UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Smart materials for biomedical applications: scaffolds and sensors"

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Short Abstract:

Based on the increasing advances in the fabrication and monitoring approaches of biomedical devices, innovative materials are being synthesized and explored to adapt and interact effectively with the specific biological environment. In this scenario, smart materials sensitive towards various stimuli such as temperature, pH, light, magnetic and electric field, can provide versatile and dynamically tunable platforms for the investigation and manipulation of several biological activities with very low invasiveness [1, 2].

Moreover, the use of advanced structured and responsive materials in combination with additive manufacturing technologies give the opportunity to design multi-functional and high-performance products. This novel approach aims to move beyond traditional design and manufacturing process towards 4D printing and the creation of dynamic structures, such as shape memory materials, with integrated functionalities [3].

The course thus aims to provide knowledge on the smart materials suitable for the design of 3D scaffolds, drug delivery systems and sensors for biomedical applications, with a special focus on devices created by means of additive manufacturing technologies.

Course Contents in brief:

- Introduction to the use of smart materials for biomedical applications
  Recent advances in the design of 3D scaffolds for tissue engineering, drug delivery platforms and sensors with particular focus on the use of smart and biomimetic materials combined to additive manufacturing technologies.
- Smart materials and mechanisms of action
  Presentation of new smart multifunctional or biomimetic materials for biomedical applications. Description of the specific mechanisms of actions considering endogenous stimulators such as pH, reactive oxygen species, hypoxia and enzyme, or exogenous stimulators such as temperature, light, ultrasound, radiation, and magnetic field. Special attention will be dedicated to smart biomaterials suitable for the design of biomimetic constructs.

- Characterization of materials and devices
  Main analysis methods used to explore the material properties before and after the manufacturing process: 1) rheological studies aimed at investigating the visco-elastic properties of materials and able to support the optimization of the manufacturing process; 2) nanoindentation technique to explore the mechanical features and stability of materials and devices; 3) micro-computed tomography to identify the structural and compositional properties of the final devices.
- Examples of applications
  Current applications, limitations, and future perspective of smart materials for the design of scaffolds and sensors. Presentation of different case studies to understand approaches and methods required to design scaffolds and sensors: synthesis of materials, manufacturing process and final validation of devices.

Total # of hours of lecture: 20

References:

[1] Genchi, Giada Graziana, et al. "Smart materials meet multifunctional biomedical devices: current and prospective implications for nanomedicine." Frontiers in Bioengineering and Biotechnology 5 (2017)

[2] Yang, Yao, et al. "Smart materials for drug delivery and cancer therapy." View 2.2 (2021)

[3] Gardan, Julien. "Smart materials in additive manufacturing: state of the art and trends." Virtual and Physical Prototyping 14.1 (2019)

CV of the Teacher

Biomedical engineer, specialized in the development of biomaterials for regenerative medicine and additive manufacturing technologies. Obtained a master's degree in Biomedical Engineering in 2016, after spending 7 months at the Newcastle University (UK), where new systems based on collagen/alginate/fibrin hydrogels were developed for encapsulation of pancreatic β-cells for the treatment of diabetes type I.
PhD in Bioengineering and Medical-Surgical Sciences, focused on the design of biomimetic collagen-based scaffolds by means of 3D printing and electrospinning technologies, developed for boosting the regeneration of bone tissue.
Participant in research activities of several national and international projects such as ERC project BOOST, EU-funded projects MOZART and GIOTTO, that led to the collaboration with important national and international universities and research institutes such as MERLN Institute of Maastricht University, Newcastle University, Universidad Complutense de Madrid (UCM), Istituto Ortopedico Rizzoli of Bologna (IOR) and Centro Piaggio (University of Pisa).
Currently a post-doc researcher at the IRIS group (Improving Regeneration by Intelligent Scaffolds), at Politecnico di Torino, working on development of innovative biomaterials ranging from the macro to the nanoscale (3D-scaffolds, micro and nanoparticles, resorbable fibers, and smart surfaces with osteoproductive, antibacterial and biomolecule release properties) and scaffold biofabrication.
Author of 23 papers including research articles and book chapters (H-index 9 and more than 270 citations) mainly in the field of biomaterials, antibacterial surfaces, surface functionalization, biofabrication and tissue engineering.

Final Exam: Team project work development

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule:

Day1 – 14:00 – 18:00

Day2 – 14:00 – 18:00

Day3 – 14:00 – 18:00

Day4 – 14:00 – 18:00

Day5 – 9:00 – 13:00