An Endothelial Cell Compatible Biosensor Fabricated using Optically Thin Indium Tin Oxide Silicon Nitride Electrodes

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Abstract

This study describes the fabrication and performance of an endothelial cell compatible, optically thin, indium tin oxide (ITO) microimpedance biosensor. The biosensor was constructed by sputtering a thin insulating layer of silicon nitride (Si$_3$N$_4$) onto a 100 nm thick ITO layer. Indium tin oxide electrodes were formed by chemically etching 250 or 500 μm diameter holes through the Si$_3$N$_4$ insulating layer. The exposed ITO electrode was electrically connected to an ITO counter electrode, approximately 2 cm$^2$ in area, via a 400 μL well containing cell culture media. A lock-in amplifier circuit monitored the impedance of porcine pulmonary artery endothelial cells (PPAECs) cultivated on the electrodes as a function of frequency, between 10 and 100 kHz, and as a function of time, at 5.62 kHz. The ITO–Si$_3$N$_4$ microelectrodes provided consistent and repeatable impedance measurements to the attachment and spreading of PPAECs. In addition, the ITO–Si$_3$N$_4$ electrodes were recyclable, robust, resistant to ethanol sterilization, and had a high optical transmittance. Most importantly, the ITO–Si$_3$N$_4$ electrodes allowed optical access for dynamic cellular attachment imaging. The 5.62 kHz time dependent cellular impedance response to the drug Cytochalasin D further demonstrated the feasibility of using this electrode configuration for dynamic cellular impedance studies.