Properties of Bio-compatible Polymers for 3D Nanostructuring

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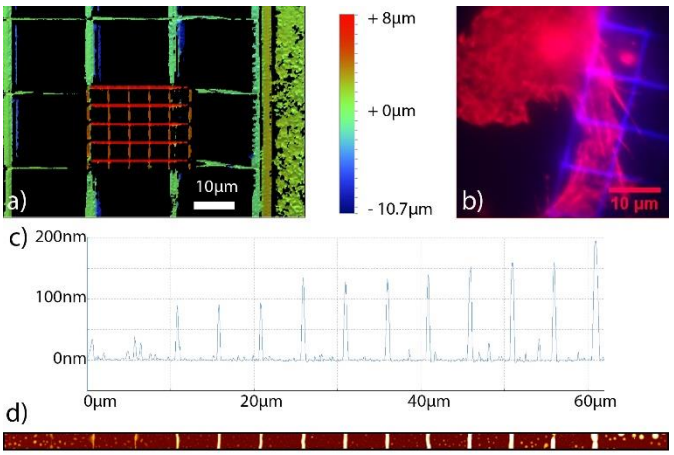
Abstract

Two-Photon Polymerization (2PP) allows fabrication of arbitrary three-dimensional structures in the sub-micrometer range with controllable spatial and material properties. For 2PP a liquid resin consisting of cross-linkable monomers and a small amount of a photo initiator is used as matrix for writing. Femtosecond laser pulses and a high numerical aperture objective are used to create a focal volume with a high energy density. Therefor a simultaneous absorption of two photons by the photo initiator is probable. The excited photo initiator decays than into a chemical active radical, which starts the radical polymerization. Thus the cross-linking of the monomers yields the solidification of the polymer.

Recent advances in three-dimensional nanolithography for tissue engineering requires for non-toxic materials mimicking tissue properties (eg. the extracellular matrix or cartilage). Typically for 3D lithography acrylate monomers are used because of their high reactivity. However, they are toxic. Up to now mostly methacrylates are used. However they are less reactive and therefore require a lower manufacturing velocity. In this work we present a new type of biocompatible polymer, which combines the reactivity of acrylates, the biocompatibility of methacrylates and the stability of thiols.

The resins are structured using 2PP with a 515nm light source, a writing speeds up to several mm/s and sub-micrometer feature sizes. In order to characterize the mechanical properties of the manufactured scaffolds, atomic force microscopy (AFM) was used. The polymers Young's modulus have been characterized and compared to different available resins.

Image



Recent Publications

1. Moritz Wiesbauer (2013) Nano-Anchors with Single Protein Capacity Produced with STED Lithography; Nano Lett., 13 (11)
2. Clemens Wolfesberger (2015) Streptavidin functionalized polymer nanodots fabricated by visible light lithography; J Nanobiotechnology, 13 (27)
3. Bianca Buchegger (2016) Stimulated Emission Depletion Lithography with Mercapto-Functional Polymers; ACS Nano, 10 (2)
4. Richard Wollhofen (2017) Functional photoresists for sub-diffraction stimulated emission depletion lithography; Optical Materials Express, 7 (7)
5. Richard Wollhofen (2018) Multiphoton Polymerized 3D Protein Assay; ACS Appl. Mater. Interfaces, 10 (2)



Biography

Boris Buchroithner started his physic education at the Johannes Kepler University (JKU) Linz with Polarisation Sensitive Full Field Optical Coherence Microscopy (PS-FF-OCM), a noninvasive and non-destructive imaging technique. Its applied in medicine and bio-imaging but lately finds a crowing community in the material science. For his diploma theses, Boris Buchroithner investigated All Electric Cantilever for bio-AFM applications at the JKU institute of Applied Experimental Biophysics. This technical extension of the common Atomic Force Microscopy (AFM) enables imaging under harsh conditions such as closed vacuum chambers. Meanwhile it is used in medical screening and protein detection. Presently Boris Buchroithner studies at the JKU Institute of Applied Physics two photon fabricated biopolymer scaffolds for bio applications.

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Notes/Comments:

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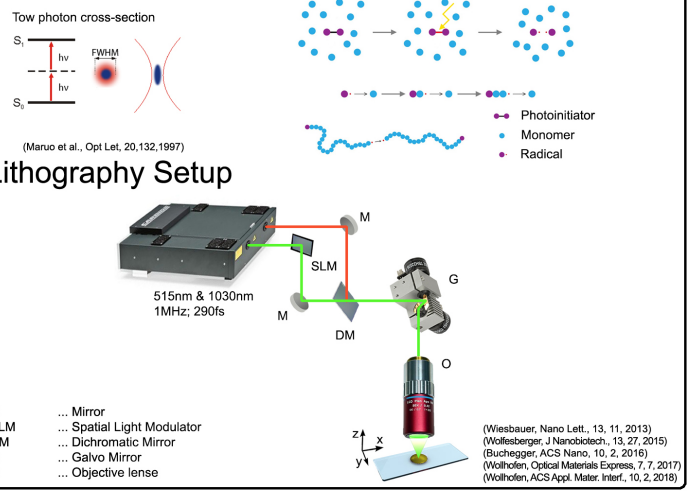
Boris Buchroithner[1], Sandra Mayr[2], Dmitry Sivun[1], Bianca Buchegger[1], Delara Hartmann[4], Yoo Jin Oh[3], Thomas Grießer[4], Peter Hinterdorfer[3], Thomas A. Klar[1], Jaroslaw Jacak[1,2]

