3D/4D microprinting of biomaterials

Philipp Mainik, Eva Blasco*

Institute for Molecular Systems Engineering & Advanced Materials, Heidelberg University, Germany

Organic Chemistry Institute, Heidelberg University, Germany

philipp.mainik@oci.uni-heidelberg, eva.blasco@uni-heidelberg.de

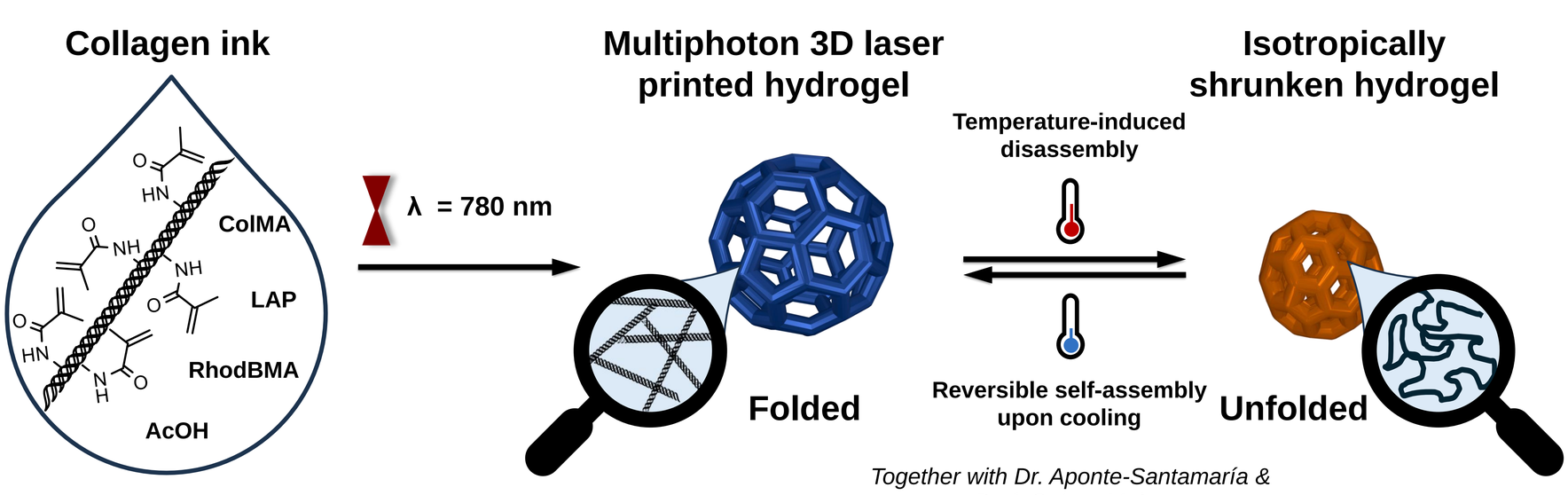
3D MATTER MADE TO ORDER

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

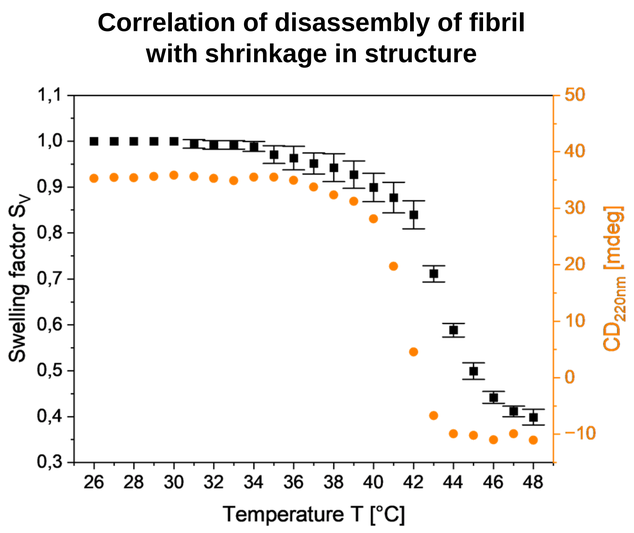
Motivation

Multiphoton 3D laser printing (MPLP) offers additive manufacturing with high spatial resolution in the micro- to nanometer range. This process is achieved by moving the focal volume of a femtosecond pulsed laser in a photopolymerizable ink and induce multiphoton polymerization along the focus trajectory. MPLP is especially interesting for shaping