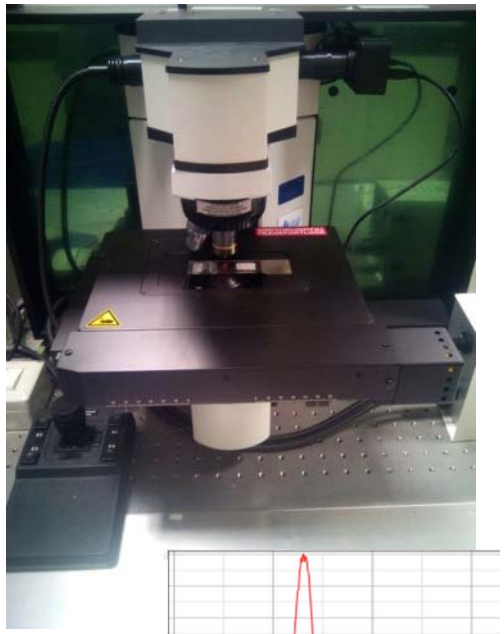
Applied Experimental Physics

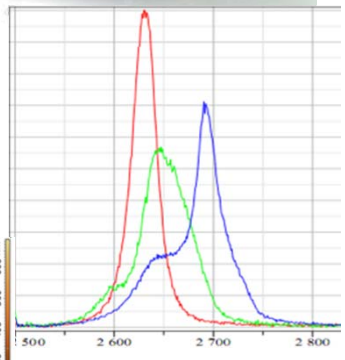
Department of Computer Science
University of Verona

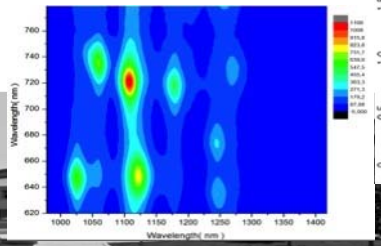
Applied Experimental Physics

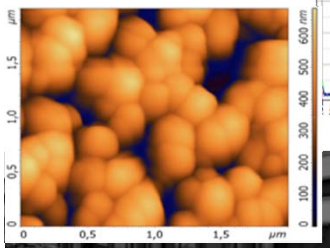
- Research in **Experimental Physics** is aimed at the study of mesoscopic phenomena in **condensed matter physics**

- Research topics span in the field of **structural** and **dynamical properties** of **solid state systems** in form of crystalline compounds or nanostructured films



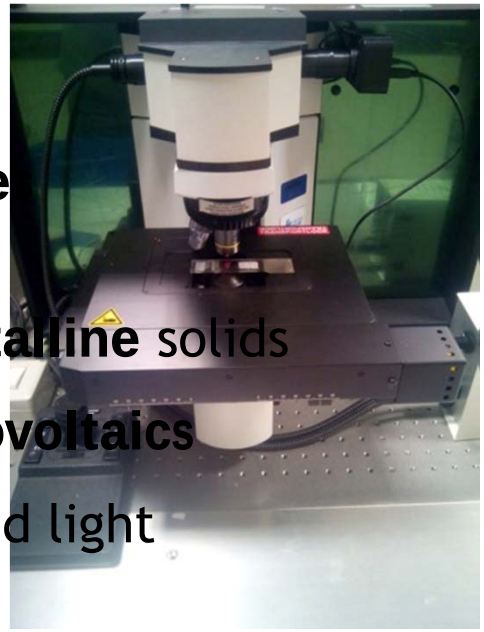




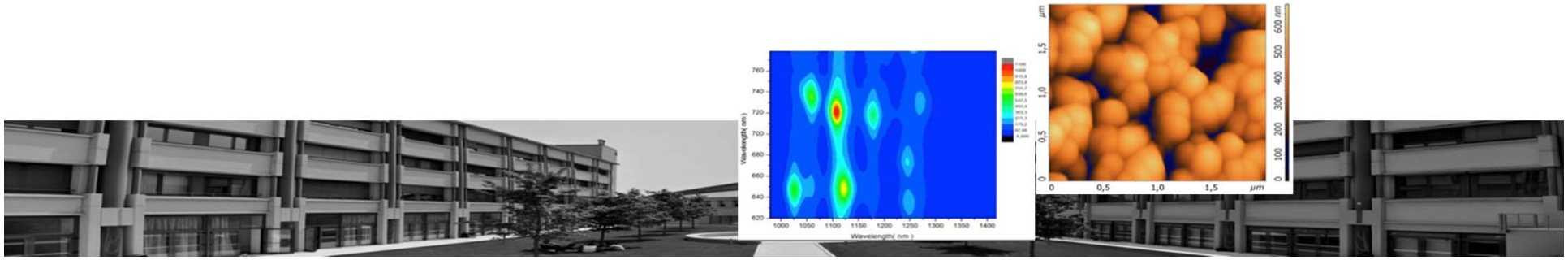


Applied Experimental Physics

Main current topics



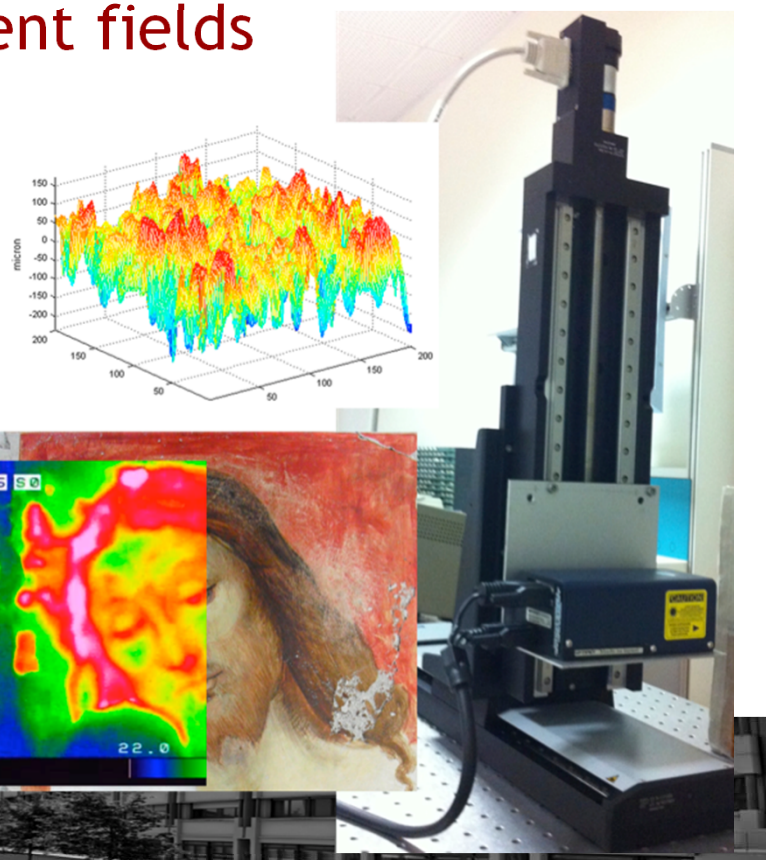
- Study of the **optical** and **electronic properties** of **nano-structured** systems
- Study of **vibrational dynamics** of **micro-crystalline** solids
- Development of **thin films devices** for **photovoltaics**
- Development of **advanced optical devices** and light modulators
- Interdisciplinary applications of **infrared Spectroscopy** and Microspectroscopy



Applied Experimental Physics

- Research in **Applied Physics** is aimed at **developing new technologies and methods** based on application of physical concepts for investigating problems in different fields

  - **Biomedicine**
  - **Biotechnology**
  - **Cultural Heritage**

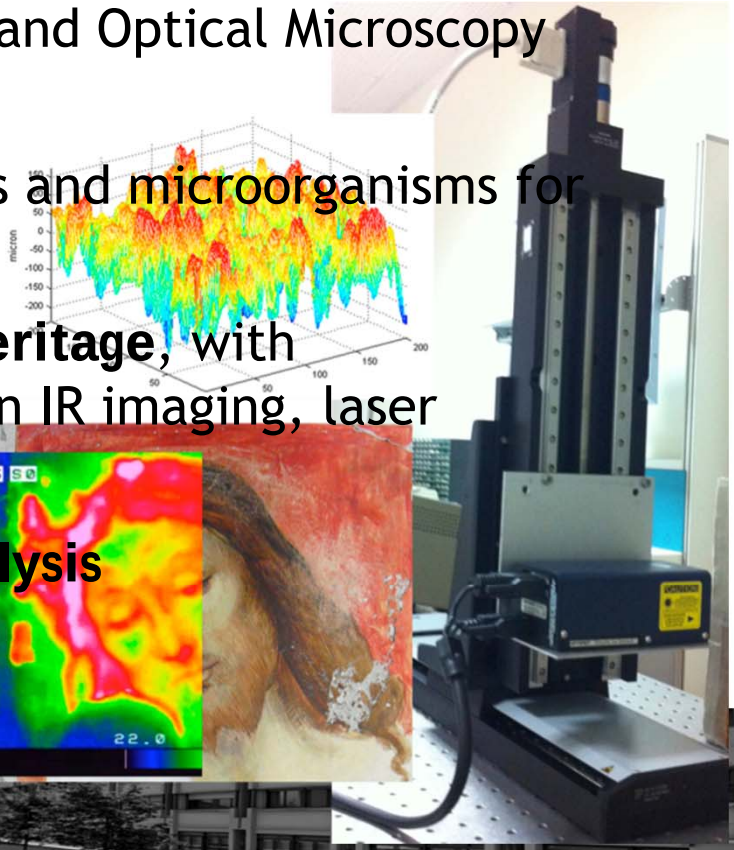


- **Interdisciplinary activities**
  - biological, medical, humanistic areas

Applied Experimental Physics

Main current topics

- **Multimodal imaging** based on Magnetic Resonance Imaging, Optical Imaging, Nuclear Medicine and Optical Microscopy for **biomedical** studies
- **FT-IR microspectroscopy** on plants and microorganisms for **biotechnological** applications
- **Optical techniques** for **Cultural Heritage**, with implementation of devices based on IR imaging, laser profilometry, speckle imaging
- **Lab spectroscopy** and **surface analysis**