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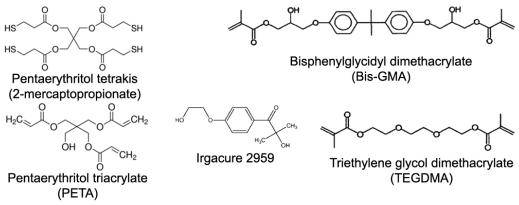
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Tow photon polymerization

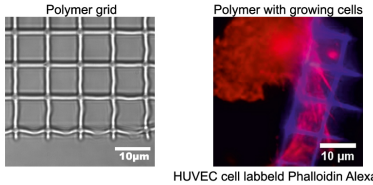


Bio-compatible resins-component



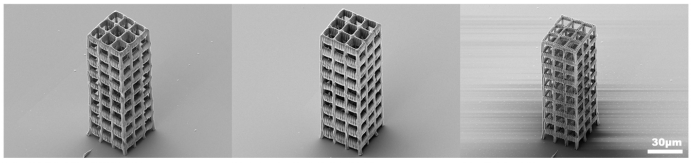
2D and 3D structuring

2D - Grids



HUVEC cell labbeld Phalloidin Alexa 647

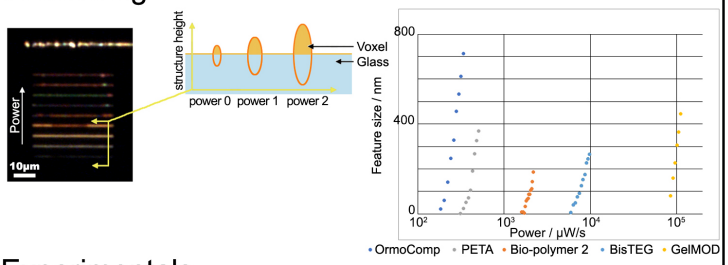
3D - structures



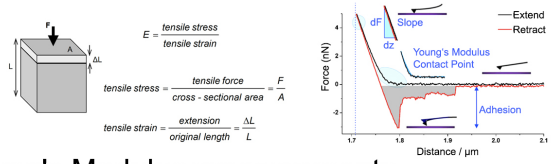
Bio-compatible polymer 1 | Bio-compatible polymer 2 | PETA (control)

Mechanical properties of the bio-compatible polymers

Structuring

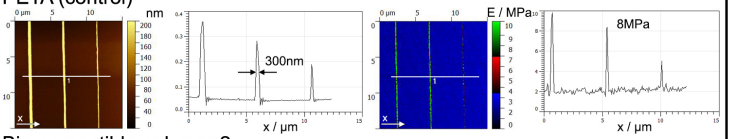


Experimentals

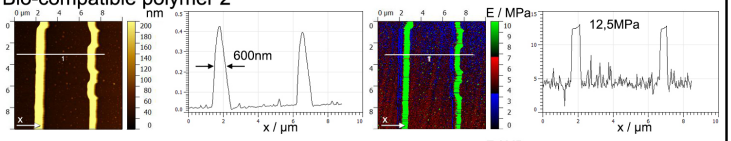


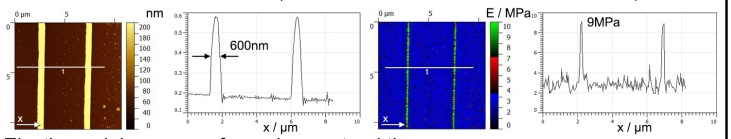
Young's Modulus measurements

PETA (control)



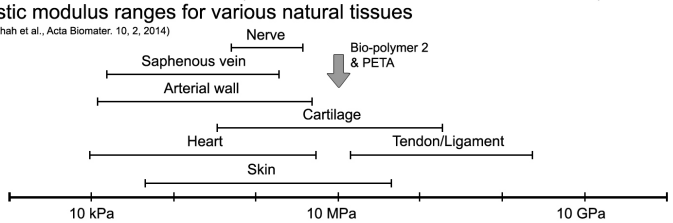
Bio-compatible polymer 2





Elastic modulus ranges for various natural tissues

(Vatankhah et al., Acta Biomater. 10, 2, 2014)



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