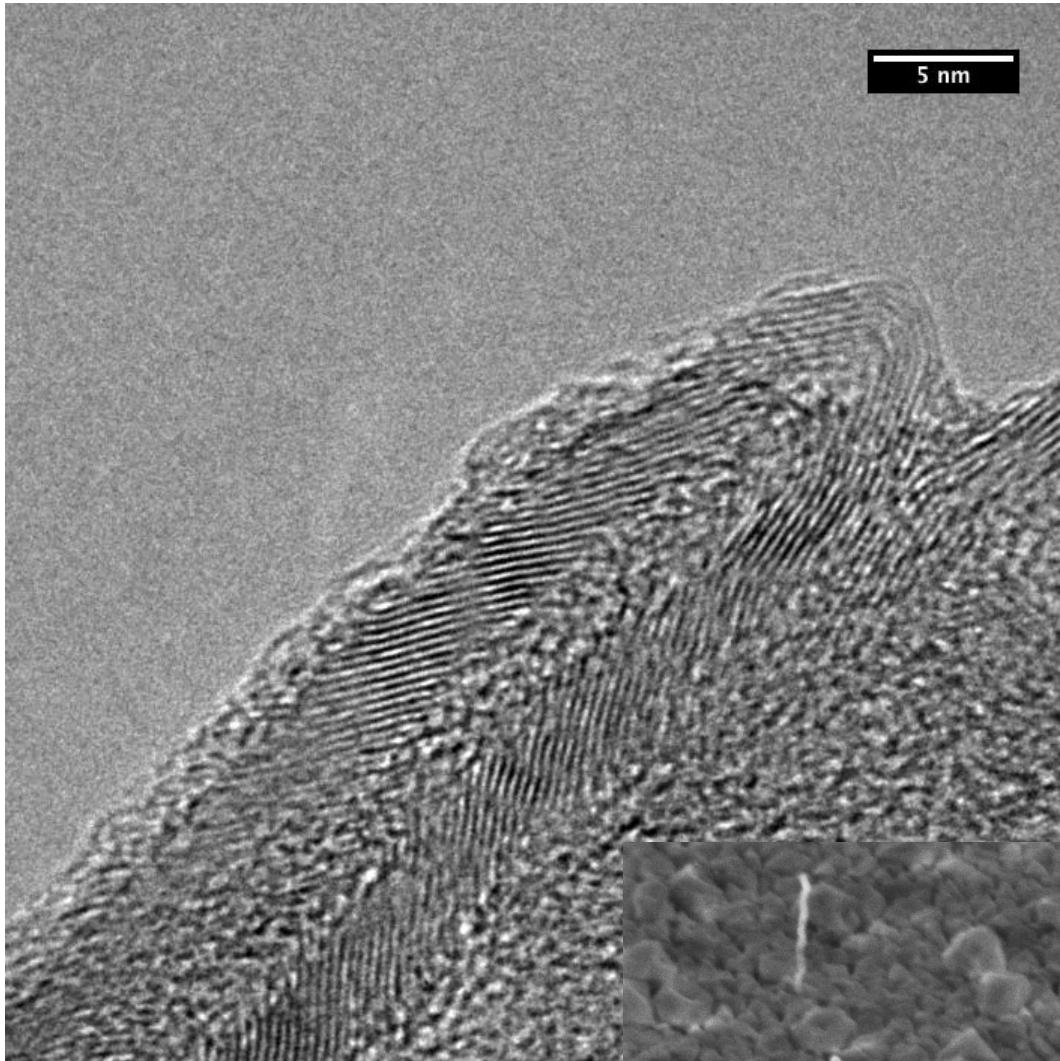
Chemical Vapour Deposition

Hot Filament

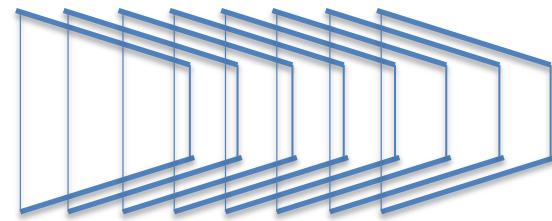


Gas di solito un Idrocarburo (HC)

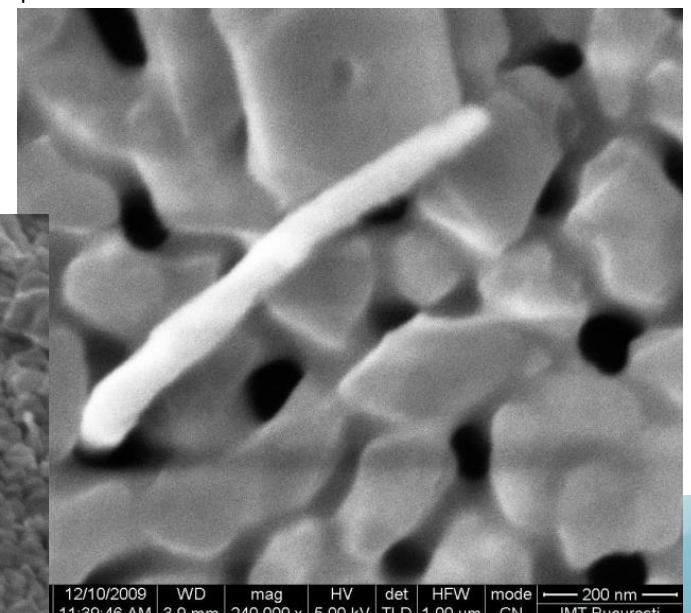
CH_4 – Metano
 C_2H_2 - Acetilene



LNF CVD – Carbon Nanotubes grow Into alumina memnbrane porous

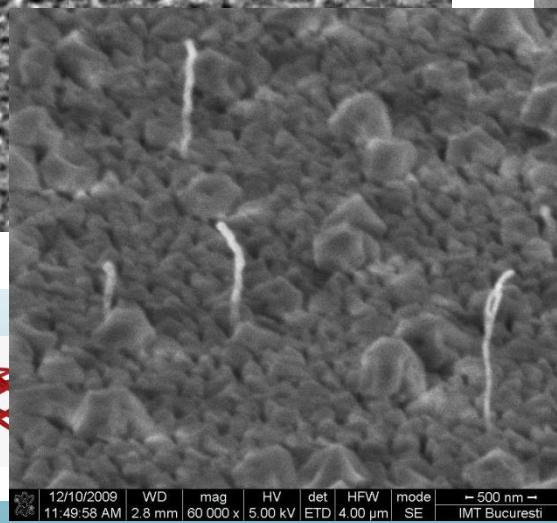


...'composed'of'stacked'graphene'nanocones'with' truncated'Ops,'realizing'a'hollow'structure,' some0mes,'as'in'this'tube,'ending'with'closed' nanocones'at'one'end.'



CATHERINE

HIGH-SPEED INTERCONNECTS



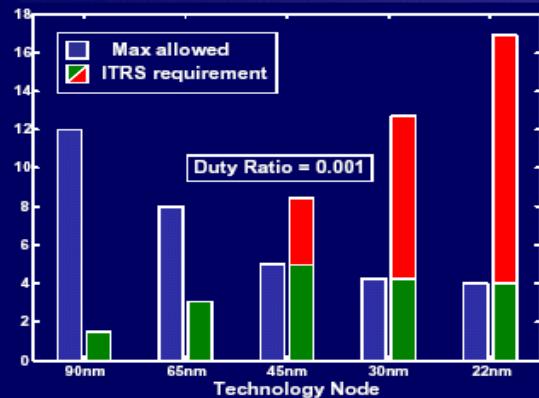
12/10/2009 | WD | mag | HV | det | HFW | mode | — 200 nm —
11:39:46 AM | 3.9 mm | 240 000 x | 5.00 kV | TLD | 1.00 μm | CN | IMT Bucuresti

12/10/2009 | WD | mag | HV | det | HFW | mode | — 500 nm —
11:49:58 AM | 2.8 mm | 60 000 x | 5.00 kV | ETD | 4.00 μm | SE | IMT Bucuresti

Next-generation nano-interconnects

Limitazione dall'utilizzo del Cu:

- Electromigration Lifetime: strongly reduces with temperature
- Limits maximum current carrying capacity....

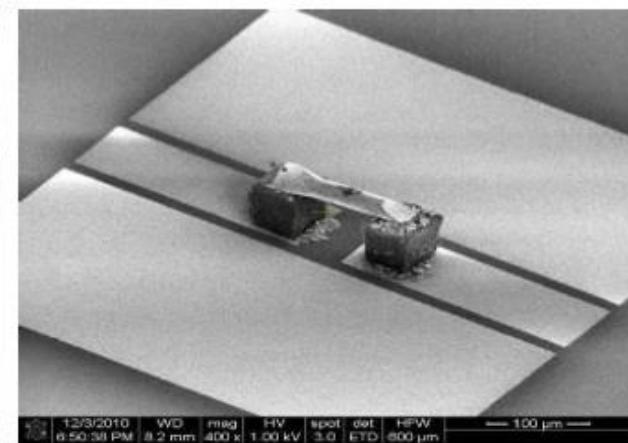
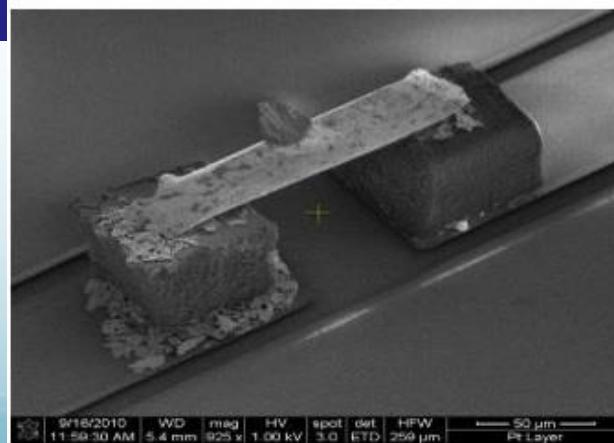


Maximum allowed J based on self-consistent (EM+Self-heating) solutions...

Significant deficit in current carrying capacity for local vias....

Increasing via size and/or number will be expensive....

