



SAPIENZA
UNIVERSITÀ DI ROMA

Research and teaching activities in the Materials Science curriculum

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<https://sites.google.com/uniroma1.it/nano-surface-physics/home>

*PhD in Mathematical Models for Engineering, Electromagnetism and Nanosciences,
Sapienza University, Roma, Italy, November 21st 2019*

outline

Curriculum of Materials Science

- Members of the PhD board**
- Teaching, courses**
- A couple of examples of research activity**

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outline

Curriculum of Materials Science

- Members of the PhD board
- **Teaching, courses**
- A couple of examples of research activity

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 2020)

S1, Basic Module, ~40 hours (4 ECTS):

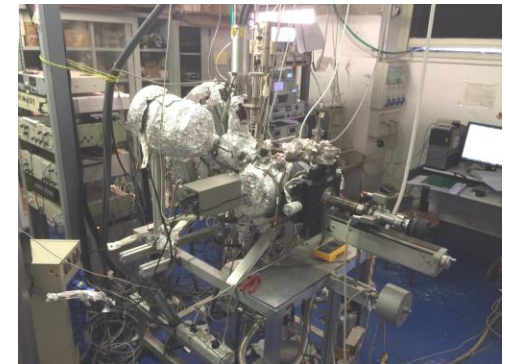
Interazione radiazione-materia, spettroscopia di fotoemissione e assorbimento / Interaction of Electromagnetic Radiation with Matter, Photoelectron Spectroscopy and Absorption

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 (~20 hours):

- **V. Foglietti (CNR, Roma Tre):** Micro and nano-fabrication techniques
- **G. Capellini (Roma Tre):** Microscopy techniques



S1. 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 2020)

as also courses for this PhD School from the other curricula
(Electromagnetism, Mathematics)



Curriculum of Materials Science

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- Teaching, courses: **other courses**, from the Master Courses in Physics, Chemistry or Nanotechnology
- A couple of examples of research activity

List of useful courses from the Master degree:

I semestre/ I semester

Master S2 M.G. Betti (Corso di Laurea Magistrale in Fisica), “Surface Physics and Nanostructure”, 48 ore (6 CFU / ECTS)

Master S3 D. Dini (Corso di Laurea Magistrale in Chimica Industriale), “Chimica Fisica dello Stato Solido e dei Materiali Nanostrutturati”, 48 ore (6 CFU / ECTS)

Master S4 M.A. Navarra (Corso di Laurea Magistrale in Chimica Industriale), “Sistemi di produzione ed accumulo dell'energia”, 48 ore (6 CFU) / ECTS

II semestre/ II semester

Master S5 M. Grilli (Corso di Laurea Magistrale in Fisica), “Many Body Physics”, 60 ore (6 CFU / ECTS)

Master S6 C. Mariani (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie), “Fabbricazione e caratterizzazione di nanostrutture”, 48 ore (6 CFU / ECTS)

Master S7 A. Martinelli (Corso di Laurea Magistrale in Chimica Industriale), “Laboratorio di Macromolecole”, 84 ore (9 CFU / ECTS)

Master S8 M. Rossi (Corso di Laurea Magistrale in Ingegneria delle nanotecnologie), “Microscopie e tecniche di nanocaratterizzazione ”, 90 ore (9 CFU / ECTS)

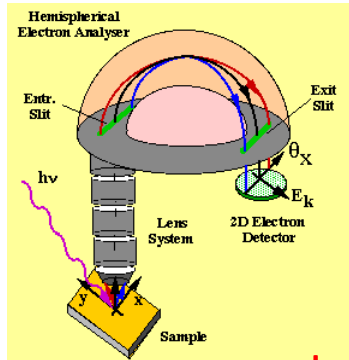
Master S9 D. Passeri (Master in Nanotechnology Engineering), “Electron Microscopy and Related Techniques”, 90 ore (9 CFU / ECTS)

outline

Curriculum of Materials Science

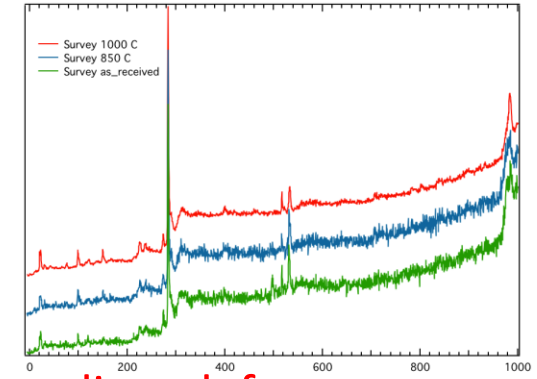
- Members of the PhD board
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spectroscopy and microscopy techniques

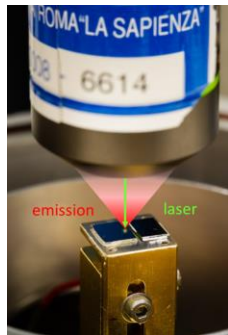


X-ray Photoelectron Spectroscopy (XPS) and Angular Resolved Photoelectron Spectroscopy (ARPES)

Phys. Dept. @ Sapienza and SR sources

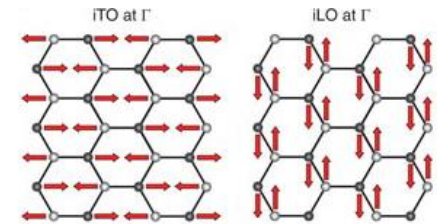


spectral density of electronic states: chemical state, bonding, defects, ...