Physics @ UNIVR

Gino Mariotto
RAMAN Lab

Stefania Residori
OPDATE Lab

Pasquina Marzola
MRI Lab

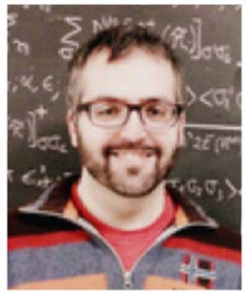
Alessandro Romeo
LAPS Lab

Francesca Monti
IRIS Lab

Federico Boschi
OPTICAL IMAGING Lab

Claudia Daffara
OPDATE Lab

Nicola Daldosso
FLUO Lab



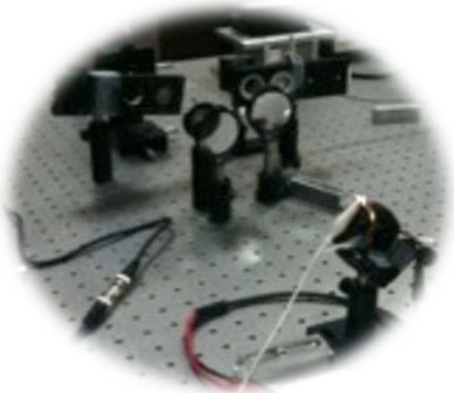
Marco Zanatta
RAMAN Lab

7 Physics LABS

RAMAN

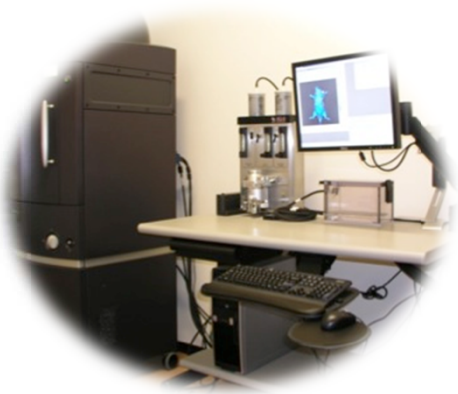
FLUO-LAB

IRIS



OPTDATE

LAPS



OPTICAL IMAGING

MRI

RAMAN LAB

RESEARCH

- **Vibrational dynamics** of **micro-crystalline** solids
- **Phonon confinement** effects in **nanostructured** systems, i.e.: metal nanoclusters, quantum dots
- Structural and dynamics of **carbon-based low-dimensional systems**

COMPETENCES

- Fully polarized **Raman analysis** of single micro-crystals in both backscattering and 90° scattering geometry
- **Raman mapping** of **composite films**
- **Vibrational imaging** of **biological systems** (cells and tissues)

PEOPLE – G. Mariotto, M. Giarola, A. Kumar, M. Zanatta

RAMAN LAB

Vibrational Raman spectroscopy

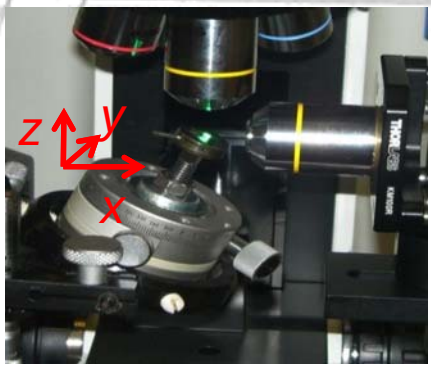
- Vibrational dynamics studies on micro-crystalline solids
- Frequency and symmetry detection of vibrational modes
- Symmetry selection of vibrational modes exploits the polarization of laser beam in combination with single crystal orientation
- Raman micro-spectroscopy
  - high spatial resolution - micrometric scale

Micro-Raman LAB

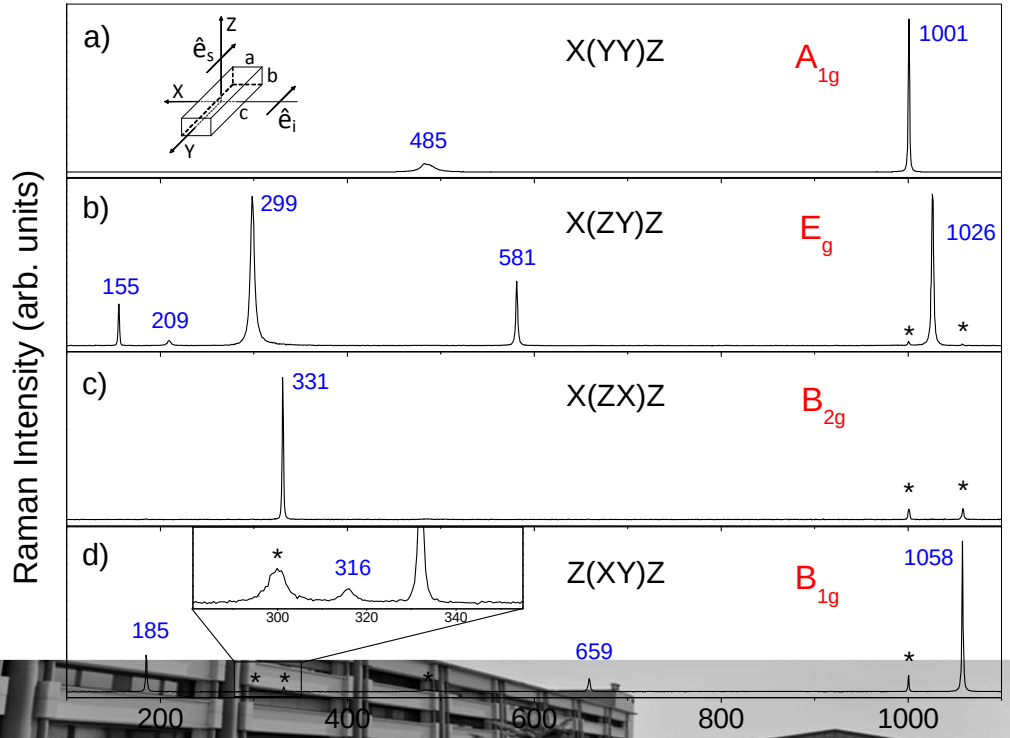
RAMAN LAB

Home-made upgrading of Micro-Raman apparatus

90° micro-sampling + micro-manipulation



90° scattering experiments on single micro-crystals properly orientated by using a micro-manipulator operated under direct optical monitoring.



Accurate symmetry selection of Raman active modes of preliminary oriented single micro-crystals (the case of of YPO_4):

- Twelve expected Raman modes:

$$\Gamma_R = 2A_{1g} \oplus 4B_{1g} \oplus 1B_{2g} \oplus 5E_g$$

- Twelve observed modes (cm^{-1}):

A_{1g} : 485; 1001

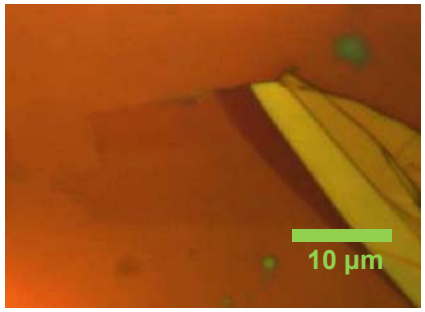
B_{1g} : 185; 316; 659; 1058

B_{2g} : 331

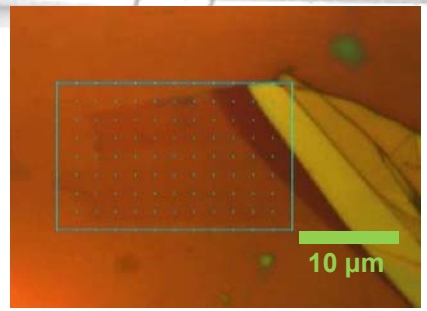
E_g : 155; 209; 299; 581; 1026

G. Mariotto

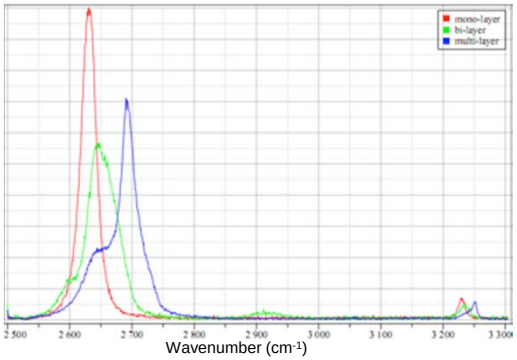
Raman mapping: grafene



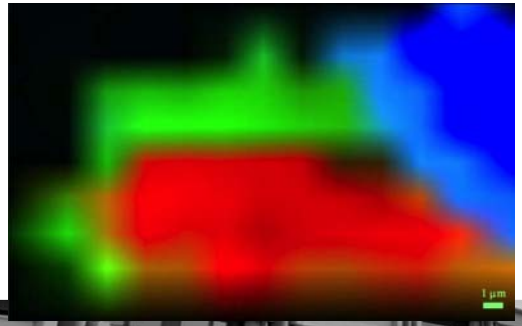
Acquisition of **many spectra in different points** on the sample, through a controlled motorized stage