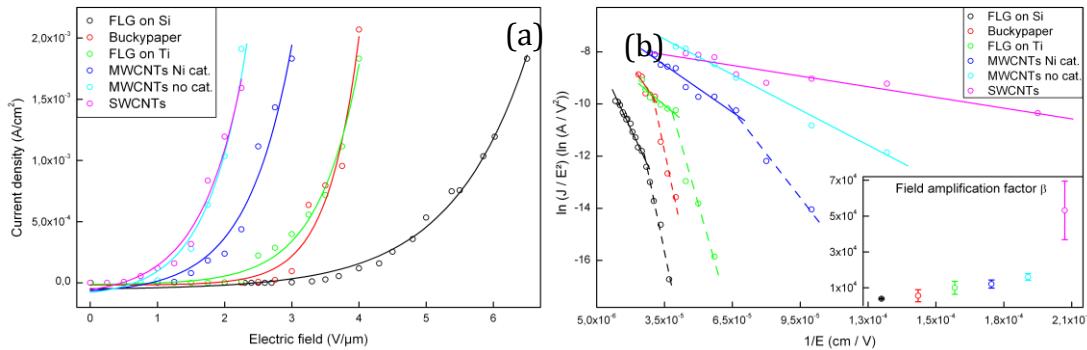
Im et al., IEDM 2002; Srivastava et al., VMIC 2004



Field Emission

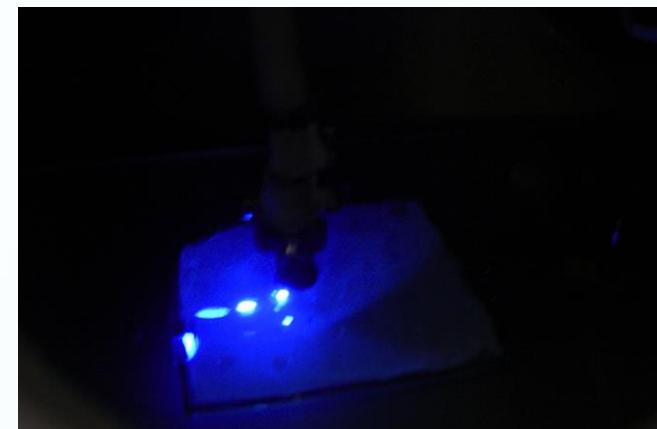


S. Bellucci et al Journal of Nanophotonics, Vol. 4, 043501 (2010)

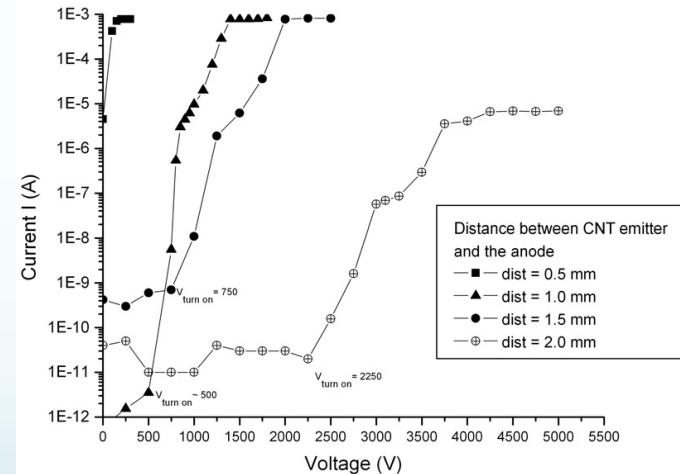


In (a), the current density is presented as a function of applied electric field for: FLG grown on silicon, FLG grown on titanium, buckypaper, SWCNTs, MWCNTs grown without a catalyst and MWCNTs grown with a nickel catalyst. The same field emission data is plotted in (b) according to the FN equation. The inset shows the field amplification factors obtained from the slope of the linear continuous fit.

S. Bellucci et al. Nanoscience and Nanotechnology Letters
10/2011; 3(6):907-912.



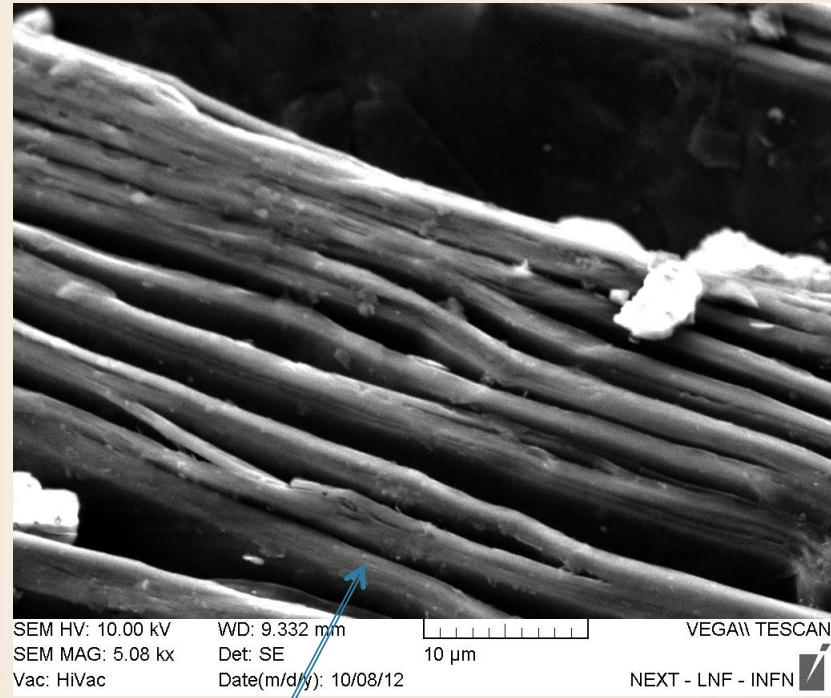
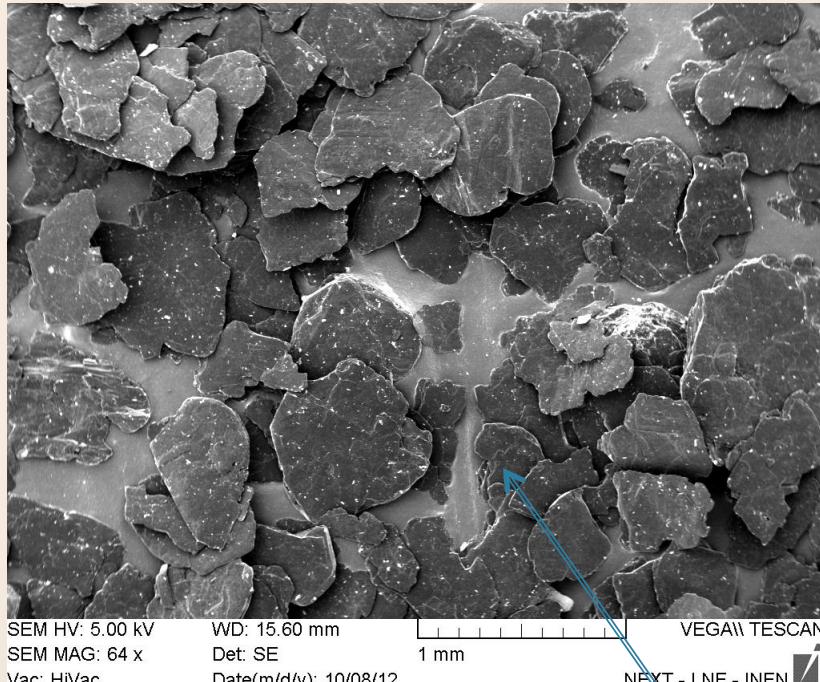
Semi-log plot of FE current vs applied voltage for CNT prepared by arc discharge



S. Bellucci et al

Journal Phys.: Condens. Matter 19 (2007) 395014 (7pp)

Graphene NanoPlates

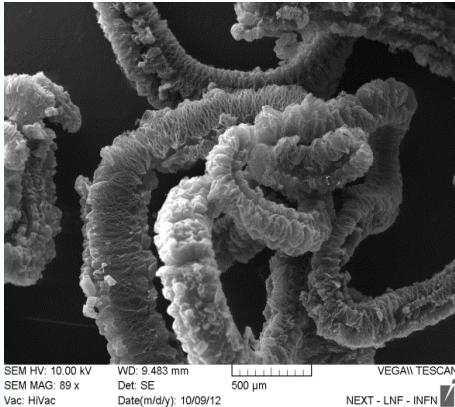


Grafite intercalata con solfiti o nitrati

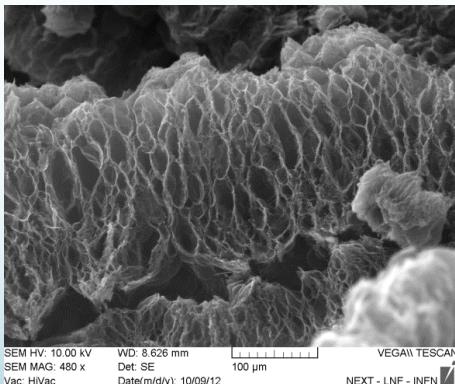
Graphene NanoPlates

After expansion

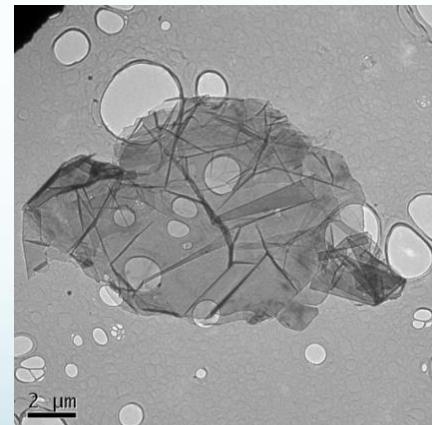
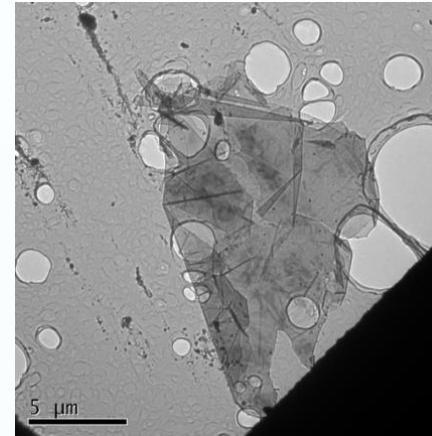
- Worm like structure



