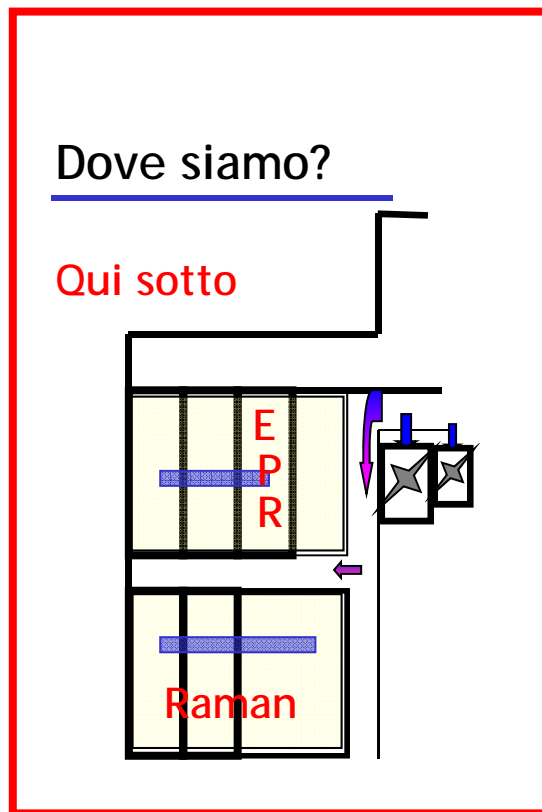


Spettroscopia Raman (e non solo) @ Dip. FISICA:

Chi siamo?

Pietro Galinetto - Resp. Lab. Raman
Maria Cristina Mozzati - Resp. Lab EPR
Enrico Giulotto
Vittorio Bellani



Scienza dei materiali

- energetica, spintronica, fotonica, elettrochimica
- Famiglia Carbonio
- Nanomedicina - Biotecnologie
- Beni Culturali
- Scienze forensi
- Mineralogia

In quali ambiti di ricerca?

Con chi?

Collaborazioni nazionali e internazionali

UniMi, UniMiB
CNR-Mi
UniCatt-Bs, Elettra-TS
UniPR, UniSa
UniGe, IIT, CNR Ge,
Fondazione Arvedi,
Polizia di Stato - Racis
Arkedos - Zonca -
NEST Laboratory & Scuola
Normale, Pisa
.....

A.S. CR (Prague)
R.A.S. S.Petersburg(Russia)
UAM -Madrid
Hebej Un. Tianjin-China
Armenian SPU
NAS, Armenia ...

Come?

Attività Sperimentale a Pavia:
Spettroscopia Raman & SERS
EPR + Susc. Mag.

- Fisica per Biologia (EG)
- Fisica per Scienze della Terra (PG)
- $\frac{1}{2}$ (Spettroscopia dello Stato Solido) (PG)
- Tecnologie Fisiche e Beni Culturali (PG e MCM)
- Fisica dei dispositivi elettronici a stato solido (VB)

**Attività
didattica**

Possibilità di tesi
specialistiche e
triennali

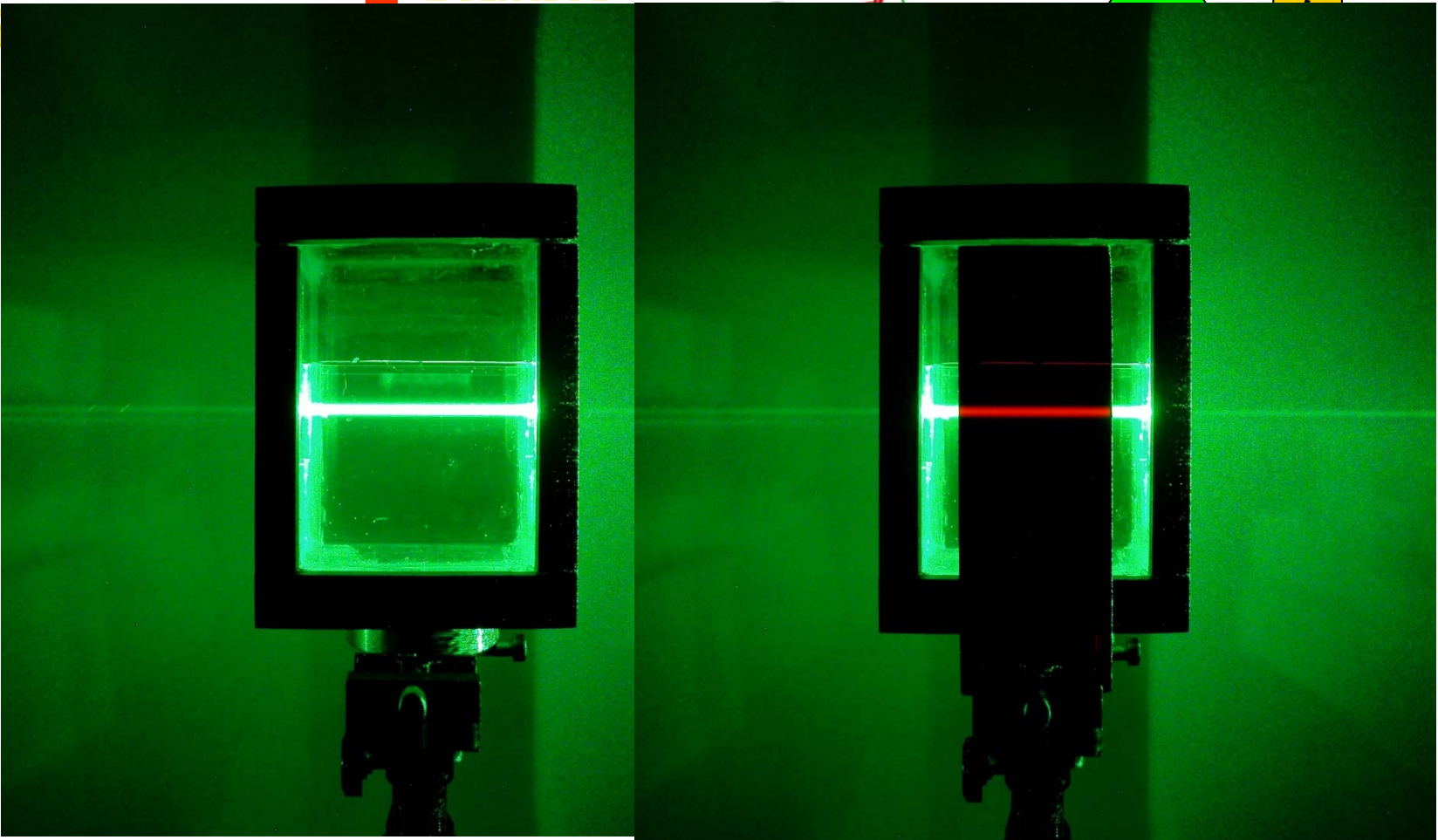
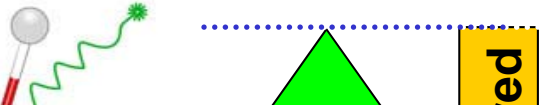
Raman Spectroscopy

