UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Nanotechnology & Innovation

2324-1-FSM01Q016

Aims

The aim of the course is to provide in depth knowledge on various classes of nanomaterials that will constitute the main ingredient of future nanotechnologies. For each materials class, the synthesis approaches and the physical mechanisms underpinning their functionality will be studies discussed in detail with particular focus on size-related processes, such as quantum and dielectric confinement.

Applications of nanomaterials in various technological fields will be considered and their functioning principles will be studied, highlighting promising strategies for their design and optimization.

Regulation aspects regarding health, safety and environmental aspects of nanotechnology will be discussed.

Contents

The following classes of nanomaterials will be discussed:

1. Metal clusters: Bottom-up and top-down synthesis approaches, surface functionalization, electronic structure and size effects. Optical properties and photophysical processes. APplication in optoelectronic devices, sensors and biologic imaging.

2. Plasmonic metal nanoparticles: basic principles of plasmonics in dielectric confined nanomaterials, dielectic confinement, plasmon resonance and size/environment effects. Optical properties vs. size and dimensionality. Hot carriers in nanoaterials. Plasmon enhanced Raman spectroscopy. Plasmon enhanced fluorescence. Coulomb blockade effect and the concept of charge quantization. Applications in thermotherapy and sensing.

3. Colloidal semiconductor nanocrystals (cahlcogenides and metal halide perovskites): Synthesis and surface chemistry, density of states in 3D and in 2-0 dimensional systems, electronic properties, excitonic (fine) structure, size an shape effects. Heterostructures and wave function engineering. Detailed photophysics, Electric transport.

Doping and magnetic properties. Applications in LASERS, LEDs, bioimaging and energy technologies.

Detailed program

0. Introduction to Nantechnology:

- Hystory

- Health and safety aspects

- Regulations on nanomaterials

1. Metal Clusters:

- Synthesis approaches (top-down and bottom-up)

- Surface functionalization

-Electronic structure and size effects

- Photophysics and optical properties

- Optoelectronic devices, sensors and biomarkers based on metal clusters.

2. Plasmonic Nanoparticles

- Basic principles of plasmonics in low-dimensional systems

-Dielectric confinement

- Plasmonic resonance vs. size and envronment

- Coulomb blockade

- Plasmon ehnhanced Fluorescence

- Plasmon enhanced Raman scattering

- Hot carrier phenomena in metallic nanoparticles

- Applications in thermo-therapy and sensing

3. Colloidal Semiconductor Nanocrystals

- Colloidal synthesis, mechanisms

- Surface chemistry

- Electronic confinement and density of states in semiconductor nanostructures

- Electronic properties and exciton structure

- Size effects on the electronic properties

- Heterostructures: design criteria and synthesis aproaches

- Wavefunction engineering

- lead halide perovskite nanocrystals vs chalcogenides

- Doping

- Photophysics and magnetic properties

- Application in LASERS, LEDs, bioimaging and renewable energy technologies.

Prerequisites

Basic chemistry and chemical physics. Quantum mechanics, solid state physics.

Teaching form

Classroom lectures

Textbook and teaching resource

Books suggested by the lecturer, slides and review articles.

Semester

Second semester

Assessment method

Presentation by the candidate (20-25 minutes) on a subject of choice pertinent to the course and oral discussion.

Office hours

To be agreed with the professor.

Sustainable Development Goals

CLEAN WATER AND SANITATION | AFFORDABLE AND CLEAN ENERGY | INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES