CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Suryaprakash Vengadesan

Project Number

S0324

Project Title

Carbon-MEMS Suspended Nanogap: Current Amplifying Working Electrode for Biosensor

Abstract

Objectives/Goals

Point-of-Care diagnostics demand for a versatile, inexpensive, sensitive, and simple-to-use electrochemical sensor. Currently, many products on the market use expensive optical detection techniques that require bulky, complicated instruments, when compared to electrochemical detection. Thus, I fabricated a novel working electrode utilizing the electrochemical redox coupling phenomenon which enhances and amplifies the generated current for selective detection of biomarkers.

Methods/Materials

Utilizing scalable microfabrication techniques including Electromechanical Spinning, pyrolysis of UV-cured microstructures and a Joules heating process, I was able to produce inexpensive and scalable working electrodes. I proceeded to run COMSOL Multiphysics simulations to analyze the effects of various geometries on the performance of the electrode, simulating and running Cyclic Voltammetry experiments for the detection of ferricyanide. With proper sample preparation and integration into a Lab on Chip device, the electrochemical sensor can be used for early stage cancer detection, bacteria detection, antibiotic susceptibility testing (AST) and other diagnostic applictions.

Results

Merging inexpensive manufacturing techniques, I was able to control the length and position of glassy carbon nanofiber. By inducing high biases through the CNFs, gradual fiber thinning and eventual breakdown resulted in a working electrode with sub 100nm gaps to manipulate nanoscale objects. The Cyclic Voltammetry simulations and experiments quantify the electrode#s high sensitivity and ability to detect ultra-low concentrations of analytes.

Conclusions/Discussion

The electrochemical properties of the nanogap, which were computed through mass transport simulations, illustrate the effect of nanogap size and CNF#s diameter # both increasing current density. Furthermore, calculated surface concentrations confirmed the low limit of detection, ideal for commercial use.

Summary Statement

I fabricated nanometric electrodes from carbon nanofibers and performed electrochemical simulations & experiments to quantify their high selectivity and ability to amplify signal current while maintaining an inexpensive price.

Help Received

Professor Marc Madou, Ehsan Shamloo, and Dian Song supervised the progressions of this project and provided useful discussions.