1 in 10^7 photons is scattered inelastically



Incident
L

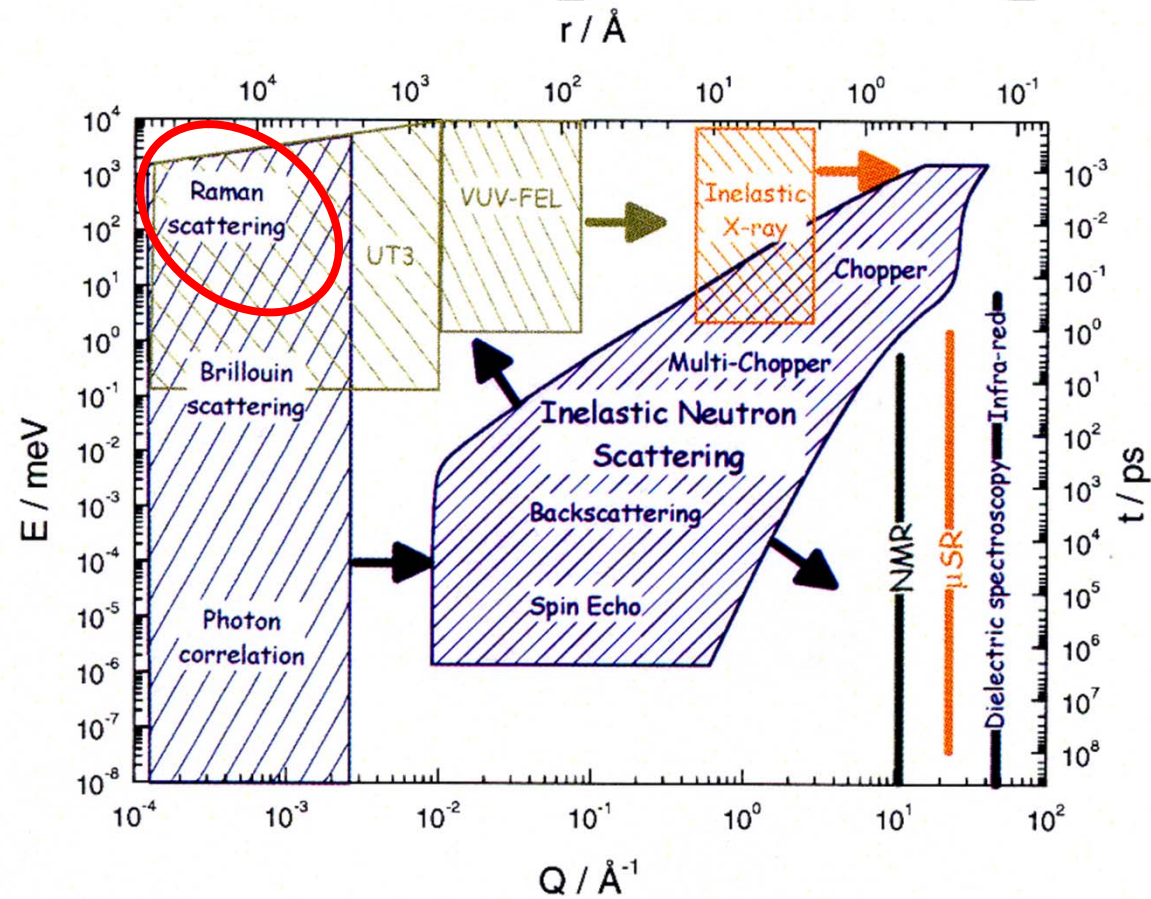
Scattered



= 1
= 0

Raman Shift (cm^{-1})

Vibrational spectroscopies

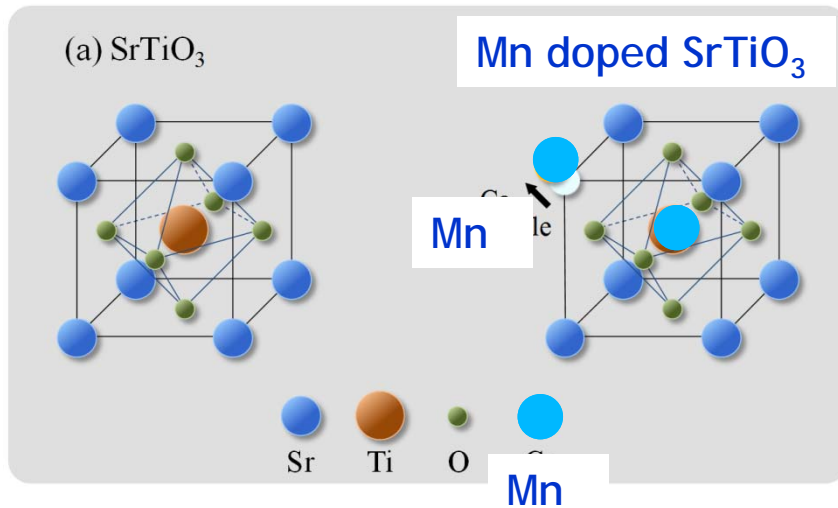


da "Introduction to vibrational spectroscopies" J. Serrano

Structural Investigation in Single Crystal and Ceramic Mn:SrTiO₃

STRUCTURAL INVESTIGATION OF MANGANESE DOPED...

1



STRUCTURAL INVESTIGATION OF MANGANESE DOPED SrTiO₃ SINGLE CRYSTAL AND CERAMIC

G.F. Mancini¹, P. Ghigna¹, M.C. Mozzati², P. Galinetto², M. Makarova^{3,4}, P. Symikov⁵, L. Jastrabik³ and V.A. Trepakov^{3,5}

¹Dipartimento di Chimica, INSTM and IENI-CNR, Università di Pavia, Italy

²Dipartimento di Fisica, Università di Pavia, Italy

³Institute of Physics AS CR, NA Slovance 2, 182 21, Prague 8, Czech Republic

⁴WPI-MANA NIMS, 1-1 Namiki, Tsukuba, Ibaraki, 305-0044 Japan

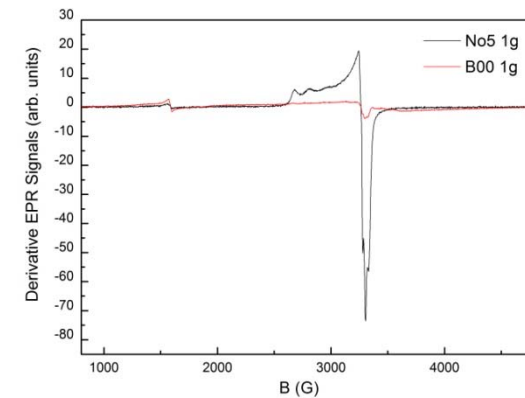
⁵Ioffe Physical-Technical Institute RAS, 194 021 St-Petersburg, Russia

FERROELECTRICS 463, 1, 31-39 (2014)



