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Computational Design of GLAD-based Non-enzymatic Glucose Sensors

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ABSTRACT

Measurement of glucose concentration in sweat would allow diabetic patients to monitor blood sugar levels without frequent invasive blood draws. However, the relatively low concentrations of glucose in sweat compared to blood have prevented the adoption of sweat-based monitoring. Recently, glancing angle deposition (GLAD) has been used to fabricate nanostructured nickel-oxide electrodes that can measure glucose concentrations through electrochemical coupling with the conversion of glucose to gluconolactone. GLAD is a single-step physical vapour deposition method that merges oblique angle deposition with precise substrate rotation to engineer nanostructures with a high degree of control over morphological properties such as porosity, film thickness and density, which helps to improve the sensitivity of sensors. Recently, the GLAD technique and its applications have improved significantly. However, theoretical studies still lag behind empirical ones. Moreover, with access to modern numerical methods, we can study the effects of different geometrical parameters with much less effort compared to experiment. More importantly, with the aid of computational modelling, we can optimize these parameters for designing the sensors. Here we develop computational models to examine how geometry affects the sensitivity and response time of GLAD-based electrochemical sensors. We have developed a reaction-diffusion model of the surface-catalyzed reactions in the GLAD nanostructure, which we solve with the finite element method. At the first stage of this project, a simple 2D model of the sensor has been modelled. Afterwards, a parametric study on the geometry of the model, specifically the depth and width of the structure has been carried out. This research will contribute to designing more efficient biosensors that have higher accuracy and offer superior detection limits, high reproducibility, and high sensitivity.