Talk __

Gentle Micro/Nano-Engineering for Fragile Material Microsystems

Professor Juergen Brugger
Director Microsystems Laboratory,
Institute of Microengineering, School of Engineering
Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland
Group Website: https://www.epfl.ch/labs/lmis1/

ABSTRACT

Polymer-based micro- and nano-systems (MEMS/NEMS) have a great potential for stretchable electronics and biomedical applications and substantial progress is made in process and integration technologies. We must admit though that up to now the techniques to engineer fragile functional polymers into reliable 3D microsystems for daily use are far way from the perfection we appreciate from integrated silicon microelectronics with its scalable wafer-scale manufacturing. One reason for that is that due to the wide choice of materials involved and the variety of required shapes in soft-material systems a standard fabrication platform with the appropriate tools and processes is not yet available.

This talk will provide an overview of recent achievements in advanced micro and nano-manufacturing and associated key techniques than can be applied also to fragile materials, where harsh process steps using charged beams and etch chemistry may be harmful. I will in particular present nanostenciling, capillary assembly and local thermal processing. Together they form part of the gentle toolbox for future micro/nano-manufacturing applicable for the engineering of soft, flexible, wearable and implantable microdevices.

High-resolution stenciling [1] keeps allowing us to investigate highly localized material deposition without the need for harsh lithography steps such as high-energy beam exposure and etching or development. Examples include metallic nanostructures (< 50 nm) on rigid and flexible polyimide, parylene, SU-8 and PDMS substrates for biosensors. More recently the reduced flux through stencils in PVD allows controlling surface crystallization of molecules for improved organic electronics. Capillary assisted assembly is a particularly mild (water based) method to position large cargos of prefabricated nanoscale building blocks from a colloidal solution into a deterministic surface layout, with high yield and nm-control on individual position, orientation and inter-particle gap [2]. Another example is local thermal processing of functional material with

sub-micrometer resolution which is a emerging technique that uses a scanned heated nanoprobe [3] to write thermal patterns into resists, supramolecular polymers, silk 2D materials [4] among others. The talk will show advantages and limits of each technique and provide some guidance how they could be combined in mix-and-match approaches with conventional methods to become part of the future manufacturing platform for soft material MEMS and NEMS, such as polymer power-MEMS [5] and biodegradable drug release microcapsules [6].

References:

[1] O. Vazquez-Mena, et al. Resistless nanofabrication by stencil lithography: A review, Microelectronic Engineering, 132 (2015) 236-254.

[2] V. Flauraud, et al. Nanoscale Topographical Control of Capillary Assembly of Nanoparticles, Nature Nanotechnology (2017)

[3] ST Howell et al., Thermal scanning probe lithography—a review, Microsystems & Nanoengineering 6 (1), 1-24

[4] X. Liu et al. Thermo-mechanical nanocutting of two-dimensional materials, Advanced Materials (accepted for publication) (2020)

[5] XS Zhang et al., All-in-one self-powered flexible microsystems based on triboelectric nanogenerators, Nano Energy 47, 410-426

[6] M Rüegg, et al., Biodegradable Frequency‐Selective Magnesium Radio‐Frequency Microresonators for Transient Biomedical Implants, Advanced Functional Materials 29 (39), 1903051

BIOGRAPHY

Juergen Brugger is Professor of Microengineering and co-affiliated to Materials Science. Before joining EPFL he was at the MESA Research Institute of Nanotechnology at the University of Twente in the Netherlands, at the IBM Zurich Research Laboratory, and at the Hitachi Central Research Laboratory, in Tokyo, Japan. He received his Master in Physical-Electronics and his PhD degree from Neuchatel University, Switzerland. Research in Juergen Brugger's laboratory focuses on various aspects of MEMS and Nanotechnology. The group has made several important contributions to the field, at the fundamental level as well as in technological development, as demonstrated by the start-ups that spun off from the lab. In his research, key competences are in micro/nanofabrication, additive micro-manufacturing, new materials for MEMS, increasingly for biomedical applications. He published over 200 peer-refereed papers and supervised 20 PhD students. Former students and

postdocs have been successful in receiving awards and starting their own scientific careers (6 professors so far). Juergen Brugger has been appointed in 2016 Fellow of the IEEE “For contributions to micro and nano manufacturing technology”. In 2017 he was awarded an ERC AdvG in the field of advanced micro-manufacturing.