Printed sensor arrays and devices for cellular bioelectronics

Nouran Adly[1], Bernd Bachmann[1,2], Jan Schnitker[1], Alexey Yakushenko[1] Korkut Terkan[1], Philipp Rinklin[2], Andreas Offenhäusser[1], and Bernhard Wolfrum[1,2]

1 Institute of Bioelectronics (PGI-8/ICS-8), Forschungszentrum Jülich, 52425 Jülich, Germany

2 Neuroelectronics, Munich School of Bioengineering, Department of Electrical and Computer Engineering, Technical University of Munich (TUM), Boltzmannstr. 11, 85748 Garching, Germany

Email: bernhard.wolfrum@tum.de

Inkjet printing is an attractive method for cost-effective rapid prototyping of electronic devices. In particular, disposable sensor systems may benefit from this additive fabrication technology as it enables the production of low-cost and flexible devices using a variety of different materials and layouts.
Here, we report the fabrication of disposable gold and carbon microelectrode arrays on diverse hard and soft polymeric substrates that rely solely on inkjet-printing technology. We demonstrate the use of printed devices for cellular bioelectronics by extracellular recording of action potentials from cardiomyocyte-like cells. Propagation of action potentials across a confluent cell layer can be readily observed and responses of the cell network to drug application evaluated.
Furthermore, we demonstrate how typical limitations concerning the resolution of inkjet printing can be circumvented by careful tailoring printing conditions to ensure complete solvent evaporation during the printing process or introducing multilayer printing technology [1,2]. In the former approach, the lateral distance between printed elements can be controlled down to the micrometer regime without prior substrate patterning or surface modification. Thus, electrochemical redox cycling devices with micrometer gaps are readily fabricated. We show that these printed devices can be used as low-cost biosensors for the detection of ssDNA.

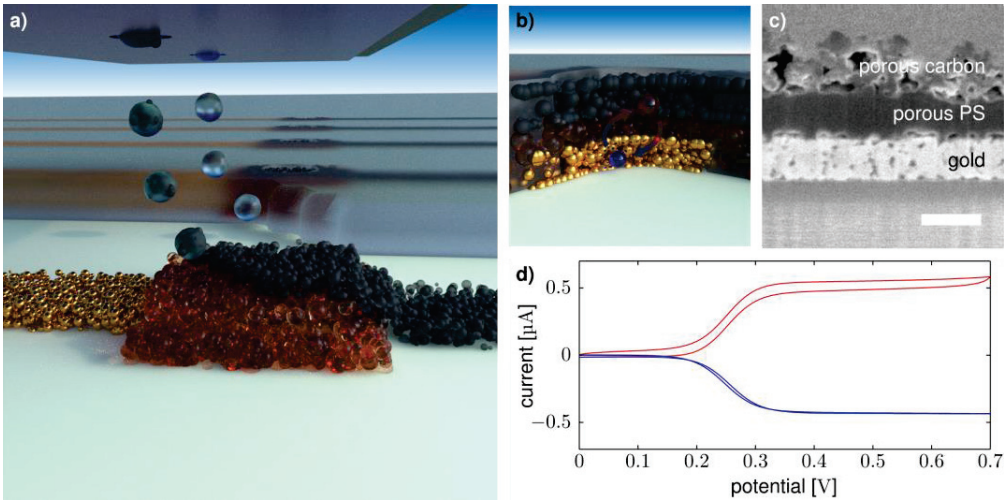

Figure 1: Ink-jet printing of multilayer devices for electrochemical detection [1]

[1] Wolfrum B, Kätelhön E, Yakushenko A, Krause K J, Adly N, Hüske M and Rinklin P 2016 Nanoscale Electrochemical Sensor Arrays: Redox Cycling Amplification in Dual-Electrode Systems *Acc. Chem. Res.* **49** 2031–40

[2] Adly N Y, Bachmann B, Krause K J, Offenhäusser A, Wolfrum B and Yakushenko A 2017 Three-dimensional inkjet-printed redox cycling sensor *RSC Adv* **7** 5473–9