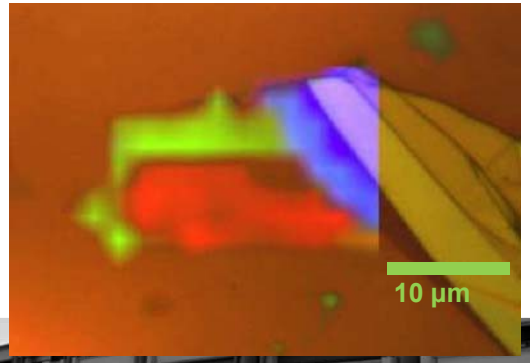
Raman spectra from a single, two and multi-layers **graphene sample**



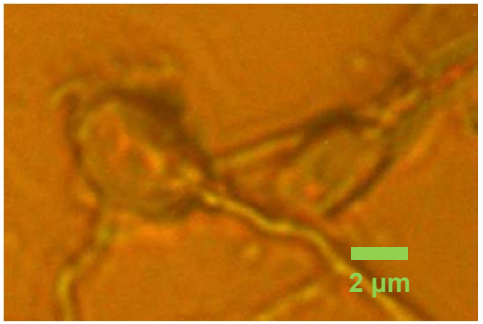
use of **spectra** of components to **create images**.



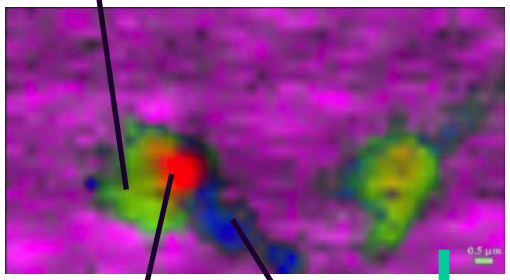
Raman micro-spectroscopy image and **optical image** overlay

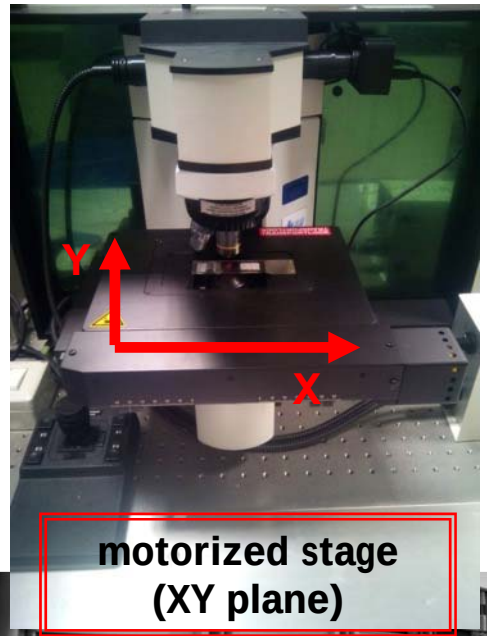


Raman imaging of biological tissue



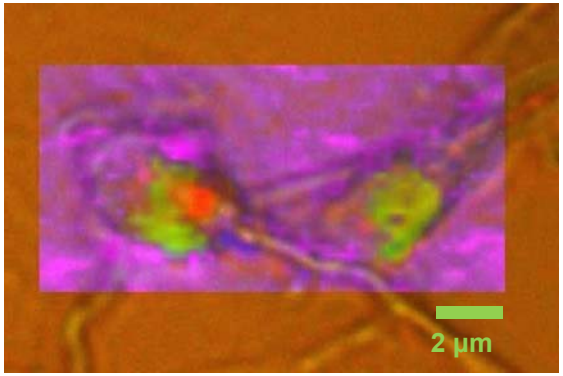
The "create" **clustering** procedure automatically identifies a number of reference spectral components using a factor analysis algorithm





motorized stage (XY plane)

Raman map - optical image overlay



Fluorescence LAB

RESEARCH

- **Optical characterization** of light emitting materials and nano-materials
- Study of **nanomaterials** for drug delivery
- Optimization of the **fluorescence** for new bio-markers

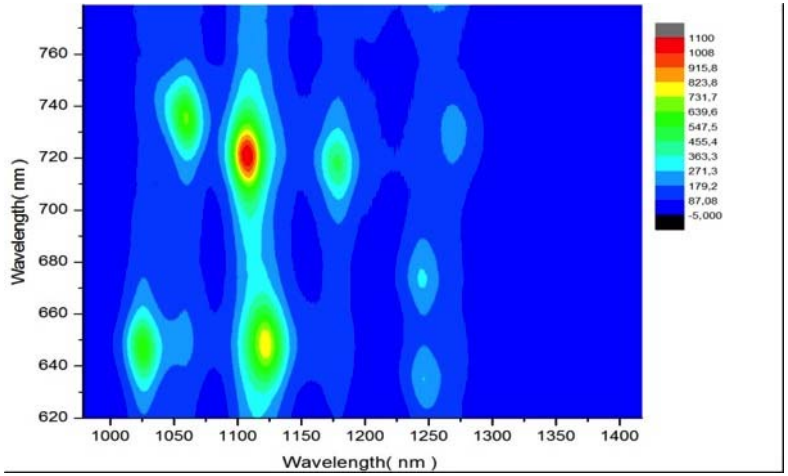
COMPETENCES

- **Optical and structural characterization** of nano-materials
- **Complete platform (visible-IR) for optical characterization in fluorescence**:
  Absorption spectra, Excitation/Emission(with 3D maps), Lifetime (time resolved fluorescence), Quantum efficiency

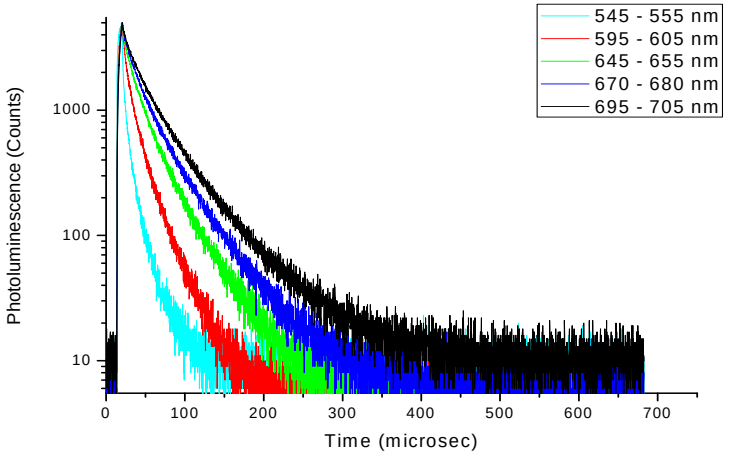
PEOPLE – N. Daldosso, Ali Ghafarinazari

Fluorescence lab: examples

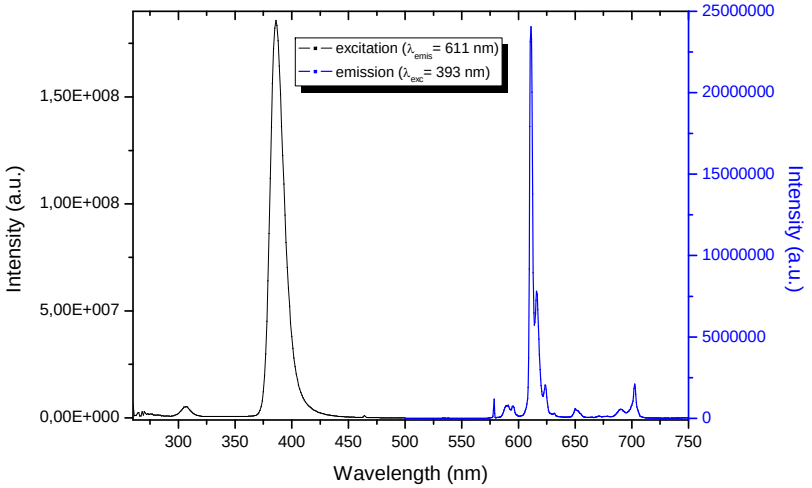
3D map (excitation-emission)
carbon nanotubes



