Bioelectronic devices for the interfacing with DNA, proteins, and neurons

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The recording of (bio)-chemical signals from biological systems is a rich source to disclose information about the status of living matter, educts and products of biochemical processes, as well as the composition of the environment. We develop new concepts of electronic and electrochemical sensors for the detection of minute amounts of analyte molecules not only with high sensitivity and selectivity but also with high resolution in time and space. The ambipolar properties of an electrolyte-gated graphene field-effect transistor (GFET) can be used to fabricate frequency-doubling biochemical sensor devices [1]. The extraordinary high carrier mobility of graphene and the strong electrolyte gate coupling provide the graphene ambipolar frequency doubler an unprecedented unity gain, as well as a detection limit of ~4 pM for 11-mer single strand DNA molecules in 1 mM PBS buffer solution. Alternatively, Silicon-Nanowire Transistors can be used as an intraoperative biosensing platform with which we can quantitatively detect as little as one disseminated tumor cell (DTC) per lymph node within an hour [2]. We demonstrated that the biosensing platform is able to detect the presence of circulating tumor cells (CTCs) in the blood of colorectal cancer patients.

On the other side silicon-based microstructures are gaining importance in fundamental neuroscience and biomedical research. Precise and long-lasting neuro-electronic hybrid systems are at the center of research and development in this field. Nowadays, the best approach to study the electrophysiological activity of neurons in vitro and in vivo is based on planar microelectrode arrays (MEA) or field-effect transistors (FET) which can be integrated with microfluidic devices. However, the weak coupling between cell membrane

and electrode surface is one of the major limiting factors [3] and technology of 3D nanostructures for cell-chip coupling is currently a vivid field of investigation. Our present study focuses on the investigation of cell-chip interfaces with optimized 3D nanoelectrodes for extracellular recordings. We have shown in a previous study that one can effectively guide cells with mushroom-shaped 3D-nanoelectrode and simultaneously record electrical activity from electronic cells [4]. Additionally, we have investigated the cell adhesion on two kinds of nanoelectrodes: cylinders and mushroom-shaped structures. To this end, we have performed focused ion beam cross-section cuts through the cell chip interface and subsequent imaging with scanning electron microscopy [5] to determine the exact outline of the membrane deformation caused by the underlying nanoelectrode.

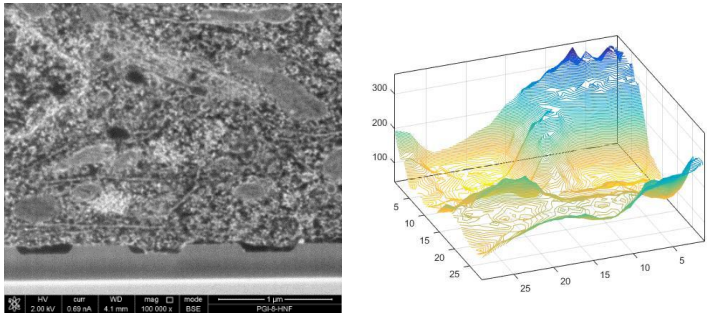

Figure 1: Investigation of the neuro-electronic interface by scanning electron microscopy (SEM) (left) and surface plasmon microscope (SPM) (right).

REFERENCES:

1. W. Fu, et al. *Nano Lett*. **16**, 2295 (2016)
2. D. P. Tran, et al. *ACS Nano* **10**, 2357 (2016)
3. K. Toma, et al. *ACS Nano* **8**, 12612 (2014)
4. F. Santoro, et al. *Nano Lett*.13: 5379 (2013).
5. F. Santoro, et al. *ACS Nano* **8**, 6713 (2014).