NANOMEDICINE AND NANOTOXICOLOGY
Nanotoxicology

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OVERVIEW

Human exposure to nanomaterials during production and use of products that can release nanoparticles or nanofibers can cause adverse affects in workers and in users. Moreover, the dispersion of nanomaterial in the environment can cause possible effects also in the environment. The aim of the course is to learn how nanomaterials can interact with human body, what are the entry routes, what are their possible adverse effects, how can we prevent exposure. The course is focused on the prevention measures to be applied in workplaces to protect workers from exposure to nanomaterials.

TOPICS

Nanomaterials interaction with human body: routes of entry, biodistribution and excrection.
The evaluation of exposure in workers through inhalation, oral and skin routes.
Animal and human data on adverse effects of nanomaterials in internal organs.
The measures to be applied to prevent exposure to nanomaterials.
A proposal for risk assessment.
How to reduce the exposure risk in laboratory.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

Students will do a written test to verify the knowledge of the protective measures to apply in laboratory and a risk assessment simulation for a standard activity.

FURTHER INFO

For further info write to larese@units.it.

MOLECULAR SELF-ASSEMBLING AND NANOSTRUCTURES

Characterization of 2D SAM properties

Alberto Morgante
University of Trieste, Dep. of Physics
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OVERVIEW

The objective of the modulus is to introduce the students to experimental characterization of SAM on 2D systems. The module contains an introduction to surface and interface crystallography to enable the students to understand the scientific literature on SAM structure and an introduction to the main experimental techniques available for the study of SAM 2D structures and application to selected examples among the most studied SAM structures.

TOPICS

2D periodic structures, Bravais lattices, defects in 2D periodic structures, reconstruction and relaxations, terminology for 2D structures and overlayers, absorption site. Introduction to the main experimental techniques for the study of SAM 2D structures with a particular focus on synchrotron radiation techniques. Application of the techniques to examples selected among the most studied SAM structures.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be available.

EXAM

The assessment of the knowledge is based on the discussion of a specific issue based on few (2-3) scientific papers assigned to the student sometime before the exam.

FURTHER INFO

For further info write to amorgante@units.it.

NANOMEDICINE AND NANOTOXICOLOGY
Relationship between preventive medicine and drug delivery systems

Vanessa Nicolin
Clinical Department of Medical, Surgical and Health Science
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OVERVIEW
Understand the relationships between preventive medicine, early diagnosis and drug delivery systems. Properties of use, structural characterizations, limits.

TOPICS
Description of the principles of prevention and diagnostic medicine in relation to continuous or controlled release of nanotechnological vehicles. Combined use of nanoelectronic materials and their relationship between miniaturization of drug delivery systems and reduction of patient side effects.

READING MATERIAL
Powerpoint presentation, videos and links to web resources for possible further information.

EXAM
Each student will be asked to present in 15 minutes the relationship between nanomedicine and preventive medicine using different technical approaches.

FURTHER INFO
For further info write to nicolin@units.it.

MOLECULAR SELF-ASSEMBLING AND NANOSTRUCTURES

Self-assembled Monolayers in 3D

Lucia Pasquato
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OVERVIEW

The objective of the modulus is to introduced the students to self-assembling monolayers in three dimensions (nanoparticles); to give the students the knowledge of the techniques useful to characterize both the inorganic component and the monolayers, to exploit their features presenting also study cases and applications. The students are expected to develop skills in the relationship between nature of the components and expected functional properties, stability and limitations of the nanosystems.

TOPICS

Hybrid Organic-Inorganic Nanoparticles: Synthetic methodologies for the preparation of monolayers protected clusters. Characterization of these hybrid materials. Packing of the ligands forming the monolayer.
Mixed monolayers, control of the morphology. Methodologies to characterize mixed-monolayers on curved surfaces. Design of complex nanoparticles for applications in the biomedical field and in material sciences.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

The assessment of the knowledge is based on the discussion of a specific issue based on few (2-3) scientific papers assigned to the student sometime before the exam. Alternatively, the student has to propose a design and step-by-step preparation/characterization of functional monolayer protected nanoparticle for a specific application.

FURTHER INFO

For further info write to lpasquato@units.it.