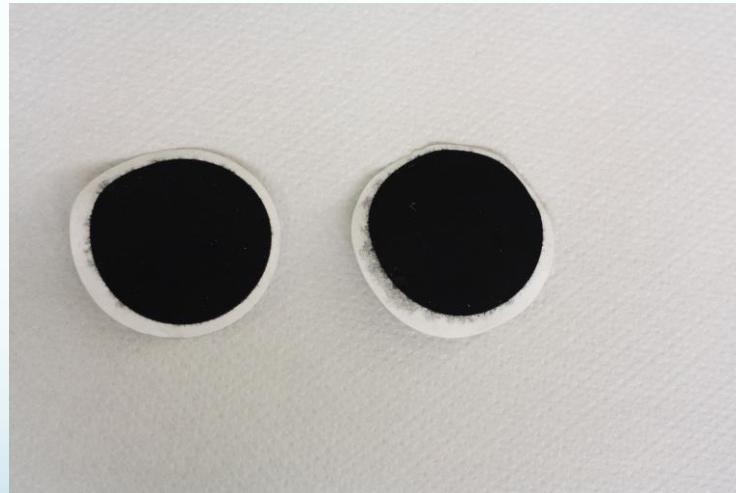
Ultrasonic Bath



- Very large particle area
- Thickness: 4±5 planes

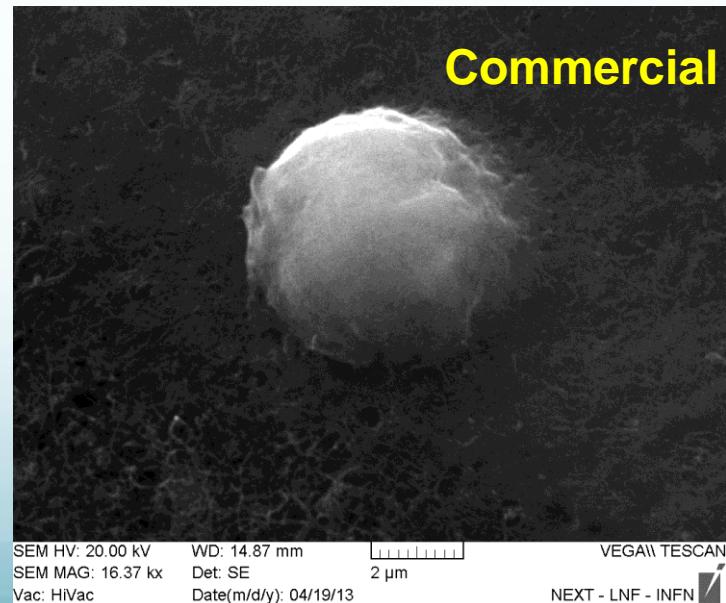
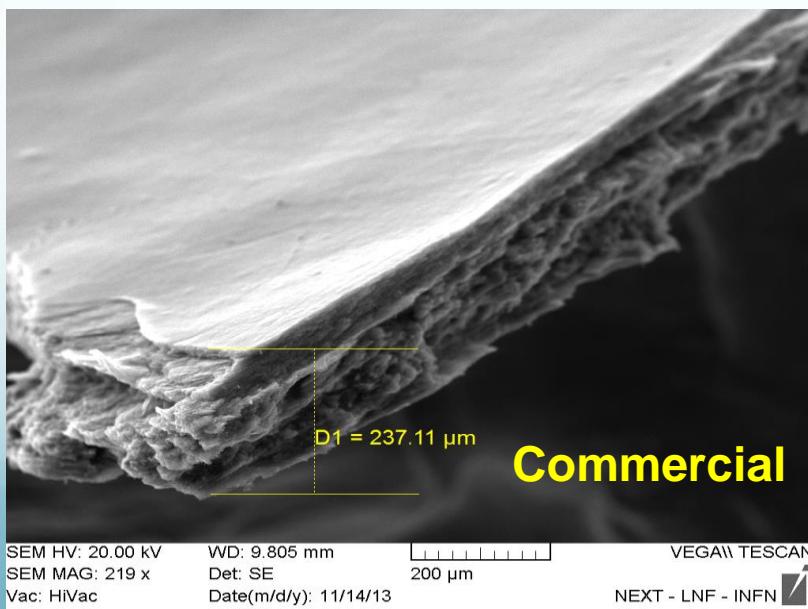


By means of a short treatment with **ultrasounds in isopropylic alcohol**, the graphene layers can be free from the worm like overall structure, thus forming particles with the two dimensional lateral sides having sizes about tens micrometers and a thickness less than 2-3 nm

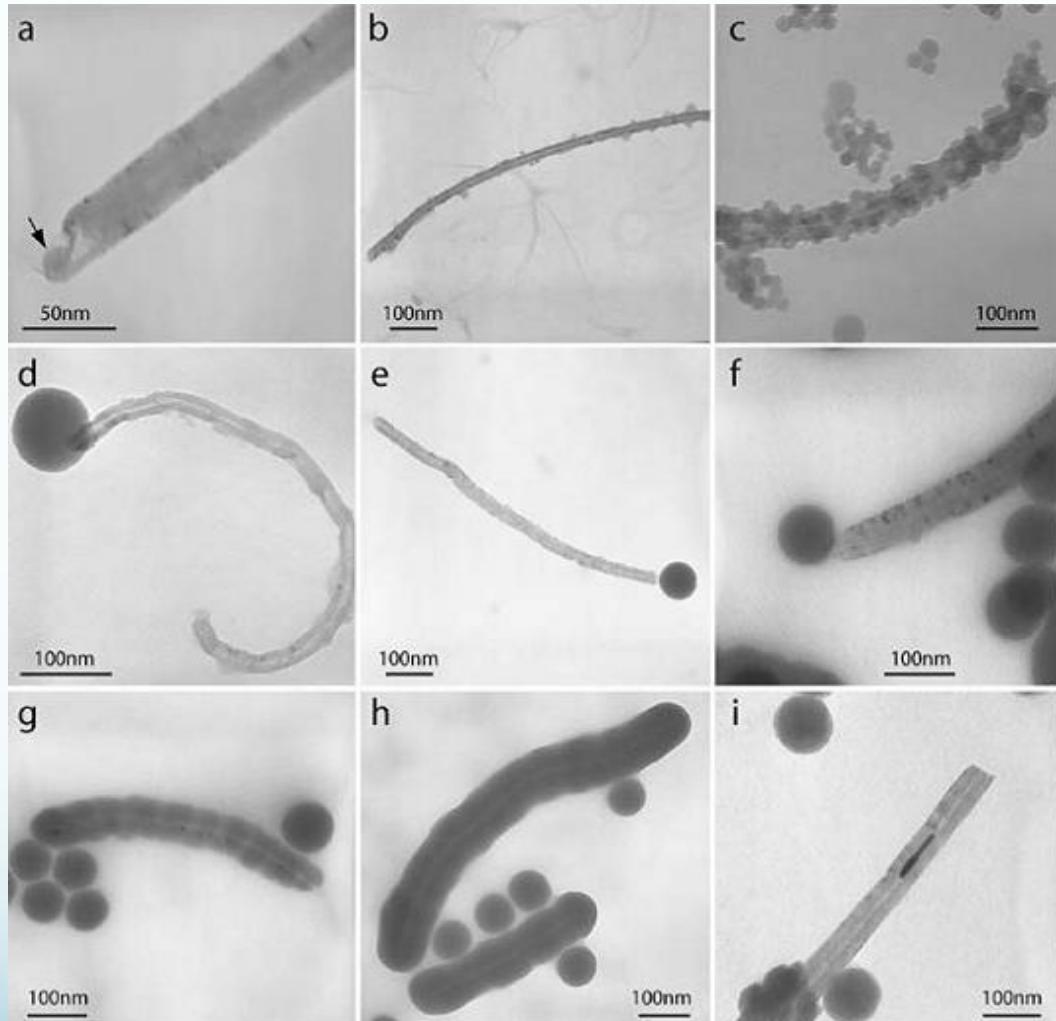


Filtrazione

Buckypaper



Funzionalizzazione per Biosensore



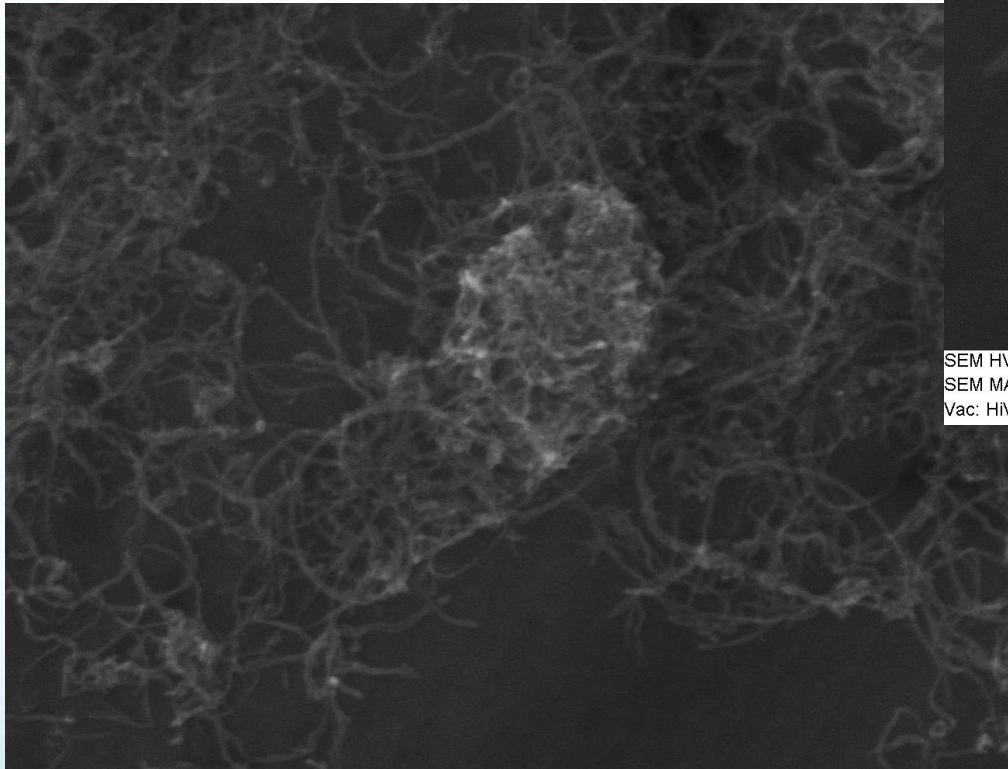
Transmission electron microscopic images of the CNT–nanocomposites prepared using conditions for small (a–c) or large (d–i) silica nanobeads.

The arrow in panel (a) indicates a nanobead at the tip of the CNT.

The arrow in panel (i) indicates a polymerized silica inside a CNT.

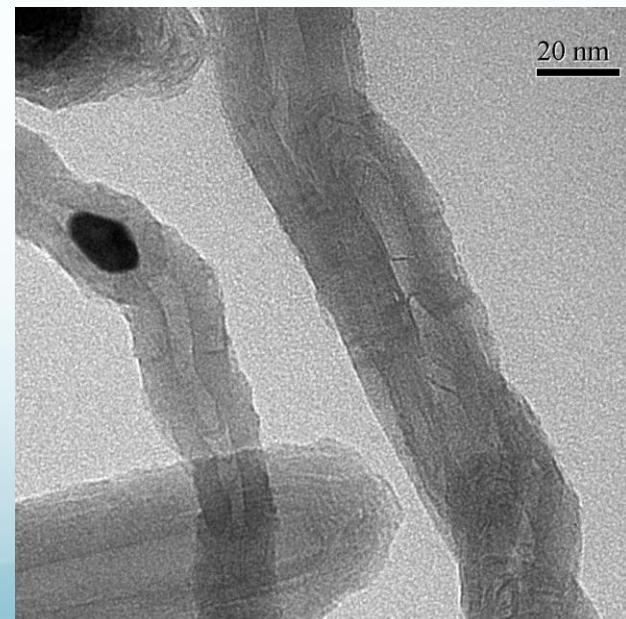
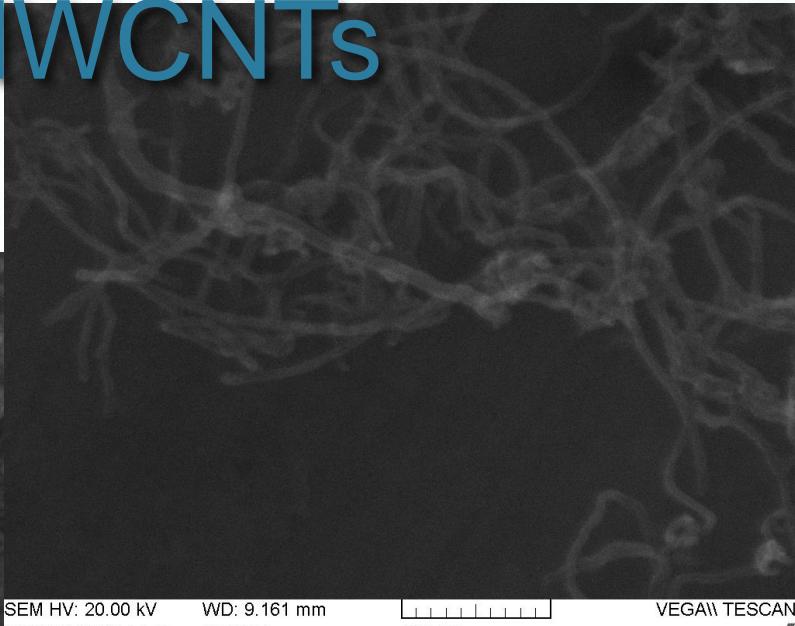
Commercial CVD MWCNTs

