PhD school in Science and Technology of Chemistry and Materials – XXXIV cycle
8 scholarships- Curriculum Nanochemistry
at Istituto Italiano di Tecnologia & University of Genoa, Italy

Online application till June 12th, 2018

Information and application at https://www.studenti.unige.it/postlaurea/dottorati/XXXIV/EN/

Research thematic

1.Plasmonic, photonic, and electrical properties of metal and semiconductor nanosystems
Tutors:Roman Krahne, Vincenzo Caligiuri

The optoelectronic properties of nanostructures can be tuned by their size, shape and dielectric environment. This project aims at integrating suitable semiconductor nanocrystals or films of nanocrystals into innovative plasmonic or photonic cavities, and to develop such systems as proof of concept devices in light emission. One particularly interesting approach is to incorporate emitting nanocrystal films in layered metal-dielectric structures that manifest tunable plasmon-polariton resonances, and we described our initial results in Caligiuri et al., ACS Photonics 2018, DOI: 10.1021/acsphotonics.8b00121. We foresee that this platform, which in principle allows to obtain strong or weak coupling between the emitters and the plasmonic cavity, depending on how the emitters are incorporated, can be exploited for efficient LEDs or lasers, or as sensing devices that exploit the plasmonic effects.
Requirements: The successful candidate will work on the design of the device structure, its fabrication, as well as on the study of the optoelectronic properties in a state-of-the-art clean room and spectroscopy labs. We are looking for excellent and highly motivated candidates with a degree in physics, chemistry, electrical/electronic engineering or material science. Experience in clean room fabrication (lithography, atomic layer deposition), metamaterials, optical spectroscopy, or electrical characterization is a plus. Furthermore, the optoelectronics group at IIT is part of the EU-RISE project COMPASS (www.compassproject.eu), which gives PhD students the chance of some months of research experience at top research institutions in the USA.
For further details concerning the research theme, please contact: Roman.Krahne@iit.it, Vincenzo.Caligiuri@iit.it

2. Emergent hybrid nanostructures for light driven nano-batteries
Tutors: Liberato Manna, Ilka Kriegel

Battery research is a booming topic in the 21st century. Lithium-ion batteries are to date the most popular battery types used in all common portable electronics. However, for nowadays energy requirements, it is of major importance to develop ways to fully harness the solar resource. The concept to exploit the solar energy to charge a battery would therefore solve many current problems related to solar energy storage, and is a radically new approach. In this project we will explore new innovative ideas to exploit the full potential of the incoming sunlight by developing methodologies to efficiently store solar energy and the possibility to release it on demand. For this we will implement doped metal oxide nanocrystals that have shown the potential to store extra charges after light absorption in a capacitive charging process. In a hybrid system, combining these nanocrystals with layered two-dimensional (2D) materials such as MoS_2, permanent charge separation has been obtained. The latter 2D material is atomically thin and therefore very sensitive to the surrounding. The key characteristics are strain induced variations of the bandgap enabling charge transport to areas of higher valence band energy and therefore favor charge separation. Within this project we will explore the characteristics of this hybrid system and in particular the potential of ultrathin layered 2D materials for charge separation and charge storage by inducing controlled strain to the structure with the final aim to be implemented as light driven nano-battery.
Requirements: We especially look for candidates with degrees in Chemistry, Materials Science, Physics or Chemical Engineering and who are interested in a very interdisciplinary research approach between materials fabrication and characterization, optical microscopy and spectroscopy, electrochemistry and theoretical modeling.
For further details concerning the research theme and any related questions we encourage you to contact: Ilka Kriegel ilka.kriegel@iit.it and Liberato Manna liberato.manna@iit.it.