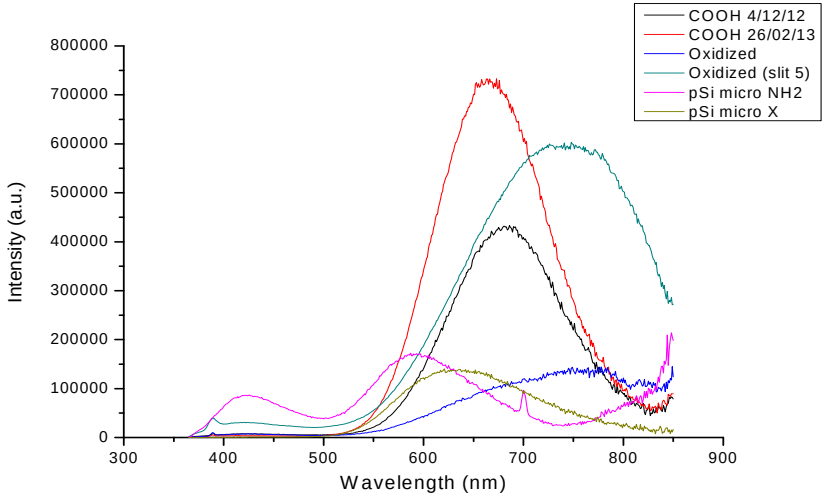
Time-resolved PL
(Si nanoparticles)



Eu:(TTA)3Phen Emission and excitation spectrum

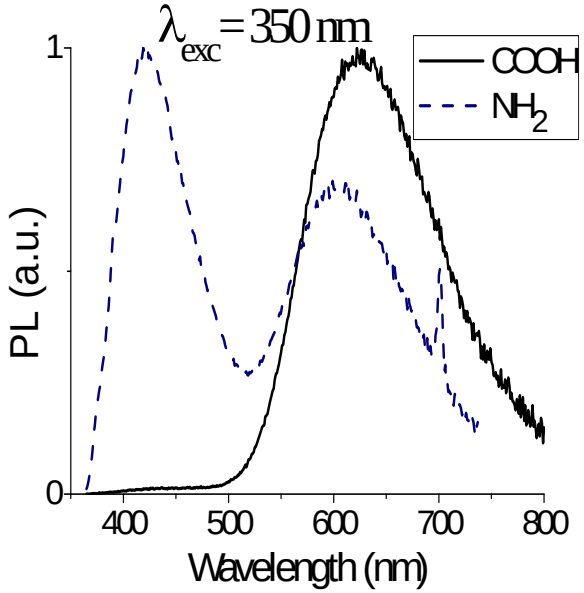


Emission spectra of **microporous silicon** in relation of superficial functionalization

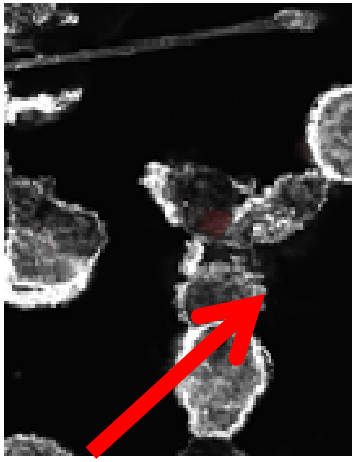


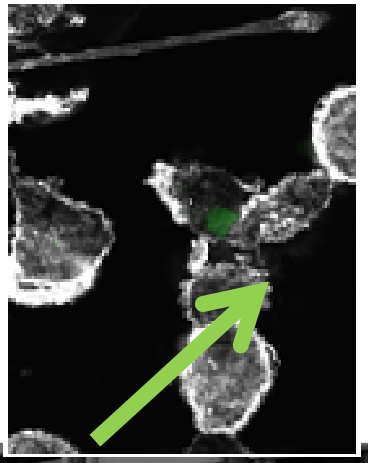
Silicon Nanostructures for medical applications

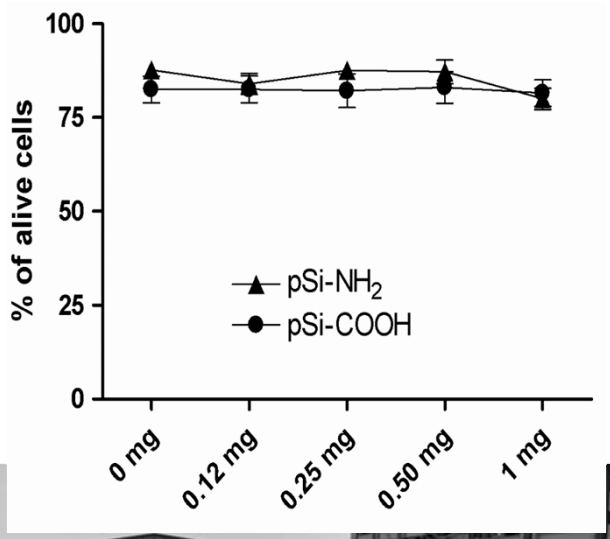
Surface functionalization also affected on the optical properties.



pSi







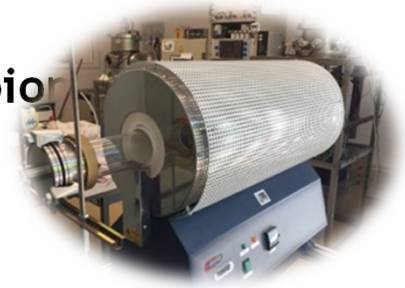
Conventional Confocal microscopy confirmed that HDS **up taken** pSi and pSi is **light emitting in different colours** inside the cells.

LAPS

Laboratory for Photovoltaics and Solid State Physics

RESEARCH

- Deposition of **thin films**, fabrication and study of second generation **solar cells**.
- Morphological analysis of **nanostructures** for **bio** applications.



COMPETENCES

- **Vacuum deposition:** thin film growth by RF sputtering, Thermal vacuum evaporation, Pulsed Electron deposition.
- **Chemical deposition:** nanofilms growth by chemical bath position, spin coating, doctor blading
- **trical and Morphological characterization:** Current-voltage, acitance-voltage, admittance spectroscopy, atomic force icroscopy.

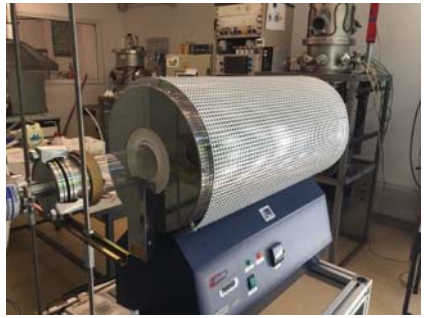
PEOPLE – A. Romeo, D. Menossi, E. Artegiani

Deposition of thin films & solar cells

3 Thermal Vacuum deposition systems

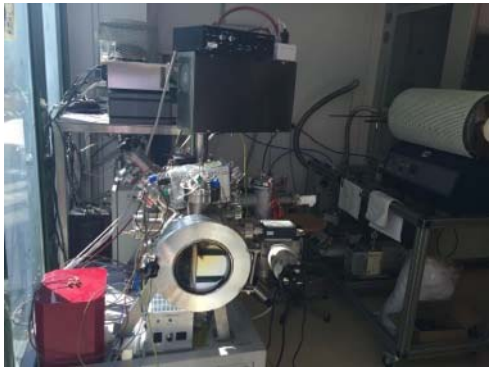


Furnaces



RF-magnetron sputtering

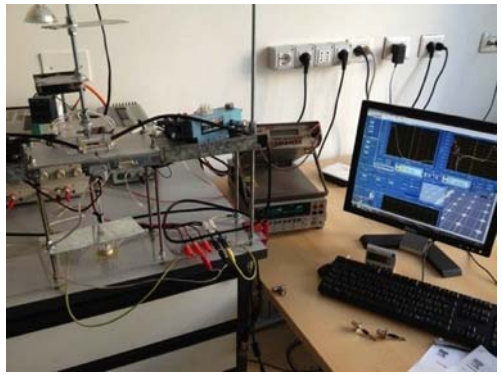
Pulsed Electron deposition



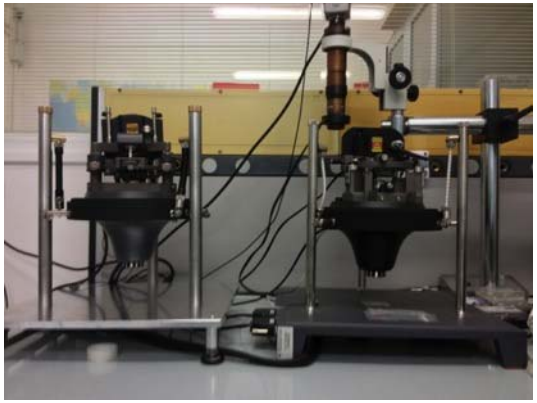
Chemical deposition systems

Characterization of materials and devices

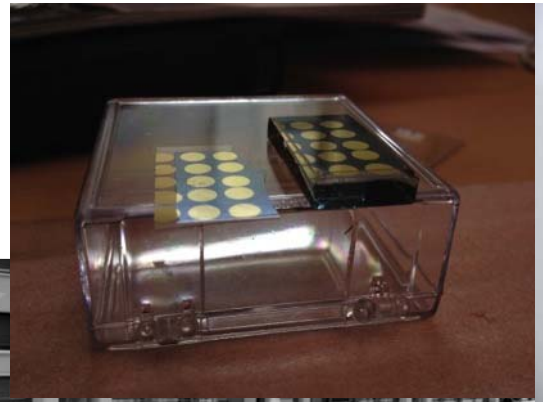
I-V and Impedance spectroscopy systems with N2-cryostat