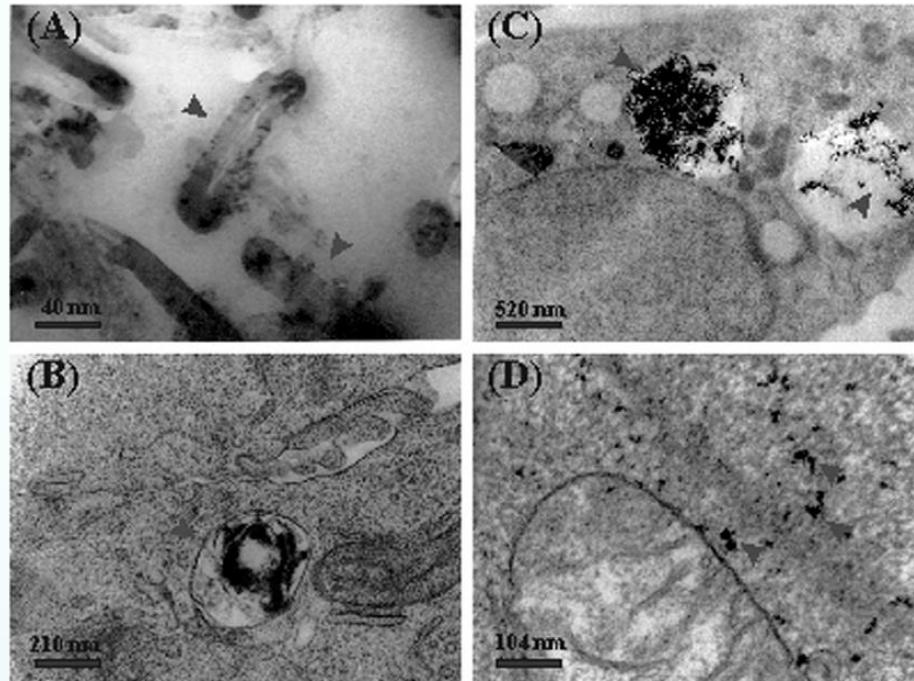
20-40nm



SEM HV: 20.00 kV WD: 9.159 mm
SEM MAG: 38.33 kx Det: SE
Vac: HiVac Date(m/d/y): 12/17/14

2 μm VEGA\ TESCAN
NEXT - LNF - INFN



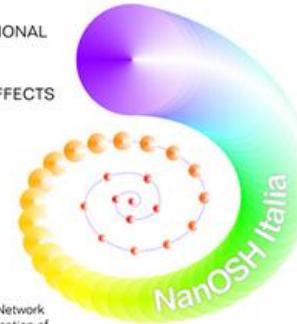


Transmission electron microscopy of (A) MWCNTs; (B) MWCNTs inside MCF-7 cellular vesicle; (C) MWCNTs-COOH inside MCF-7 cellular vesicles; (D) cytosolic distribution of MWCNTs-OH in MCF-7 cells.

MULTIWALLED CARBON NANOTUBES-INDUCED CYTOTOXIC EFFECTS ON HUMAN BREAST ADENOCARCINOMA CELL LINE

S. Bellucci, S. Dinicola, P. Coluccia, M. Bizzarri, A. Catizone, F. Micciulla, I. Sacco, G. Ricci, A. Cucina – CAS 2012 – International Semiconductor conference - 978-1-4673-0738-3/12/\$31.00 © 2012 IEEE

Tossicità

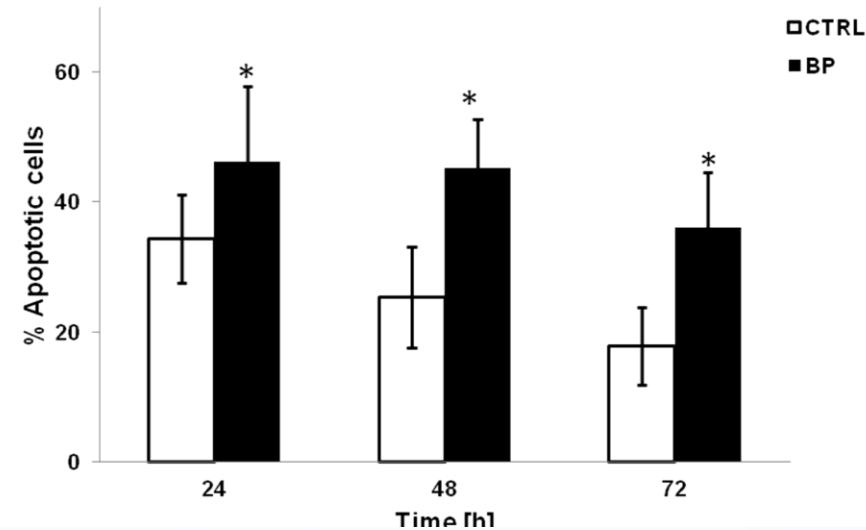


Produced by
The National Network
for the identification of
preventive and protective
measures related to the occupational
exposure to nanomaterials (NanOSH Italia)

The cytotoxicity evaluation of MWCNT buckypaper treatment on human and cancer cells was carried out for the first time on **human colorectal, breast and leukemic cancer cell lines in vitro**, while having no effect on proliferation and viability of normal human arterial smooth muscle cells and human dermal fibroblasts in vitro.



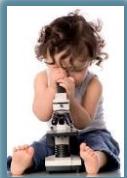
Tossicità



Growth inhibition, cell-cycle alteration and apoptosis in stimulated human peripheral blood lymphocytes by multiwalled carbon nanotube buckypaper, O Zeni, A Sannino, S Romeo, F Micciulla, S Bellucci, MR Scarfi Nanomedicine, 1-10 (2014)
Cytotoxicity of Multiwalled Carbon Nanotube Buckypaper in Human LymphocytesO Zeni, A Sannino, S Romeo, MR Scarfi, L Coderoni, F Micciulla, I Sacco, ...

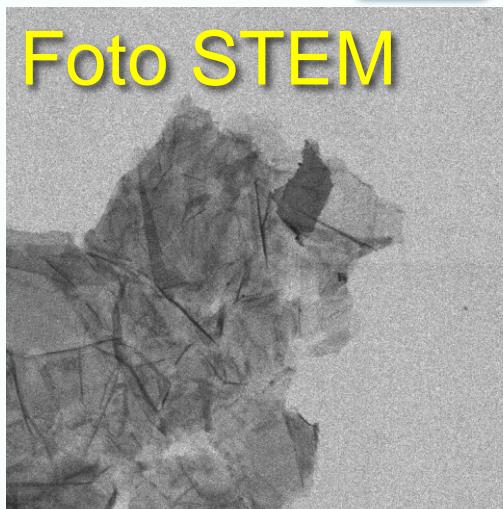
Sensors and Microsystems, 489-493 (2011)

Toxicological and biological in vitro and in vivo effects of carbon nanotubes buckypaperS Bellucci
Semiconductor Conference, 2009. CAS 2009. International 1, 107-116

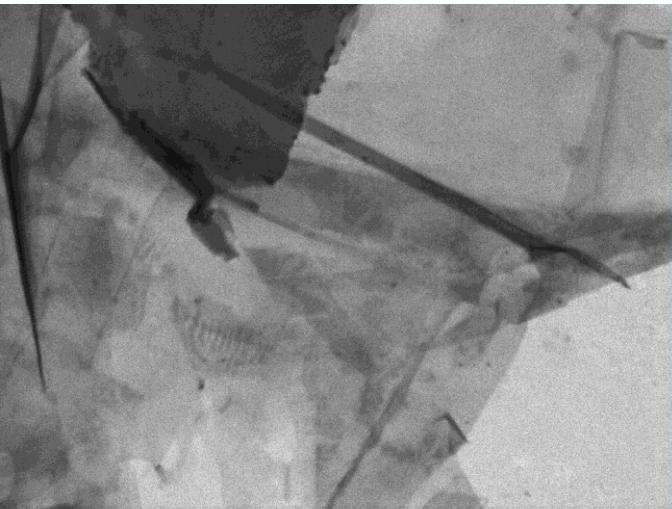


Microscopia

Foto STEM

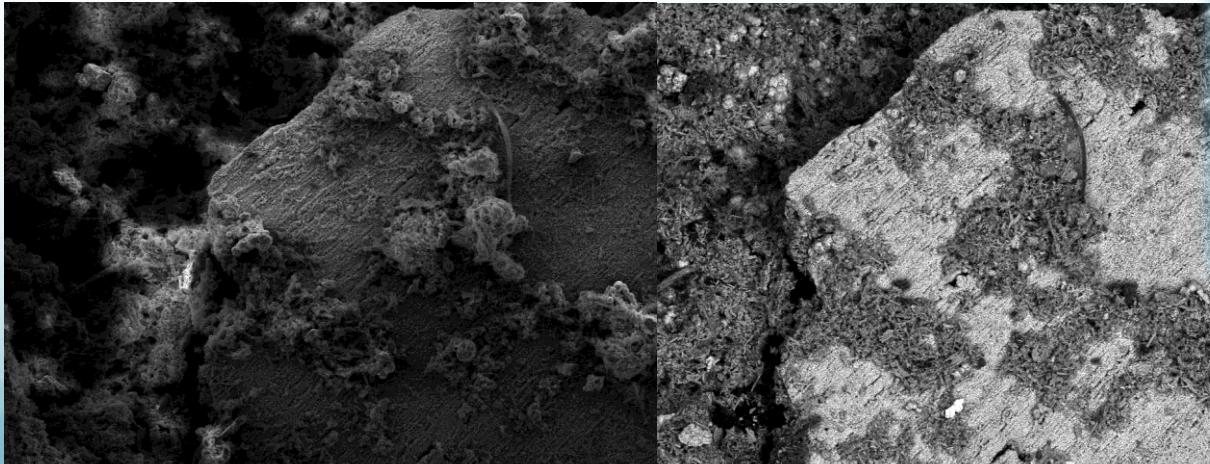


SEM HV: 30.00 kV WD: 7.048 mm
SEM MAG: 11.70 kx Det: TE_b
Vac: HiVac Date(m/d/y): 06/25/14



SEM HV: 30.00 kV WD: 7.454 mm
SEM MAG: 62.11 kx Det: TE_b
Vac: HiVac Date(m/d/y): 06/25/14

VEGA|| TESCAN
NEXT - LNF - INFN



SEM HV: 20.00 kV WD: 15.60 mm
SEM MAG: 201 x Det: SE
Vac: HiVac Date(m/d/y): 01/22/15

