Research and teaching activities in the Materials Science curriculum

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PhD in Mathematical Models for Engineering, Electromagnetism and Nanosciences, Sapienza University, Roma, Italy, November 21st 2018

outline

Curriculum of Materials Science

- Members of the PhD board

- Teaching, courses

- A couple of examples of research activity

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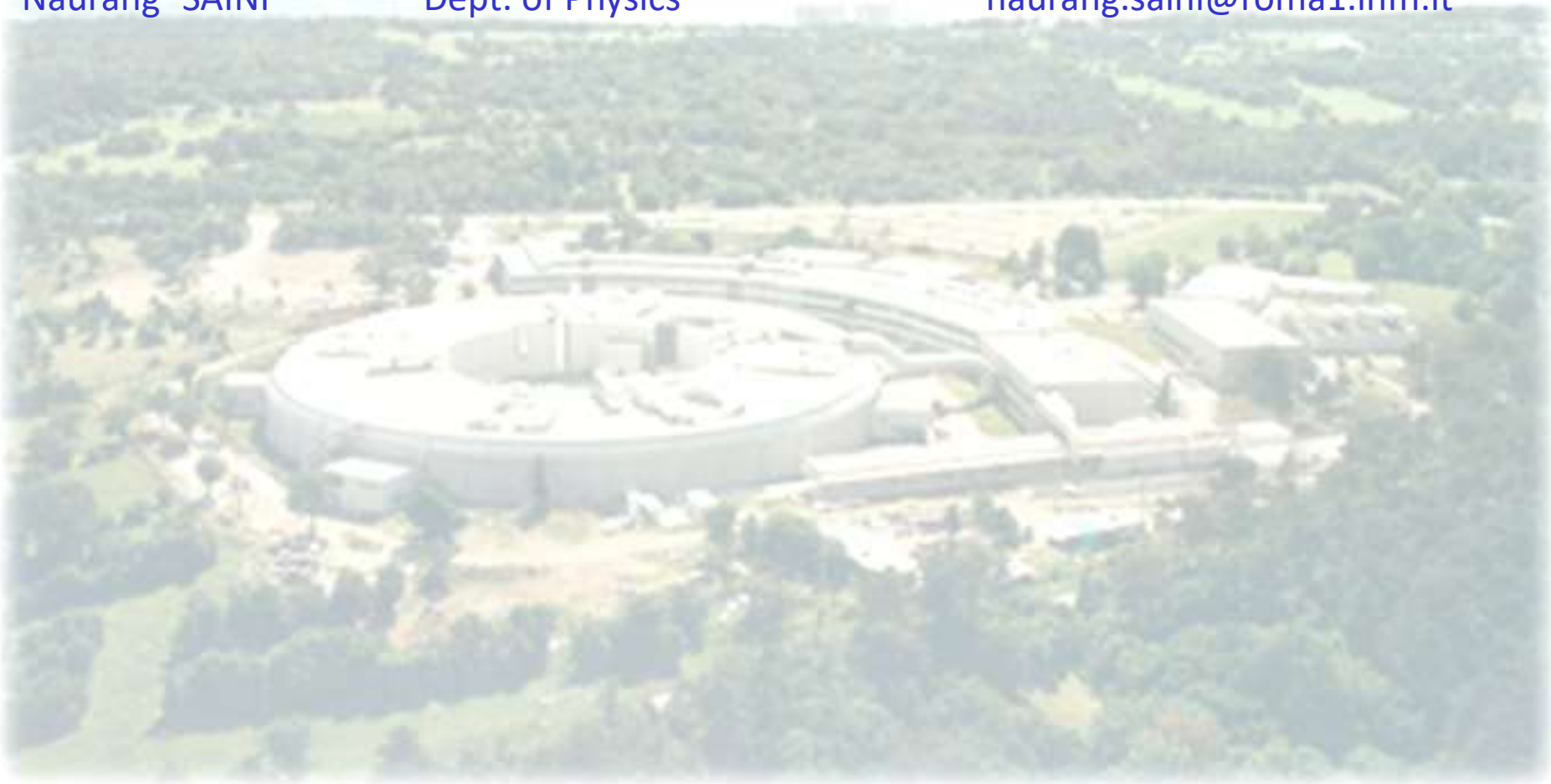

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Curriculum of Materials Science

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Curriculum of Materials Science

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- **Teaching, courses: specific for the PhD school**

- A couple of examples of research activity

Metodi sperimentali per la determinazione di struttura e proprietà elettroniche di sistemi aggregati di bassa dimensionalità

Experimental Methods for the Determination of the Structure and the Electronic Properties of Low-Dimensional Solid Systems

(January/February-May 2019)

Basic Module, 30-32 hours (4 ECTS):

Interazione radiazione-materia, spettroscopie di fotoemissione e assorbimento / Interaction of Electromagnetic Radiation with Matter, Photoelectron Spectroscopy and Absorption