Elements of Molecular Modeling for Nanotechnology

Paola Posocco
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OVERVIEW
Material simulation methodologies have become a powerful tool for scientists especially now with the advent of faster computing capability and sophisticated computer programs. The course is intended for PhD students who would like to use/understand molecular simulation to complement their experimental research and have no previous experience in that. The course will introduce in a simple way the hierarchy of computational modelling methods used nowadays as standard tools for searching for, rationalising and predicting structure and properties of nanomaterials at different length and time scale. The emphasis will be on helping to develop a feel for the correct "tool" to use in the context of a typical nanotechnology-related problem, by describing limitations and strengths of each method.

TOPICS
Introduction to molecular modeling, structural databases and visualization of molecular structures, fundamentals of computational quantum mechanics, energy minimization and force field; canonical ensembles, periodic boundary conditions, classical molecular dynamics, coarse-grained molecular dynamics, glossary.

READING MATERIAL
The slides of the course, which include relevant bibliographic references for each topic, will be made available from the teacher.

EXAM
Each student will be asked to present and discuss in 10 minutes how molecular modeling could be used to improve her/his research. As an alternative, students can also present a scientific paper (previously agreed with the teacher) from the recent literature covering aspects of molecular modeling for nanotechnology, explaining the principles of the techniques used and critically discussing the results.

FURTHER INFO
For further info write to paola.posocco@dia.units.it.

MICROSCOPIES FOR NANOTECHNOLOGY
Infrared Spectroscopy: from Macro to Nanoscale on the Molecules of Life

Lisa Vaccari
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OVERVIEW
A brief introduction to infrared vibrational spectroscopy, both on theoretical and experimental aspects (sampling, instrumentation, and sources) will be given. The course then will focus on bio-spectroscopy, providing the fundamental for understanding potentialities and applicability of the technique for bio-sample analysis. After a general introduction on the vibrational features of bio-macromolecules, selected examples of infrared spectroscopy, microscopy and nanoscopy experiments will be detailed with the aim to motivate the students to find possible synergies with their PhD programs.

TOPICS
1. Infrared spectroscopy
    a. Basic concepts on Theory and Instrumentation
    b. A brief history of IR spectroscopy at SR facilities
       IRSR: Generation and properties
2. Infrared bio-spectroscopy
    a. On the vibrational features of bio-macromolecules
3. From macro to nanoscale on the molecules of Life
    a. Soft X-ray radiation damage
    b. SR-FTIR microscopy under physiological conditions
    c. SR Collective Enhanced IR Absorption microscopy for protein conformational studies
    d. Vibrational spectroscopy at the nanoscale

READING MATERIAL
The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM
Each student will be asked to present in 10 minutes how infrared spectroscopy could be used to characterize her/his samples, underlining advantages and limitations, in comparison with other characterization techniques. To this aim, literature papers related to the PhD topic will be suggested by the teacher, as starting point for the presentation and discussion.

FURTHER INFO
For further info write to lisa.vaccari@elettra.eu

MICROSCOPIES FOR NANOTECHNOLOGY
Scanning Probe Microscopies

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Consiglio Nazionale delle Ricerche – Istituto Officina dei Materiali (CNR-IOM)
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OVERVIEW
The invention of Scanning tunnelling microscopy (STM), in the early '80s, shed new light into the nano-world, allowing, for the first time, to image single atoms and molecules. Since those first results, the quality of STM imaging improved, and today high resolution can be routinely achieved on more and more complex systems and in a variety of environmental conditions. In parallel, atomic force microscopy (AFM) and a number of related techniques were developed, extending the field of scanning probe microscopy (SPM) for the characterisation of different and well-defined material properties with nanoscale resolution.
This short course aims at providing the basics of scanning probe techniques and at offering an overview on their possible applications when operated in different environments: air, vacuum, liquids, high pressure. Particular emphasis will be dedicated to applications on nanostructured materials and samples of biological interest.

TOPICS
The course will be structured as follows:
1. Scanning Tunneling Microscopy, Atomic Force Microscopy and related techniques: basic operational principles.
2. Scanning Probe methods for imaging at atomic resolution.
3. Scanning Probe methods for characterisation of electronic, transport and mechanical properties with nanometer resolution.
4. Scanning Probe methods to manipulate nanosystems.