VEGA|| TESCAN 0.00 kV
201 x
NEXT - LNF - INFN

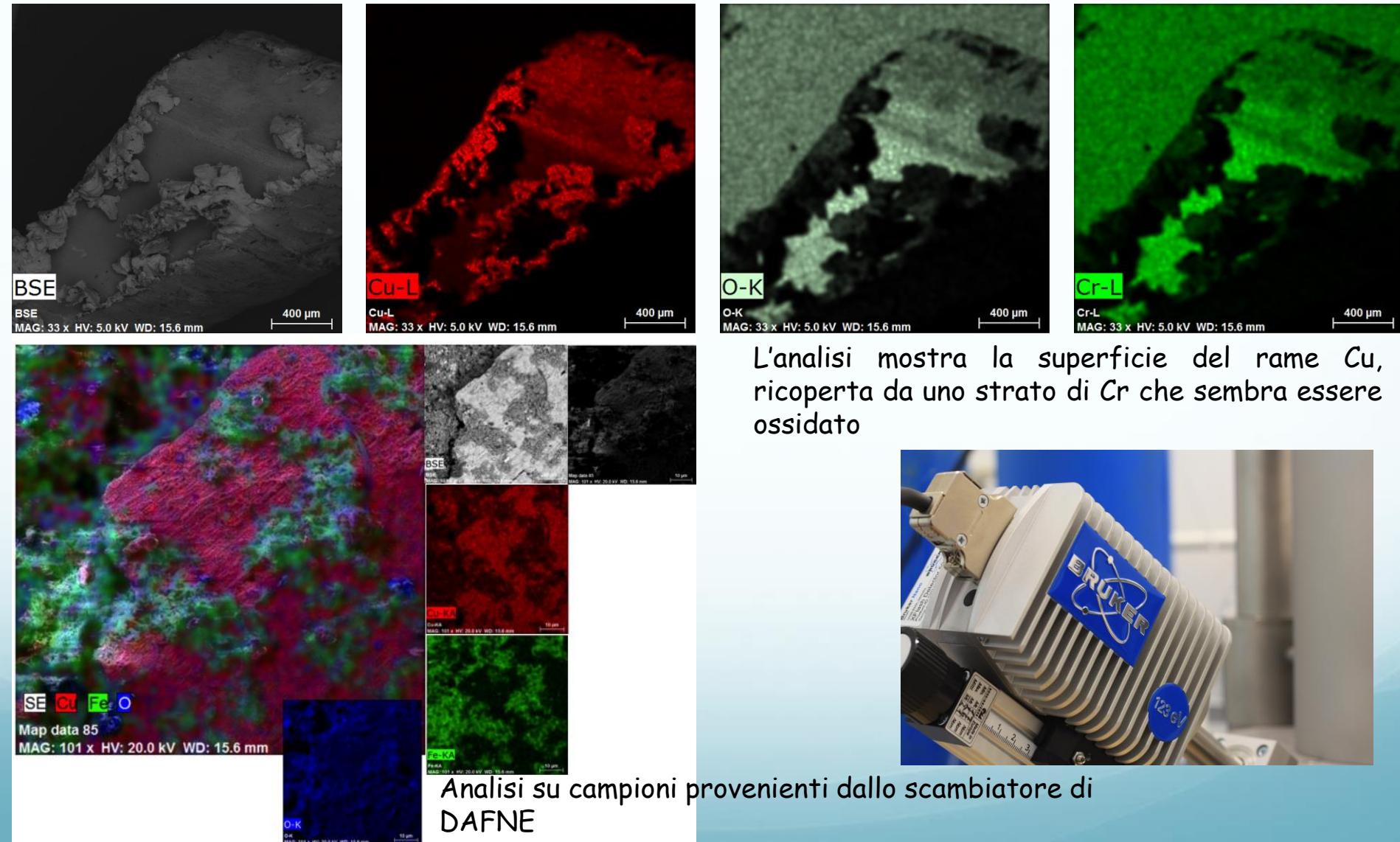
WD: 15.60 mm 200 µm
Det: BSE
Date(m/d/y): 01/22/15

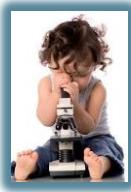
VEGA|| TESCAN
NEXT - LNF - INFN



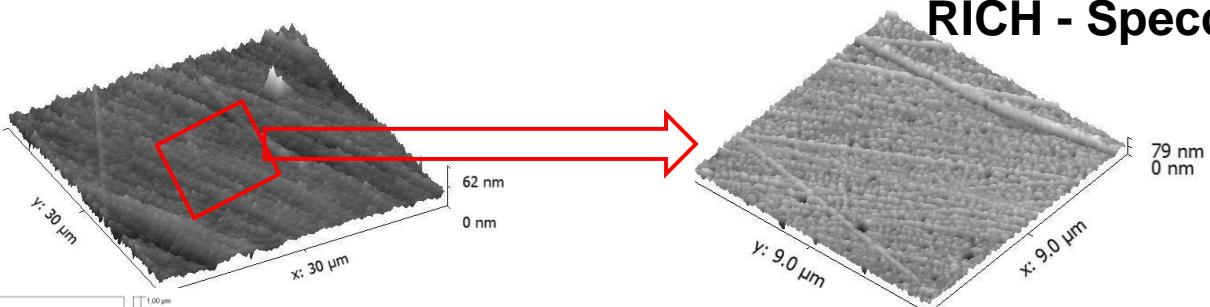
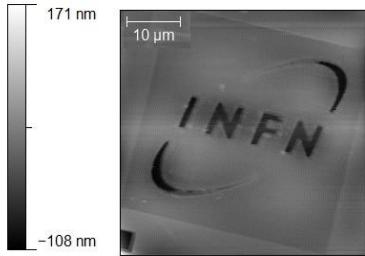
Characterization: Images SEM, Example 1

Cu sample obtained from resonant cavity in LNF DAPHNE particle accelerator
Elemental Microanalysis @ NEXT Nanotechnology Laboratory INFN-LNF

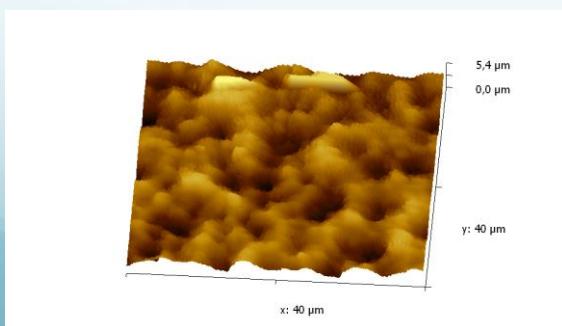
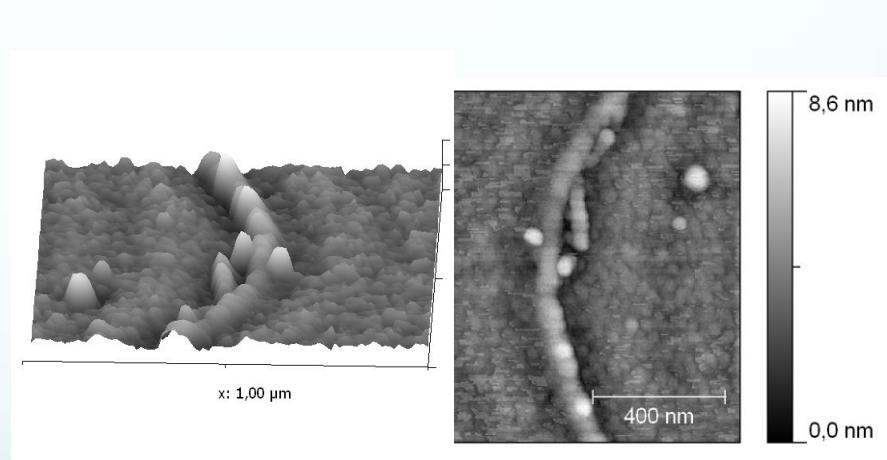
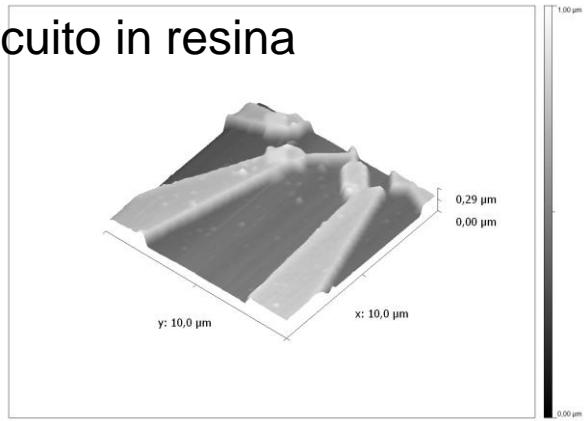




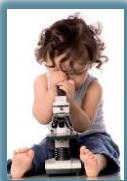
Microscopia



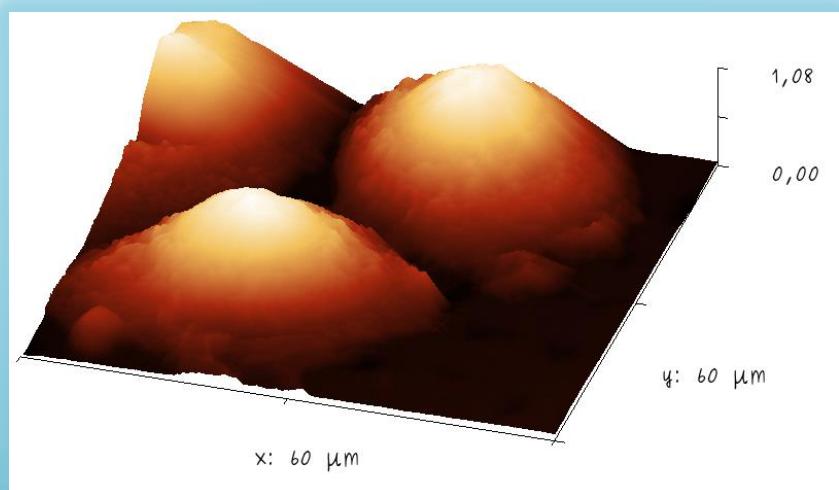
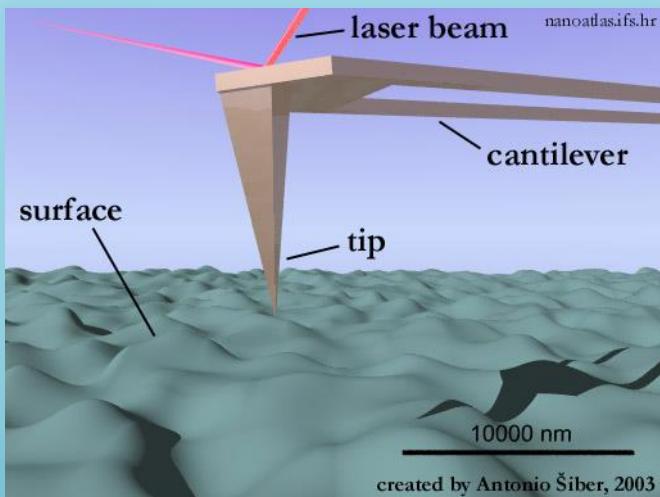
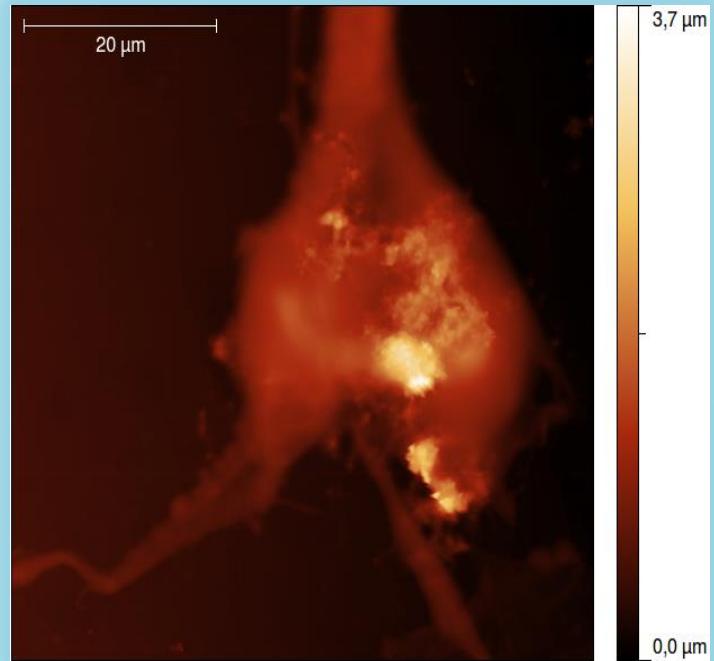
Circuito in resina