Vaso di Licurgo

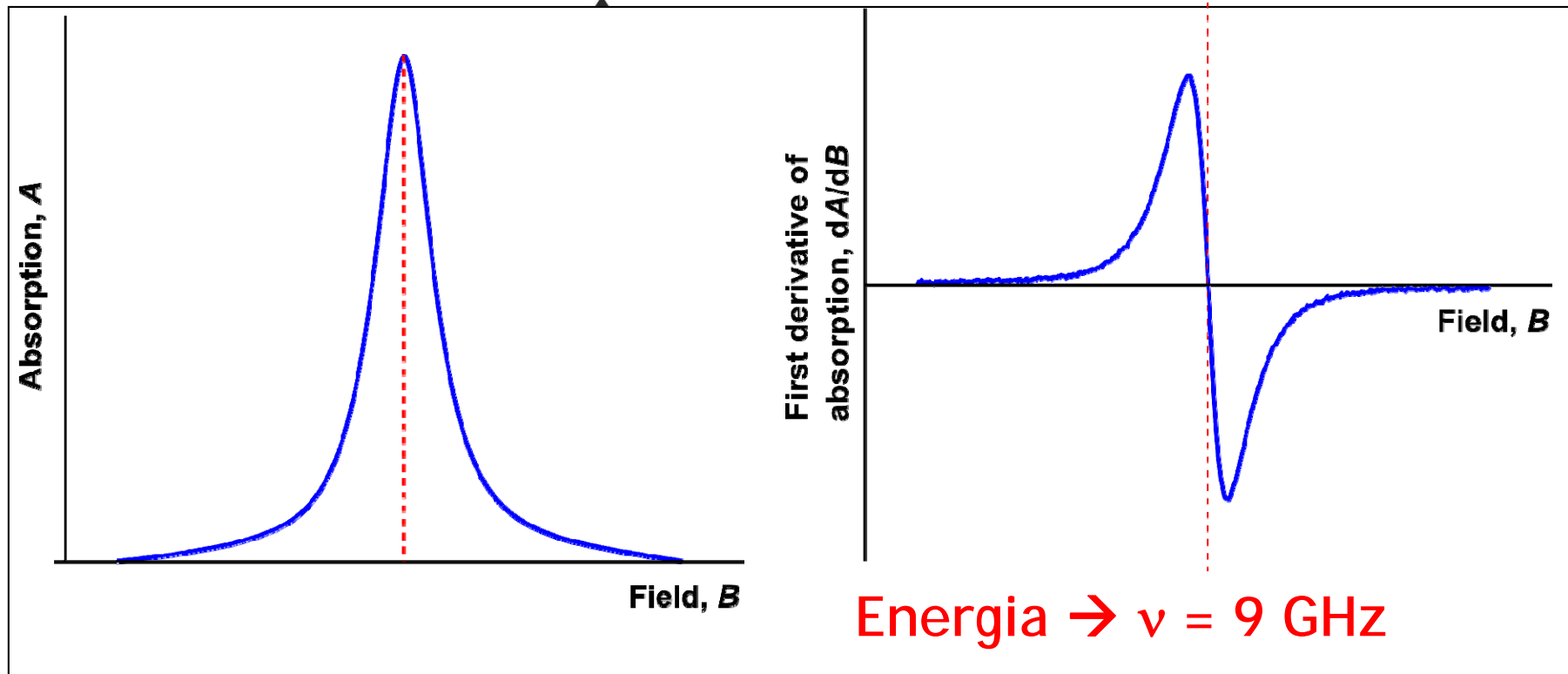
Siamo ancora capaci
di fare il vetro rosso?
Come?



Mozzati - Galinetto

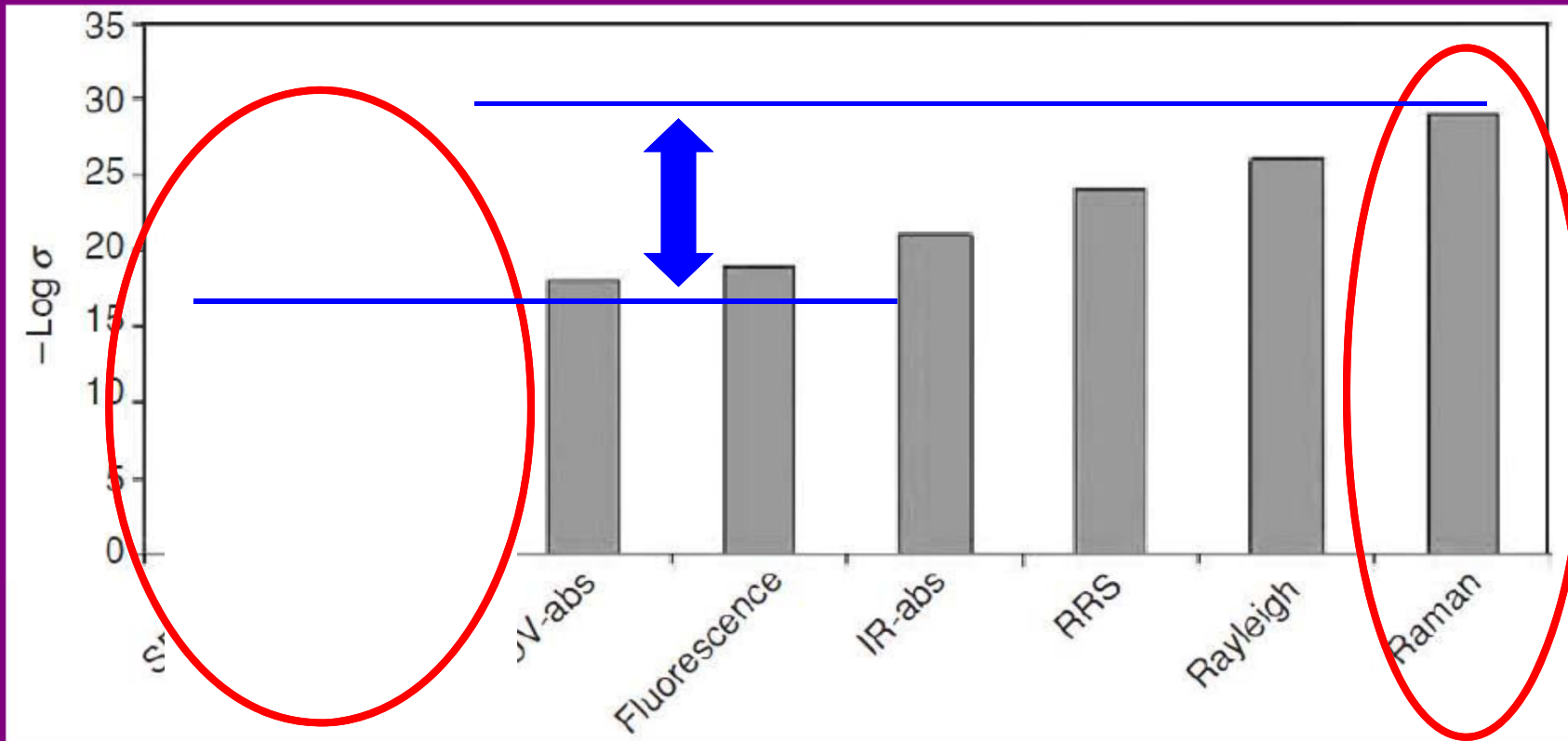
Electron Paramagnetic Resonance

or It's fun to flip electrons!



EPR: rivela transizioni di dipolo magnetico in sistemi paramagnetici diluiti
Indagine dello stato fondamentale, delle caratteristiche di simmetria dell'intorno,
delle interazioni magnetiche locali di ioni di elementi di transizione e di terre rare.
Individuazione di difetti paramagnetici preesistenti o indotti.

Cross-sections of the optical processes



R. Aroca, Surface-Enhanced Vibrational Spectroscopy, J. Wiley & Sons Ltd, 2007

$$p = \alpha E$$

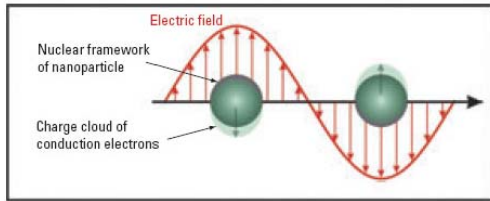
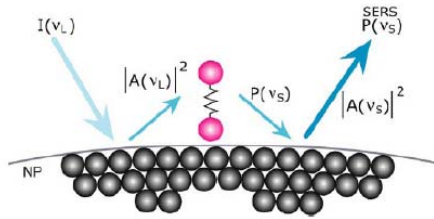
p - induced (not permanent) electric dipole moment of a molecule
 α - polarizability
 E - electric field

$$\alpha = \alpha_0 + \left(\frac{\partial \alpha}{\partial r} \right) \Delta r$$

$$\Delta r = r_{max} \cos(2\pi \nu t)$$

$$E = E_0 \cos(2\pi \nu_0 t)$$

SERS Surface Enhanced Raman Scattering



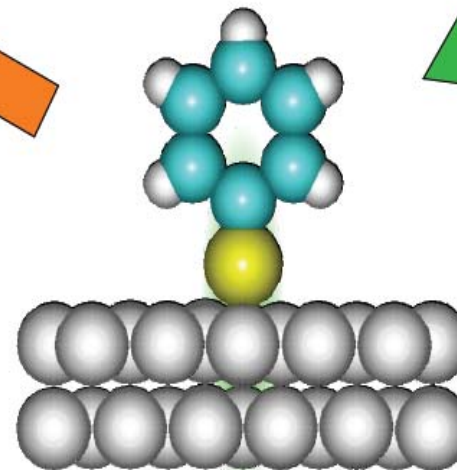
$$\text{Enhancement Factor (EF)} = \frac{\sigma_{\text{SERS}}}{\sigma_{\text{Raman}}}$$

$$\vec{\mu} = \hat{\alpha} \vec{E}$$

Chemical Electromagnetic

Raman Scattering
($\omega_0 - \omega_{\text{vib}}$)