biomaterials in 3D for biomedical studies due to the achievable subcellular resolution. The objective of the two presented works was to develop a stimuli-responsive natural-based polypeptide ink and to investigate the possibility of MPLP directly in organisms. Our results present a starting point for the preparation of stimuli-responsive implants to achieve controlled actuation or triggered releases.

Microprinting of responsive collagen

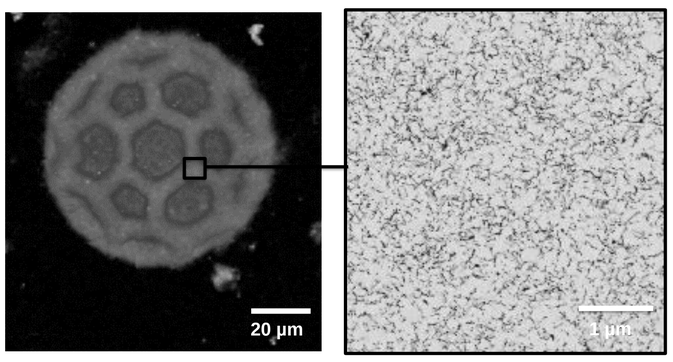


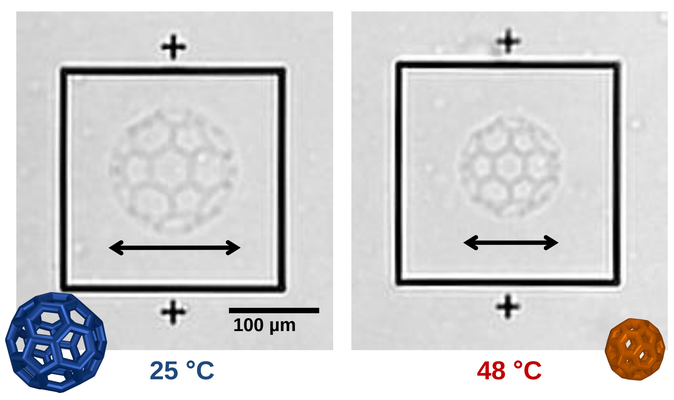
Together with Dr. Aponte-Santamaría & Prof. Gräter, Mainz

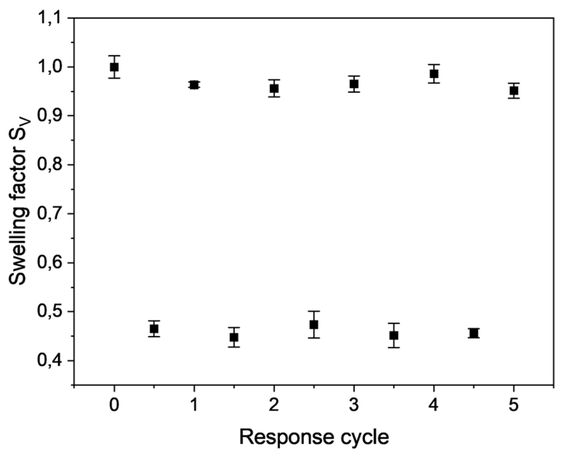


Ink components & their roles

ColMA	Polymerizable collagen methacrylamide
LAP	Water soluble photoinitiator
RhodBMA	Fluorescent comonomer
AcOH	pH control for room temperature stability