Superficie di Vetro con nanoparticelle di Rame



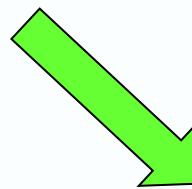
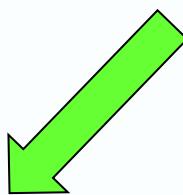
Microscopia



Materiali nanocompositi

Matrice

- Resina epossidica
- Ceramiche
(Allumino Fosfato)



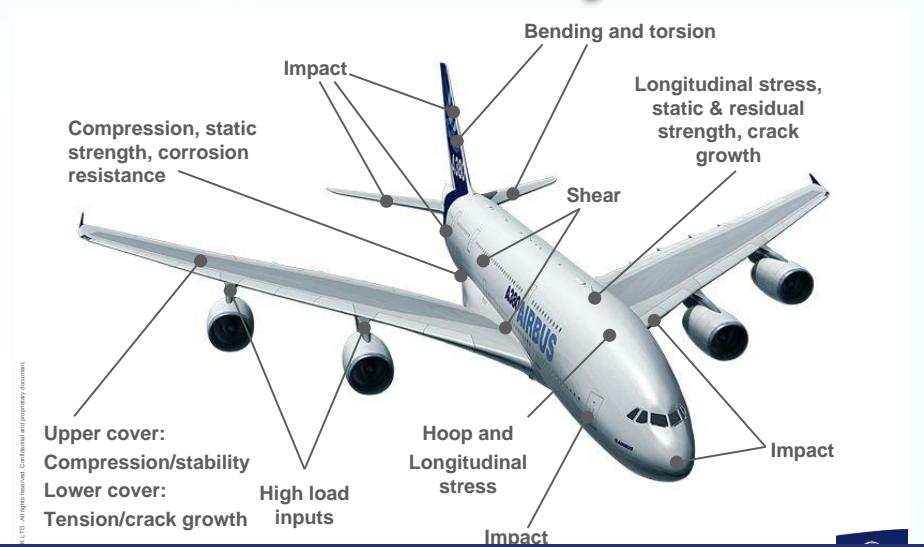
Filler

- Nanotubi di carbonio
- GNPs
- SiC
- CB
- Grafite
- WS₂

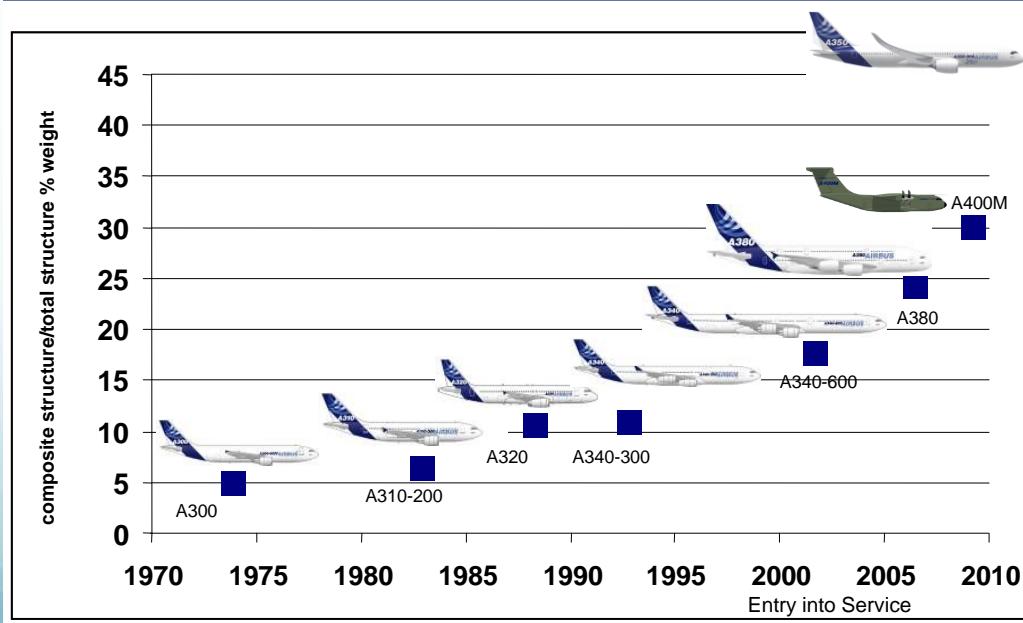
Realizzazione di un nanocomposito con funzione
di rivestimento contro le EMI.



Applicazioni dei nanocompositi

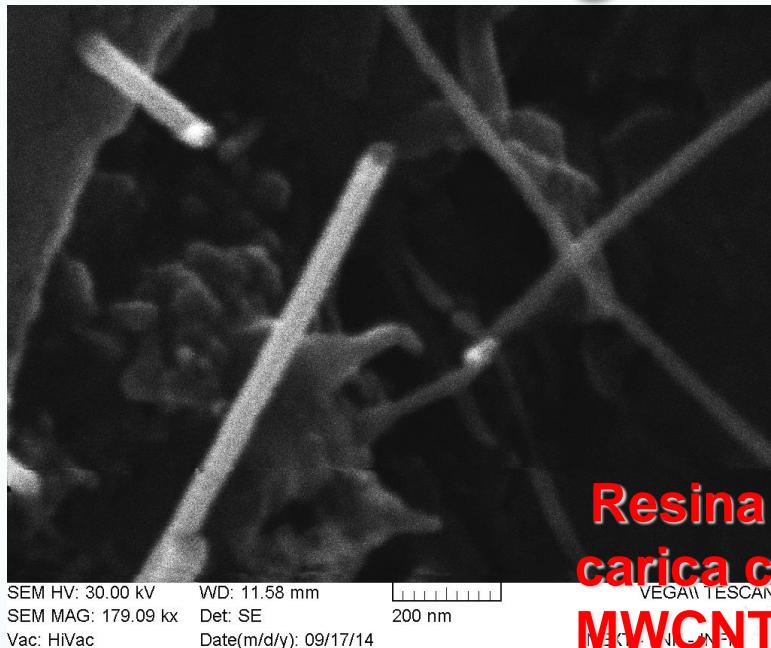


Composites introduction on Airbus aircraft

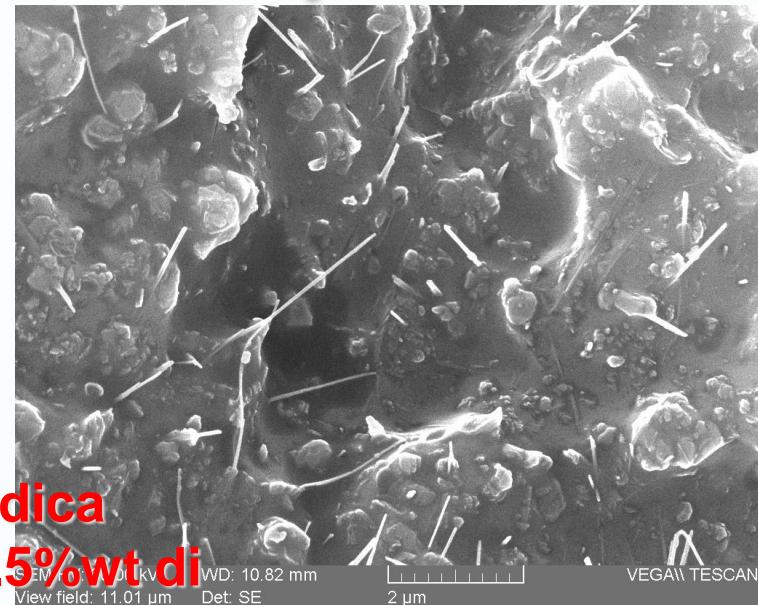
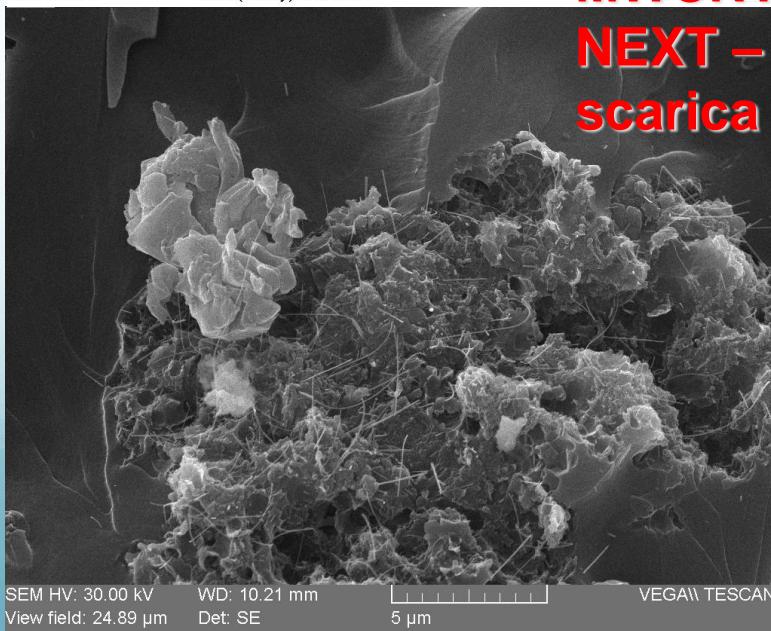


Fonte Airbus 2007

Immagini di Nanocompositi



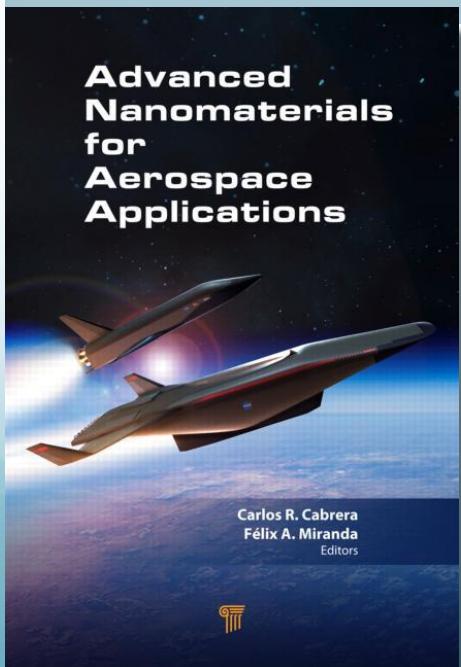
Resina Epossidica
carica con lo 0.5%wt di
MWCNT prodotti nel
NEXT – LNF con la
scarica ad arco



Shielding Effectiveness

PRIN2008- DENSE; EU FP7 BY- NanoERA project FP7-266529; FP7 project FAEMCAR

- ✓ Nuovi Materiali con elevata efficienza di schermatura elettromagnetica e adatte proprietà meccaniche e chimico fisiche (peso, resistenza a corrosione, etc.) possono显著mente accrescere la Compatibilità Elettromagnetica; **prevenire** gli accessi non autorizzati ad informazioni del networks; **ridurre** l'impatto su apparati elettronici da attacchi dovuti a impulsi EM;

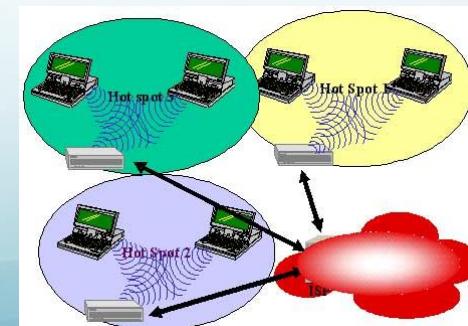


- ✓ Progettazione di un **coating elettromagnetico** con proprietà controllate..