Optical and Raman spectroscopy at sub-mm scale

Phys. Dept. @ Sapienza

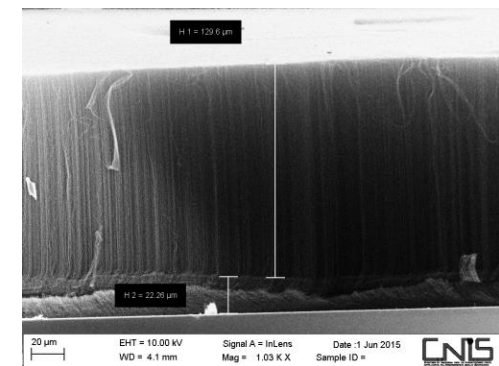


IR scattering, vibrational structure, fluorescence of quantum dots, etc.

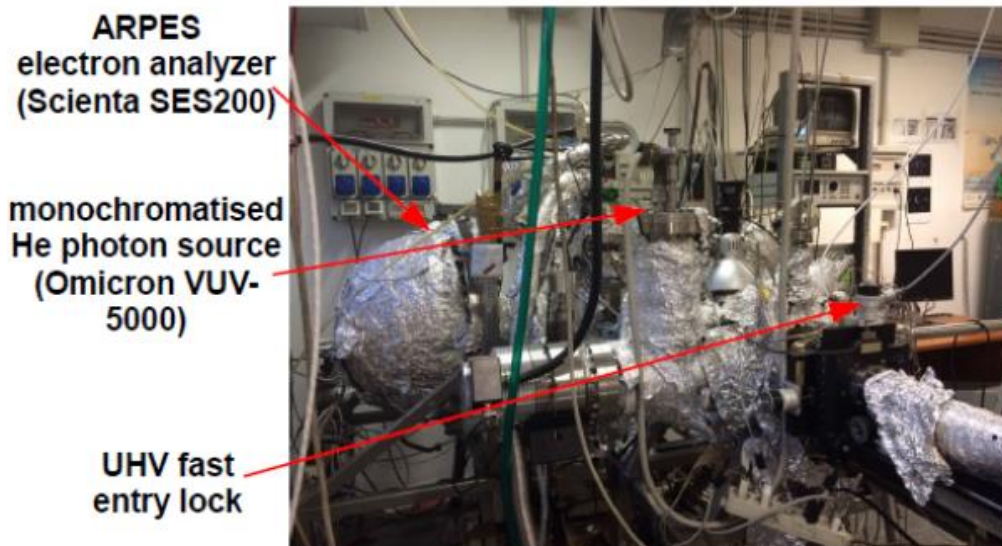
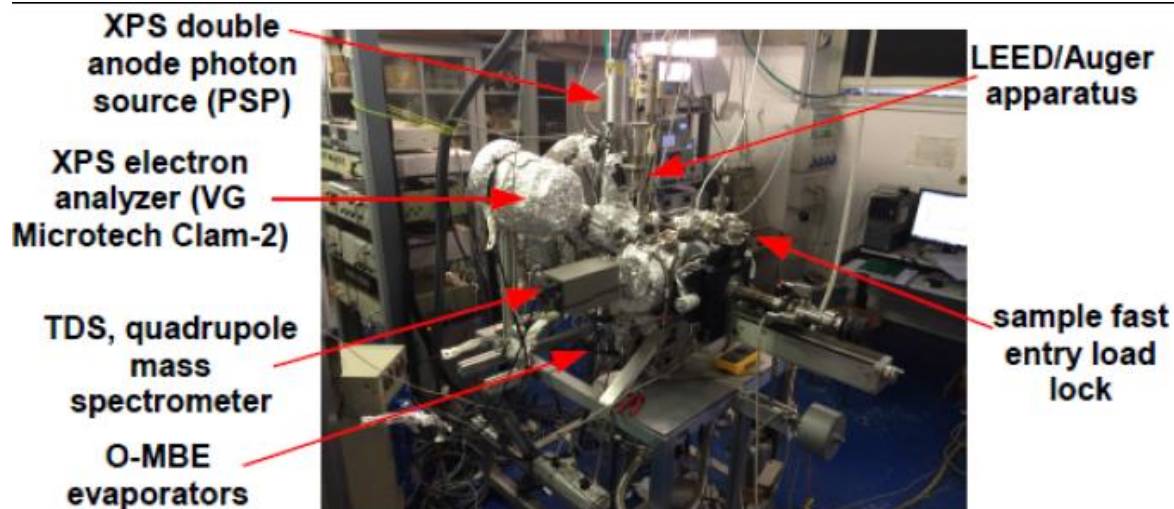


