PhD in Materials Science and Technology

Research Title: Smart 3D Printable Hydrogels for next generation Biomedical Devices (HYDROPRINT3D)

Funded by	Politecnico di Torino (Joint Research Projects with Top Universities)

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Context of the research activity	This research activity lays in the frame of the initiative "Joint projects to support research collaborations with excellent international organizations" ,funded in the frame of the multi-year Agreement 2016-2018 between Politecnico di Torino and Compagnia di San Paolo. So the PhD activity will be a collaboration project between Politecnico di Torino in Italy and Hebrew University of Jerusalem in Israel. Regarding the context of the activity, the PhD will be focused on polymeric 3D printing. 3D printing(3DP) is a groundbreaking technology that is becoming every day more important; it is predicted to revolutionize our actual production process, overcoming the economy of scale. Today, polymeric 3DP is mostly used to produce prototypes and models for engineers and designers, however it is gaining importance in niche application where customization of the structures is of primary importance, such as production of biomedical devices.

	In fact 3DP enables fabrication of components from a patient's own medical images, such as computed axial tomography and magnetic resonance imaging, allowing the fabrication of custom-designed and patient-specific constructs with high complexity. This is not possible using conventional fabrication techniques. Moreover, it enables on-demand fabrication of medical products, allowing in-house production as well as in remote areas. This technology is currently used in a large variety of medical applications including dentistry, anatomical models, medical devices and tissue engineering scaffolds. A further step in the evolution of 3DP in biomed would be developing structures using materials able to modify their properties upon exposure to altered environmental conditions, enabling the so called 4D printing. The Hydroprint3D project falls in this frame, aiming to develop biocompatible 3DP hydrogels with stimuli responsive behavior, producing 4D printable biomedical devices. In Hydroprint3D, various scientific and technological challenges will be addressed, formulating hydrophilic (i.e. hydrogel) materials which show biocompatibility and could be shaped through light induced 3D printing, exploiting very precise but fast and cost effective stereolithographic technologies such as Digital Light Processing (DLP). At the same time these hydrogels will show shape memory effect (SME), being able to change their printed shape under external stimuli (e.g. in a physiological environment), enabling the fabrication of 4D printable biomedical devices.

Objectives	In the last decade there was a huge increase in 3D printing field, especially in the development of new, faster, more precise and cost effective 3D printers. However, to further enhance this technology and to bring it in everyday life, the same effort is requested in the development of new functional 3D printable materials. In particular in medicine, the fast and easy personalization of biomedical devices could represent a fundamental step. For this reason the main goal of Hydroprint3D project is to develop novel printable biomaterials with smart properties. To achieve this objective an accurate design of printable formulations in compulsory, in order to impart smart functionalities such as SME to the printed objects, as well as a deep knowledge of chemical-physical phenomena occurring during the printing process. These competences fit perfectly with the scientific background developed in Politecnico di Torino and Hebrew University of Jerusalem.

	On one hand the Politecnico di Torino has an international-*renowned expertise* on the development of photocurable formulations, material synthesis and characterization. Moreover biomaterials could be furtherly exploited taking advantage of the recently constituted inter-departmental "Polito Bio^{MED} Lab". On the other hand, Prof. Magdassi group has a huge experience on the formation of 2D and 3D functional inks including materials with SME, including the production of 4D structures. To fabricate 4D biocompatible hydrogels, the following tasks will be developed within the Hydroprint3D project. • Development of photocurable hydrogels with shape memory properties; evaluation and optimization of the SME under external stimuli; • Study and optimization of 3D printing process of the developed formulations; evaluation of the properties of the 3D printable materials; modifications of the 3D printable formulations in order to achieve good printability and SME. • Design of suitable biomedical device (e.g. stent), mutually exploiting materials properties and architecture features; • Study of the biocompatibility of the printed structures and modification of the formulations and printing parameters accordingly. Since this PhD will be part of a Joint project, the PhD candidate will spend 18 months in Turin and 18 months in Jerusalem (not continuously). In particular the PhD from Polito will focus his/her activities on the following goals: • Development of photocurable hydrogels with SME, optimization of the formulation in order to control and maximize the shape memory effect under the desired stimulus (e.g. physiological environment); • Study of the biocompatibility of developed materials; • Modification of the printable formulations in order to gather SME, printability and biocompatibility; • Study of the biocompatibility of 3D printed structures.

Skills and competencies for	The PhD candidate should have competencies in Materials' Science

the development of the activity	and Engineering or in Chemistry, in particular in Polymer Technologies. A certain knowledge of photopolymerization is highly recommended as well as experience on the development of photocurable formulations. Moreover the candidate should present familiarity with the most common characterization techniques for polymeric materials (IR, DSC, TGA,…). The knowledge of 3D printing and/or biocompatibilty tests is not mandatory since the beginning, even if useful, since it will developed during the activity.