3. Nanostructured materials for applications in electrocatalysis
Tutors: Liberato Manna, Dipak Shinde

Efficient electro-catalysts offers a path towards the utilization of renewable energy sources to synthesize fuels, such as hydrogen, and value added chemicals, such as alcohols and ammonia. Our research efforts are directed towards chemical and electrochemical synthesis of nanostructures of various metals, metal oxides, chalcogenides and phosphides. The synthesized nanomaterials are then deposited on substrates to realize ad-hoc electrodes, which are utilized as catalysts for various technologically important reactions like water splitting to obtain hydrogen, CO_2 reduction to obtain alcohols and N_2 reduction to obtain ammonia. We also put particular attention on the mechanisms underlying the catalytic reactions of our materials which we investigate by performing a deep characterization of the electrodes before and after their actual operation.
Requirements: The ideal candidate must have a Master Degree in one of the following areas: Material Science, Chemistry, Chemical Engineering or Physics. For further details concerning the research theme, please contact: liberato.manna@iit.it, Dipak.Shinde@iit.it

4. Nanostructured materials for energy-related applications

Tutors: Liberato Manna, Luca De Trizio

The research activity proposed here will be dedicated to the synthesis and characterization of nanomaterials, with applications in energy conversion. For example, solar cells, allowing direct conversion of solar energy into electrical power, perfectly embrace the current increasing demand for new "green" energies to replace fossil fuels. Also, light emitting diodes (LEDs), a highly energy efficient lighting technology, have the potential to strongly lower the consumption of electricity required for lighting our countries, as they use at least 75% less energy than incandescent lighting. Colloidal semiconductor nanocrystals (NCs) have been shown as promising materials for low-cost and high efficiency solar cells and LED devices thanks to their unique properties as well as simple and safe solution phase syntheses and film fabrication. This research activity will be first focused in the synthesis of nanocrystals, including for example metal chalcogenides, pnictides and halide perovskites. The synthesis of nano heterostructures, in which the properties of two different materials can be combined together, will be also pursued.
Requirements: The ideal candidate must have a Master Degree in one of the following areas: Material Science, Chemistry, Chemical Engineering or Physics.
For further details concerning the research theme, please contact: liberato.manna@iit.it, Luca.DeTrizio@iit.it

5. Science and technology of 2D materials-based inks for polymer-composite applications

Tutor: Francesco Bonaccorso

The aim of this research theme is devoted to the development of graphene and two dimensional (2D) crystals for energy storage applications and their integration with other nanoparticles such as silicon. The emphasis will be on lithium ion battery applications, for which one key step is to identify novel candidate 2D crystals for the electrodes and the fine tuning of the electrochemical performances of hybrid electrodes 2D crystals/nanoparticles. The focus will be mainly on nanoscale layered materials, such as transition metal dichalcogenides and layered metal oxides, which are capable of hosting lithium in between the layers. The first part of the research activity will be devoted on the production of graphene and other 2D crystal inks with controlled morphological and rheological properties, by a top-down synthesis approach for the realization of such inks. The as produced inks will be studied in detail for what concerns their optical, structural, electrochemical and electrical transport properties. In addition, electrochemical studies will be carried out at every stage of the project, starting from the as-prepared nanocrystals up to the final battery assembly.
Requirements: We especially look for candidates with top class degrees in Chemistry, Materials Science, Physics or Chemical Engineering.
For further details concerning the research theme, please contact: Francesco.Bonaccorso@iit.it;

6. Development of stimuli-responsive polymeric/ inorganic nanopatforms

Tutor: Teresa Pellegrino

A critical drawback of current anticancer chemotherapy is that the drugs are delivered not only to malignant cells but also to healthy ones. Existing treatments would be by far more specific and efficient if the drugs could be carried and released selectively to the tumor site under local related stimuli or external triggered activation mechanisms. The present PhD project will focus on the development of stimuli-responsive polymers that can respond to cellular stimuli such as the enzymatic action (*i.e.* enzymatic degradation, glucose oxidase, etc.), the pH of the tumor environment, and the presence of radical oxygen species in combination with local heat that is generated by inorganic nanoparticles (magnetic nanoparticles or photo-ablation nanoparticles).