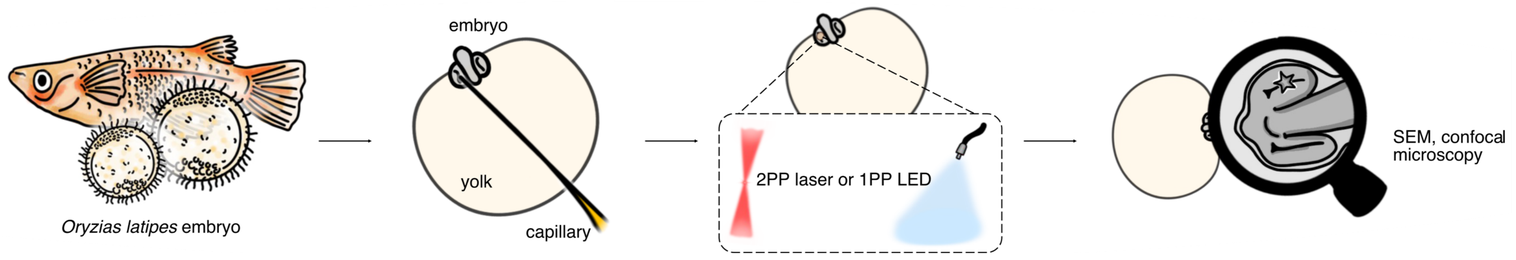






Microprinting of biomaterials *in organismo*

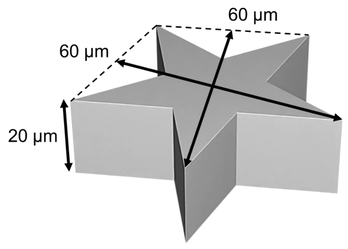
Together with Dr. Afting & Prof. Wittbrodt, Heidelberg



Important requirements

- ☑ Low viscosity ink for injection
- ☑ Hydrophobic ink
- ☑ Multiphoton 3D printable ink
- ☑ Biocompatibility of the process & materials
- ☑ Metabolization of non-printed ink over time

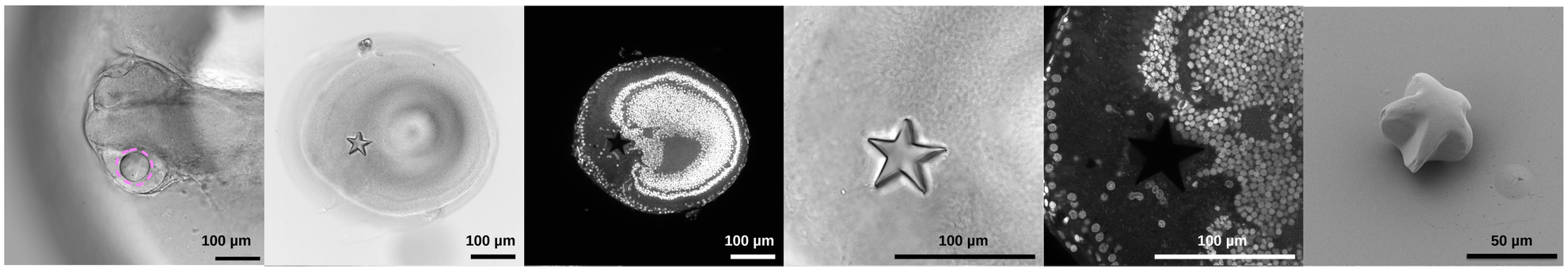
Star model



Microprinting

Raising and whole-mount staining of embryo

Extracted



Acknowledgement

DFG Deutsche Forschungsgemeinschaft

Excellence Strategy, EXC 2082/1 – 390761711

Carl Zeiss Stiftung

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Excellence Networks, Phase 2&3

HEiKA Heidelberg Karlsruhe Strategic Partnership

More details

Mainik *et al.*, *Small* **2025,** 21, 2408597.

Afting† & Mainik† *et al.*, *Adv. Sci* **2024**, 11, 2401110.