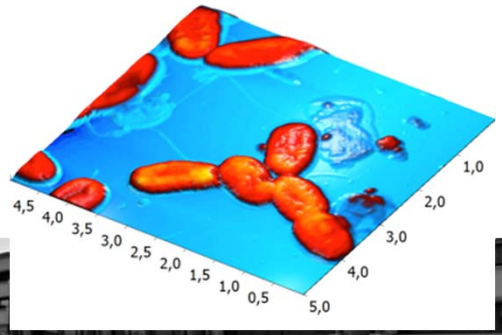
2 NT-MDT Atomic Force Microscopes



Rigid and flexible solar cells



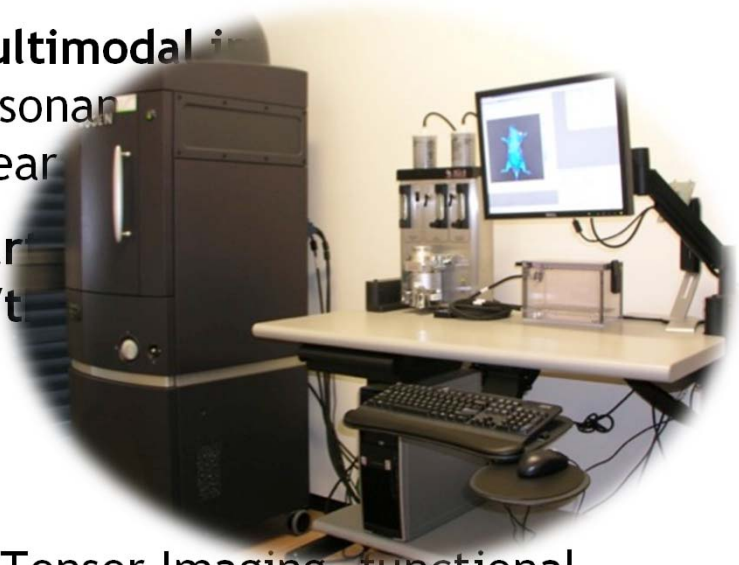
Bio structures analysis



MRI and Optical Imaging LAB
Applied Physics for BIOMEDICINE

RESEARCH

- development of innovative and **multimodal i**
  applications based on Magnetic Resonan
  Optical Imaging, Microscopy, Nuclear
- **characterization of novel nanopar**
  materials as potential **diagnostic /t**



COMPETENCES

- Advanced **MRI methods**: Diffusion Tensor Imaging, functional MRI and in vivo localized spectroscopy
- **Fluorescence**, **Bioluminescence**, **Cerenkov** imaging
- Confocal and Multi-photon **Microscopy**

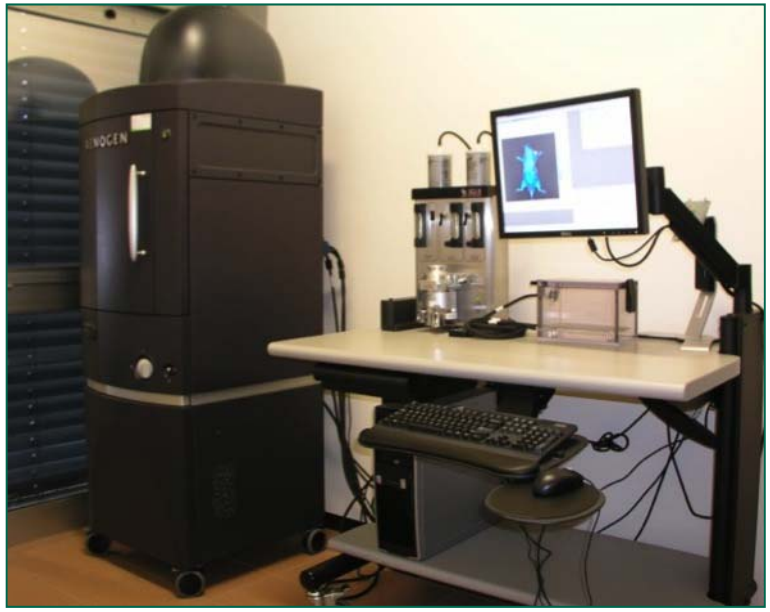
PEOPLE – F. Boschi, P. Marzola

Optical Imaging LAB
Applied Physics for BIOMEDICINE

OPTICAL IMAGING

techniques based on detection of VIS and Near-IR coming from:

- **Fluorescence sources** (FLI)
- **Bioluminescence sources** (BLI)
- **Radioactive sources**
  - Radionuclide imaging (RLI)
  - Cerenkov imaging (CLI)

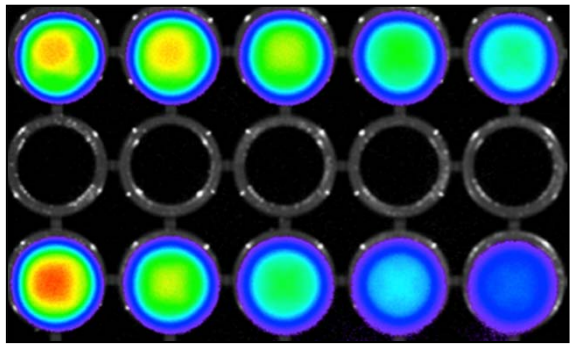


Optical Imaging LAB

IVIS Spectrum optical imager
(Perkin Elmer)

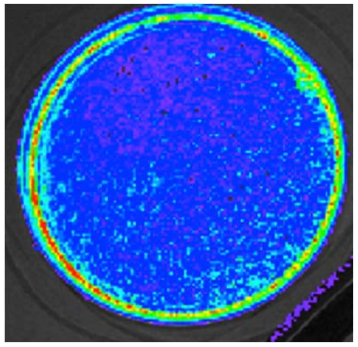
Optical Imaging LAB
Applied Physics for BIOMEDICINE

Fluorescence (FLI)



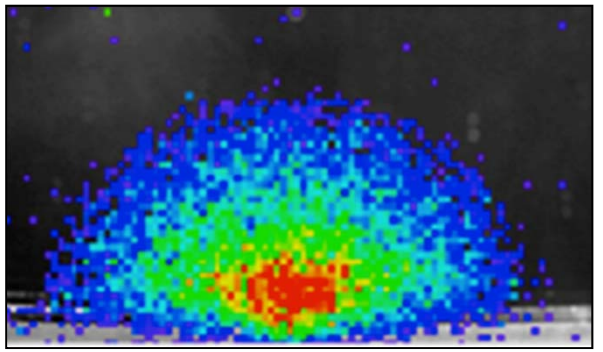
detection of fluorescent light from dyes linked to **biological molecules** and **nanoparticles**

Bioluminescence (BLI)



detection of light emitted by cells in **enzimathic process** (reaction luciferine-luciferase in firflies)

Radioactive sources (RLI, CLI)



detection of photon emission in **biological tissue** interacting with radioactive contrast agent

APPLICATION - imaging of living organisms and materials

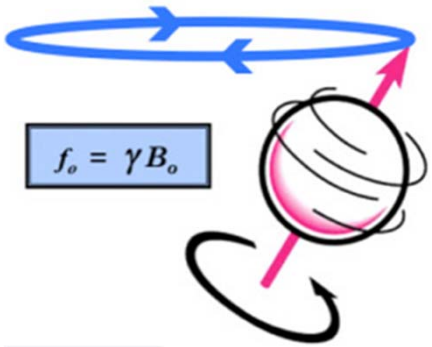
cancer disease, inflammation, neurodegenerative processess, drug evaluation, stem cell imaging

F. Boschi

MRI LAB
Applied Physics for BIOMEDICINE

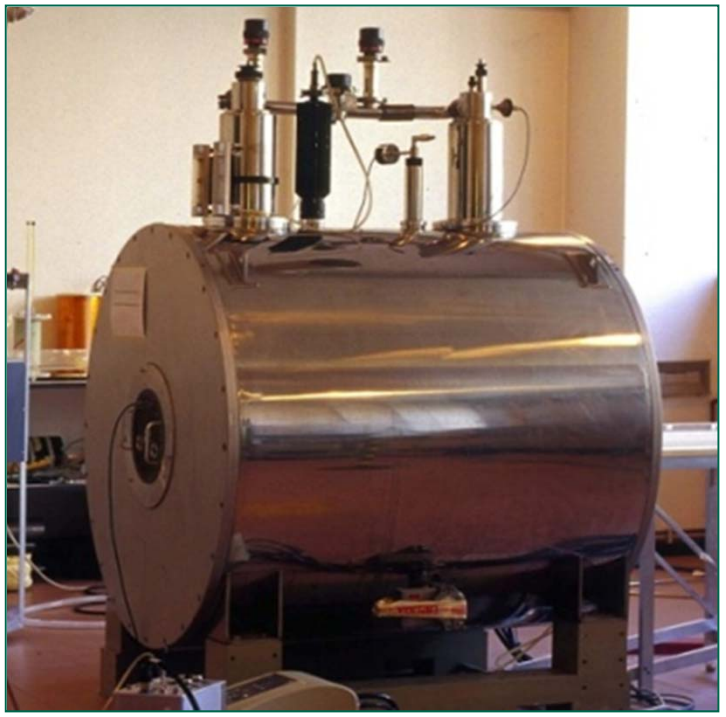
MAGNETIC RESONANCE IMAGING (MRI)

based on the Nuclear Magnetic Resonance Signal from protons in water and fat tissues