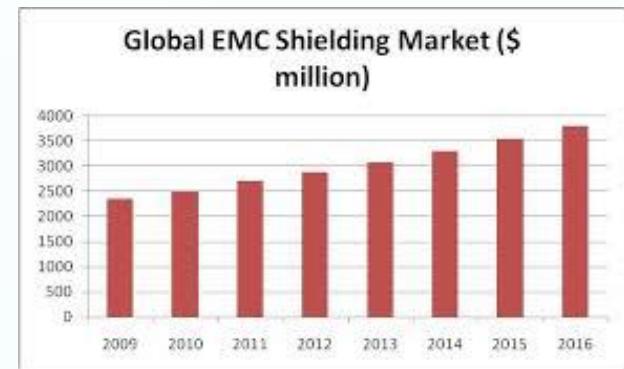
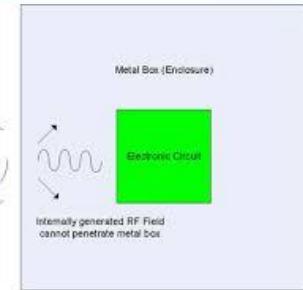
Information Technology Shielding



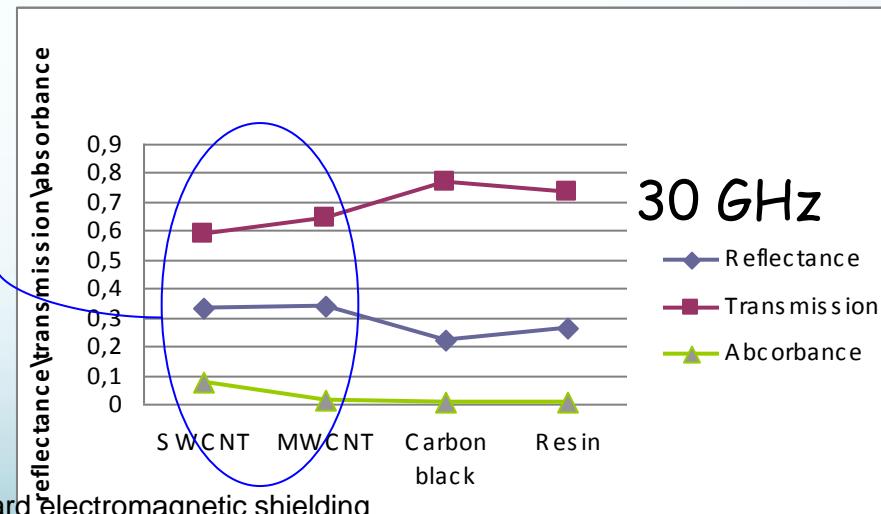
Wireless Handset Shielding



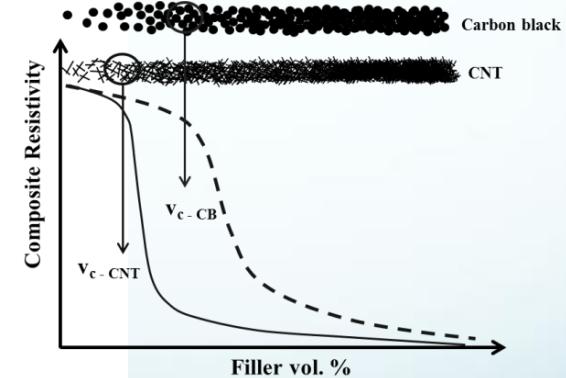
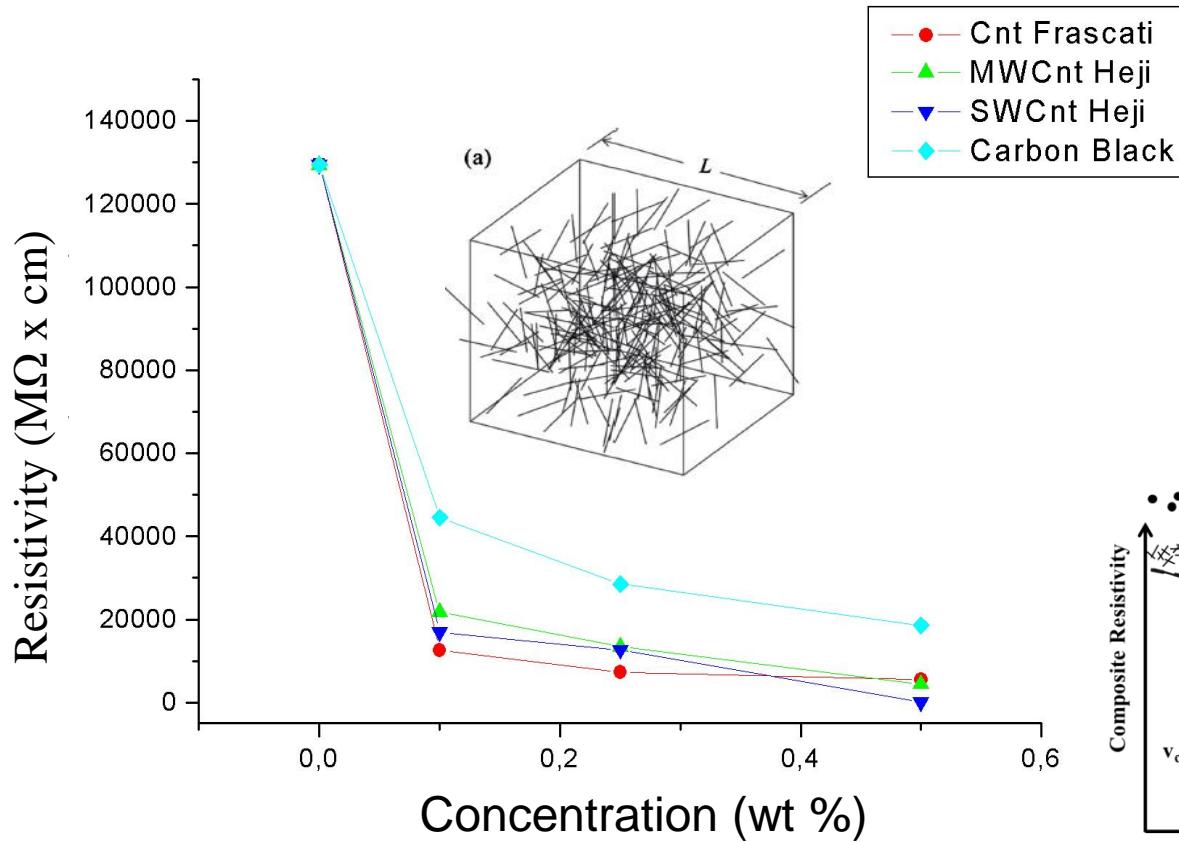
Shielding Effectiveness



- ✓ SWNT in 0.5wt% being incorporated into epoxy resin leads to 20% increase of reflectance ability and up to 10% increase of absorption ability of the given resin based composites
- ✓ MWNT in 0.5wt% contribute slightly less than SWNT

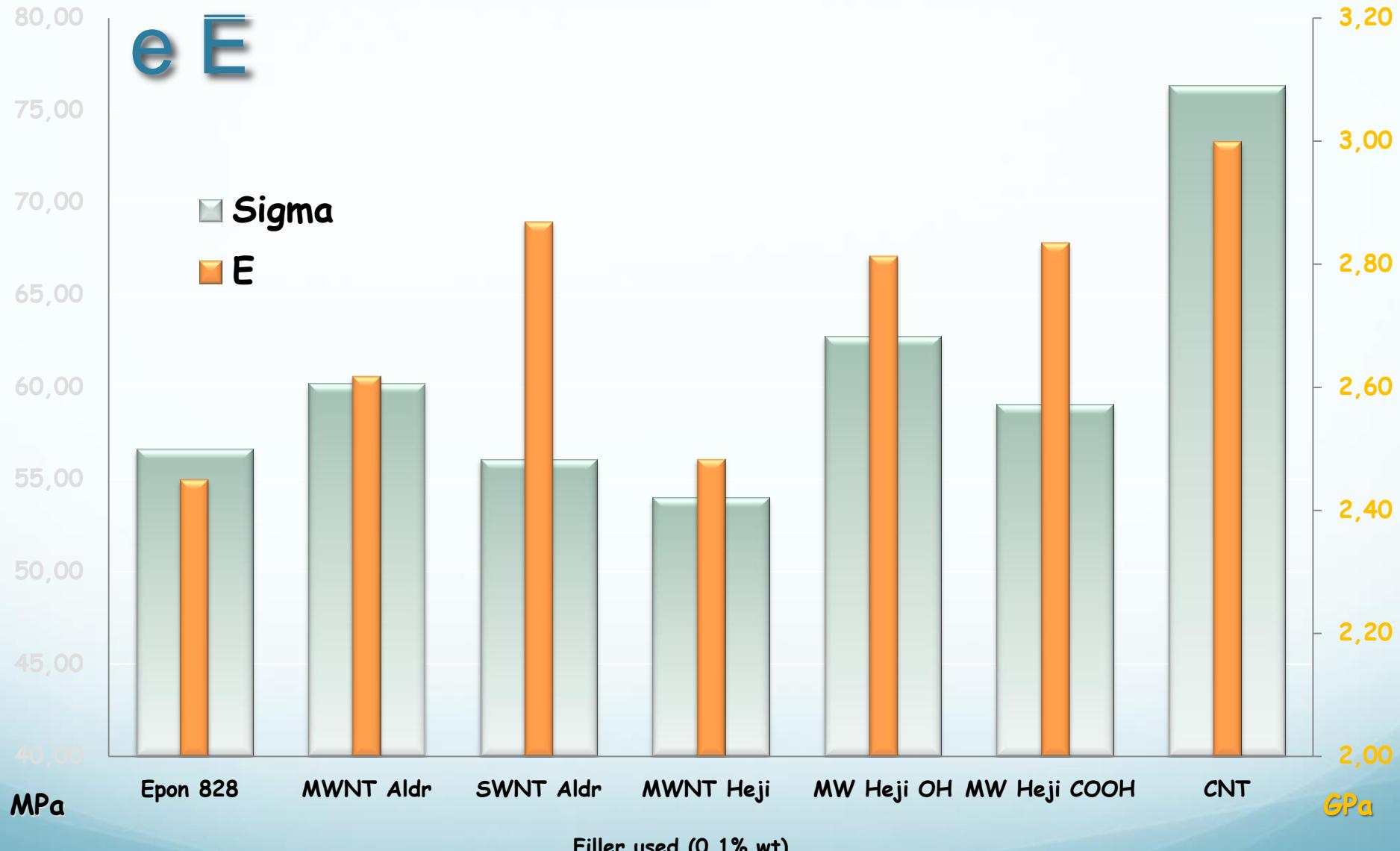


Resistivity vs Concentration



Smart Materials and Structures Based on Carbon Nanotube Composites- Sang-Ha Hwang, Young-Bin Park, Kwan Han Yoon and Dae Suk Bang