READING MATERIAL
The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM
Each student who attends the Course on Microscopies for nanotechnology will be requested to pass the exam for one specific module only. Each student who selects this module for the exam will be asked to prepare and discuss with the teacher a 30 min presentation structured as follows. In the first part, one of the SPM techniques discussed during the course should be presented, with main focus on its working principles and on the information it can provide. In the second part, a selected scientific publication, previously agreed with the teacher, should be described, highlighting the advantage of the SPM technique of choice in clarifying a specific scientific question.

FURTHER INFO
For further info write to africh@iom.cnr.it

PHOTOEMISSION AND ABSORPTION SPECTROSCOPY FOR MATERIAL SCIENCE

X-ray Photoelectron Spectroscopy

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OVERVIEW

Since the seventies X-ray Photoelectron Spectroscopy has played a key role in determing the geometric and electronic structure of solid surfaces. Due to their high localization, core electrons are extremely sensitive to the chemical state and to the local environment, and for this reason can be used for the identification of atomic local configurations. The combination of high energy resolution now attainable with this technique and the reduced data acquisition time has opened the possibility to probe the physical and chemical properties of a large variety of systems and to shed light on complex processes taking place on the surface of materials.
After a brief review of the history of photoemission the module will focus on the discussion of the main principles of the experimental technique. Recent experimental results in this field will be discussed with the aim of illustrating the breakthroughs achieved in this technique by the employment of x-rays generated by synchrotron light sources.

TOPICS

1) Electron excitation using x-rays; photoionization cross-section; photoelectron mean free-path and surface sensitivity; core-electron binding energies: initial and final state effects. The many-body contributions. The effects of phonon, electrons-holes and plasmons excitations. (3 hours)
2) Experimental set-ups. X-ray sources. Soft x-ray synchrotron radiation. Electron energy analysers. Measurement of the overall experimental energy resolution. Calibration of the energy scales. Detectors. (1 hours)
3) Chemical shifts: the ability to distinguish species in different chemical environment. Atoms and molecules in different adsorption sites. Surface and bulk atoms in transition metal and semiconductor surfaces. Oxidation state for different metals. Surface alloys. Chemical reactivity. Two-dimensional materials. (4 hours)

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

Each student will be asked to present in 30 minutes how XPS could be used to characterize her/his samples, underlining advantages and limitations, or how her/his samples could be used to enhance the performance of the technique. As an alternative, students can also present three scientific papers from the recent literature about nanotechnology and x-ray photoelectron spectroscopy, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO

For further info write to abaraldi@units.it

PHOTOEMISSION AND ABSORPTION SPECTROSCOPY FOR MATERIAL SCIENCE

X-ray Absorption Spectroscopy

Luca Bignardi
Department of Physics, University of Trieste
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OVERVIEW

In this 10-hour module I will give an overview about x-ray absorption spectroscopy techniques applied to material science. After a brief introduction about the interaction of x-rays with matter, the course will show the characteristics and potentialities of several x-ray absorption spectroscopies for the characterization of several properties of materials. Moreover, the students will be encouraged to link the topic of their research project with the content of the course.

TOPICS

1. Introduction. Fundamentals of interaction of x-rays with matter related to XAS.
2. X-ray absorption spectroscopy. Extended X-ray absorption fine structure (EXAFS) spectroscopy.
3. Near-edge x-ray adsorption fine-structure (NEXAFS) spectroscopy.
4. X-ray fluorescence, X-ray microscopy.
5. X-ray circular magnetic dichroism. X-ray standing wave.

READING MATERIAL

The slides of the course, including relevant bibliographic references, will be made available from the teacher.

EXAM

Each student will be asked to present in 30 minutes how the techniques presented in the course could be used to characterize her/his samples, underlining advantages and limitations. As an alternative, students can also present a scientific paper from the recent literature that employs one of the x-ray adsorption spectroscopy techniques discussed in the course, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO

For any additional information, write to lbignardi@units.it

PHOTOELECTRON AND ABSORPTION SPECTROSCOPIES FOR MATERIALS SCIENCE

X-ray Photoelectron Diffraction (XPD)

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OVERVIEW

After a brief introduction of the X-ray Photoelectron Diffraction (XPD) physics concepts and the related experimental aspects (instrumentation, sample environment, etc.), the module will focus on the fundamentals of the technique that is used for the determination of the atomic structure of solid surfaces and nanostructures. Single scattering and multiple-scattering pictures, to rationalize and extract the structural information from the measured XPD data, will be discussed. Particular emphasis will be given to the use of synchrotron radiation as photon source in the XPD experiments.