PHYSICS – Nuclei in external magnetic field

- Spin inversion by absorption of radiofrequency wave
- Emission of the resonance signal

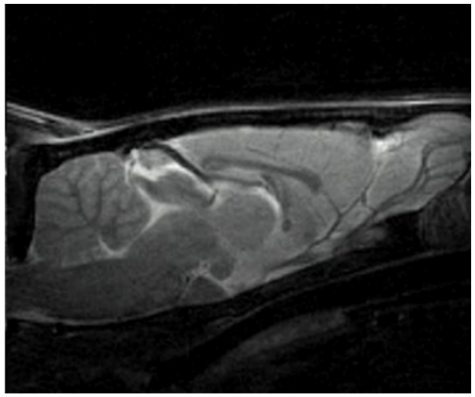


MRI LAB

4.7 T Magnetic Resonance Tomograph (Bruker)

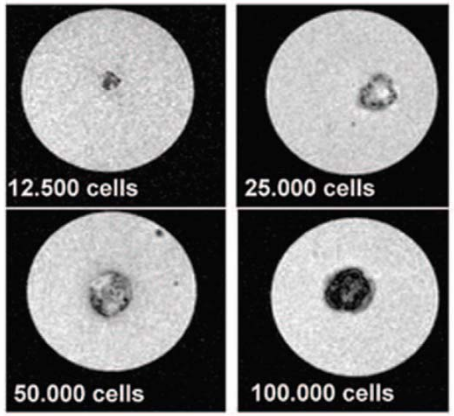
MRI LAB
Applied Physics for BIOMEDICINE

In Vivo Magnetic Resonance Imaging



MRI provides morphological and functional information of **living organisms** in non-invasive way with high spatial resolution

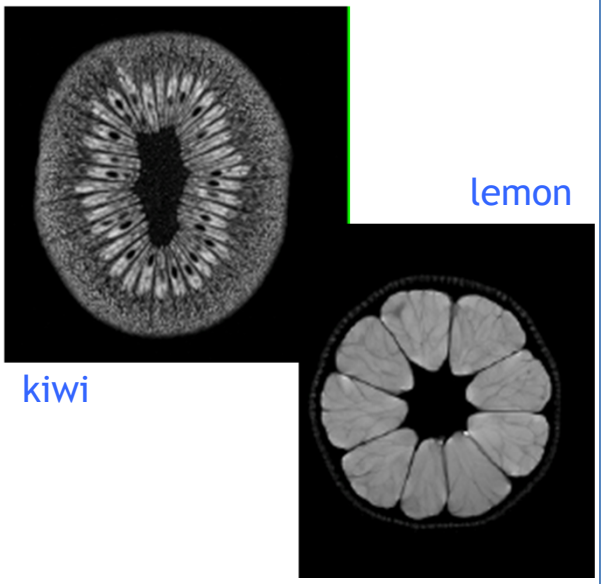
Cellular Imaging



MRI is a powerful technique for detection of **living cells**

- stem cells labeled with nanoprobes are detected with high sensitivity

Biotech Imaging



MRI can also be applied to study morphology and physiology of **vegetables**

APPLICATION - imaging of living organisms and materials

P. Marzola

IRIS LAB

IR Application for Interdisciplinary Studies

RESEARCH

- FT-IR spectroscopy and **micro-spectrosc**
  with **multivariate statistical analysis**
  molecular **characterization of micr**
  cell wall
- IR spectroscopy for **sample analysi**

COMPETENCES

- Mid-Infrared spectroscopy experimental techniques
- Spectral data analysis through data mining techniques (PCA, HCA, Heat-maps)
- Characterization of biochemical components and metabolic processes

PEOPLE – F. Monti, C. Daffara

IRIS LAB

IR Application for Interdisciplinary Studies

FT-IR micro-spectroscopy

- absorption of MID-IR radiation by chemical bonds
- various measurement techniques:

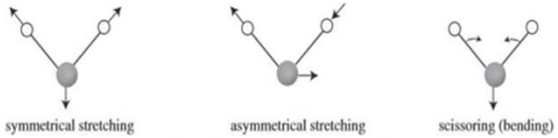
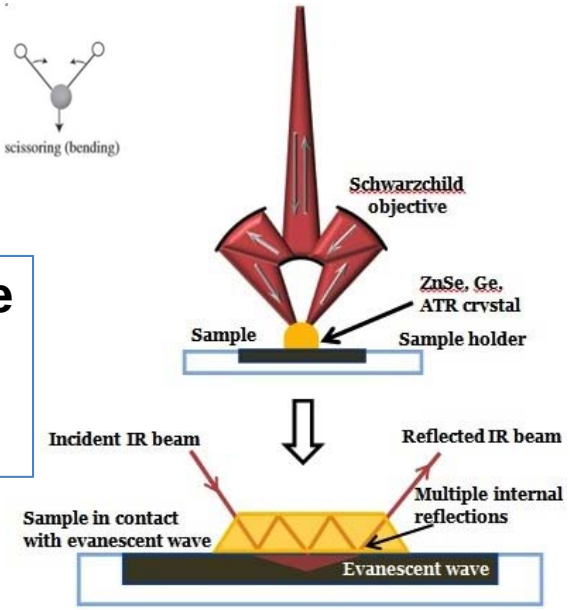


Figure : Stretching and bending vibrational modes for H_2O

- **VIS/IR microscope**
- **Transmission**
- **ATR**



IRIS LAB

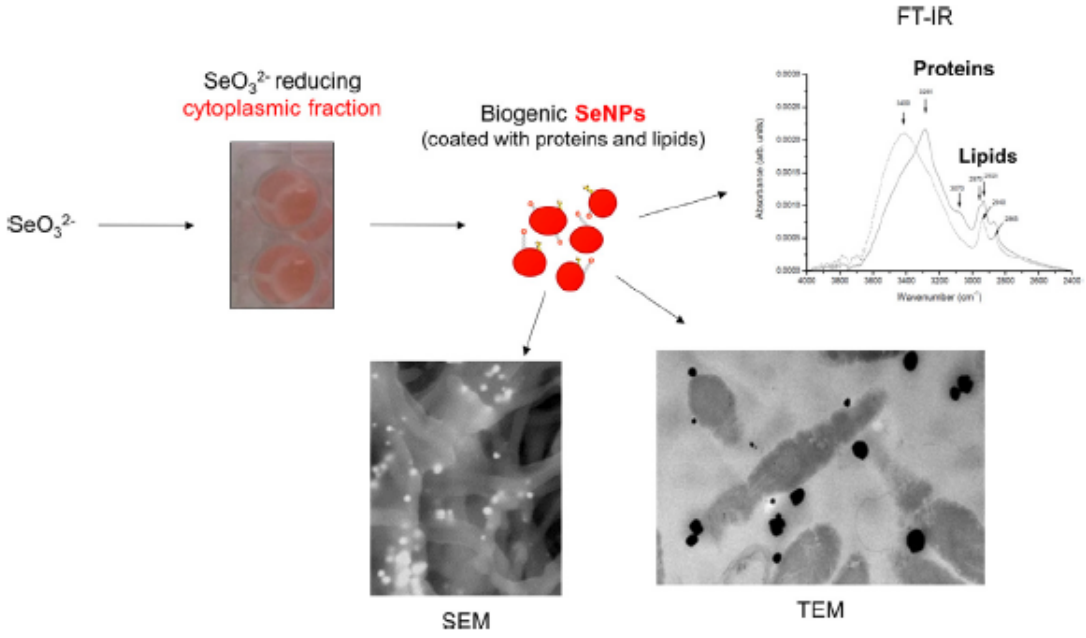
Vertex 70 spectrometer,
Hyperion 3000 microscope (Bruker)

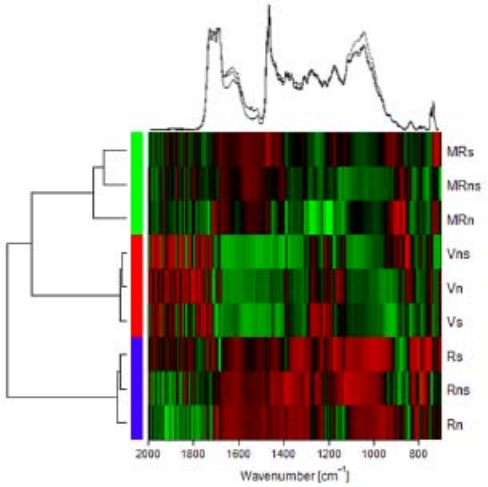
F. Monti

IRIS LAB

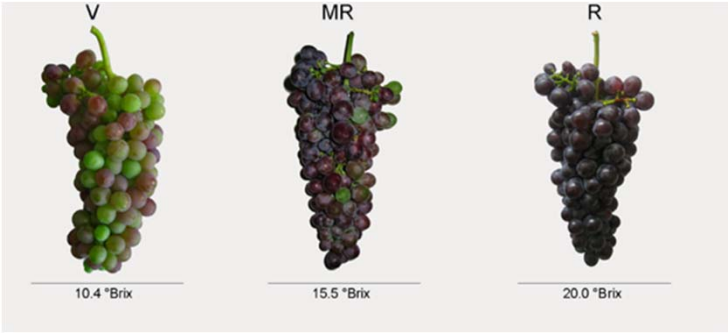
IR Application for Interdisciplinary Studies