C. Mariani (Roma La Sapienza) and **A. Ruocco (F. Offi) / S. Mobilio** (Roma Tre)
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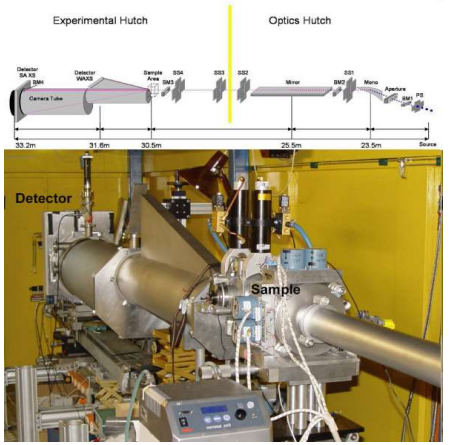
Basic Theory and Experimental-Instrumental methods - Electron-matter and Electromagn.-matter interaction – **Photoelectron Spectroscopy**, angular-resolved photoemission, band structures – Auger electron spectroscopy – core level and chemical bondings - **Low-D Systems and Nanostructures** – Multiple-Scattering - **X-Ray Absorption,** EXAFS and XANES - Introduction to **Synchrotron Radiation** and to the new Free-Electron Laser (FEL) sources



Specialistic Module/s (~14-16 hours, 2-3 ECTS):

- **A. Bravin** (ESRF): Metodi sperimentali di imaging tomografico con luce di sincrotrone / Experimental methods of tomographic imaging with synchrotron radiation
- **V. Foglietti** (CNR, Roma Tre): Tecnologie di micro e nano sistemi
- **G. Capellini** (Roma Tre): Formazione in microscopia

Curriculum of Materials Science

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- **Teaching, courses: other courses, from the Masters in Physics or Chemistry**

- A couple of examples of research activity

List of useful courses from the Master degree:

I semestre / I semester

MS1 M.G. Betti (Corso di Laurea Magistrale in Fisica), “Surface Physics and Nanostructure”, 48 ore (6 CFU / ECTS)

MS2 L. Galantini (Corso di Laurea Magistrale in Chimica Industriale), “Chimica Fisica dello Stato Solido e dei Materiali Nanostrutturati”, 48 ore (6 CFU / ECTS)

MS3 S. Panero (Corso di Laurea Magistrale in Chimica Industriale), “Sistemi di produzione ed accumulo dell'energia”, 48 ore (6 CFU) / ECTS

II semestre / II semester

MS4 M. Grilli (Corso di Laurea Magistrale in Fisica), “Fisica dei sistemi a molti corpi”, 48 ore (6 CFU / ECTS)

MS5 C. Mariani (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie), “Tecnologie di fabbricazione di nanostrutture e processi di autoassemblaggio”, 48 ore (6 CFU / ECTS)

MS6 A. Martinelli (Corso di Laurea Magistrale in Chimica Industriale), “Laboratorio di Macromolecole”, 90 ore (9 CFU / ECTS)

MS7 M. Rossi (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie), “Microscopie e tecniche di nanocaratterizzazione ”, 90 ore (9 CFU / ECTS)

MS8 I. Fratoddi (Corso di Laurea Magistrale in Chimica Analitica), “Chimica dei materiali polimerici”, 48 ore (6 CFU / ECTS)

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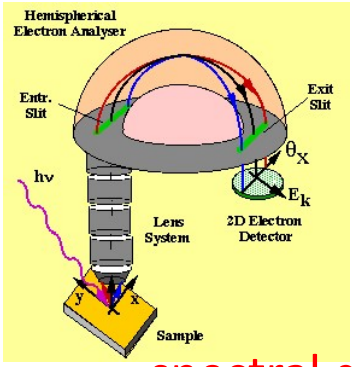
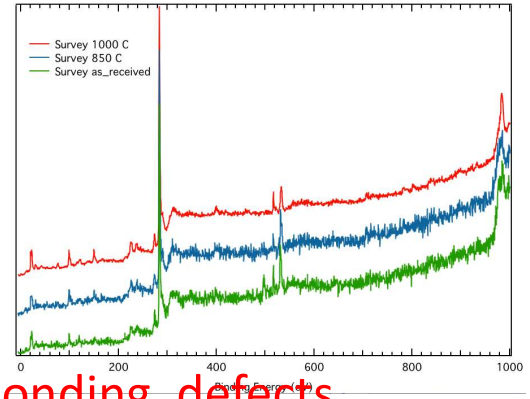
spectroscopy and microscopy techniques

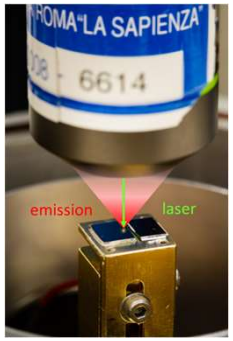


X-ray Photoelectron Spectroscopy (XPS) and Angular Resolved Photo Electron Spectroscopy (ARPES)

Phys. Dept. @ Sapienza and SR sources

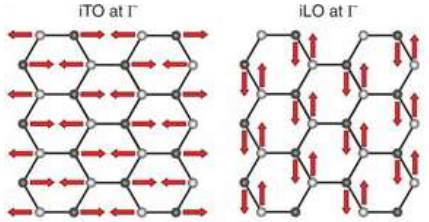


spectral density of electronic states: chemical state, bonding, defects, ...

