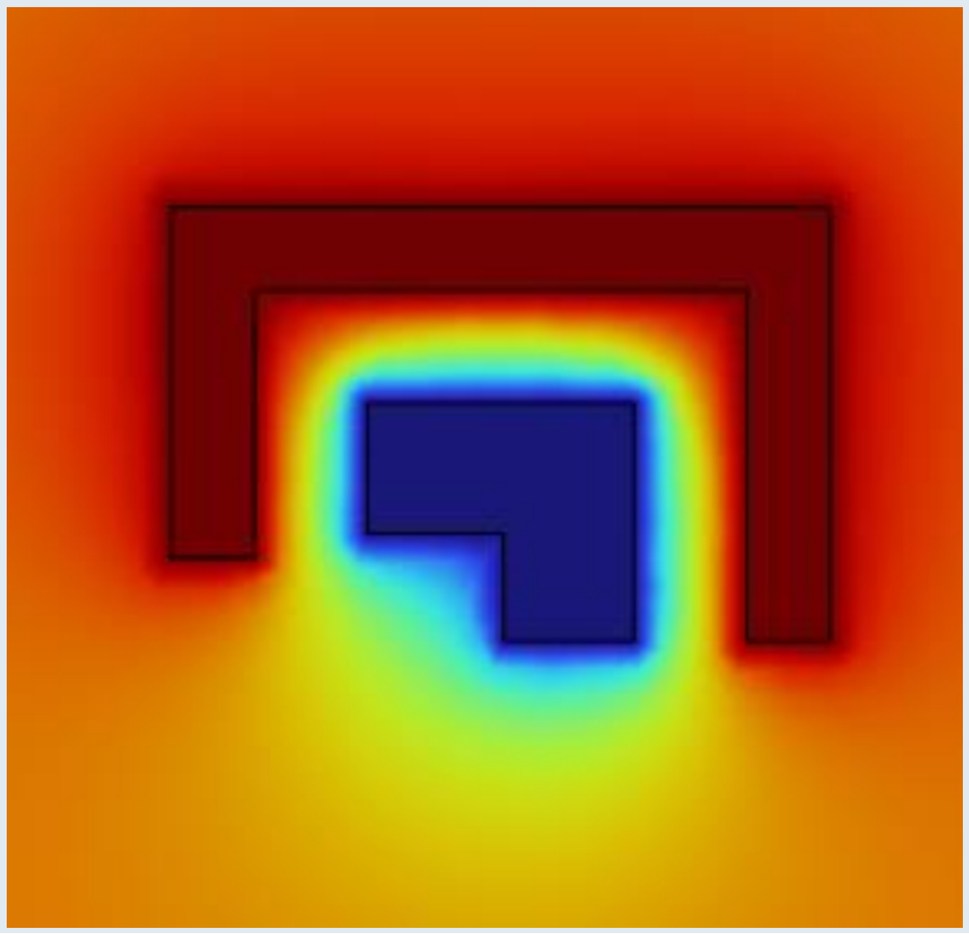

Geometry Optimization of Enzymatic Electrochemical Glucose Sensor

Electrode geometry plays an important role in enhancing the signal of electrochemical sensors. In this work, three different electrode geometries are compared for a case of enzymatic glucose sensor.

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Abstract

It is essential to develop devices with higher sensitivity to achieve better sensing resolution. Geometrical arrangement of the electrodes, directly affects the electric field distribution and, thus, the signal. In this study, COMSOL was used to optimise the electrode geometry of an electrochemical glucose sensor, and then validated it by performing experiments on the optimised electrodes. Two aspects of electrode geometry are investigated: the spacing between the working and counter electrodes and the various electrode shapes. finger type, interdigitated, and circular/arc electrode geometries chosen for this study.

Figure 1:

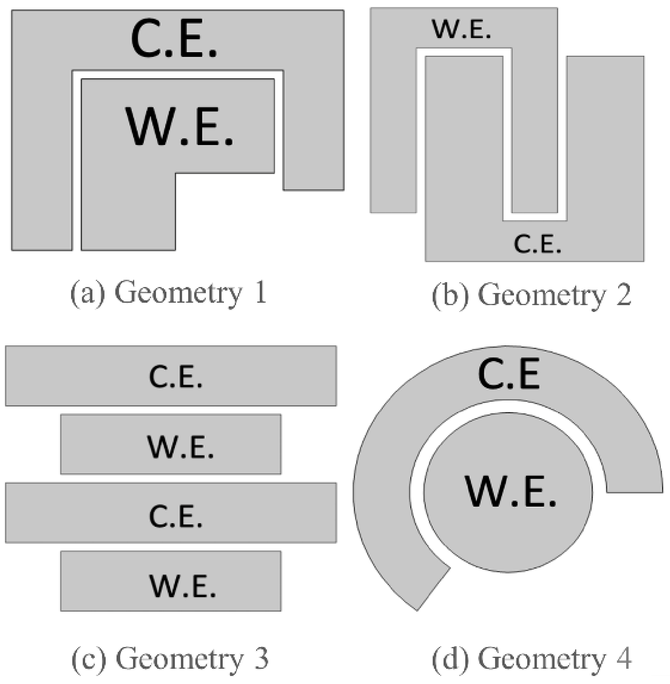
Different electrode geometries

(a) finger type,

(b) Interdigitated

(c) simplified version of (b)

(d) circular/ arc type.



Methodology

Reactions

$$Glucose + GOx_{(ox)} \rightarrow Gluconic\ Acid + GOx_{(red)} \quad (1)$$

$$GOx_{(red)} + 2Fe(III) \rightarrow GOx_{(ox)} + 2Fe(II) + 2H^{+} \quad (2)$$

$$Glucose + 2Fe(III) \rightarrow Gluconic\ Acid + 2Fe(II) + 2H^{+} \quad (3)$$

$$2Fe(II) \rightarrow 2Fe(III) + 2e^{-} \quad (4)$$

Governing Equations

Michaelis-Menten model: $V = \frac{V_{max}[Glucose]}{(K_m + [Glucose])}$

(Fick's I and II laws) $J(x) = -D\frac{\partial C(x)}{\partial x}$ $\quad \frac{\delta C}{\delta t} = -D\frac{\partial^2 C(x)}{\partial x^2}$

Results

The electrochemical response (average current density) decreased with increasing electrode spacing, an optimised spacing of 0.15mm was chosen while keeping the limitations of the printing processes.

The geometries with the greatest overlap of perimeter between working and counter electrodes had the best electrochemical response.

Hence, geometry 2 with the greatest perimetric proximity provided the best sensor response.

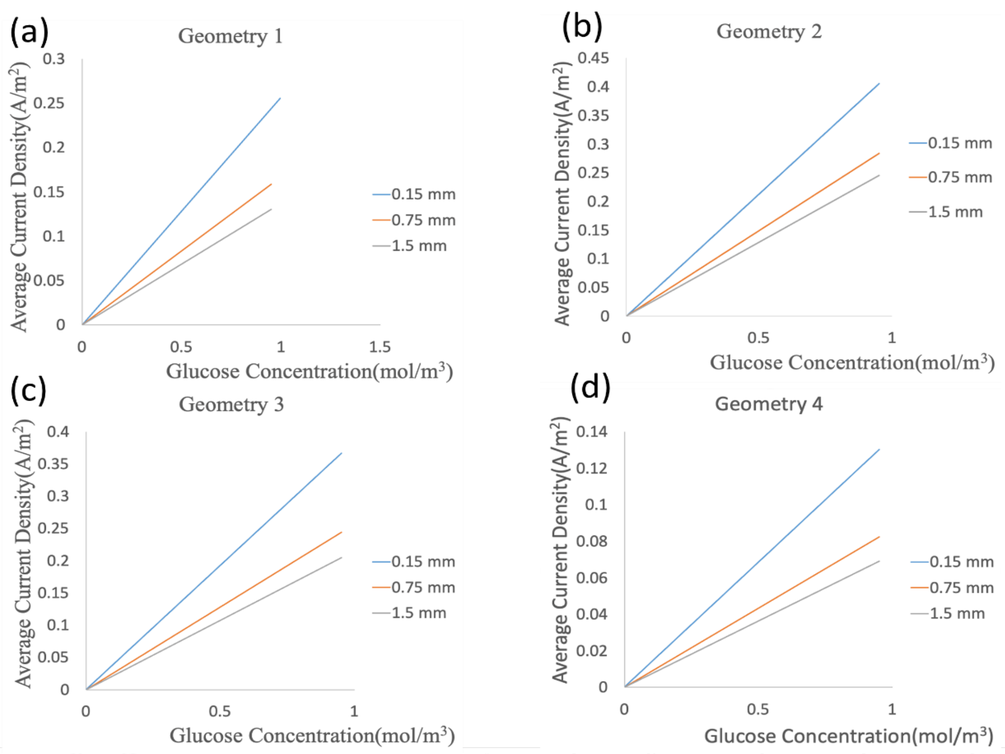


Figure 2: Current vs concentration plots for various electrode spacing for (a) finger type, (b) Interdigitated (c) simplified version of (b) and (d)circular/ arc type electrode.

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