Scanning Electron Microscopy (SEM) at sub-mm scale

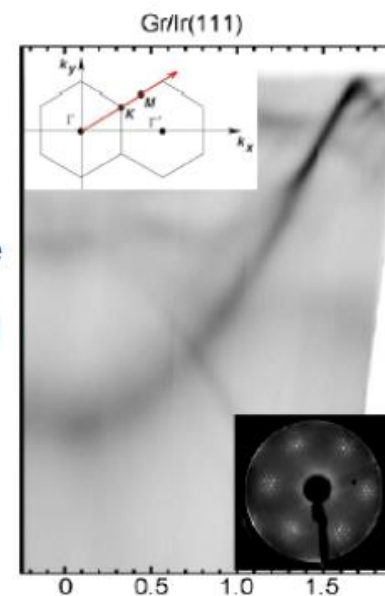
CNIS lab. @ Sapienza



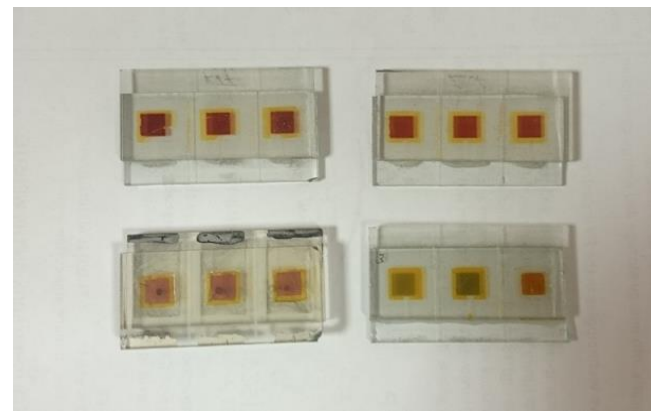
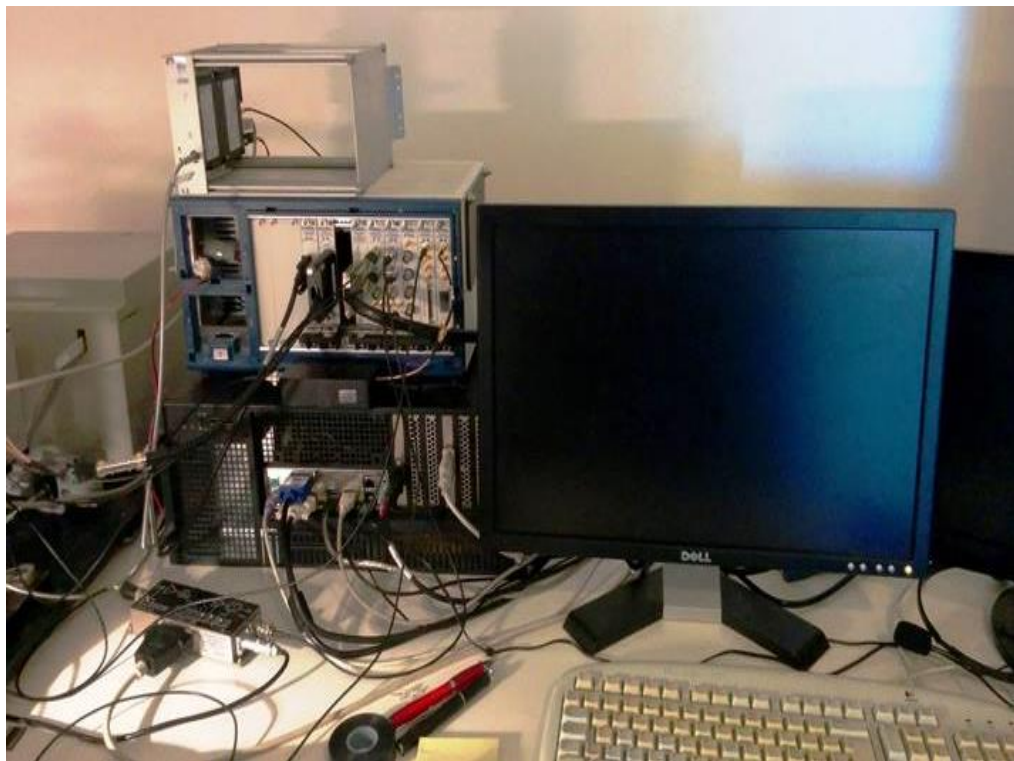
photoemission laboratories



surface electronic band structure of graphene along the Γ KM direction of the Brillouin zone