Laser Excitation
(ω_0)



Nobel Metal (eg. Au)

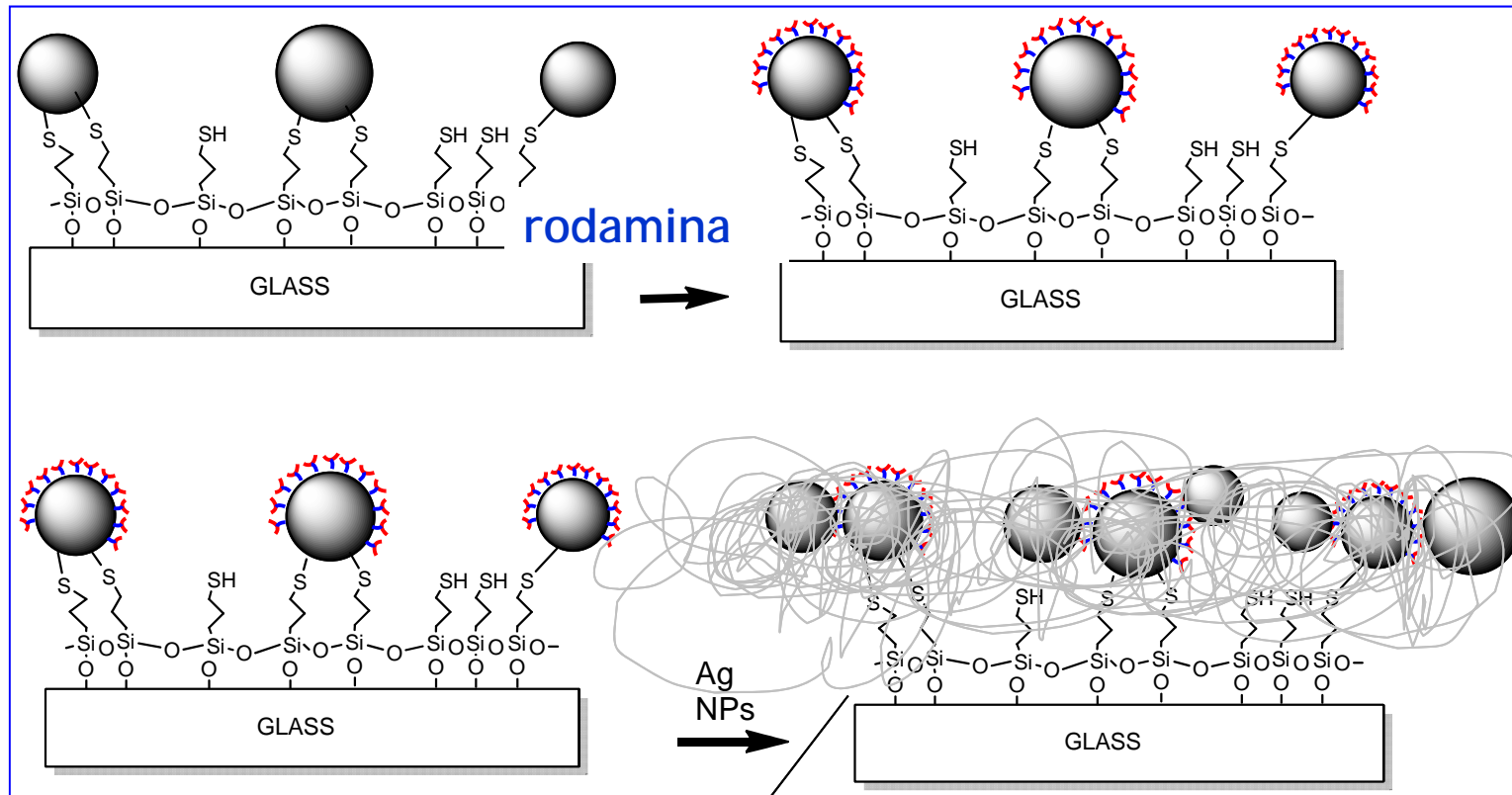
$$EF = \frac{|\mathbf{E}_{out}|^2 |\mathbf{E}'_{out}|^2}{|\mathbf{E}_0|^4}$$

The (complex) electric field inside the sphere is constant

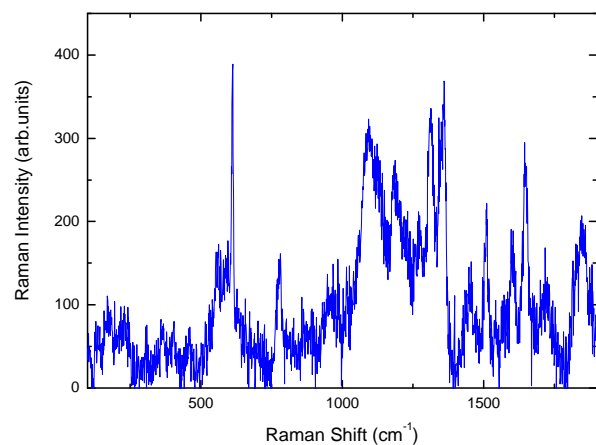
$$E_{in} = \frac{3\epsilon_M}{\epsilon(\omega) + 2\epsilon_M} E_0$$

Land, and Van Duyne, *Anal. Chem.*, 77, 338A-346A (2005).

Lo studio e la realizzazione di vetri funzionalizzati ad attività antibatterica sono di notevole importanza per tutte le applicazioni connesse all'impianto di dispositivi medicali e in generale per la biomedicina



$$EF = \frac{?? |E_{out}|^2 |E'_{out}|^2}{|E_0|^4}$$



J Nanopart Res (2013) 15:2047
 DOI 10.1007/s11051-013-2047-x

RESEARCH PAPER

Mixing thiols on the surface of silver nanoparticles: preserving antibacterial properties while introducing SERS activity

Angelo Taglietti · Yuri A. Diaz Fernandez ·
 Pietro Galinetto · Pietro Grisoli ·
 Chiara Milanese · Piersandro Pallavicini