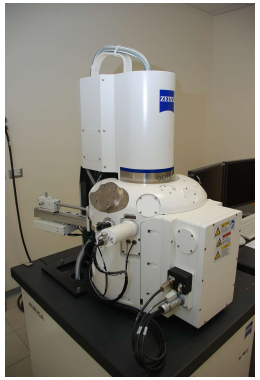


Optical and Raman spectroscopy at sub-mm scale

Phys. Dept. @ Sapienza

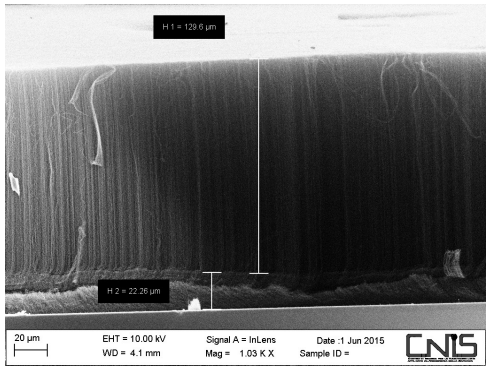


IR scattering, vibrational structure, fluorescence of quantum dots, etc.

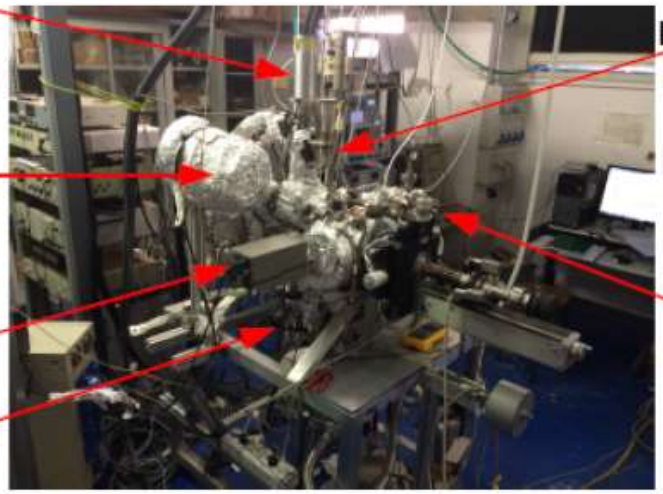


Scanning Electron Microscopy (SEM) at sub-mm scale

CNIS lab. @ Sapienza