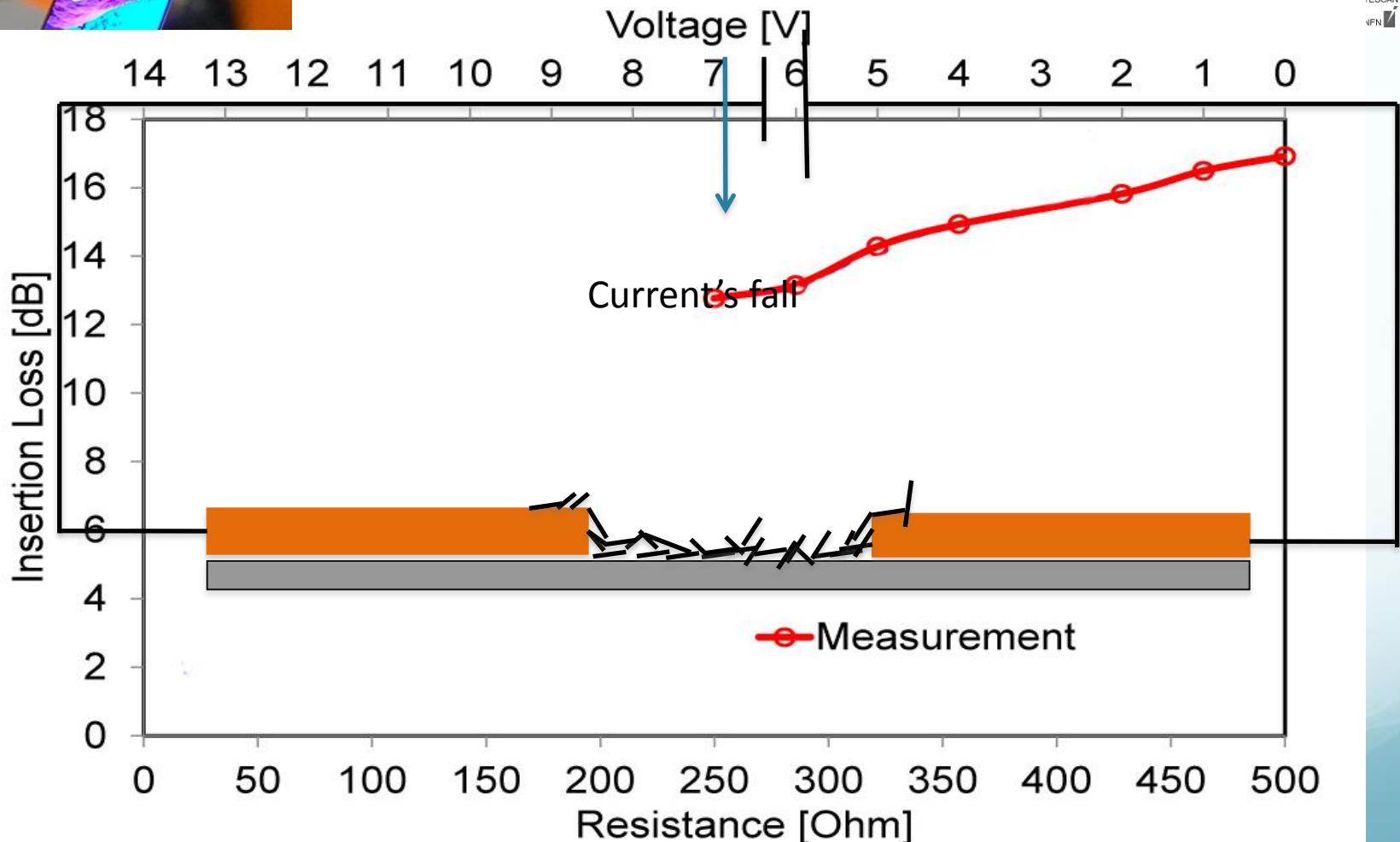
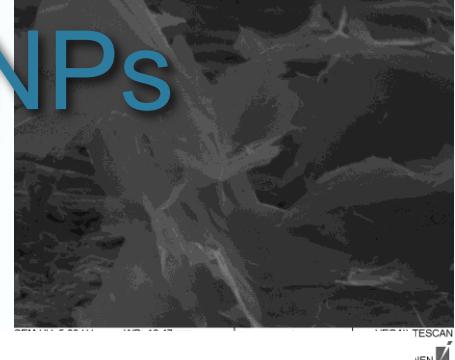
L'effetto del metodo di sintesi su σ e E



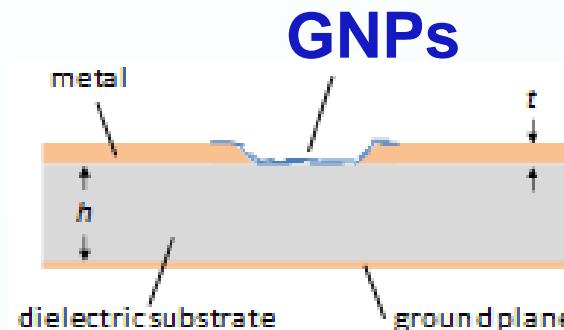
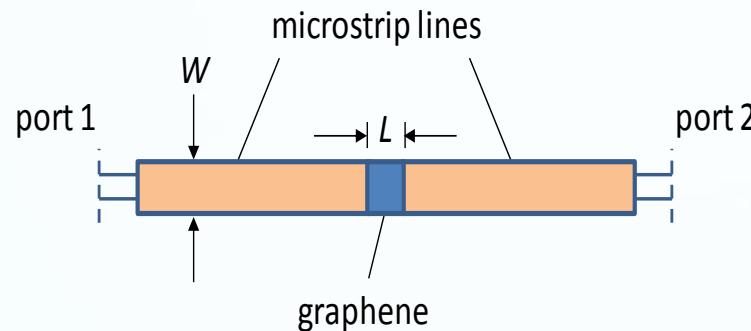
S.Bellucci, F Micciulla, I Sacco, G De Bellis, G Rinaldi

Electromagnetic Compatibility, 2009. EMC 2009. IEEE International Symposium ...

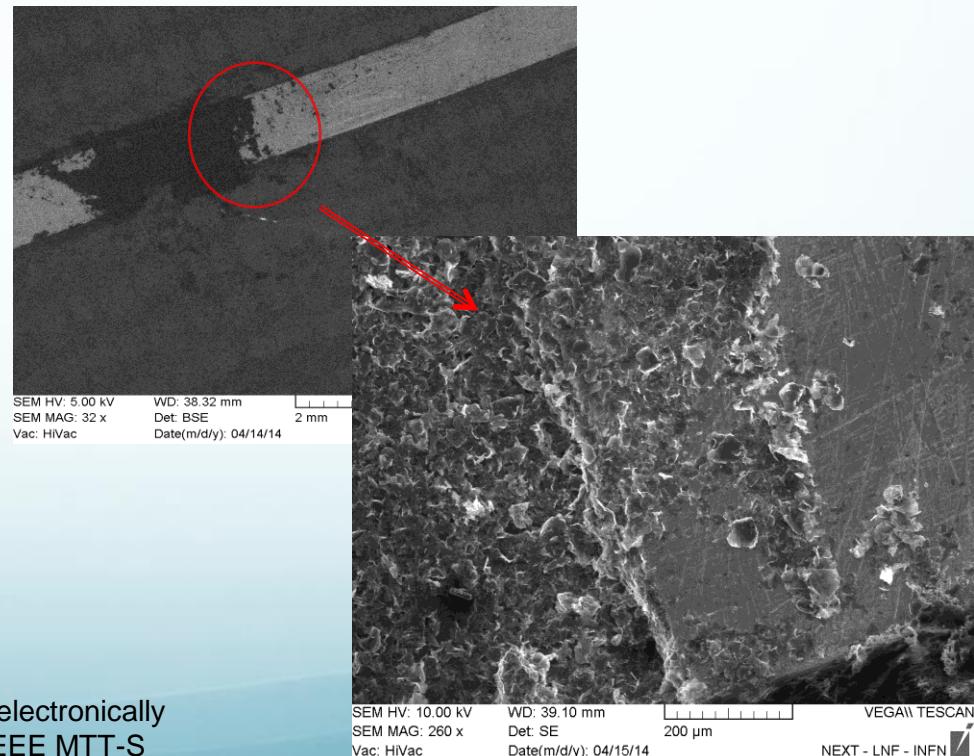
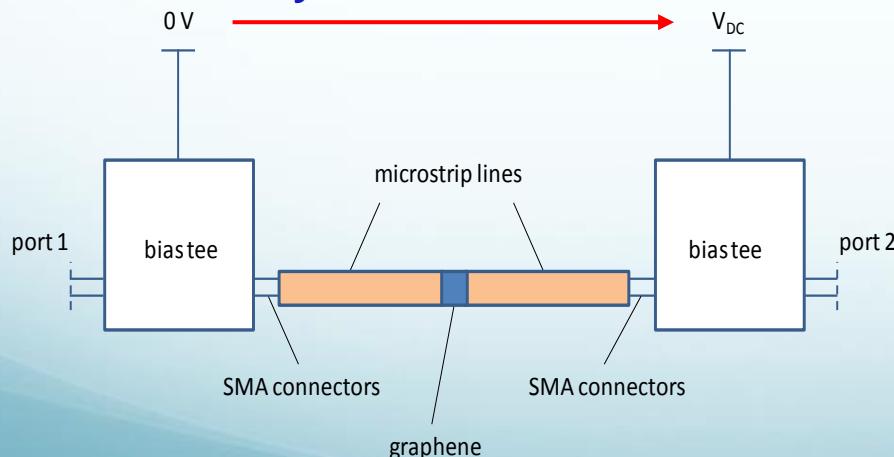
Misure Elettriche GNPs



Progettazione di una microstriscia regolabile in resistenza



GOAL: tuning the graphene conductivity

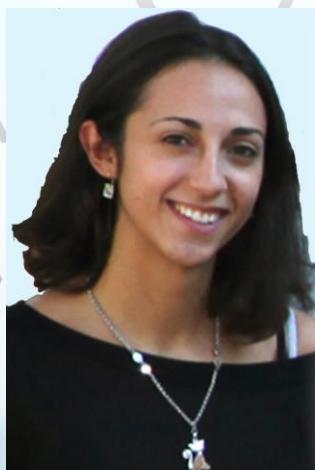


Il MONDO
della SCUOLA,
della RICERCA
e dell'IMPRESA
insieme per
l'INNOVAZIONE:

NANOSCIENZA E NANOTECNOLOGIA

I.T.I.S. "G.Galilei" di Arezzo, 11 e 12 marzo 2013







Grazie
per la vostra attenzione!