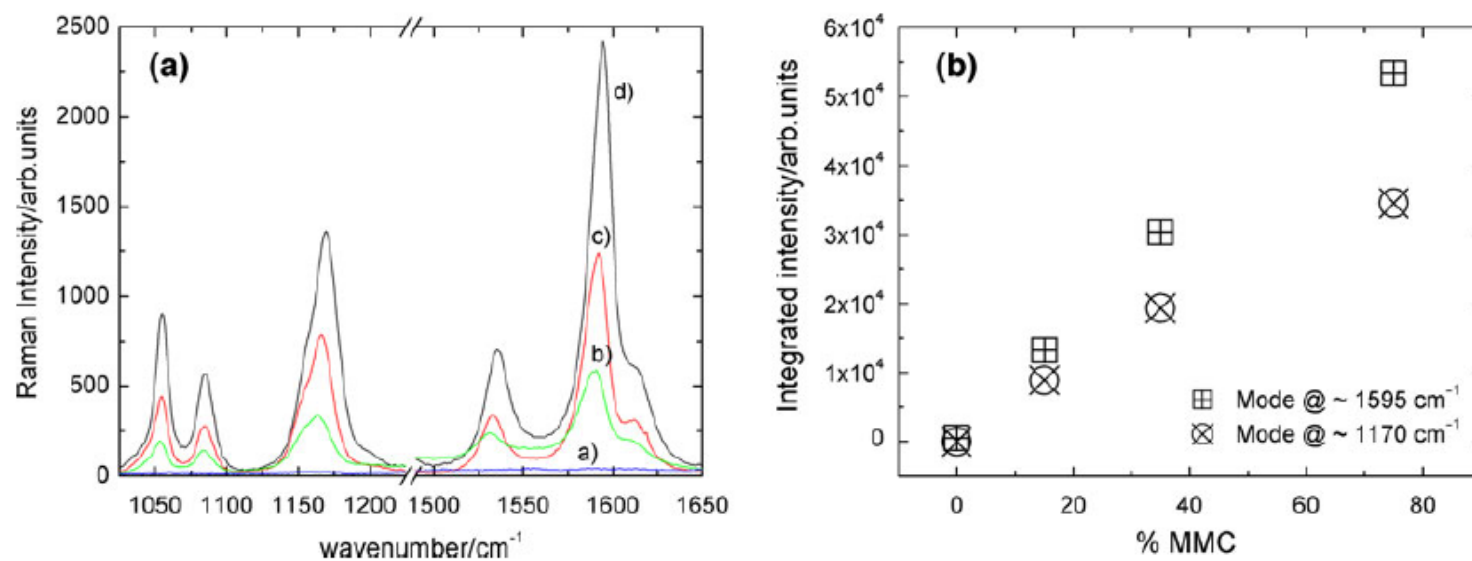
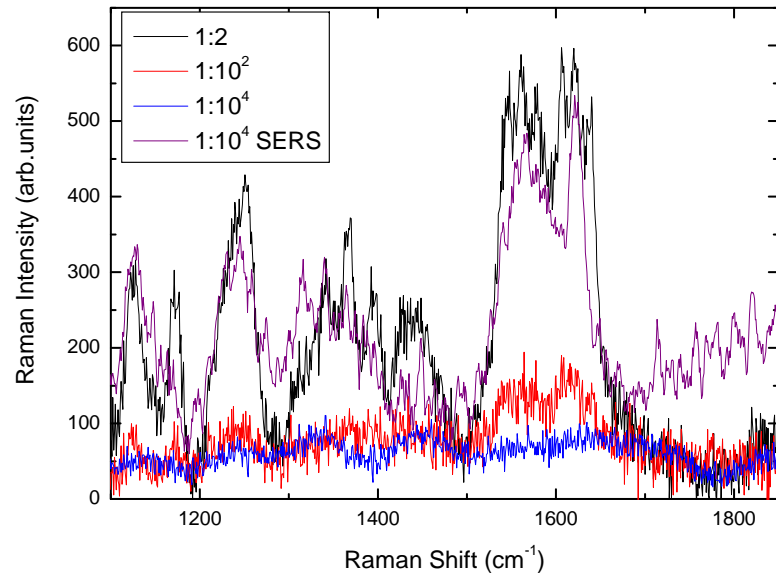


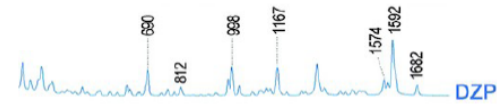
Fig. 5 a Details of SERS spectra for different coating compositions of MGAgnPs: a 100 % GSH; b 85 % GSH–15 % MMC; c 65 % GSH–35 % MMC; d 25 % GSH–75 % MMC. b Integrated intensities of SERS signal for the modes at ~1,170 and ~1,595 cm⁻¹

Nuove metodologie per le Scienze Forensi: la spettroscopia Raman nella rilevazione di tracce ematiche o di tracce di sostanze psicotrope in materiale ematico

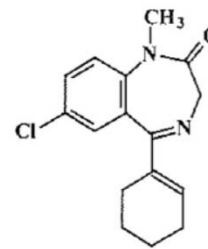


Spettri Raman degli standard

Diazepam

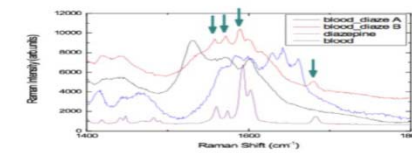
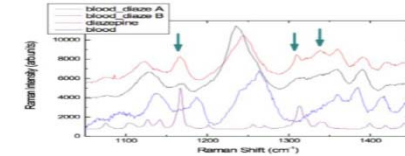
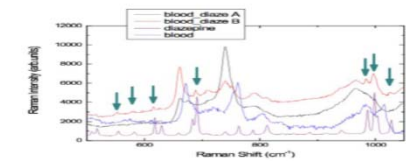