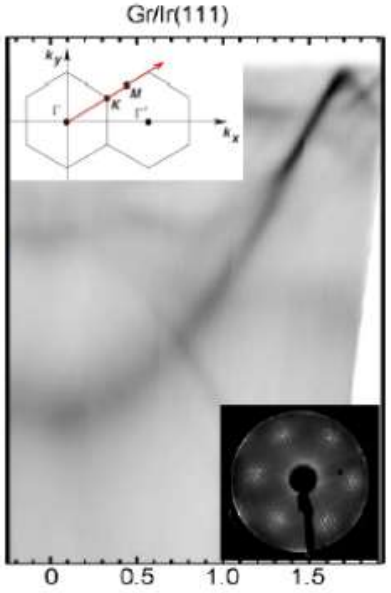


photoemission laboratories

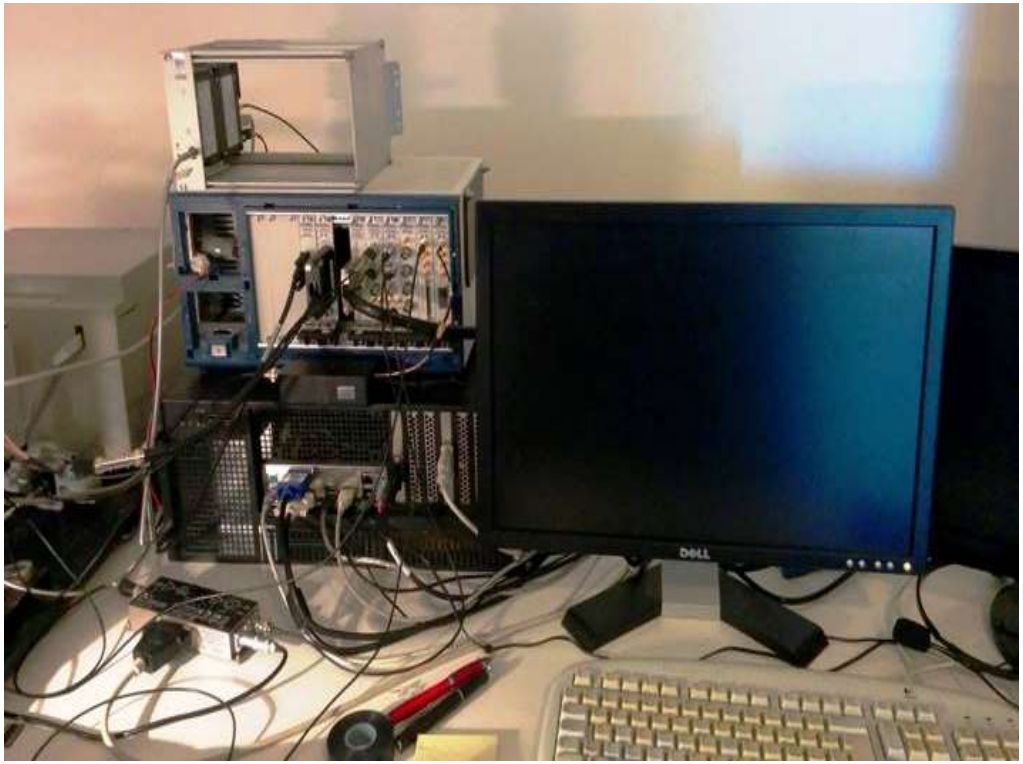


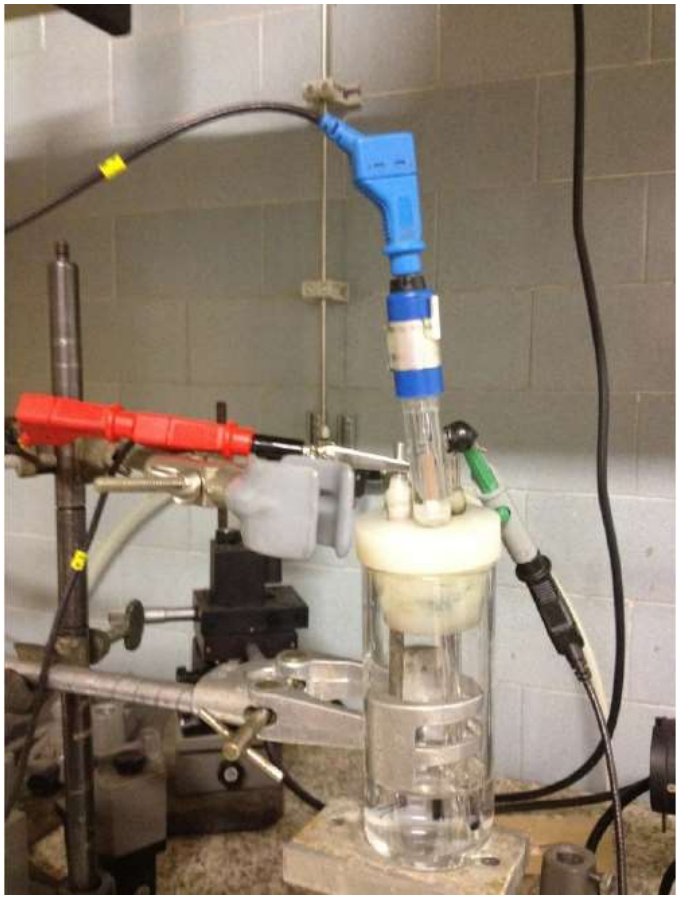
Graphene/Ir(111) moiré diffraction pattern

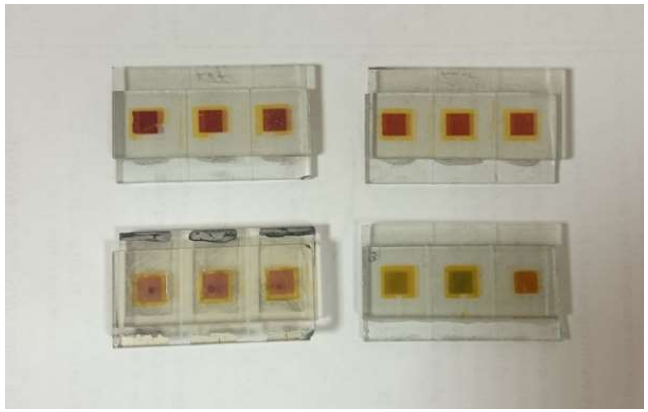
surface electronic band structure of graphene along the ΓKM direction of the Brillouin zone



electrochemistry apparatus

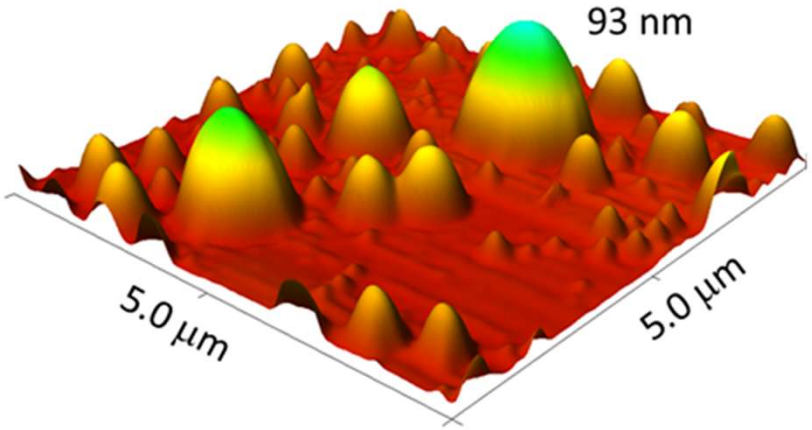


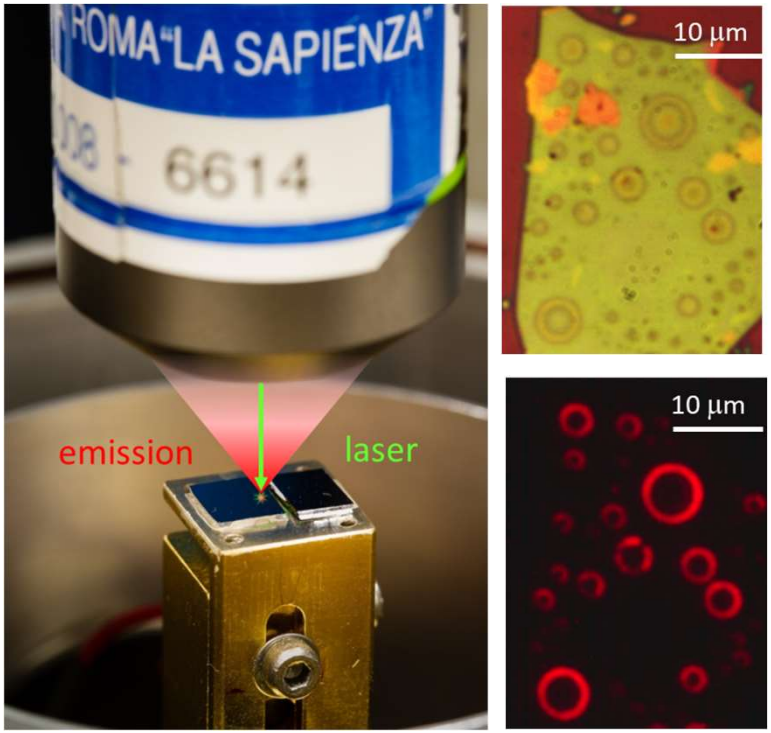


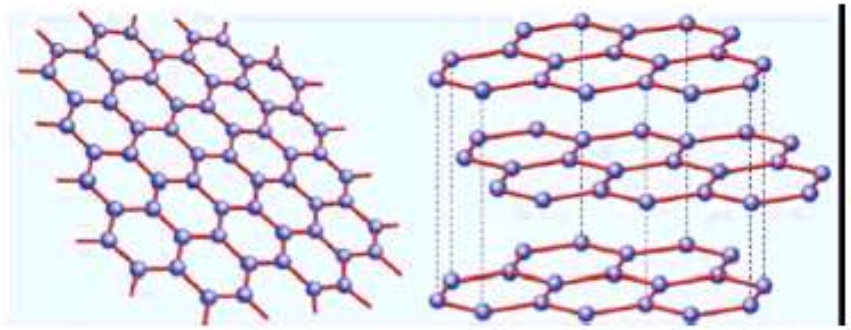


optical fluorescence / Raman apparatus

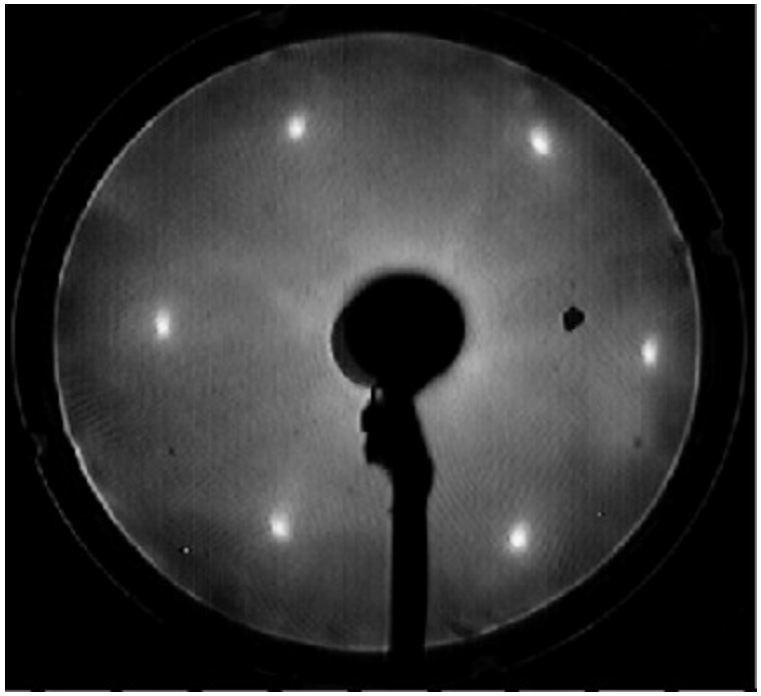
Optical spectroscopy
on deformed
two-dimensional
crystals