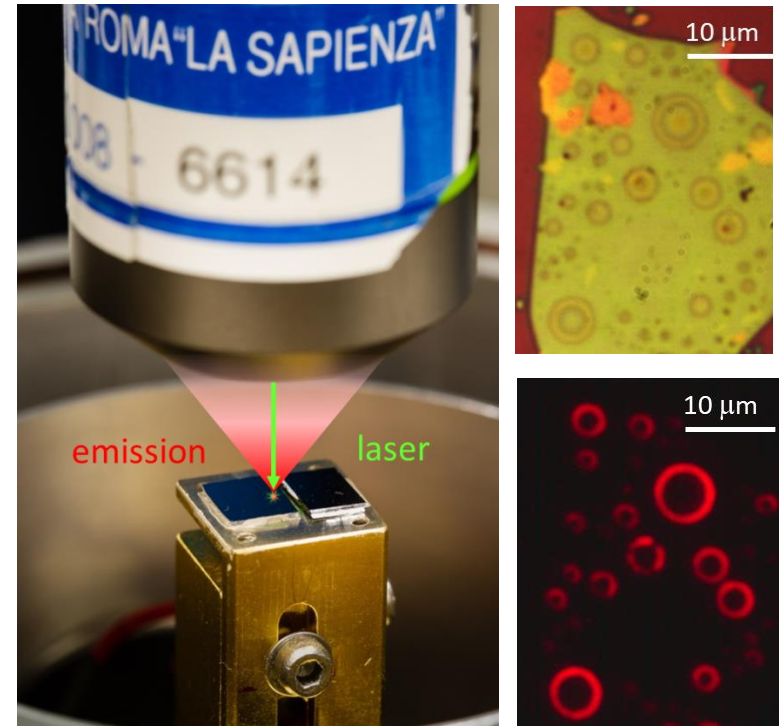
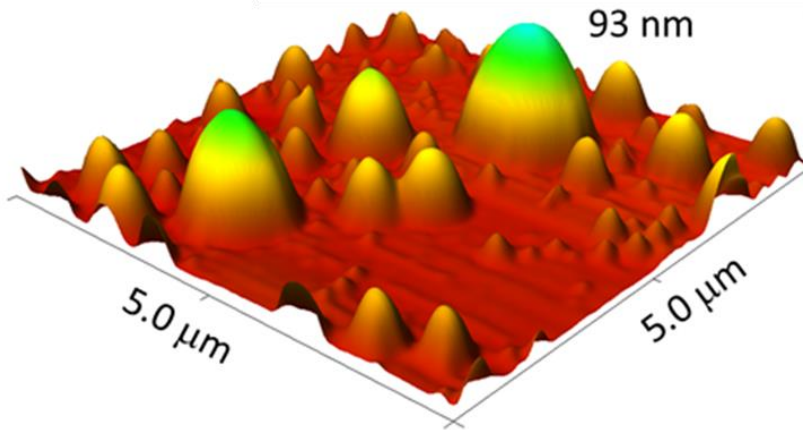


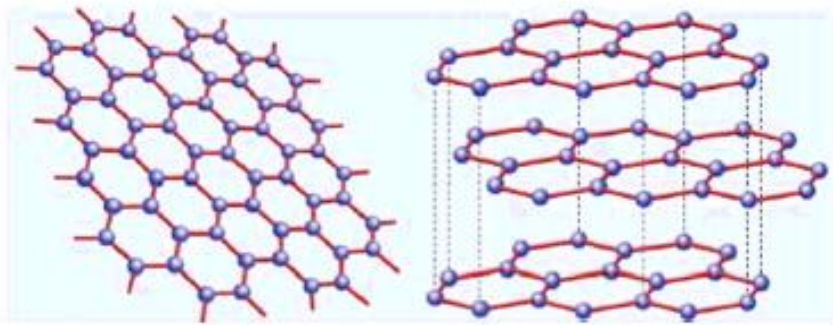
electrochemistry apparatus



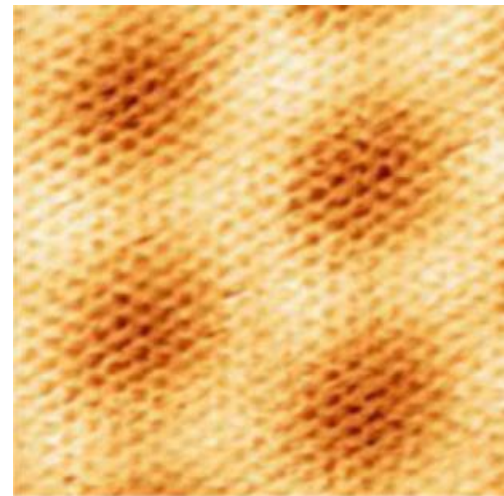
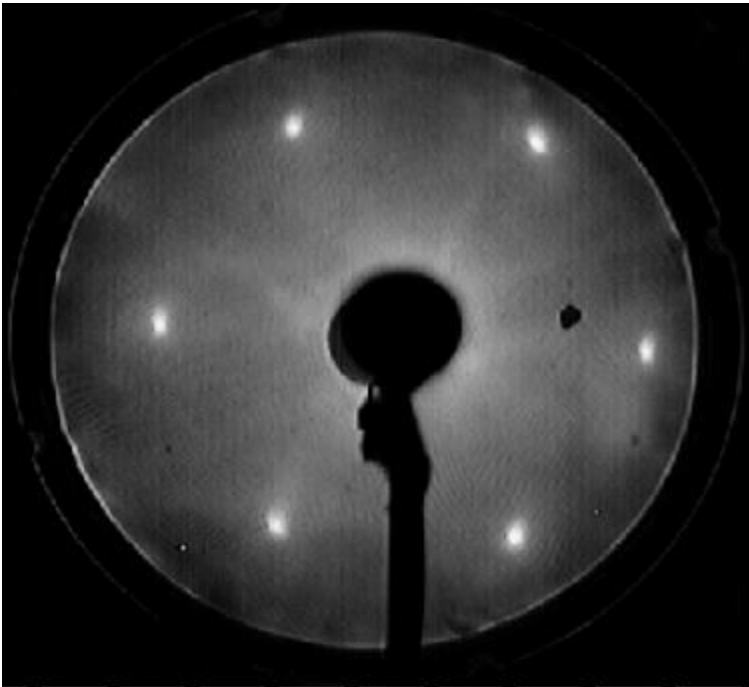
optical fluorescence / Raman apparatus