Application of the technique to determine the structural properties of materials, starting with clean and adsorbate covered surfaces, moving to nanostructured materials and 2D systems like graphene, boron nitride and transition metal dichalcogenides will be discussed together with an outlook on its frontier areas.

TOPICS

1) Introduction to X-ray photoelectron diffraction
   Review of the physical basis
2) XPD: Instrumentation and implementation
   angle and energy scan photoelectron diffraction
   forward scattering
3) Structural analysis
   multiple scattering simulations of photoelectron diffraction data
   XPD on clean metal surfaces, adsorbates, on 2D materials to determine their structure, orientation, corrugation and stacking in the multilayer case.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

Each student will be asked to present in 30 minutes how XPD could be used to characterize her/his samples, underlining advantages and limitations. As an alternative, students can also present three scientific papers from the recent literature dealing with X-ray photoelectron diffraction applied to surfaces or low dimensional systems, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO
For further info write to silvano.lizzit@elettra.eu.

PHOTOEMISSION AND ABSORPTION SPECTROSCOPIES FOR MATERIALS SCIENCE

Valence Band and Angle Resolved Photoemission Spectroscopy ARPES

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OVERVIEW

After a brief review of the valence band and related solid-state physics concepts, and an introduction to the experimental aspects (instrumentation, sample environment, resolution effect, etc.) of angle resolved photoemission spectroscopy (ARPES), the module focus on the fundamentals of this technique, both within the single-electron picture and beyond it, i.e. including many-body effects, to rationalize the measured ARPES results. Application of this powerful technique to the investigation of the electronic structure of materials, like metal surfaces, superconductors, and of the prototypical 2D material graphene, is discussed together with an outlook on its frontier areas.

TOPICS

1) Introduction to valence band photoemission spectroscopy
   Brief review to solid state physics: Crystal & reciprocal lattices, and the band structure of solids
2) ARPES: Instrumentation and implementation
   Fundamentals and single-electron picture, surface and bulk states, surface vs bulk sensitivity, energy and momentum resolution
3) Matrix element effects
   Beyond the single-electron picture, many-body effects and the spectral function
   ARPES on metals, superconductors, on a purely 2D material: graphene
   Summary and outlook.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

Each student will be asked to present in 30 minutes how ARPES could be used to characterize her/his samples, underlining advantages and limitations, or how her/his samples could be used to enhance the performance of ARPES. As an alternative, students can also present three scientific papers from the recent literature about nanotechnology and angle resolved photoemission spectroscopy, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO

For further info write to luca.petaccia@elettra.eu.

Optical Spectroscopy, SERS

Alois Bonifacio
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University of Trieste
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OVERVIEW
After a brief introduction to optical spectroscopy and its experimental aspects (sampling, instrumentation, etc.), the course will focus on the synergistic interplay between optical spectroscopy and nanotechnology, with a strong focus on surface techniques such as SERS. In particular two complementary aspects will be addressed: i) the use of nanotechnology to enhance the performance of spectroscopic techniques (in terms of sensitivity of spatial resolution), as well as ii) the use of optical spectroscopy to characterize nano-objects (e.g. nanoparticles, nanostructured surfaces).

TOPICS
1. Broad introduction to optical spectroscopy
   a. Overview of fundamentals, from fluorescence to Raman
   b. A quick tour of instruments for optical spectroscopy
2. Nanotech for spectroscopy
   a. Metal, carbon and seminconductor nano-objects: their use in spectroscopy
   b. SERS: a tutorial
   c. Other surface-enhanced spectroscopies (TERS, SEIRA, SEF)
   d. Applications: analytical chemistry, material sciences and biomedicine
3. Spectroscopy for nanotech
   a. Spectroscopy to characterize nanostructures
   b. SERS characterization of SAMs and capping layers
   c. Single-molecule spectroscopy (SERS, fluorescence)

READING MATERIAL
The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM
Each student will be asked to present in 10 minutes how an optical spectroscopy could be used to characterize her/his samples, underlining advantages and limitations, or how her/his samples could be used to enhance the performance of an optical spectroscopy. As an alternative, students can also present a scientific paper from the recent literature about nanotechnology and spectroscopy, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO
For further info write to abonifacio@units.it.

