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RESEARCH THEMES
DOCTORATE SCIENCES AND TECHNOLOGIES OF CHEMISTRY AND MATERIALS

NOTE: In this file you can find additional information on some research themes summarized in the call November, 2024.

Summary

Curriculum Nanosciences

1. Development of light-sources based on colloidal quantum dots

Supervisor(s): Francesco di Stasio, Paola Lova

Short title	Quantum dot LEDs
Expanded Title	Light-emitting diodes based on colloidal quantum dots
Description	The Photonic Nanomaterials group aims at developing light-emitting diodes operating in the visible and short-wave infrared spectral ranges exploiting the unique properties of colloidal quantum dots (QDs). QD chemistry enables on-demand tailoring of the light-emission properties of the final nanomaterial in combination with solution processing enabling the low-cost fabrication of light-emitting diodes (LEDs).Currently, the group is focusing on the development of two main types of LEDs based on QDs (either small or large-footprint ones): short-wave infrared ones (940 – 1600 nm) based on InAs or Hg-based QDs and blue LEDs (400-450 nm) exploiting CdSe, perovskites or Ga-based QDs. The PhD candidate will focus on the synthesis of QDs and their implementation of LEDs carefully design to obtain high external quantum efficiency and brightness. In addition, the PhD candidate will carry out detailed optical characterization of the synthesized

	QDs (steady-state and time-resolved photoluminescence, photon statistics, etc…) top correlate chemical properties with the light-emission properties. Importantly, the PhD candidate will engage in collaborations with other group members, given the interdisciplinary nature of the proposed research theme, which requires a variety of skills for implementation
References	Advanced Science, 2312482 (2024), Advanced Optical Materials, 2400554 (2024), ACS Photonics, 10, 1662–1670 (2023), ACS Energy Letters, 7, 3788-3790 (2022)
Main Supervisor	Dr. Francesco Di Stasio, Photonic Nanomaterials (https://photnano.iit.it/) – Istituto Italiano di Tecnologia, Francesco.DiStasio@iit.it
Additional Supervisor	Dr. Paola Lova, Dipartimento di Chimica e Chimica Industriale (https://chimica.unige.it/) – Università degli studi di Genova, paola.lova@unige.it
Essential expertise	
i)	Master degree in Materials Science, Chemistry, Physics or related disciplines
ii)	Highly motivated
iii)	Willing to undertake a challenging research project
iv)	Interest in working in an interdisciplinary teamskills required for the project development.
Desirable expertise	
i)	Colloidal synthesis of quantum dots (II-VI, III-V, perovskites)
ii)	Functionalization of quantum dots (ligand exchange procedures both in solution and solids)
iii)	Fabrication and electro-optical characterization of light-emitting diodes
iv)	Characterization of quantum dots (comprehensive investigation of their structural, optical and morphological properties)

2. Rapid fabrication of graded layered nanomaterials (funded by 2023 ERC Consolidator Grant EVA, programme Horizon Europe, GA 101124411)

Supervisor(s): Milena Arcignegas

Short title	Rapid fabrication of graded layered nanomaterials
Expanded Title	Design and synthesis of intrinsically functional graded layered nanomaterials through rapid liquid deposition
Background	Advanced functional devices require the integration of distinct materials (polymers, ceramics, metals) with different properties to achieve high performance in aerospace, biomedicine, electronics, and automotive. A major structural challenge is associated with localized (mechanical, thermal, electrical) stresses due to property mismatch at different scales, thus causing premature malfunction and failure. Research has focussed on compositional or structural material gradients (in at least one spatial direction) to enable the

	fabrication of "in-one" body parts (mostly inorganics) with exceptional properties. Examples at rather macroscale include AlGaAs with graded bandgap for solar cells, or Al2O3/Ti with graded mechanical stiffness for bioimplants. However, in light of miniaturization technology, there is a need to translate this concept to nanomaterials. The Automated Nanomaterials Engineering group at IIT aims to explore rapid fabrication strategies for constructing 2D layered nanomaterials with graded properties, aiming to revolutionize the landscape of advanced materials engineering
Description	In this PhD project, we will exploit different rapid fabrication routes based on controlled liquid deposition to deliver functional graded layered nanomaterials. This will include direct laser writing and drop-on-demand injection to intercalate consecutive organic and inorganic layers, as a means to create mechanical and optical gradients in the final layered films. These nanostructures will be subjected then to a complete (structural, chemical, surface, mechanical, and optical) characterization, including the assessment of their stability against moisture and temperature. The layered nanomaterials will be engineered to optimize their graded mechanical and optical properties.
Main Supervisor	Dr. Milena Arciniegas, Milena.Arciniegas@iit.it
Essential expertise	
i)	Excellent Master Degree in Materials Science, Chemical Engineering, Chemistry, Physics, or similar
ii)	Highly motivated
iii)	Creative
iv)	Excited to work in an interdisciplinary team
Desirable expertise	
i)	Experience in direct laser writing and controlled liquid deposition
ii)	Experience in structural and optical characterization
iii)	Knowledge in materials wet-chemical synthesis
iv)	Knowledge in automated synthesis methods