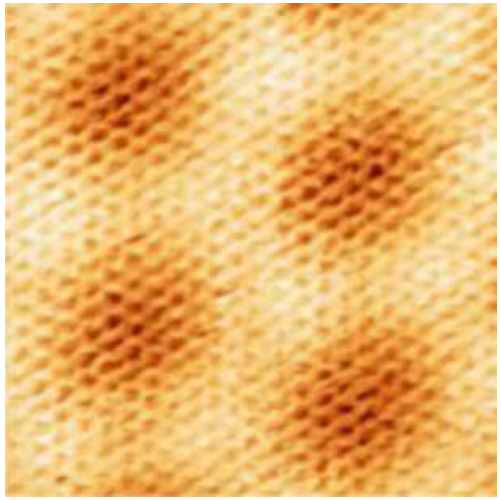






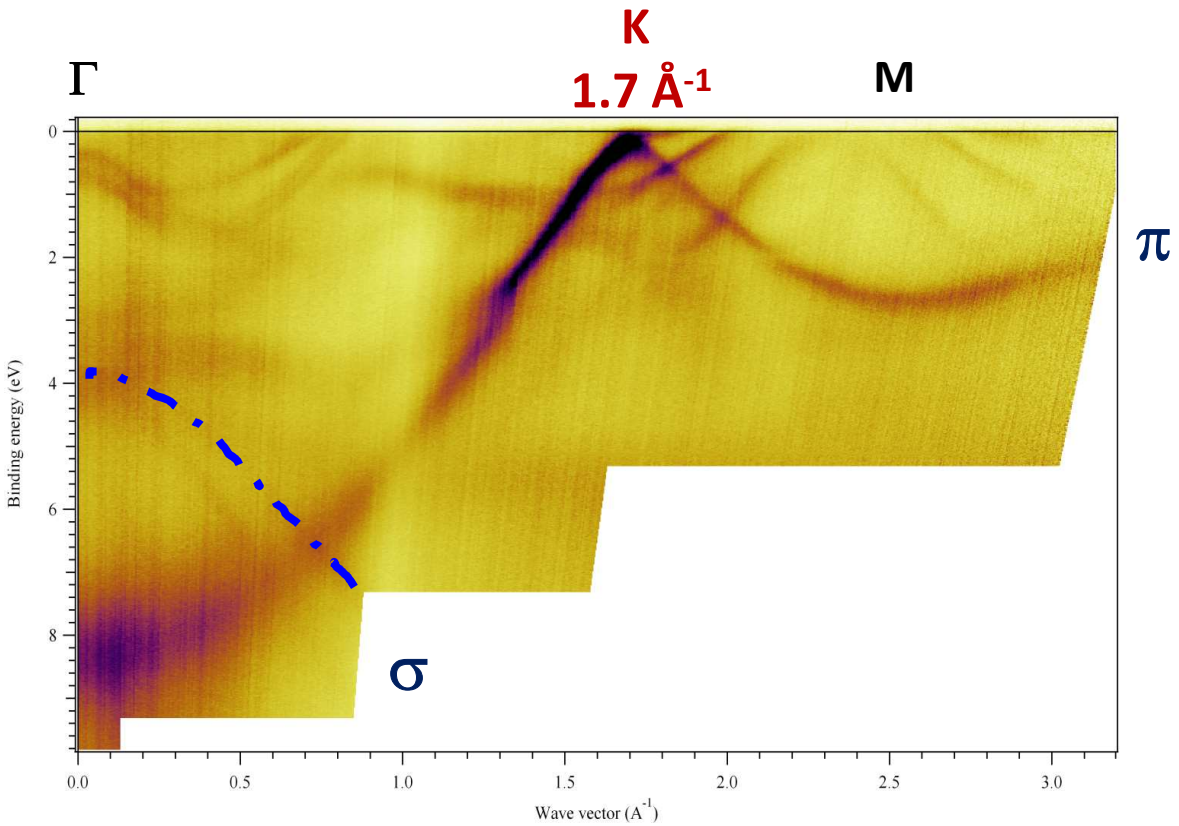
graphene

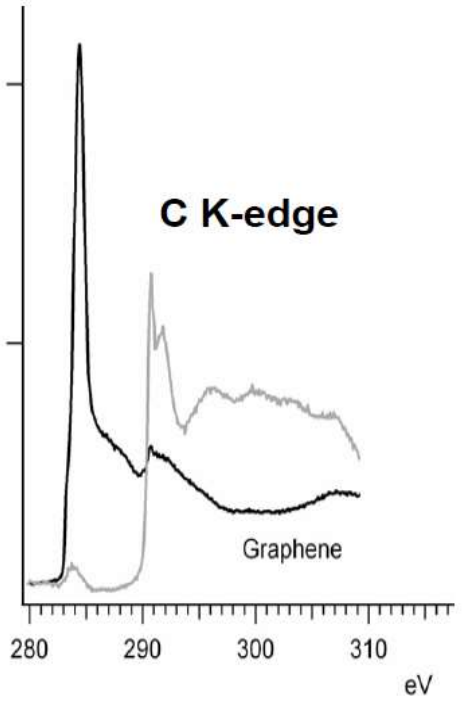




Massimi et alii, *Beilstein J. Nanotechnol.* **5**, 308 (2014)

photoemission: experimental band structure of graphene (real 2D system)

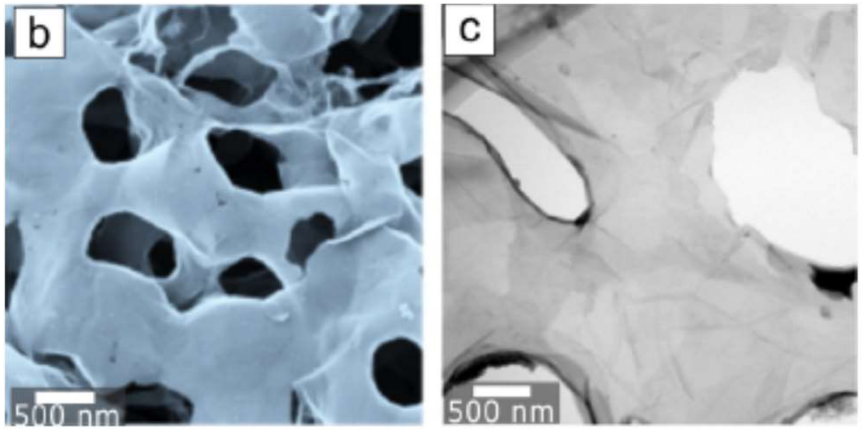


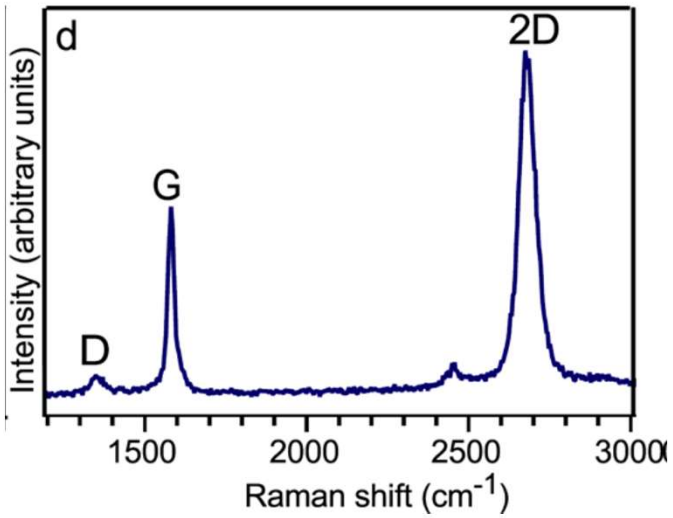


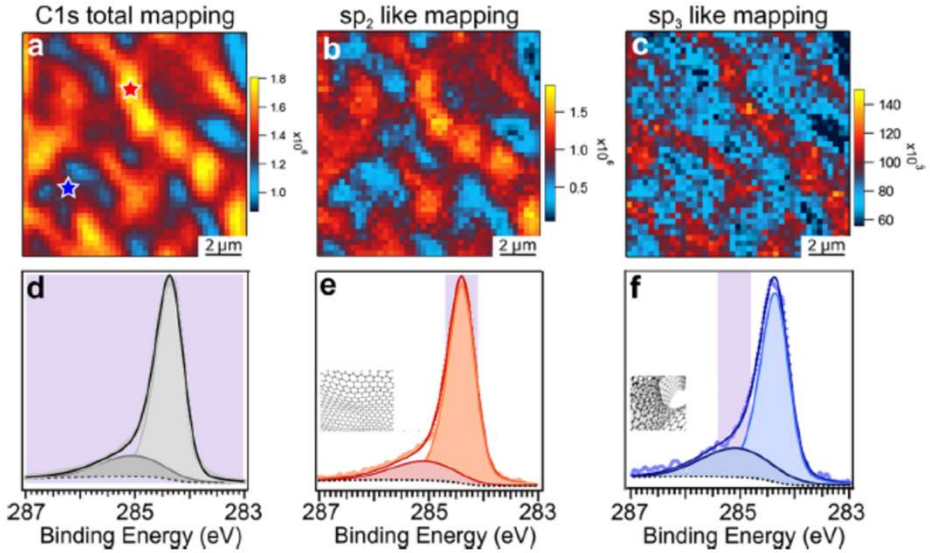
$$E(\mathbf{k}) = \pm t\sqrt{1 + 4\cos(\sqrt{3}ak_y/2)\cos(ak_x/2) + 4\cos^2(ak_x/2)}$$

