Research Proposal

Title: “Design, micro-fabrication and testing of bioinspired cell scaffolds for improved cell adhesion” (PhD research project)

Scholarship: ≈20 k€/year (taxes according to Italian regulations, scholarship amount may increase)

Duration: 3 years

Supervisor: Prof. Antonio Papangelo

University: Department of Mechanics (DMMM) Politecnico di Bari – Department of BioScience, University of Bari

Research topic

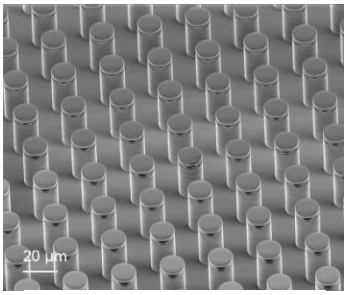

Figure 2 – Micro-structured surface for interface functionalization ©Nanoscribe

Figure 1 - TriboDynamics Lab at DMMM, PoliBa

Social ageing is stressing European public health systems. Tissue alterations due to ageing is one of the main causes of detachment (lost of intimate adhesion) between different layers of human organs, for example as it happens in the detachment of the neurosensory retina from the underlying retinal pigment epithelium that causes retinal detachment potentially leading to blindness [1]. Receptors which adhere on cells and membranes permit transmembrane connections, and adhesion is fundamental for the anchorage of the cellular membrane to the cytoskeleton [2]. (i) Rapid medical treatments strongly influence the possibility to fully or partially recover the tissue functionality, with more favourable recover if treatments are provided soon after the appearance of first symptoms. Delays in medical treatment provision leads often to invasive surgery, which is socially expensive in terms of both costs and as it does not guarantee full recovery to the organ functionality [3]. Furthermore, (ii) the same tissue, in different patients, may present large variability hence the possibility to develop ad-hoc interfaces and scaffolds is attracting much interest [3]. Considering these needs (i-ii), the present PhD research proposal aims at developing experimental protocols for the design and fabrication of biomimetic interfaces “on demand” for optimized cell adhesion. In this respect the fundamental enabling technology will be represented by fast prototyping based on the two-photon polymerization (2PP) microfabrication system available at the TriboDynamics (DMMM, PoliBa). The 2PP technology allows to fabricate 3D scaffolds and interfaces with high spatial resolution (down to 200 nm), over an area of 100 cm^2. Photoresins with different mechanical properties can be used, with Young modulus ranging from GPa to kPa. Biocompatible (not-cytotoxic) and biodegradable photoresins (IP-L, IP-Visio) are available which can be used for cells growth [4]. The proposed research will be carried on in collaboration with the Department of Bioscience and Biotechnology of the University of Bari (DBB, UniBa), which will support the project providing in-depth knowledge of the physiology of the tissues and cells to be considered. The research is planned as follows: (0-6 months) literature overview of the physiology of biological

interfaces suffering adhesion degradation, (6-9 months) conceiving a biomimetic interface for adhesion of cells based on the physiology of biological interfaces, (9-18 months) numerical analysis of the adhesive properties of the micro-structured interfaces, (18-30 months) microfabrication of biomimetic interfaces via 2PP high-resolution 3D printing, (24-36) analysis of the biological interactions between cells and biomimetic surfaces in collaboration with the DBB of UniBa. Design will be supported by finite element numerical simulation, possibly adding multiphysics effects, for example aiming at taking into account the possibility of biological fluids at the interface between the cells and the biomimetic surface. The project is multidisciplinary as it aims at developing innovative numerical/fabrication protocols for providing rapid response to the need to repristinate tissue adhesion among different cells layers, thus aiming at a prompt maintenance and restoration of the tissue function, minimizing invasive surgical approaches. The proposal objectives are perfectly in line with the scope of the PNRR, in particular with the actions undertaken for human wellbeing. Indeed, it is strategic for Italian and European health care systems to implement the most effective technologies and tools to reduce the disease burden and the social impact of common disease in aging populations. Versatile biohybrid interfaces with upgradable mechanical/topographic features will eventually be achieved, with potential application to different biological diseases causing adhesion degeneration between cell layers alleviating socioeconomical implications. Interface testing in terms of adhesive/mechanical performances (peeling test, debonding test, maximum adhesive force at detachment) will be conducted at the TriboDynamics Lab (PoliBa) in collaboration with the DBB (UniBa) in an iterative optimization process of fabrication and functional verification. A minimum period of 6 months of research abroad will be guaranteed, thanks to the active collaborations with CNRS (Lyon, France) and with the Hamburg University of Technology (Germany). The research outputs will be disseminated according to the principle of Open Science.

References

[1] de Souza et al. (2012). DOI : 10.1016/j.exer.2012.02.009
[2] Elbourne et al. (2019). DOI: 10.1016/j.jcis.2019.03.050
[3] Shakibania et al. (2022). DOI: 10.1039/D1ME00178G

[4] Song et al. (2020). DOI: 10.1002/adhm.201901217

Please, apply at antonio.papangelo@poliba.it attaching your CV.