SFB/TRR 225 „From the fundamentals of biofabrication towards functional tissue models" Seminar Series 2021

"Using deterministic chaos for facile high-throughput fabrication of ordered multilayer micro- and nanostructures: continuous chaotic printing"

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In ZOOM platform (link will be provided in advance)

Guests are welcome!

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ABSTRACT

Today, tissue engineering evolves exponentially and provides real solutions to create biological models and solve clinical problems. However, we still face challenges that hinder its full potential to generate complex and large-size tissues and organs. Here we present advances in chaotic bioprinting, an additive manufacturing technique that enables the creation of complex biological structures at an unprecedented level of resolution and throughput.

Continuous chaotic printing uses chaotic advection for deterministic and continuous extrusion of fibers with internal multilayered structures. Two or more free-flowing materials are coextruded through a printhead containing a miniaturized Kenics static mixer (KSM) composed of multiple helicoidal elements. This produces a fiber with a well-defined internal multilayer microarchitecture at high-throughput (>1.0 m min^{-1}). The number of mixing elements and the printhead diameter determine the number and thickness of the internal lamellae, which are generated according to successive bifurcations that yield a vast amount of inter-material surface area (~10^2 cm^2 cm^{-3}) at high resolution

(~10 µm). This creates a new opportunity to produce structures with extremely high surface area to volume (SAV). Comparison of experimental and computational results demonstrates that continuous chaotic 3D printing is a robust process with predictable output. The simplicity and high resolution of continuous chaotic printing strongly supports its potential use in novel applications.

Here, we illustrate the application of continuous chaotic bioprinting into the fabrication of complex multi-layered bacterial microcosmoi. We demonstrate that the degree of resolution achieved within these constructs can be finely controlled up to the range of a few microns of separation between layers and that the degree of interface between bacterial layers greatly matters for competition.

We also demonstrate the application of tissue-like structures in which living layers of muscle cells evolve into a coherent segment of muscle. Lumina can be easily built into these constructs by using a combination of sacrificial and permanent inks and a multi-port modification to the chaotic printhead.

We are currently exploring more applications of chaotic printing into tissue engineering such as the fabrication of vascularized cancer models, and multi-cell type tissue-like architectures where distinctive mammalian cell layers share a high amount of common interface.

Different fields, outside biosciences and technologies, are also in pursuit of simple and robust ways to create multilayered and multi-material structures to attain functionalities that monolithic materials do not exhibit. We envision that chaotic printing may be applied to technological scenarios such as the fabrication of batteries, superconductors, super catalytic surfaces, and 3D microfluidic reactors.