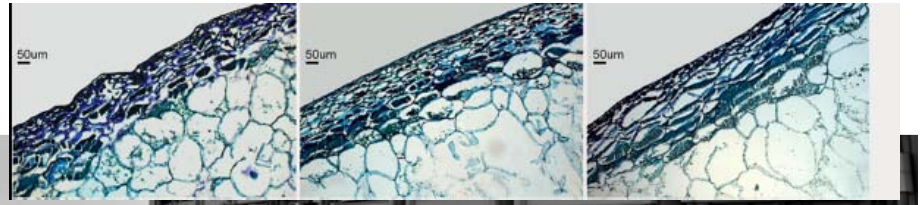
FTIR analysis on biosynthesized Selenium nanoparticles

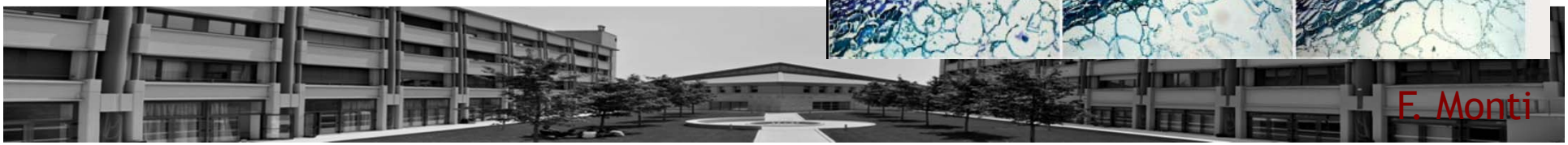




FTIR analysis on grape berry skin







F. Monti

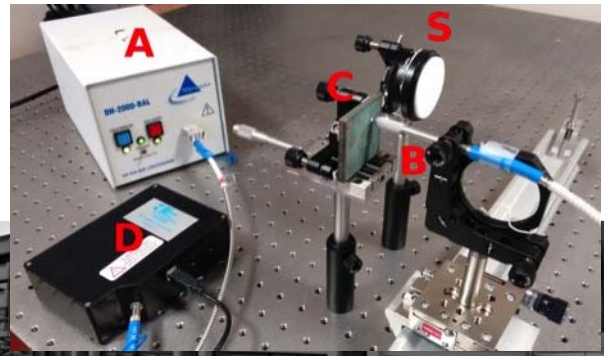
OPDATE LAB
Applied Physics for CULTURAL HERITAGE

RESEARCH

- development of **optical techniques** for **nondestructive analysis**
- implementation of **portable devices**
- **Artwork diagnostics "in situ"**

COMPETENCES

- Optical and IR **imaging**, **spectral** techniques
- **Thermal** imaging
- **Surface analysis**
  - laser profilometry, speckle techniques
- **IR spectroscopy** on artwork materials



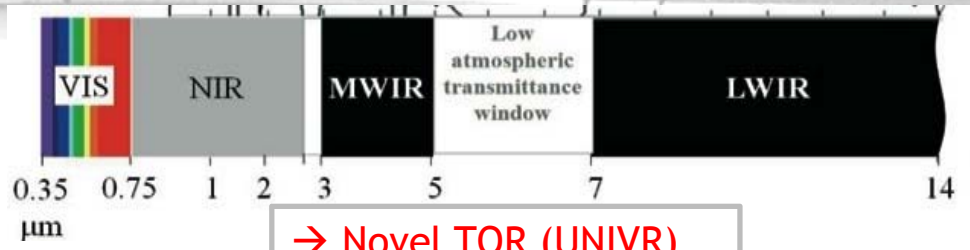
PEOPLE – C. Daffara, F. Monti, G. Marchioro

OPDATE LAB

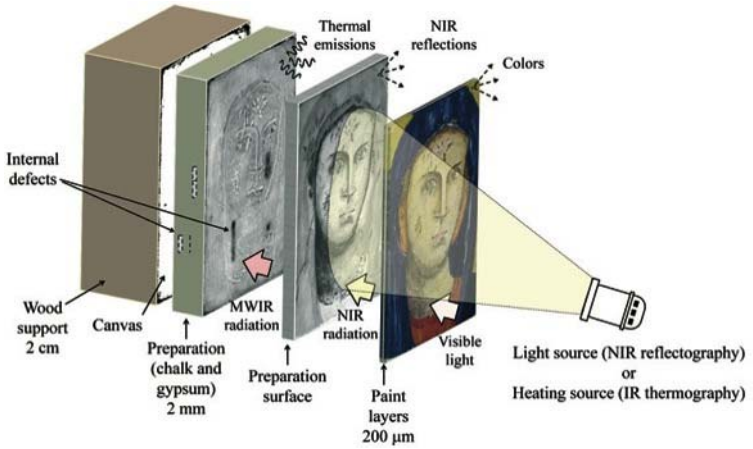
Applied Physics for CULTURAL HERITAGE

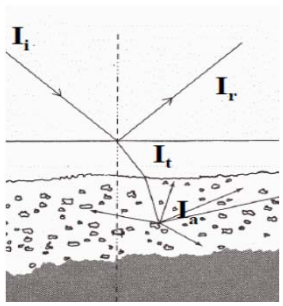
2D - Infrared imaging

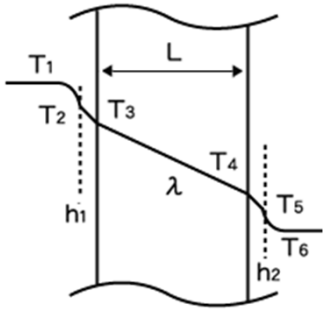
Reflective - Thermal band

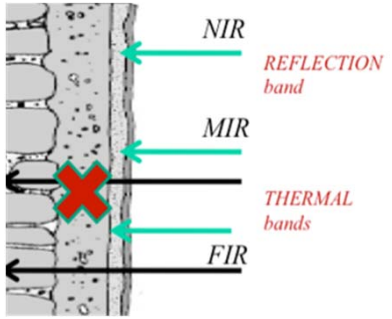


→ Novel TQR (UNIVR)









PHYSICS

radiation interaction – heat diffusion

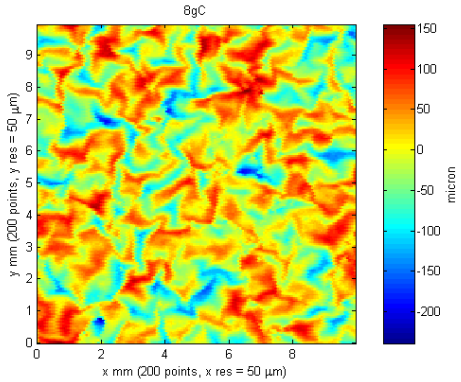
VIS	NIR	MIR REFLECTION	FAR EMISSION

Art diagnostics in situ

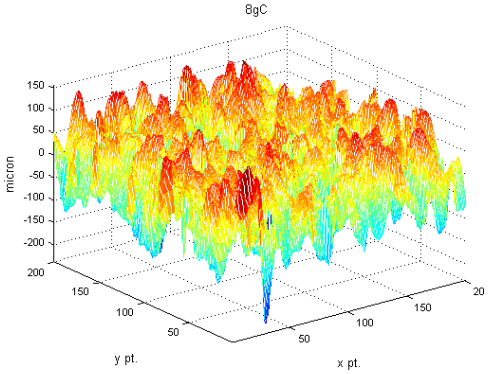
- ❑ **multispectral**
- ❑ **multi layer**

OPDATE LAB
Applied Physics for CULTURAL HERITAGE

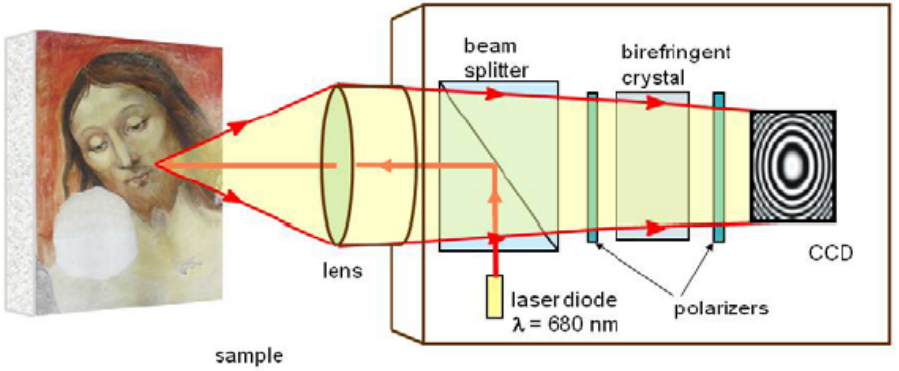
3D - Surface Analysis
Laser profilometry