Optical spectroscopy
on deformed
two-dimensional
crystals

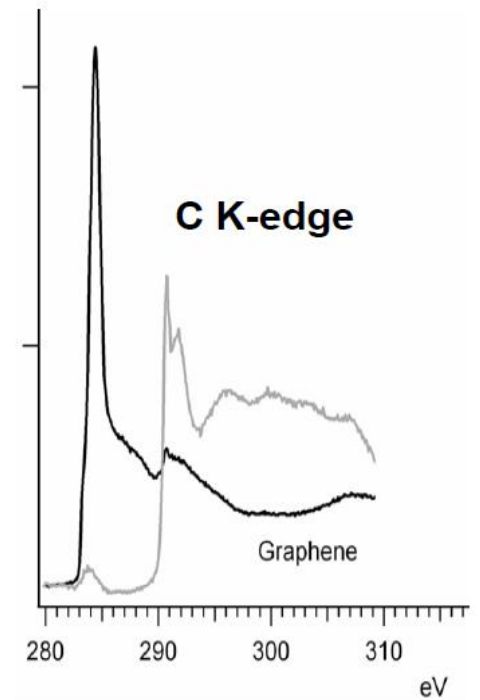
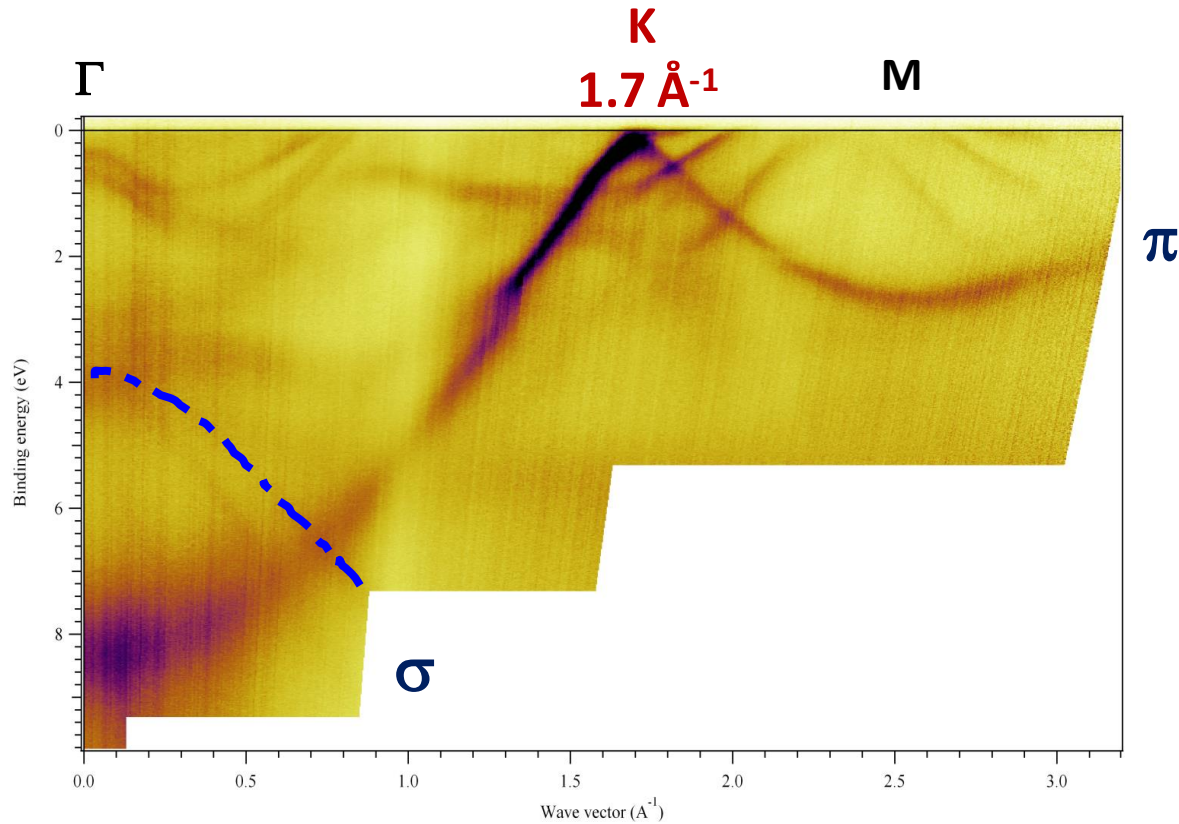




