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Abstract

Automation of 3D-printed perfusion bioreactor processes for the vascularization of bone scaffolds

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Abstract:
An in-vitro vascularization process of a 3D-printed scaffold with endothelial cells is a multi-step approach requiring tight control of growth parameters. Viable bone tissue implants depend on the large-size formation of homogeneously distributed blood vessels and microvascular networks even deep inside the scaffold. An effective vascularization process shall minimize supply gradients of oxygen, and nutrients and aims to remove metabolites to avoid its accumulation resulting in negative biological events at the core of the scaffold. One of the greatest challenges in engineering bone implants, therefore, has been the realization of high-quality vascularized bone scaffolds. Current commercially available bioreactors produce at inconsistent quality and require highly skilled operators to manage growth conditions, manually. Parameters such as the pH value, temperature, dissolved oxygen, nutrient concentration, cell viability, and biochemical and mechanical stimuli all play an important role in controlling the seeding of the scaffold and its homogeneous vascularization in the bioreactor [1]. The perfusion bioreactor is the most promising type of reactor that is able to pump oxygen and nutrients directly through the scaffold [2]. However, achieving full automation and robust control of bone bioreactor processes and the continuous real-time monitoring of essential in-vitro growth parameters are challenges inhibiting commercialization of tailored bone implants to a reasonable price and quality. Diamond biosensors in a redundant multi-sensor approach exhibit low biofouling rates and show promising results in the in-situ monitoring of the bioprocess conditions for the full operation time of single-use perfusion bioreactors [3, 4].

Biography:
Tom Zimmermann was head of the business unit Biohybrid Systems at Fraunhofer and is with the Michigan State University since 2017. His activities are in the interdisciplinary and strongly collaborative research fields of biomedical diagnostics, automation of biotechnological bioreactor processes, and diamond power converters. He graduated with a M.S. in solid-state electronics at the University Ulm (Germany), in 2002. Having received a PhD degree in electrical engineering from the University Ulm (diamond and III-V devices), he joined the University of Notre Dame, in 2006. Here, he pursued research in high-power high-frequency devices, first as post-doc and later on as research assistant professor. In 2017, he completed a certificate in International Regulatory Affairs of Medical Devices at the University of Lübeck (Germany), and he received a MBA in Entrepreneurship at the Berlin School of Economics and Law (Germany), in 2018. His research record: 30+ peer-reviewed papers, 60+ conferences.

Recent Publications:
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2. S.-I. Roohani-Esfahani, P. Newman, H. Zreiqat, "Design and Fabrication of 3D printed Scaffolds with a Mechanical Strength Comparable to Cortical Bone to Repair Large Bone Defects", Sci Rep 6(1), 19468, 2016.
3. S. Mross, T. Zimmermann, N. Winkin, M. Kraft, H. Vogt, "Integrated multi-sensor system for parallel insitu monitoring of cell nutrients, metabolites, cell density, and pH in biotechnological processes", Sensors and Actuators B: Chemical 236, 937-946, 2016.
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