3. Automated functional nanomaterials discovery (funded by 2023 ERC Consolidator Grant EVA, programme Horizon Europe, GA 101124411)

Supervisor(s): Milena Arcignegas

Short title	Automated functional nanomaterials discovery
Expanded Title	Data-Driven Innovation in Broadband Emitting Layered Perovskites
Background	The self-intercalation of organic and inorganic components in two-dimensional layered perovskites brings up new avenues for the structural engineering of efficient white light emitters from a single material. While prior investigations mainly use random selection of the building blocks, our Automated Nanomaterials Engineering

	Unit aims to explore an experimental approach based on the integration of synthesis parameters, molecular descriptors, and automated workflows, to identify and define optimal conditions and tools to accelerate the discovery of high-performance nanomaterials.
Description	In this PhD project, you will develop automated protocols for an automated robot-based workflow and create data routines. The project covers the complete process from the initial experimental conditions, the development and implementation of an autonomous evaluation of the data, to the preparation of new layered structures. You will have the opportunity to implement scripts and software tools to streamline data handling and ensure accuracy and consistency. The materials prepared through the automated workflow will be structurally and optically characterized in a closed loop. Your work will play a crucial role in advancing the field of automated synthesis, driving innovation, and improving efficiency in nanomaterial research.
Main Supervisor	Dr. Milena Arciniegas, Milena.Arciniegas@iit.it
Essential expertise	
i)	Excellent Master Degree in Chemistry, Chemical Engineering, , Computational Chemistry or related fields
ii)	Highly motivated
iii)	Creative
iv)	Excited to work in an interdisciplinary team
Desirable expertise	
i)	Knowledge on programming languages such as Python or MATLAB
ii)	Experience in automated synthesis
iii)	Knowledge in materials wet-chemical synthesis
iv)	Experience with data analysis and machine learning technique

4. Photonics and optoelectronics of novel low-dimensional nanomaterials

Supervisor(s): Roman Krahne

Short title	Photonics and optoelectronics of novel low-dimensional nanomaterials
Expanded Title	Light-matter interaction and photonics in emerging solution-processed nanomaterials with complex and anisotropic architectures
Description	We are investigating emerging nanomaterials for light emission, integration with optical resonators, and optoelectronic applications with novel functionalities. We focus on emerging low-dimensional hybrid organic/inorganic nanomaterials in which the composition can be designed to obtain the desired properties. We are also interested in combinations with plasmonic nanosystems that can be realized either by self-assembly or top-down

	fabrication. This PhD project will target the synthesis of the novel nanomaterials and exploration of different strategies towards devices in light emission, energy conversion and photodetection.
Main Supervisor	Dr. Roman Krahne, roman.krahne@iit.it
Essential expertise	
i)	Master Degree in Physics, Chemistry, Mechanical Engineering, Nanotechnology, Material Science, or similar
ii)	Profound knowledge in solid-state physics and semiconductor devices
iii)	Knowledge in chemical synthesis and optical characterization tools
iv)	Enthusiastic to work in a creative and international environment
Desirable expertise	
i)	Experience in nanomaterial fabrication
ii)	Experience in optical spectroscopy
iii)	Experience in nanofabrication (clean room)
iv)	Experience in electrical characterization

Curriculum Chemical Sciences and Technologies

5. Synthesis of levoglucosenone derivatives using sustainable synthetic technologies (funded by 2023 ERC Starting Grant CIRCULARIZE, programme Horizon-ERC, GA 101114664)

Supervisor(s): Alessandro Pellis

As part of the CIRCULARIZE project funded by the European Research Council (ERC) of the European Union under the Starting Grant program (ERC-2023-STG), this PhD position is announced on the topic: synthesis of levoglucosenone derivatives using sustainable synthetic technologies.

The project aims to carry out chemo-enzymatic modifications on levoglucosenone to prepare compounds of potential industrial interest and/or as building blocks for the synthesis of smart polymeric materials. The synthetic processes will involve the use of microwaves, cellulose-derived organic solvents and immobilized biocatalysts while reaction products will be analyzed using techniques such as LC-MS, GC-MS, GPC, and NMR.

For further details concerning the research theme, please contact: alessandro.pellis@unige.it.