graphene

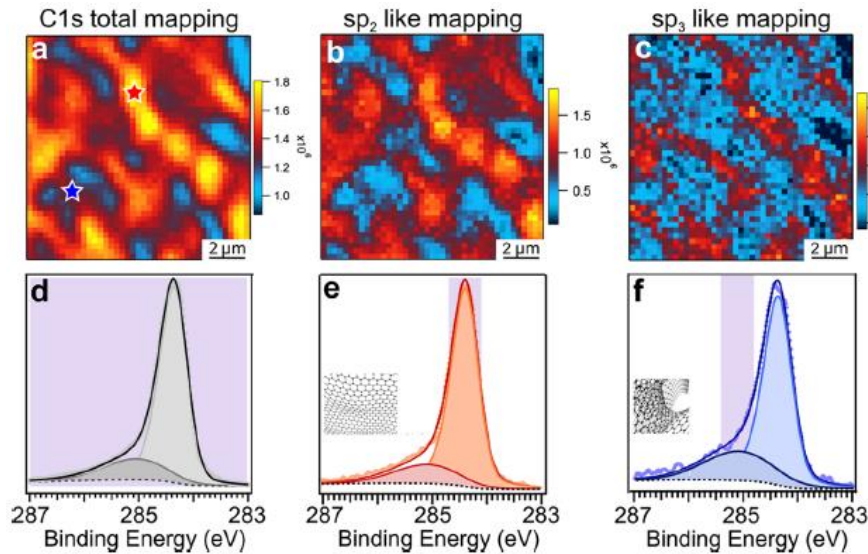
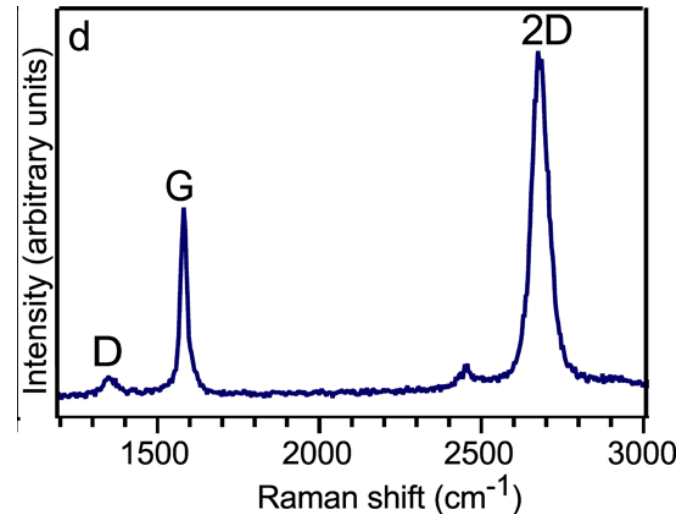
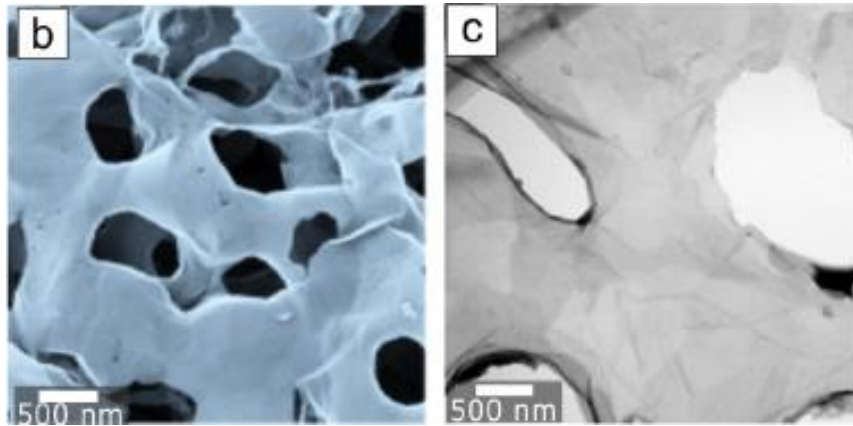


photoemission: experimental band structure of graphene (real 2D system)