Diazepam



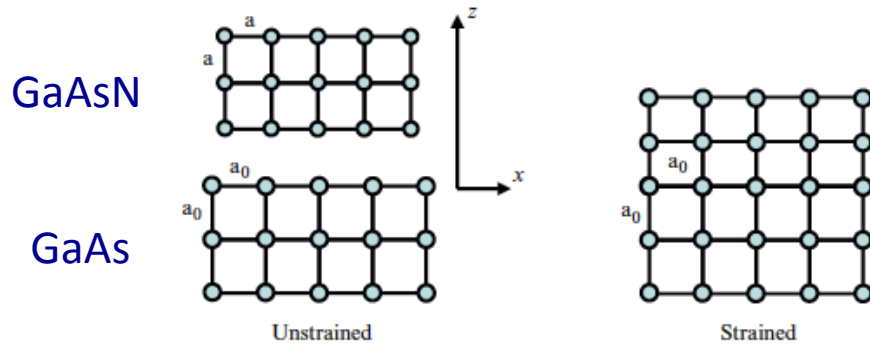
Formula Bruta: C₁₆H₁₃ClN₂O

Nome IUPAC: 7-cloro-1-metil-5-fenil-1,3-diidro-2H-1,4-benzodiazepin-2-one



Eterostrutture di fili di GaAsN in GaAsN:H su substrato di GaAs

Presenza di strain reticolare



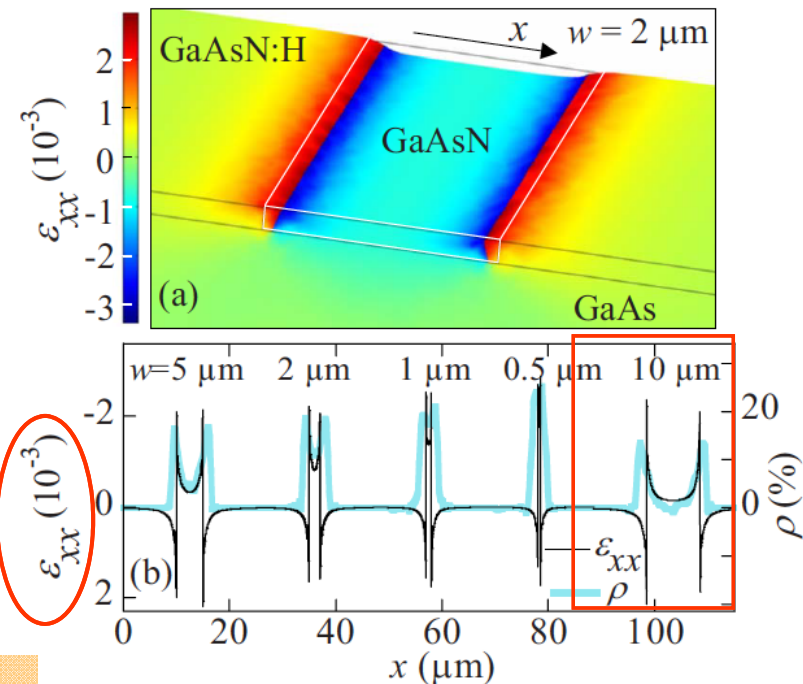
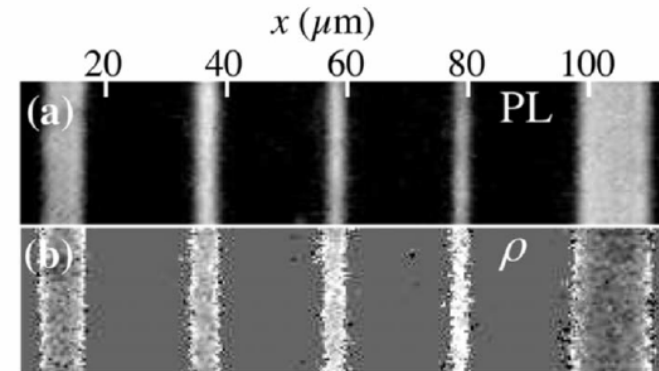
Il film iniziale di GaAsN su GaAs, di spessore 200nm, è in condizioni di strain biassiale tensile.

L'eterostruttura di fili GaAsN fra barriere di GaAsN:H è ottenuta con idrogenazione selettiva.

Nell'eterostruttura fili/barriere è presente strain uniaxiale (ϵ_{xx}) modulato spazialmente.

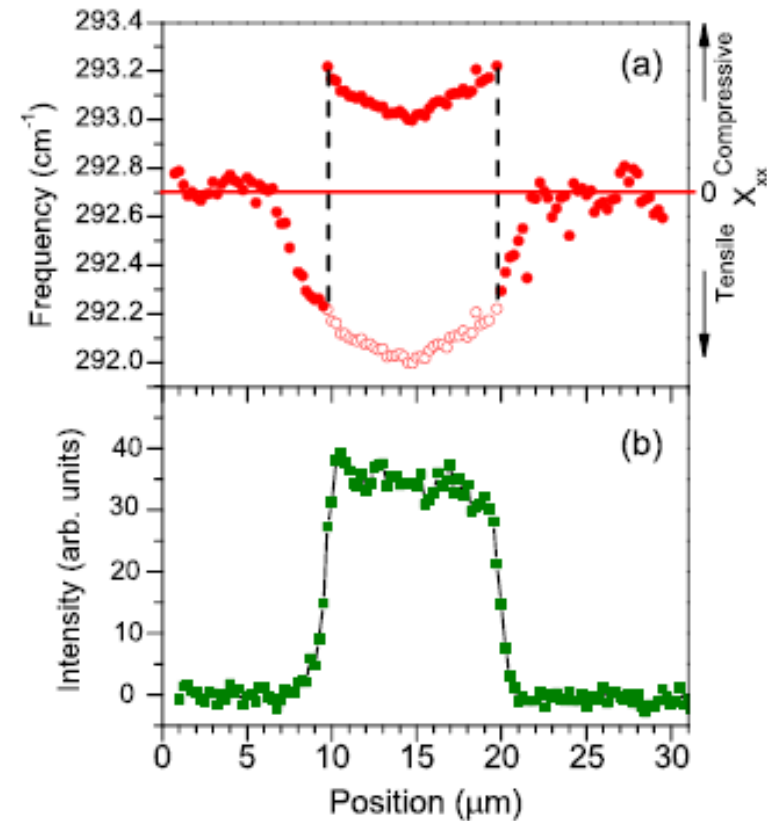
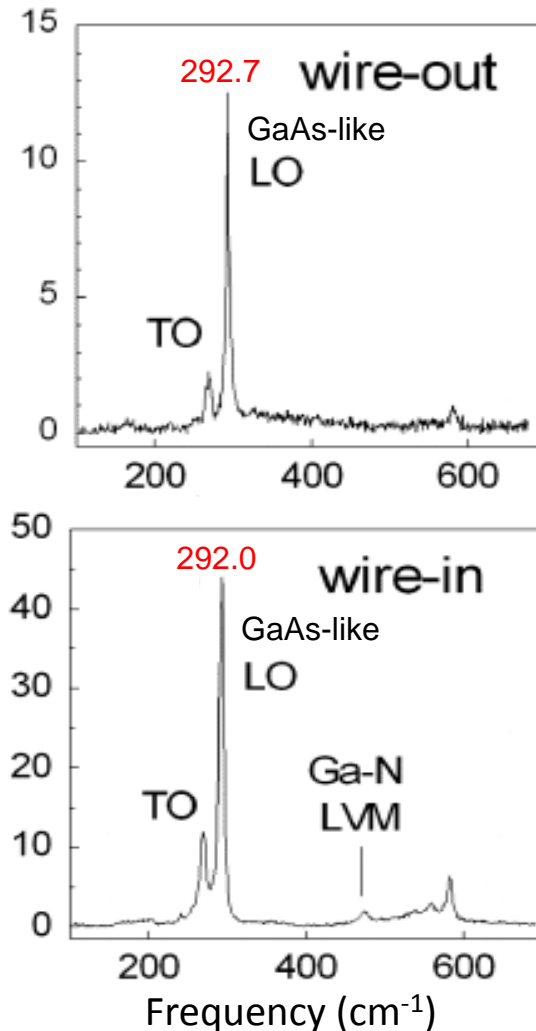
La polarizzazione della emissione in PL (ρ) si correla con la modulazione dello strain uniaxiale (ϵ_{xx}) ricavato da simulazioni.

Imaging mediante fotoluminescenza (PL) di fili di differente larghezza.



Mappatura dello strain in fili GaAsN/GaAsN:H mediante Raman scattering

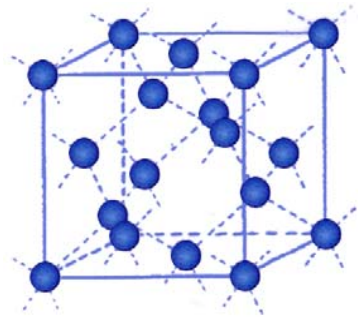
La frequenza del fonone LO dipende dallo stato di strain del materiale



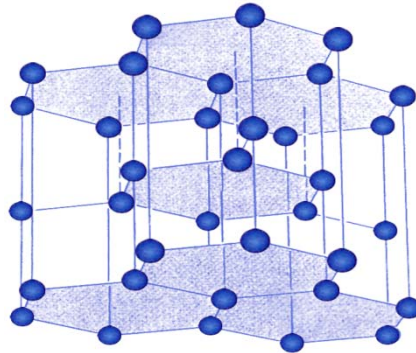
(a) Andamento della frequenza del fonone LO GaAs-like lungo una linea perpendicolare ad un filo.

(b) L'andamento dell'intensità integrata del modo localizzato Ga-N lungo la medesima linea segue in modo accurato la variazione della composizione.

