Short bio

Prof. Dr Sven Ingebrandt studied physics at the Johannes Gutenberg University Mainz (JOGU) (1991-1998). From 1998 to 2001 he worked as a PhD student in the Max-Planck Institute of Polymer Research, Mainz. He received his PhD in Physical Chemistry in 2001 (JOGU). Afterwards he was working as a postdoctoral researcher at RIKEN Institute, Wako, Tokyo, Japan (2001-2002). Then he moved as a group leader to the Research Center Jülich, Germany (2002-2008). In 2008 he was appointed as a Professor of Biomedical Instrumentation to the University of Applied Sciences Kaiserslautern, Germany. In 2018 he joined RWTH Aachen University on a chair professorship of Micro- and Nanosystems in conjunction with the institute directorship of the Institute for Material in Electrical Engineering 1. Main research activities are micro- and nanosystems for biomedical and environmental sensing. He published >100 journal papers, several book chapters and 4 patents.

Abstract

Top-down fabricated silicon nanowire arrays with multi-parametric transducer capability for biomedical sensing

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In the field of biomedical sensing silicon field-effect transistors with dimensions from micro- to nanoscale are widely used as transducers. Since the first introduction of ion-sensitive field-effect transistors (ISFETs) [1], they are utilized for various applications. Very often enzymatic reactions are used to specifically capture the molecules of interest and to generate secondary responses like for instance surface-near pH changes [2]. In general, the pH-sensitivity is the primary response of ISFETs, since the typically-used gate oxides are sensitive to protonation and de-protonation in an electrolyte solution. The commonly used transducer principle is potentiometry, where changes in surface potential at the liquid-solid interface are sensed and related to changes in source-drain currents of the devices. In affinity-based binding assays this method is preferentially used as well to detect small, charged biomolecules. However, in this case it is advised to work in low concentrated buffer solutions in order to sense within the Debye screening length of only a few nm defined by the ionic strength of the solution.

In the last decade various kinds of nanowire sensors were introduced – most of the time silicon nanowires (SiNWs). In many works, conductance changes of the wires upon biomolecule binding are displayed. This is very similar to the above-described method for ISFET devices reading changes in drain-source current, which is corresponding to a conductance change. A rarely-used readout principle for ISFETs is the recording of impedance spectra, which is very similar to the electrochemical impedance spectroscopy with metal electrodes. This method is very sensitive to conductance changes of the electrolyte solution as its primary response. In addition, it is well known that such devices are light sensitivite. This is most pronounced, when p-n junctions or charge carrier-depleted parts of the chips are exposed to light.

In recent years, we developed in several thesis works a platform technology to realize robust, top-down fabricated silicon nanowire ion-sensitive field-effect transistor (SiNW ISFET) arrays in various formats [3-10]. We aim in this project towards robust biomedical assays, where in many cases also influences of side-parameters such as pH, temperature, ionic strength etc. might have an influence to the recorded signals. Towards more robust readout of such platforms, we use two approaches. Firstly, we embed the sensors into microfluidic cartridges to avoid evaporation of liquid and to speed up the assay time. Secondly, we apply multiple transducer principles such as potentiometric, impedimetric and optical readout of the sensors, while using combinatorial signal processing of the different signals to relate them to the target analyte concentrations.

In this presentation, an overview of the technological SiNW ISFET platform will be presented and the applied readout and data analysis principles will be discussed on proof-of-concept biosensor assays.

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