Biophysical Electroanalysis of Human Caco-2 Tissue utilizing Microstructured Biosensors

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The interface between biological tissue and microelectrodes is a challenging field for charge transfer phenomena involving whole living cells. This paper addresses the material interface of different substrates as well as the bioelectrical analysis with microstructured electrodes. Caco-2 cells were used as biological species. Caco-2 cells are human epithelial cells that are an acknowledged pharmaceutical model for the human intestine. The electrochemical analysis of this biological sample has an application potential for drug testing and pharmacological studies. The crucial point of cell-based biosensor concepts is the unsatisfactory understanding of charge transfer phenomena at the electrochemical interface between metal electrodes and the epithelial cells respectively the electrolyte of the culture medium. Biological aspects of various inorganic substrate materials common in semiconductor technology are discussed. Tests have revealed several materials such as silicon, silicon nitride and silicon oxide as well as gold, platinum, aluminium and titanium to be biocompatible. The influence of the surface topography on cell growth was investigated with microstructured trenches and influence factors have been identified.

For bioelectrochemical studies engineered microelectrode arrays have been fabricated by optical lithography and sputter coating with gold. These microelectrode arrays were used as interface for fundamental studies on charge transmission at the cell-covered electrodes. Cyclovoltaggram measurements (Fig. 3) as well as bioimpedance spectroscopy were performed. Impedance modulus and the phase angle of Caco-2 in the frequency range from 100 Hz to 5 MHz were recorded and studied. The effect of various measurement parameters such as electrode potential and frequency of the measurement signal are discussed. The results of this multidisciplinary approach contribute a fundamental understanding of charge-related processes at the cell-electrode to the state-of-the-art.

Finally, the next steps toward a rapid practical implementation of bioimpedance spectroscopy are discussed. The application as automatized biosensors for bioelectrochemical monitoring of cell-growth will be presented. An outlook as microelectronic bio-device for drug screening will be given.

References