Characterization of Geometric Parameters on Organic Electrochemical Transistor (OECT) for Cell-based Biosensor

by

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Abstract

Organic Electrochemical Transistors (OECT), in particular, have raised plenty of interests in the field of Organic Bioelectronics because of its multiple advantages, including biocompatibility, superior amplifying characteristics and ease of fabrication. More importantly, they exhibit both electronic and ionic conductivity, which favours their measurement of tissue-related electrical information that are mostly based on the ionic currents caused by the migration of ions.

Owing to these advantages, OECTs have been extensively applied for cell-based studies, including cell-impedance sensing. Previous studies have shown that OECTs have the ability to measure Transepithelial Electrical Resistance (TEER) and cellular capacitance values that are comparable to that measured by gold-standard equipment such as Electrical Impedance Spectroscopy (EIS). Nevertheless, there still exist a corner that remains unexplored, which hinders its real applications – the influences of the geometrical variations on the device physics and working mechanisms of cell-based OECT measurement.

In the first part of this thesis, several parameters were controlled and varied to see their effects on the gain-bandwidth performance of OECT, and those parameters include scale, thickness, width-length ratio and gate electrode material. It was found that the geometrical parameters have a profound effect on the varying the transconductance and response time of OECTs, based on the variations of volumetric capacitance. On the other hand, it was found that changing gate electrode from polarizable to non-polarizable material also elevates the effective gate voltage that act on the polymeric channel, resulting in a larger current modulation.

On top of the insights obtained from the first part of results, the second half of the thesis has validated the effects of geometric variations on the sensitivity of OECT-based impedance measurement. The same batch of devices were deposited with a gastrointestinal epithelial cancer cell line called Caco-2 cells, whereas their responses were characterized by transient and spectrum measurement. Results reveal that there appears to be a range of channel areas and input frequencies over which the device is the most sensitive to the presence of membrane. It is strongly believed that this thesis would provide a guideline for the design of topologies and materials that will lead to state-of-art transistor performance for cell-based studies.

Date: 25 Jul 2018 (Wednesday)
Time: 3:00 pm
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Examination Committee:
Prof. Hongkai Wu (Chair)
Prof. I-Ming Hsing (Supervisor)
Prof. Richard Lakerveld

All are welcome!