3D Printing and bioprinting with high spatial resolution, challenges and perspectives

A. Ovsianikov

Institute of Materials Science and Technology, Vienna University of Technology (TU Wien), Austria

Additive Manufacturing Technologies Group (amt.tuwien.ac.at/Ovsianikov)

Austrian Cluster for Tissue Regeneration (www.tissue-regeneration.at)

Aleksandr.Ovsianikov@tuwien.ac.at

Additive manufacturing technologies, also referred to as 3D printing, are experiencing rapid development by providing disruptive solutions across different industrial sectors. They also play an increasingly important role in biomedical and tissue engineering applications. Bioprinting aims at additive manufacturing from materials containing living cells. These materials, often referred to as bioinks, are based on cytocompatible hydrogel precursor formulations, which gel in a manner compatible with different 3D bioprinting approaches [1]. Among the most widespread bioprinting technologies are methods based on extrusion and ink-jet material deposition. The achievable spatial resolution is therefore in the range of tens of micrometers, limited by intrinsic properties of these methods. In the context of biomedical and tissue engineering applications of 3D Printing and Bioprinting, multiphoton lithography (MPL) is an outstanding approach as it can produce features smaller than a single mammalian cell (down to around 100 nm). For example, it has recently enabled realization of highly porous microscaffolds capable of hosting individual cell spheroids [2]. MPL is also fundamentally different in that it does not rely on material deposition, instead the materials is locally modified using photochemistry induced by multiphoton absorption of ultra-short laser pulses [3]. Depending on the material MPL can produce high-resolution volumetric structures, induce photodegradation or spatially resolved covalent binding of specific molecules in the volume of the sample [4]. 3D printing of cell-containing hydrogel structures with high spatial resolution opens exciting perspectives for the engineering of 3D biomimetic cell culture matrices. Development of cell compatible and photopolymerizable hydrogels is an important step towards the latter goal. Current challenges include possible cell damage, resulting from generation of free radicals, and necessity for faster processing [5]. In this contribution, our recent progress on MPL development will be presented. Current state of the art, challenges and future perspectives will be discussed.

1. K. Hölzl, S. Lin, L. Tytgat, S. Van Vlierberghe, L. Gu, A. Ovsianikov, Bioink properties before, during and after 3D bioprinting, Biofabrication 8 (3), (2016) [doi: 10.1088/1758-5090/8/3/032002]
2. A. Ovsianikov, A. Khademhosseini, V. Mironov, The Synergy of Scaffold-Based and Scaffold-Free Tissue Engineering Strategies, Trends in Biotech. 36 (4) 348 – 357 [doi: 10.1016/j.tibtech.2018.01.005]
3. Multiphoton Lithography: Techniques, Materials, and Applications, J. Stampfl, R. Liska, A. Ovsianikov (Eds.) John Wiley & Sons (2016), [ISBN: 978-3-527-33717-0]
4. A. Ovsianikov, V. Mironov, J. Stampf, and R. Liska, Engineering 3D cell-culture matrices: multiphoton processing technologies for biological and tissue engineering applications, Expert Rev. Med. Devices 9(6), 613–633 (2012) [doi:10.1586/erd.12.48]
5. M. Tromayer, P. Gruber, M. Markovic, A. Rosspeintner, E. Vauthey, H. Redl, A. Ovsianikov and R. Liska, A biocompatible macromolecular two-photon initiator based on hyaluronan, Polym. Chem. 8, 451-460 (2017) [doi: 10.1039/C6PY01787H]