These polymers can act as nanocontainers for drug molecules. Furthermore, the inclusion of inorganic nanoparticles within the polymer will add additional advantages: i) the magnetic nanoparticles will facilitate the delivery of the nanocontainers by physical forces to the tumor site and they will act as hyperthermia agents; ii) the inorganic nanoparticles will promote the production of ROS under stimulation (magnetic heat or UV laser irradiation), and, consequently, they will facilitate the opening of the drug containers; iii) the presence of photo-sensitive molecules/nanoparticles potentiates the heat generated by the magnetic nanoparticles.
The candidate will mainly work on the preparation of the right stimuli-responsive polymers and will have control over the composition, disassembly, physical properties, and biodegradability. He/she will also develop strategies for combining polymers with inorganic nanoparticles, and for controlling the assembly of such nanoparticles and drug molecules.
Requirements: We are seeking candidates with expertise in polymer chemistry (polymerization techniques, experience in polymer grafting techniques on nanoparticles, design and control on polymer aggregate formations), polymer characterization techniques (NMR, GPC, HPLC Mass spectrometry, IR spectroscopy) and inorganic characterization techniques (TEM, XPS, XRD). Expertise in the synthesis of inorganic nanoparticles is also desirable.
The candidate will be a member of a multidisciplinary team of chemists, biologists, physicists and engineers. At IIT, state-of-the-art chemistry and biology laboratories for material preparation, cellular culturing and characterization as well as full-equipped animal facility are available.
For further details concerning the research theme, please contact: teresa.pellegrino@iit.it

7. Evaluating multimodal therapeutic effects exploiting inorganic nanoparticles on cancer stem cells
Tutor: Teresa Pellegrino

Novel inorganic heterostructures that can merge photo-ablation and magnetic hyperthermia or radiotherapy and magnetic hyperthermia is a research line that is currently being largely expanded at IIT. The objectives of this PhD thesis will focus on the study of heterostructures' biocompatibility, interactions with serum proteins, molecular and physical tumor targeting. Furthermore, cellular/tumor heat-mediated damages that occur upon photo irradiation, magnetic hyperthermia, radiotherapy or through a combination of these therapeutic approaches will be studied. Cellular studies will be conducted using 2D and 3D *in vitro* models (the latter of which involves cancer stem cells derived from patients). The aims of this project are to characterize the effects of multimodal therapeutic nanoplatforms on cancer stem cells derived by patients, evaluating the therapeutic effects not only on the whole tumor spheroids but also on the non-proliferating cancer stem cells, on the progenitor and on the most differentiated cancer cells. If required, involvement in *in vivo* animal studies will be also pursued.
Requirements: We are seeking candidates with a medical or biological background that are keen to take part in an interdisciplinary project, working at the interface between biology and material science, developing skills in the field of nano-biotechnology. Knowledge of bio-molecular techniques such as real time polymerase chain reactions, immunofluorescent techniques, transfection protocols, flow cytometry, immunoprecipitation methods, stem cell culture, and in vivo animal studyies is needed. Knowledge of nanoparticle characterization techniques such as dynamic light scattering, gel electrophoresis, elemental analysis thermo-gravimetric analysis is also desirable.
The candidate will be a member of a multidisciplinary team of chemists, biologists, physicists and engineers. At IIT, state-of-the-art chemistry and biology laboratories for material preparation, cellular culturing and characterization, as well as a full-equipped animal facility, are available.
For further details concerning the research theme, please contact: teresa.pellegrino@iit.it

8. Microfluidic processes for the synthesis and self-assembly of environmentally responsive polymers

Tutor: Nicola Tirelli

Flow chemistry deals with preparative processes operated in a continuous fashion 'open' systems; a main advantage is the control of the scale of the preparation (you produce as long as you flow), as opposed to batch processes where also the scale of the operation is fixed a priori.
When flow processes are conducted in microfluidic chips, the additional advantages are the high control and reproducibility of the mixing conditions. This allows to fine tune the details of processes that include organic and polymerization reactions, as well as the production of materials ranging from micelles and liposomes up to (cell-containing) microparticles.
This project primarily focuses on oxidation-sensitive polymers. The programme will focus both on the synthesis of new macromolecular architectures in microfluidic-assisted flow processes (with appropriate in-line analytics), and on the direct production of self-assembled aggregates (e.g. via PISA: Polymerization-Induced Self-Assembly).
The final application of such materials is as biofunctional carriers in advanced therapies of chronic inflammatory disease and of solid tumours.

Requirements: The ideal candidate must have a Master's Degree in one of the following areas: Chemistry, Material Science, Chemical Engineering. Candidates with previous research experience with polymers are strongly preferred, and a minimum background in polymer science/chemistry is required.
For further details, please contact: nicola.tirelli@iit.it

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