Raman Modes in Carbon Materials

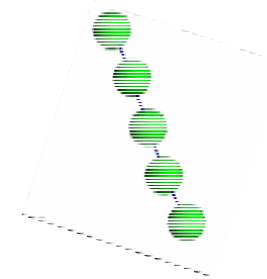


Diamond
 sp^3 (3D) 1332 cm^{-1}

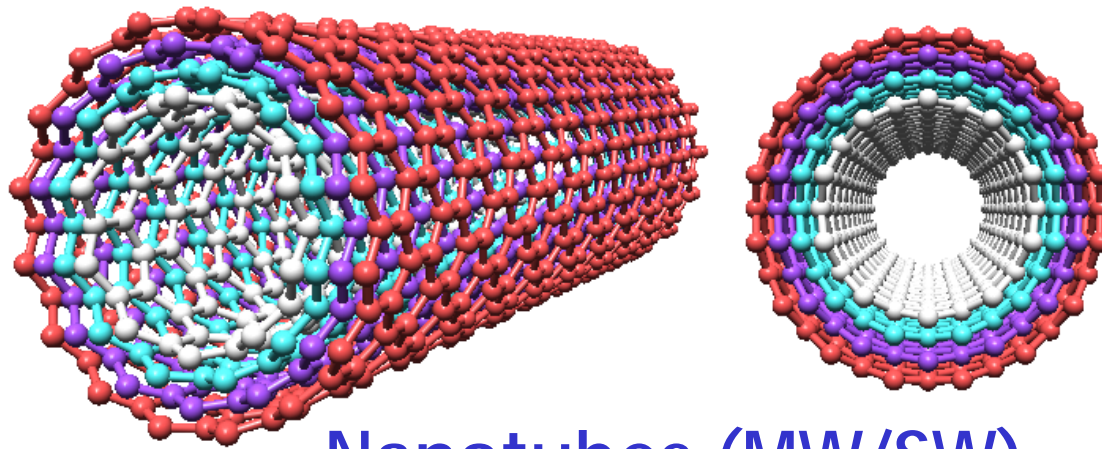


Graphite
 sp^2 (2D) 1582 cm^{-1}

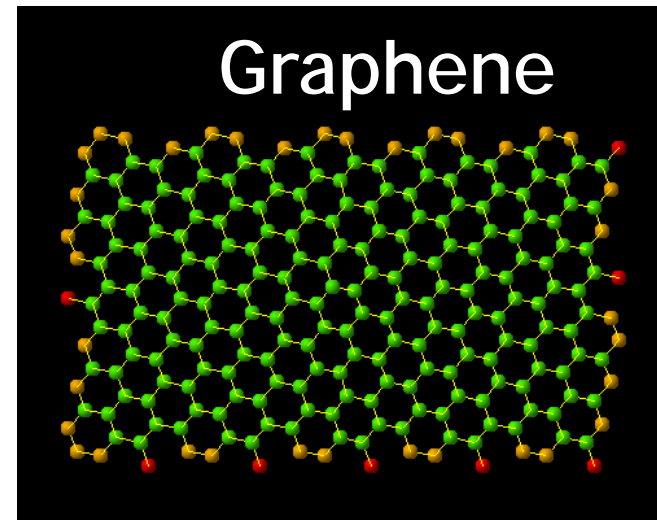
¿?



Chain
 sp^1 (1D) 1855 cm^{-1}



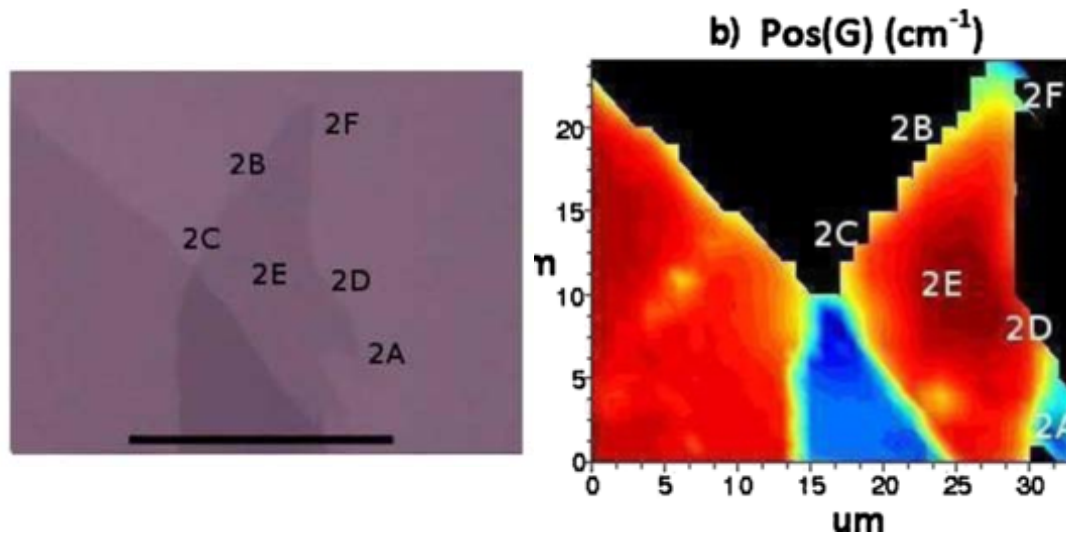
Nanotubes (MW/SW)