Roughness texture

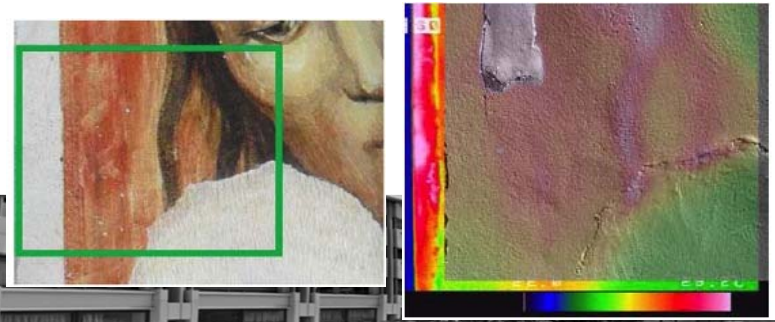


surface map



PHYSICS
optical interferometry

surface texture – subsurface defect



Integration 2D-3D

- ❑ **Material analyses**
- ❑ **surface - subsurface**

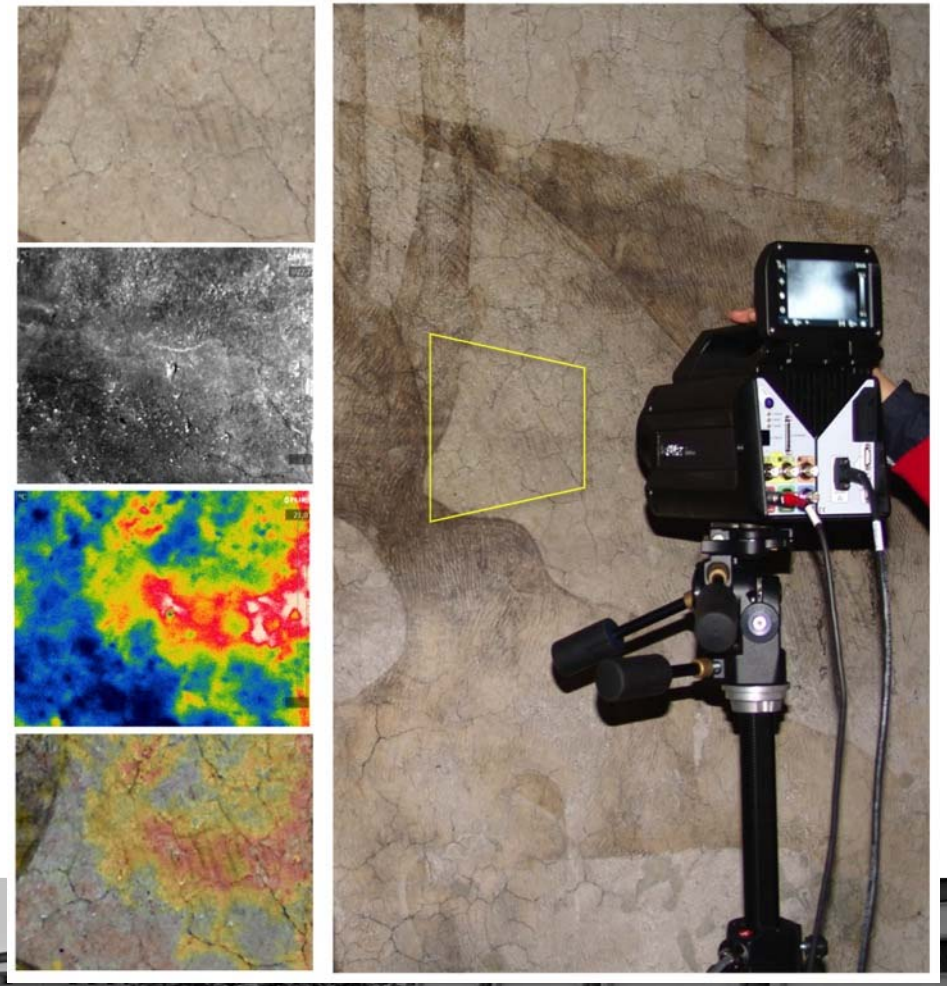
C. Daffara

UNIVR @ EXPO 2015

Monocromo
by Leonardo da Vinci

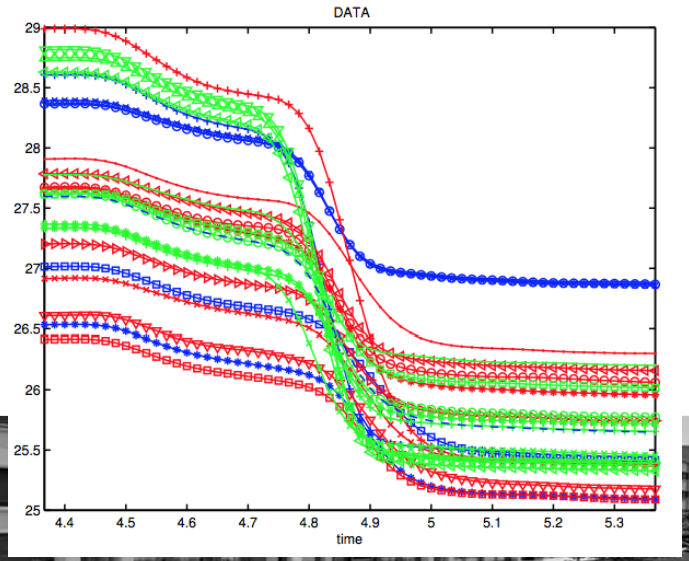
Milano - Castello Sforzesco

TQR (surface) – Termography (subsurface)



COLLABORATION

G. Orlandi (Appl Math)



SCAN4RECO
EU Project 2015-2018

"Multimodal Scanning of Cultural Heritage Assets for their multilayered digitization and preventive conservation via spatiotemporal 4D Reconstruction and 3D Printing"

- **INTERDISCIPLINARY RESEARCH**
  Applied Physics – Applied Computing

- **8 Partners**
  from 5 countries

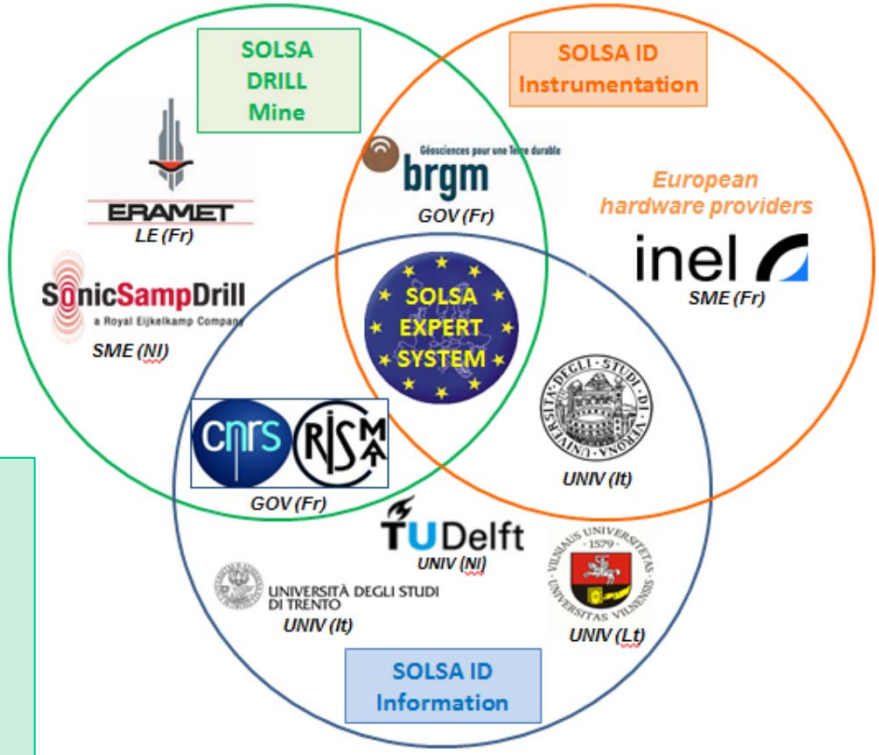
CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	Greece
IDRYMA ORMYLIA - ART DIAGNOSIS CENTRE	Greece
FRAUENHOFER INSTITUTE	Germany
UNIVERSITY OF VERONA	Italy
OPIFICIO DELE PIETRE DURE	Italy
CENTER FOR ADVANCED STUDIES, RESEARCH AND DEVELOPMENT SARDINIA	Italy
BW TEK Inc.	Germany
AVASHA GmBH.	Switzerland
RESEARCH FOR SCIENCE, ART & TECHNOLOGY Ltd.	UK

SOLSA
EU Project 2016-2020

"Sonic Drilling coupled with Automated Mineralogy and chemistry: On-Line-On-Mine-Real-Time "

CALL: Climate action, environment, resource efficiency and raw materials
TOPIC: New sustainable exploratin techonologies SC5-11d-2015

9 Partners, 9,791,000 euro of EU contribution
→ about 970,000 euro to UniVERONA



SOLSA is the first automated expert system for on-site mineralogy cores analysis that combines for the first time : X-ray fluorescence, X-ray diffraction, vibrational spectroscopies and 3D imaging along the drill core.

- . . . Спасибо большое !