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

nano-porous graphene

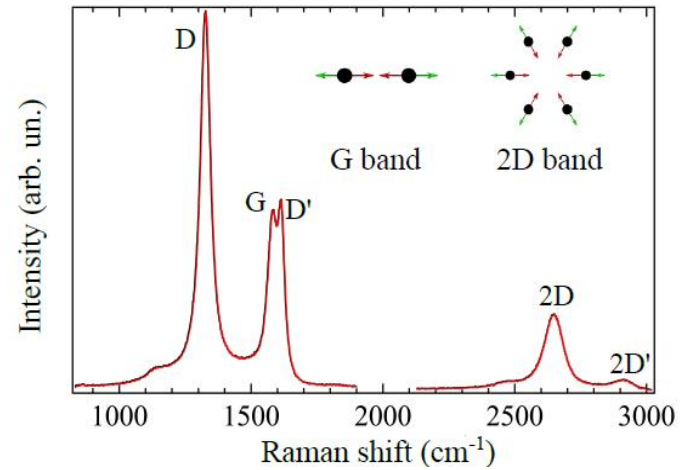
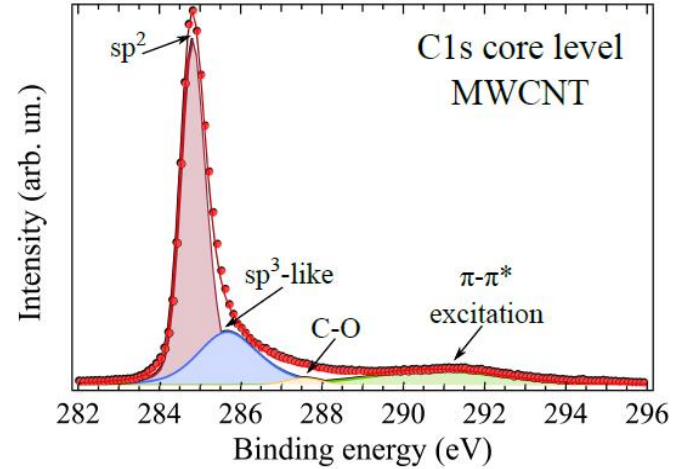
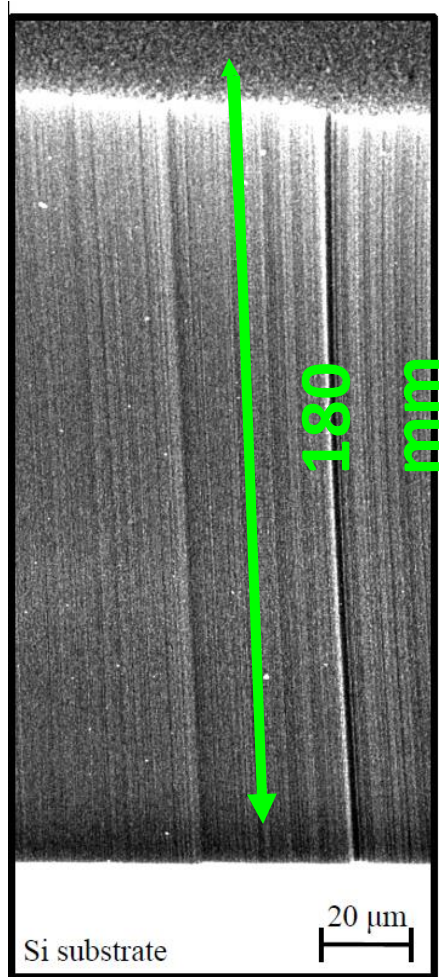


Carbon Nano Tubes (CNT)

