Università degli Studi di Genova – Istituto Italiano di Tecnologia

Corso di Dottorato "BIOENGINEERING AND ROBOTICS"
Curriculum "Bionanotechnologies"

Anno Accademico 2018-2019
Ciclo XXXIV

5 positions offered (*)

1. **Bio-scaffolds for controlled delivery of active substances and drugs**

Recent trends in biomedical and pharmaceutical research indicate that natural polymers are increasingly explored as vehicles for drug delivery. Being biocompatible and biodegradable, they can be absorbed into the body fluids without any toxic effects This PhD activity will deal with the development of bio-scaffolds of different geometries and structures based on natural polymers, and especially polysaccharides and proteins, in order to deliver incorporated natural active compounds or synthetic drugs in a highly controlled manner. Strategies to combine hydrophobic and hydrophilic drugs in common natural matrices, and their controlled simultaneous delivery will be followed. The delivery of the active compounds will be done through inhalation, ingestion or skin contact, and therefore, dedicated scaffolds will be obtained for each application, such as micro or nano-beads, fibrous mats, films, etc. The improvements of the bioavailability of the delivered substances will be also targeted.

Requirements: The ideal candidate must have a Bachelor's Degree in one of the following areas: Bioengineering, Chemical Engineering, Material Science, Chemistry, Physics, Biology.

2. **Nanoplastics in water and their interactions with other pollutants: effects in biological systems.**

Nanoplastics are emerging water pollutants which can easily interact with various chemicals and pass to the food chain, with so far unknown health effects. Due to the difficulty to recover nanoplastics from the aquatic environment the research in this field is pretty limited so far. This PhD activity will point to the fabrication of nanoplastics by laser ablation of various polymer targets in liquids in order mimic the nanoplastic pollutants present in aquatic environments. After the complete characterization of the fabricated nanoplastics, their affinity with common and emerging water pollutants, such as pesticides, drugs, dyes, heavy metal ions, flame retardants etc. will be investigated, in order to define the most stably interacting systems. The interactions of nanoplastics and nanoplastics-pollutants combined systems with cells and tissues will be then studied in order to evaluate the effects that such pollutants can have to the living organisms.

Requirements: The ideal candidate must have a Bachelor's Degree in one of the following areas: Biotechnology, Bioengineering, Material Science, Biology, Physics and Chemistry with biological specialization.

3. **Microdevices for transdermal delivery and skin investigation**

In the past few years, alternative methods to model tissue diseases and design therapeutic strategies are attracting researchers' interest, thanks to the high versatility achievable with developing biomedical technologies and the persistent ethical issues related to the animal use.
Within this contest, this PhD activity will focus on the design and development of microdevices for the assessment of transdermal drug delivery and nanomaterial skin toxicity. The device fabrication might be exploited via 3D printing, replica molding, and/or micropatterning. The validation of the design will be performed via diffusion studies, through model or artificial tissues, comparing the results with gold standard procedures (Franz cells) as well as microscopy studies. Further implementation of the system aiming to integrate temperature or pH sensitive-materials within the device will be also considered.

Requirements: The ideal candidate must have a Bachelor's Degree in one of the following areas: Bioengineering, Chemical Engineering, Material Science, Chemistry, Physics, Biology.

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(*) The 5th position has been added on June 8th following the agreement with Università di Genova

4. Multi-Parameter Scanning Microscopy

Tutor: Prof. Alberto Diaspro and Dr. Giuseppe Vicidomini

Department: Istituto Italiano di Tecnologia, "Nanoscopy and NIC@IIT" and "Molecular Microscopy and Spectroscopy" labs.

Description: Light beam scanning microscopy – confocal or non-linear [1] – allows (x-y-z-t) four-dimensional (4D) functional imaging of biological systems. It typically focuses laser beams into a tiny volume of the sample and repetitevely raster scans this probe volume across the sample to form a 4D image, which describes the spatial and temporal distribution of same sample's properties. Since, different light-matter interactions can be explored, scanning microscopy has the unique property to correlate a plethora of structural and function information. One the most used light-interaction is fluorescence. By simply recording the fluorescence light response (intensity image) from specifically labelled molecules, one can visualize the sub-cellular structures with few hundred nanometres spatial resolution, or with few tens of nanometres if combined with STED microscopy [2]. Advanced photons detection schemes give access to fluorescence spectrum, lifetime and anisotropy images, thus to biochemical and molecular structural information. On the other side, absorption and scattering mechanisms can provide structural information without the need of labelling probes (label-free).

This plethora of information is normally obtained sequentially, since any probing mechanisms requires a different detector (with different characteristics) and/or a different acquisition scheme, and/or a different analysis of the signal. However, biological systems are highly heterogeneous in time, which makes a sound correlation of all these parameters in living system almost impossible.

Aim of this project is to explore novel photon detectors able to extract simultaneously the signals stemming from different contrast mechanisms and to implement data acquisition and signal processing architectures [3] able to correlate in real-time all the information potentially accessible with a scanning microscope. This has a key impact in oncological and neurological applications.

Requirements: We are seeking a highly motivated and talented PhD student to join our interdisciplinary research teams. The successful candidate should have: (i) a degree in physics, engineering (or a related field); (ii) programming skills in MATLAB/LabView/C# for device control and synchronization; (iii) ability to work in an interdisciplinary team, willingness to work outside core expertise.

References:

[1] Diaspro A., Confocal and two-photon microscopy: foundations, applications, and advances. Wiley-Liss, New York (2002)
[2] Vicidomini G., Bianchini P., Diaspro A., STED super-resolved microscopy, Nat. Methods, 15:173–182 (2018)
[3] Castello M., Tortarolo G., Coto Hernández I., Deguchi T., Diaspro A., Vicidomini G., Removal of anti-Stokes emission background in STED microscopy by FPGA-based synchronous detection, Rev. Sci. Instrum., 88(5): 053701 (2017)

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5. Nanotechnology for cardiovascular diseases
Tutor: Dr Paolo Decuzzi

Department: Istituto Italiano di Tecnologia, "Nanotechnology for precision medicine"

Nanoparticles are revolutionizing the modus operandi of clinical scientists and physicians. In oncology, lipid-based nanoparticles and albumin complexes are used daily for the treatment of different malignancies. About 40 different nanoparticle formulations are currently ongoing clinical trials in Phase II and III, for the treatment of solid tumors and leukemia. Considerably less work has been so far dedicated to the development of nanoparticles and implants for the treatment of cardiovascular diseases, including thrombosis, atherosclerosis and heart failure. This PhD activity will focus on the design, realization and testing of nano-based systems for the controlled release of small molecules and biologicals in the management of cardiovascular diseases. The main focus will be on atherosclerosis and heart failure. The candidate will use natural and synthetic, biodegradable polymers for the synthesis of nano-based systems. These will be tested for their pharmacological performance in vitro, on cell lines and primary cells from rats and humans, as well as in vivo, in preclinical small rodent-based models.
Requirements: The ideal candidate must have a Master Degree in Pharmacy, Biomedical Engineering, or Chemical Engineering, and sufficient laboratory experience, preferably on the synthesis and characterization of nanoparticles.

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