Visualization of Non-Invasive Electrical Impedance Spectroscopy on the Volar Forearm

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Abstract

Mathematical modeling and simulation of electrical fields through the human skin provide important insights into its electrophysiological state. As the human skin is a complex multi-layer entity of different compositions, we have chosen to select representative material properties to build our skin model. We model the volar forearm skin as a 3-layer entity - comprising of stratum corneum, viable skin consisting of both living epidermis and dermis, and adipose tissue.

Through this non-invasive electrical impedance spectroscopy (EIS) model set up in COMSOL, we aim to spatially resolve the current in the different layers between the electrodes. In comparison, the commonly employed electrically equivalent circuits do not provide mechanistic understanding of impedance (potential field and currents) at the spatial dimension.

A two-dimensional axisymmetric model of a concentric 4-electrode EIS probe was implemented and the numerical simulations were carried out for frequencies from 1 kHz to 1 MHz in COMSOL. In this study, we aim to answer these fundamental questions: Where do currents flow? What does the current detection electrode measure?

We show that the current flow varies through different settings at the secondary inject. This allows us to control where the depth of the current flow. By visualizing where the currents have passed through as measured at the sense, we can determine what we have measured.

Figures used in the abstract

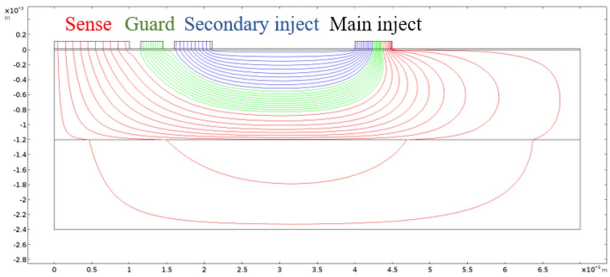

Figure 1: Current density of a 4-electrode EIS probe with secondary inject set at 10% of the potential of the primary inject. The streamlines of the current passing through the sense, guard and secondary inject are shown in red, green and blue respectively.