PhD Program in Nanotechnology
University of Trieste
A.Y. 2022-2023

MICROSCOPIES FOR NANOTECHNOLOGY
Advanced Optical Microscopy for Nanotechnology

Dan Cojoc
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OVERVIEW
After a brief introduction to optical microscopy the course will focus on techniques with applications in biology and nanotechnology. In particular, we will discuss how Digital Holographic Microscopy can be used to measure nanometric membrane fluctuation of living cells, techniques to increase the spatial resolution in fluorescence microscopy beyond the diffraction limit, and the use of optical tweezers for manipulation of micro and nanoparticles and force spectroscopy in single molecule experiments. Basic principles and some examples of applications to bio-nanotechnology will be addressed.

TOPICS
1. Optical microscopy – brief review: Image formation, lateral and axial resolution
2. Phase Contrast Microscopy, Darkfield and Polarized Light Microscopy
3. Digital Holographic Microscopy (DHM)
4. Fluorescence microscopy – basics
5. Increasing spatial resolution and SNR: FRET, TIRF and 2Photon microscopy
6. Super-resolution / nanoscopy: STED, PALM, MINFLUX
7. Optical trapping and manipulation biological samples
8. Optical tweezers force spectroscopy.

READING MATERIAL
The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM
Evaluation will be done considering the presence at the lectures and a 10-15 minutes discussion of an example of application in bio-nanotechnologies for one of the presented optical microscopy techniques, at choice. As an alternative, students can also present a different study case from the recent literature about nanotechnology and advanced optical microscopy, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO
For further info write to cojoc@iom.cnr.it.

Nanofabrication:
an Essential and Eclectic Tool for *Nano*-science and *Nano*-tecnology

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OVERVIEW
Nanofabrication is a complex combination of many different techniques and approaches developed in several decades of material science and material engineering. Micro and nanofabrication is at the core of the production computers and smartphones as well as many sensor and actuators that populate our everyday life. Nanofabrication applications, however, are much broader spanning from tissue engineering and medical devices to quantum physics. In this course we aim at providing a short introduction to the nanofabrication philosophy and technology with six example of scientific application in which nanofabrication play an essential role. During each lecture we will introduce in detail one or two techniques, describing the fundamental physics beneath them and their practical implementation.

LECTURES (2 - hours each)
1. Thin windows liquid cells for TEM and X-ray experiments
(Sputtering, optical lithography and double side alignement)
2. Ordered arrays of quantum dot and nanowires
(electron beam lithography)
3. Single nanowires, nanotubes and graphene transport
(Metal evaporation and lift-off)
4. Nanopores, nanowells and nanochannels for DNA sequencing
(wet etching and RIE)
5. Patterned surfaces for cellular growth and differentiation
(Replica mould and nanoimprint)
6. Microeletromechanicals system for biosensing.
(deep reactive ion etching and bulk micromachining)

READING MATERIAL
The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM
Each student will be asked to present in 10 minutes how one or more nanofabrication tools could be used to improve their processes, microfabricate a tool for or explore an alternative aspect of his/her research project, underlining advantages and limitations. As an alternative, students can also present a scientific paper from the recent literature about nano- and micro-fabrication as close as possible with his/her research topic.

FURTHER INFO
For further info write to dalzilio@iom.cnr.it.

NANOMEDICINE AND NANOTOXICOLOGY
Carbon Nanostructures in Nanomedicine

Tatiana Da Ros
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OVERVIEW
After a brief introduction to nanomedicine, its meaning and the most used approaches used in the field, the course will focus on the carbon nanostructures. In particular, in a first part of the course their structures, characteristics and properties, their production and functionalization methodologies will be addressed. The second part will be devoted to the presentation of their biomedical applications, mainly devoted to drug delivery and theranostics.