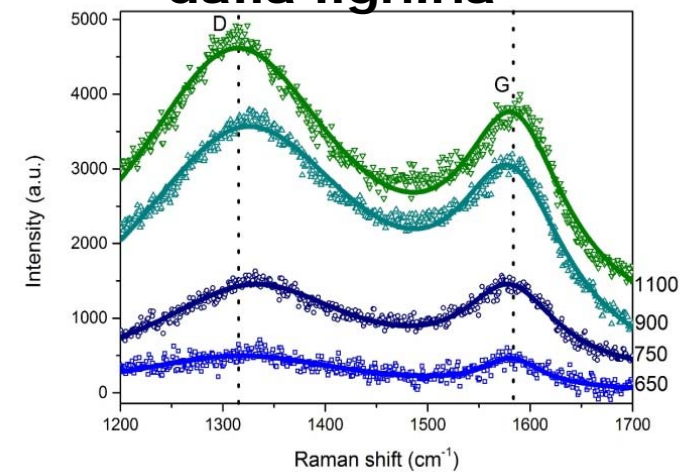
Spettroscopia Raman del grafene

V. Bellani

Mappa Raman del grafene



Grafene prodotto chimicamente partendo dalla lignina



J. Appl. Phys. **108**, 084321 (2010). *J. Mater. Chem.* **21**, 2924 (2011). *Carbon* **84**, 254 (2015).



Collaborazioni

Laboratorio di Nanochimica, CNR Bologna

Universita' di Salamanca

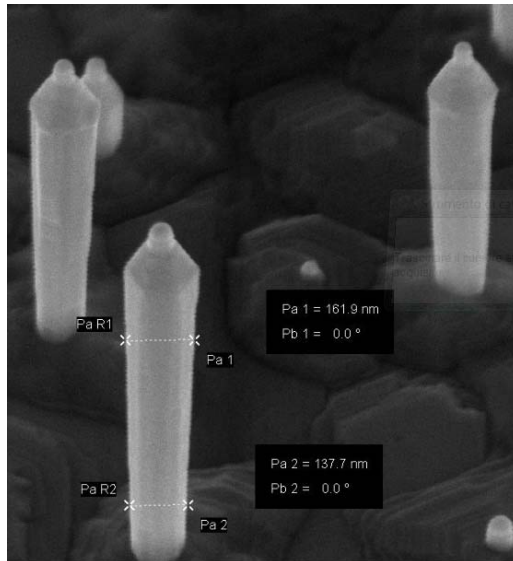


Dipartimento di chimica fisica, Università' di Pavia

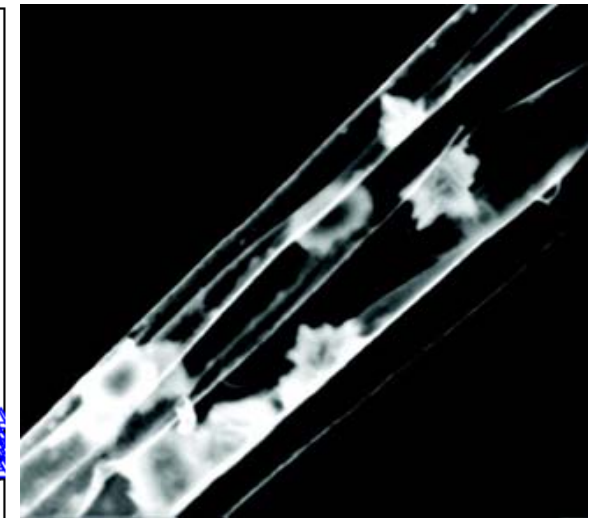
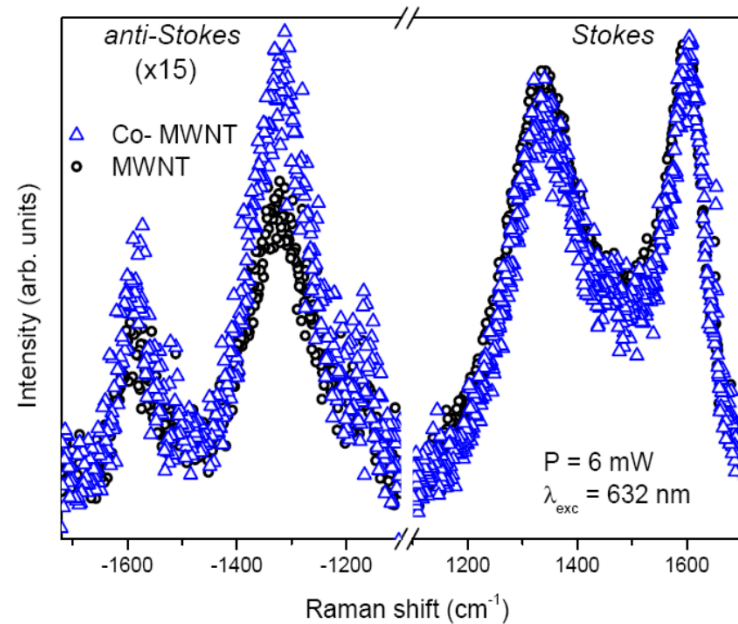
Spettroscopia Raman di nano-fili di carbonio e semiconduttori

V. Bellani

Raman of semiconductor nano-wires and carbon-nano tubes



Nanoscale 6, 788 (2014)



Collaborazioni

NEST Laboratory & Scuola Normale, Pisa

University of Brescia



Euromagnet, High Magnetic Field Laboratory



Li₁₂C₆₀: A lithium clusters intercalated fulleride

Fabio Giglio^a, Daniele Pontiroli^{a,b}, Mattia Gaboardi^a, Matteo Aramini^a, Chiara Cavallari^{a,c},
 Michela Brunelli^c, Pietro Galinetto^d, Chiara Milanese^e, Mauro Riccò^{a,*}

^a Dipartimento di Fisica e Scienze della Terra, Università degli Studi di Parma, Via G. P. Usberti 7/a, 43124 Parma, Italy

^b Laboratorio di Micro e Submicro Tecnologie abilitanti dell'Emilia Romagna (MIST.E-R), Via P. Gobetti 101, 40129 Bologna, Italy

^c Institut Laue Langevin, BP 156, 6 rue Jules Horowitz, 38042 Grenoble Cedex 9, France

^d Dipartimento di Fisica 'A. Volta', Università di Pavia, Via Bassi 6, 27100 Pavia, Italy

^e Pavia Hydrogen Lab, Dipartimento di Chimica, Sezione di Chimica Fisica, Università di Pavia, V.le Taramelli 16, 27100 Pavia, Italy

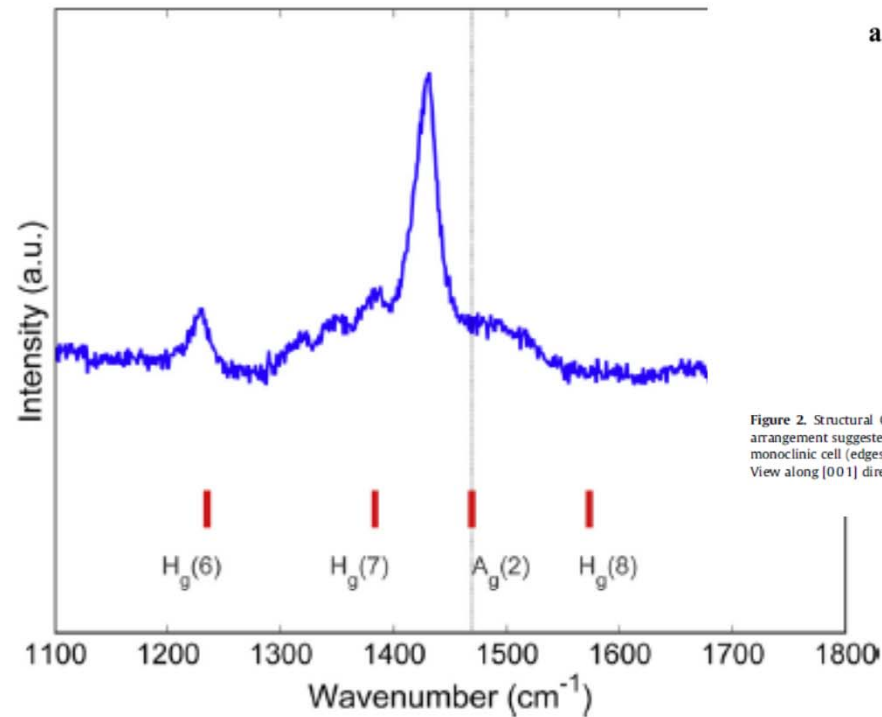


Figure 5. Raman spectrum of the Ag(2) mode shows a shift from 1469 to 1429 cm⁻¹ which corresponds to a charge transfer of 6 e⁻. The vertical thicks mark the position of the Raman peaks in pristine C₆₀.

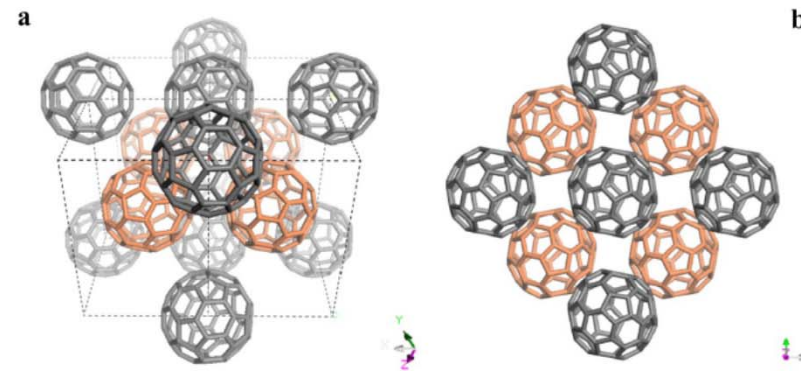


Figure 2. Structural C₆₀ molecule arrangement in Li₁₂C₆₀ obtained with MO-SA from a symmetry-unrestricted (S.G. P1) starting cell, which mimics the *fcc* molecular arrangement suggested by indexing process. The disposition of fullerenes is described by a monoclinic cell with space group P2₁/c. (a) View along the [101] direction of the monoclinic cell (edges evidenced with dotted line) shows that fullerenes with the same orientation form layers, alternatively stacked along [001] parent cubic direction. (b) View along [001] direction.

