Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
ROME TECHNOPOLE INNOVATION ECOSYSTEM

DOCTORAL COURSE PROPOSAL

Progetto Ecosistemi dell'Innovazione - Rome Technopole – Spoke 3 (CUP B83C22002890005) - Piano Nazionale di Ripresa e Resilienza - Missione 4 Istruzione e Ricerca finanziato dall'Unione Europea - Next Generation EU

PROFESSORS: Prof. Giorgio Contini (ISM-CNR), Prof.ssa Amanda Generosi (ISM-CNR), Prof. Francesco Mattioli (IFN-CNR)

TITLE

MATERIALS: from anarchy to monarchy through applications

GOALS

The goal is to provide a complete overview of materials science from atomic to large-scale devices through mesoscopic dimensions, showing how it is possible to integrate different scientific areas to achieve innovation with specific relevance to flagship FP1 - Decarbonization and digitalization in research on new green energy sources e FP5 - Digital transition through AESA (Active Electronically Scanned Array) radar technology, quantum cryptography and quantum communications. Students taking the course will understand the basic methods for producing materials at different length scales and will be able to outline their main applications in energy and communications technologies.

COURSE STRUCUTRE: 24 hours of frontal teaching in mixed mode + 8 hours of laboratory (3 credits)

Course organization
The course will be delivered in mixed mode: in-person and online lessons and in-person workshops at the CNR of the Tor Vergata Research Area, Via del Fosso del Cavaliere 100 Rome.

Audience and maximum number of participants
The event is intended for PhD students of the doctoral schools of the Universities of Lazio. A maximum of 20 participants will be admitted.

Registration and selection methods
Participation is free. Participants will be selected among the students of the Doctoral Schools of the Universities of Lazio, based on the booking order and with the methods established by each Doctoral School.

IFN
Consiglio Nazionale delle Ricerche
CNR Istituto di Struttura della Materia

Learning assessment methods
A learning assessment test, mandatory for all participants, which will consist of an oral presentation to verify that the required skills have been acquired, will be held at the end of the course. This test can be carried out either in person or remotely in a dedicated synchronous session and the date will be chosen and agreed with the participants at the end of the course. A satisfaction questionnaire will also be administered remotely.

Certificates
Upon request, participants who have followed the course for at least 80% of its duration and successfully completed the learning verification test will be issued a certificate of participation including the training hours (3 credits). You will also be asked to complete the event satisfaction questionnaire.

COURSE PROGRAM

SECTION 1 - Prof. G. Contini (8 ore di didattica frontale)

* General introduction on techniques for obtaining materials ("from anarchy to monarchy")

* An 'anarchist' approach:
  - the study of surfaces and interfaces (surfaces morphology and nanostructures; methods for preparation of atomic controlled nanostructures under ultra-high vacuum).

  - Experimental techniques for the analysis of adsorbates on surfaces:
    laboratory and synchrotron radiation experimental techniques (LEED, Photoelectron spectroscopies (PES), NEXAFS, STM, nc-AFM, other spectroscopies).

* Applications:
  - chirality in 2D nanostructures;
  - on-surface synthesis of 1D and 2D polymers using different molecular precursors (e.g. polypropylene, graphene nanoribbons, porous graphene, Kagome lattices).

SECTION 2 - Prof. F. Mattioli (4 ore didattica frontale + 8 ore di laboratorio)

Nano and Micro Fabrication Techniques
* Micro and Nano Fabrication
* Introduction: motivations and historical notes
* Moore's Law

* Optical lithography and Electron beam lithography
* Thin film deposition
* Etching
* Morphological characterization

Applications: nano fabrication and material properties

* SNSPDs superconducting nanowire single photon detectors
* Introduction to superconductivity
* Working principle
* PICs Photonic integrated circuits
* Measurement of the number of photons
* Measurement of the position of photons

Laboratory activities in clean room

* Introduction to the clean room
* Electronic beam lithography: from drawing to patterning
* Scanning Electron microscope characterization

SECTION 3 - Prof.ssa A. Generosi (12 ore di didattica frontale/mista)

Multiscale characterization and applications of technological interest

* Introduction to the properties of innovative materials: from the atomic level to the macroscopic level, passing through the mesoscopic dimensions.

* How can we tune/drive the structural, electronic, transport properties etc. of materials by reducing their dimensions: nanomaterials and 2D materials

* Mesoscopic level characterization for the optimization of new materials for energy starting from basic atomic properties:
  - Role of films, surfaces and interfaces in the most up to date energy devices.
    - Multiscale approach for the study of mesoscopic dimensions: joint and time-resolved spectroscopic/microscopic studies (in situ time resolved joint XRR-XRD-AFM)
    - Theoretical approach and examples of unconventional experimental set ups

* Innovative applications of materials on the mesoscopic scale:
  - Materials for organic, hybrid and inorganic photovoltaics (OPV based on polymeric

Bulk heterojunctions, hybrid perovskite-organic BHJ active materials, Perovskite based Photovoltaic materials): rom structural characteristics to charge transport properties up to the engineering of single and tandem cells for photovoltaic applications integrated into bio-architecture.

- materials for new latest generation green super-capacitors: new strategies towards a green chemistry approach.
- Materials for polymer membrane fuel cells.