M. Scardamaglia et alii, Journal of Physical Chemistry C **117**, 3019-3027 (2013); DOI: 10.1021/jp308861b
L. Massimi et alii, The Beilstein Journal of Nanotechnology **5**, 308-312 (2014); DOI: 10.3762/bjnano.5.34

nano-porous graphene







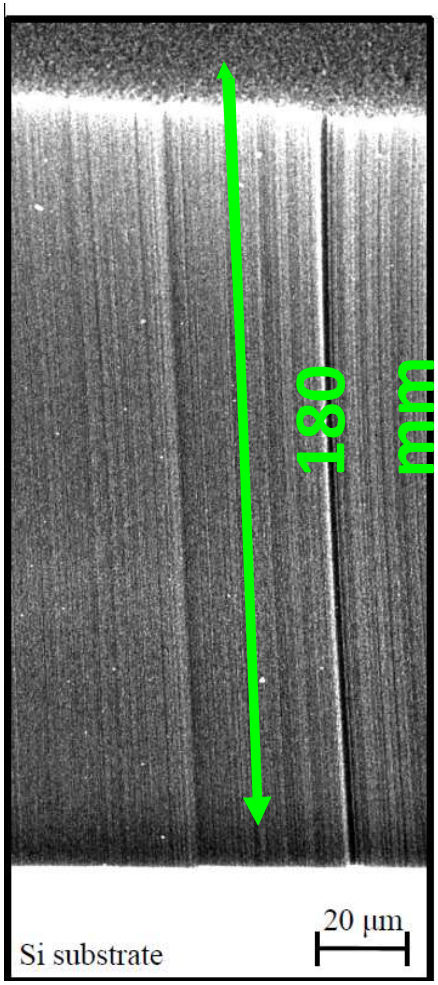
Di Bernardo et alii, "Two-Dimensional Hallmark of Highly Interconnected Three-Dimensional Nanoporous Graphene", ACS Omega 2, 3691-3697 (2017);
Di Bernardo et alii, Carbon 131, 258-265 (2018)

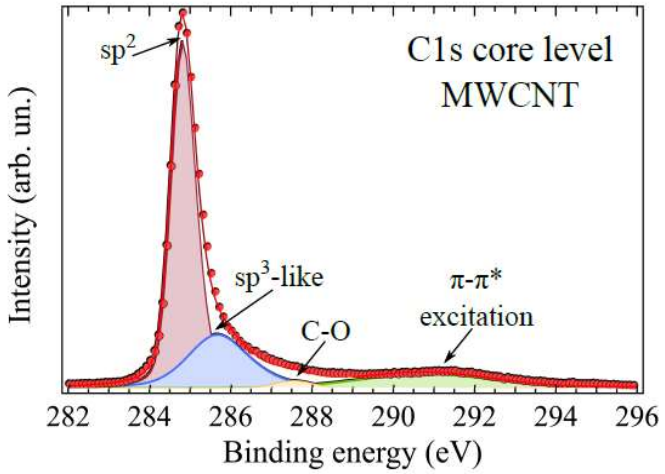
Carbon Nano Tubes (CNT)

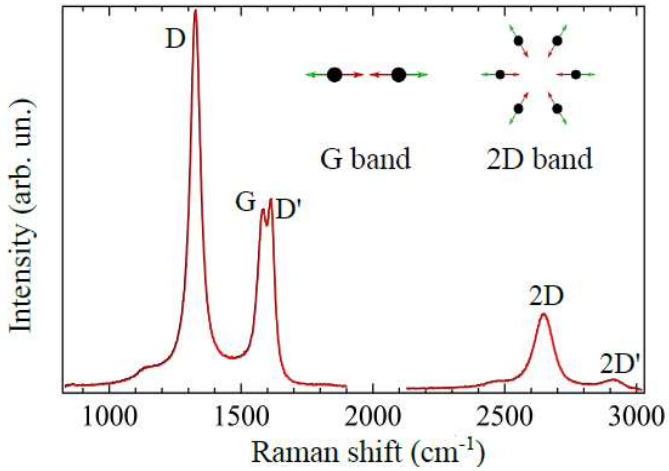
HEIGHT	$180 \pm 8\ \mu m$
DIAMETER	$20 \pm 1\ nm$

~10^4 aspect ratio

$$\mathcal{N} = 9\ x\ 10^8\ \frac{MWCNTs}{cm^2}$$







D'Acunto et alii, "Channelling and induced defects at ion-bombarded aligned multiwall carbon nanotubes", Carbon **139**, 768-775 (2018); https://doi.org/10.1016/j.carbon.2018.07.032

Acknowledgements

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SAPIENZA
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