TOPICS
1) Nanostructures in Medicine
2) Nanomedicine approaches
3) Carbon nanostructures: preparations and main characteristics
   a. Fullerenes
   b. Nanotubes
   c. Nanodiamonds
   d. Graphene and Carbon Quantum Dots
   e. Other carbon nanostructres
4) Carbon nanostructures functionalization
   a. Covalent approaches
   b. Non covalent approaches
   c. Internal functionalization
5) Biocompatibility studies on Carbon nanostructures
6) Biomedical applications
   a. Drug delivery
   b. Imaging
   c. Tissue regeneration

READING MATERIAL
The used presentations will be provided together with some specific articles.

EXAM
Test with multiple-choice and open-ended questions.

FURTHER INFO
For further info, please contact the teacher: Tatiana Da Ros, email: daros@units.it, phone: +39 040 558 3597.

MOLECULAR SELF-ASSEMBLING AND NANOSTRUCTURES

Nanostructures in Catalysis

Paolo Fornasiero
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OVERVIEW

After a brief introduction to heterogeneous catalysis and on the role of nanomaterials will be presented.
The course will briefly focus on the synergistic strategies to obtain nanomaterials with enhanced catalytic properties in term of activity, stability or selectivity. Key examples includes preparation of core-shell and hierarchical materials for catalytic methane oxidation and for photocatalytic water splitting. Standard and advanced characterization techniques, used to analyze the material nanostructure, will be critically discussed when pertinent.

TOPICS

1. Broad introduction to heterogeneous catalysis
    a. Overview of fundamentals, from surface area effect to material heterogeneity
    b. A quick tour of synthesis of metal and metal oxide nanoparticles and nanocrystals
2. Nanotech in catalysis
    a. Nanosize effect on catalytic properties
    b. Nano gold vs bulk gold in catalysis
    c. Nano effect on semiconductors and band gap modulation
    d. Applications: analytical chemistry, material sciences and biomedicine
3. Energy and environmental application of Nano catalysts
    a. Pd@CeO_2 core-shell catalysts for methane catalytic oxidation and SOFC
    b. Pd@TiO_2 core-shell catalysts for CO_2 electrochemical reduction
    c. Nanostructured TiO_2 for water splitting.

READING MATERIAL

The slides of the course, some of which include bibliographic references, will be made available from the teacher.

EXAM

Each student will be asked to discuss the role of nanotechnology in catalysis with pertinent examples, underlining advantages and limitations. As an alternative, students can also present a scientific paper from the recent literature about nanotechnology and catalysis, explaining the principles of the technique used and critically discussing the results.

FURTHER INFO

For further info contact the teacher at pfornasiero@units.it.

MICROSCOPIES FOR NANOTECHNOLOGY

Synchrotron-based Imaging and Spectromicroscopy Tools for Characterization of Complex Matter

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OVERVIEW

The goal is to provide basic knowledge for the most advanced synchrotron-based methods for 'nano-research' such as complementary chemical-structural imaging, micro- spectroscopy, coherent diffraction imaging of individual nano-structures ranging from inorganic to organic and bio-materials.
The complementary capabilities of different X-ray microscopy approaches in terms of imaging, spectroscopy, spatial and time resolution are strongly requested by the multi-disciplinary research programs at the synchrotron facilities and have motivated continuous investments in development of instrumentation for imaging with spectroscopic analysis.
The lectures will present and compare the principles and potentials of modern x-ray microscopes using various approaches in imaging and micro-spot spectroscopy, based on detecting and filtering of emitted electrons and transmitted, emitted or scattered photons.
Selected results obtained at Elettra and other laboratories will illustrate the potentials of different type microscopy and imaging in material and life sciences.

TOPICS

The course will cover the following topics:

1. Principle approaches for spatially resolved imaging and spectroscopy using photon sources: contrast mechanisms and spectroscopies for probing at different depth scales. It will include: concepts for realization lateral resolution, contrast mechanisms based on x-ray interaction with matter and brief overview of all related imaging and spectroscopic methods.
2. Photoelectron spectro-microscopy and imaging using photon microprobe: instrumentation, methodology and applications.
3. Transmission/emission microscopy in scanning and full-field imaging mode: absorption, phase and chemical imaging.
4. Coherent diffraction imaging using synchrotrons and FELs.

READING MATERIAL

The slides of the course and review articles will be provided.

EXAM

Written test and oral discussion for relevance to the thesis.

FURTHER INFO

After the lectures the students will visit the beamlines where some demonstrative training will be offered.