Opto-Electric Cellular Biosensor Using Optically Transparent Indium Tin Oxide (ITO) Electrodes

Chang K. Choi 1, Chuck H. Margraves 1, Seung I. Jun 2, Anthony E. English 1, Philip D. Rack 2 and Kenneth D. Kihm 1,*

1 The University of Tennessee, Dept. of Mechanical, Aerospace, and Biomedical Engineering, Knoxville, TN 37996 USA; Chang K. Choi, Presently at Oak Ridge National Laboratory, Bioscience Division, Oak Ridge, TN 37831 USA
2 The University of Tennessee, Dept. of Material Science and Engineering, Knoxville, TN 37996 USA; Seung I. Jun, Presently at dpiX, LLC, Process Engineering Group, Colorado Springs, CO 80916 USA

* Author to whom correspondence should be addressed; E-mail: kkihm@utk.edu

Received: 29 January 2008 / Accepted: 16 May 2008 / Published: 19 May 2008

Abstract: Indium tin oxide (ITO) biosensors are used to perform simultaneous optical and electrical measurements in order to examine the dynamic cellular attachment, spreading, and proliferation of endothelial cells (ECs) as well as cytotoxic effects when exposed to cytochalasin D. A detailed description of the fabrication of these sensors is provided and their superior optical characteristics are qualitatively shown using four different microscopic images. Differential interference contrast microscopy (DICM) images were acquired simultaneously with micro-impedance measurements as a function of frequency and time. A digital image processing algorithm quantified the cell-covered electrode area as a function of time. In addition, cytotoxicity effects, produced by the toxic agent cytochalasin D, were examined using micro-impedance measurements, confocal microscopy images of stained actin-filaments, and interference reflection contrast microscopy (IRCM) capable of examining the bottom morphology of a cell. The results of this study show (1) the dynamic optical and electrical cellular characteristics using optically thin ITO biosensors; (2) qualitative agreement between cell-covered electrode area and electrical impedance during cellular attachment; (3) in vitro cytotoxicity detection of ECs due to 3 μM cytochalasin D. The present opto-electric biosensor system is unique in that a simultaneous and integrated cellular analysis is possible for a variety of living cells.