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

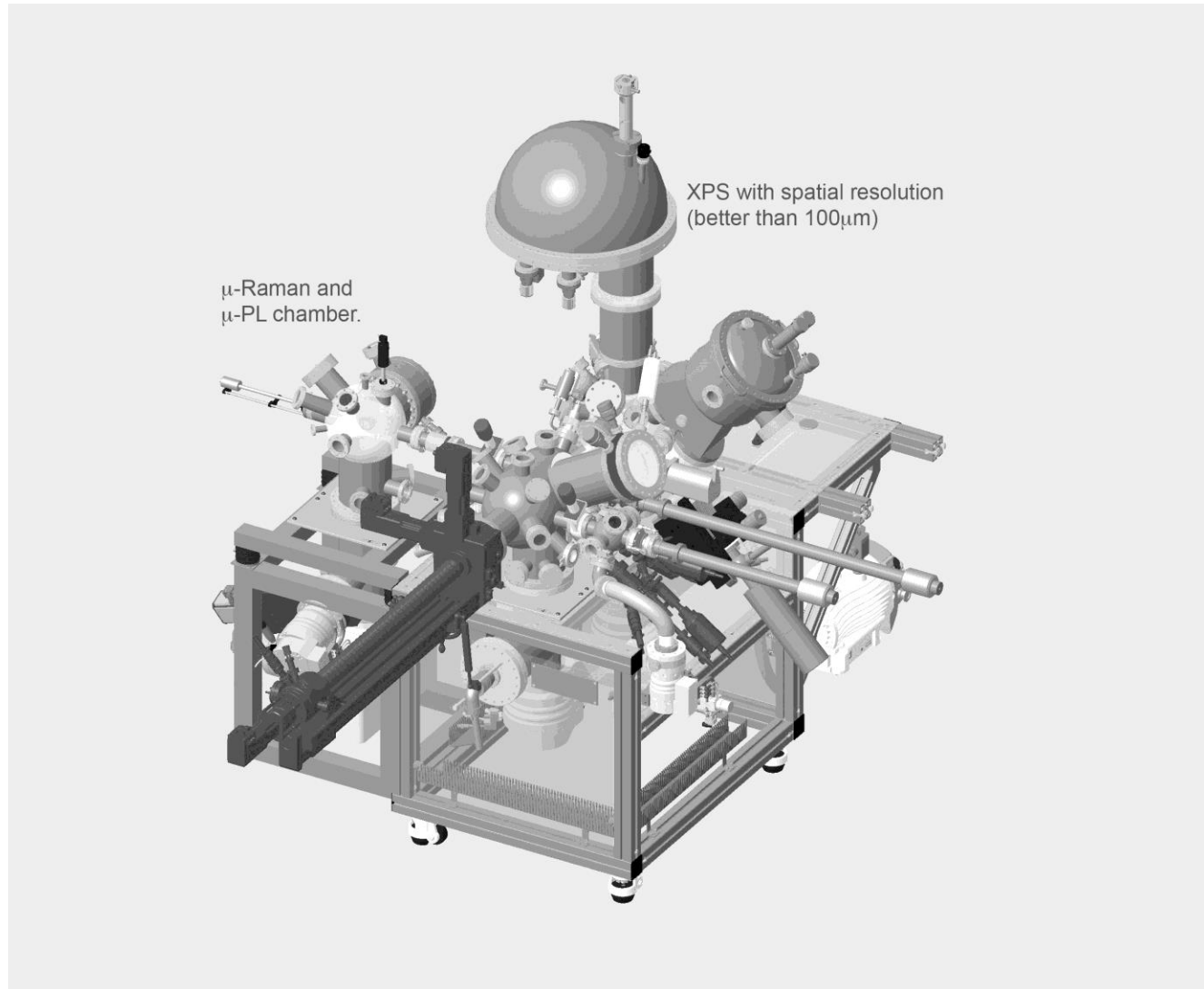
$\sim 10^4$ aspect ratio

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



**the new Spectro-Microscopy Laboratory of the Amaldi excellence
Research Center
(Department of Physics)**

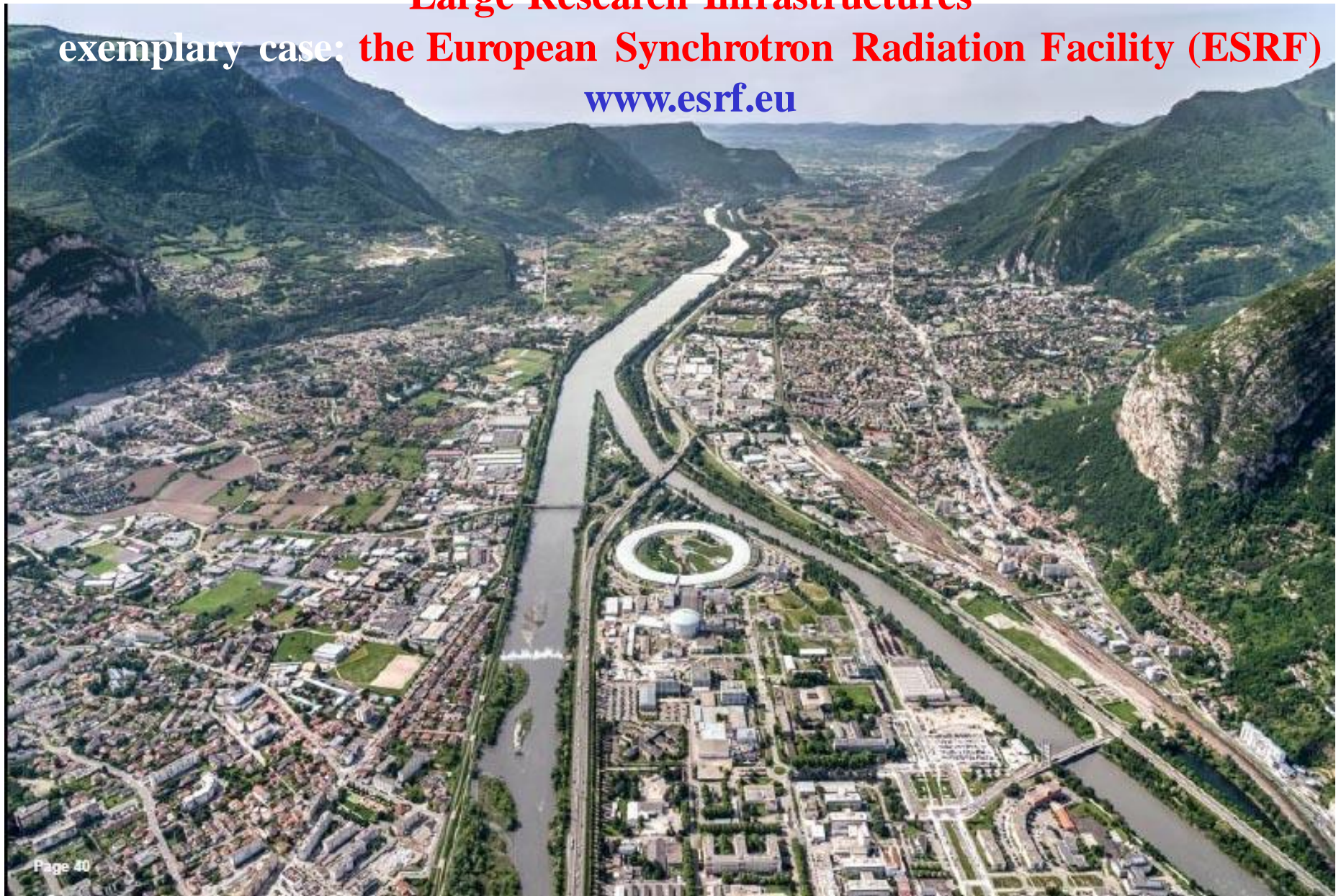
http://www.roma1.infn.it/amaldicenter/mat_sci_3G_ifos.html



Large Research Infrastructures

exemplary case: **the European Synchrotron Radiation Facility (ESRF)**

www.esrf.eu



PhD students can have access to LRI, like the ESRF, with open-access on the only basis of scientific merit

Acknowledgements

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