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Glucose sensor based on nano-baskets of tin oxide templated in porous alumina by plasma enhanced CVD

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ABSTRACT

A feasibility study of glucose oxidase (GOx) immobilized tin oxide thin films, consisting of nano-baskets, for glucose sensing is presented. The nano-baskets of SnO_2 were grown on in-house fabricated anodized aluminum oxide pores of ~80-nm diameter using plasma enhanced chemical vapor deposition (PECVD) at an RF power of 60 W. Hydrated stannic chloride was used as a precursor and O_2 (20 sccm) as a reactant gas. The deposition was carried out from 350 to 450 °C at a pressure of 0.2 Torr for 15 min each. Deposition at 450 °C resulted in crystalline film with basket-like (nano-sized) structure. GOx was immobilized by physical adsorption (soaking films in GOx solution containing 1000 units for 3 h). Increase in film conductivity was noticed after GOx immobilization. The immobilized films were found sensitive to glucose ($C_2H_{12}O_6$, dextrose) concentration from 10 to 360 mg/dl. Sensitivity increases linearly with glucose concentration. Nano-baskets resulted in higher sensitivity in comparison with other structures. From the elemental analyses of the films after GOx immobilization, GOx was found covalently attached with tin oxide, as evident by N 1s peak in the photoelectron spectra. A possible sensing mechanism is presented and discussed.

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1. Introduction

The human senses are the best examples of specialized neural sensors. Clark and Lyons (1962) were the first to report the amperometric biosensor for continuous monitoring of glucose in cardiovascular surgery, since then a number of techniques and methodologies focusing on improvements of signal transduction and immobilizations of the biological recognition element, glucose oxidase (GOx), have been extensively established. The most widespread example of a commercial biosensor is the blood glucose biosensor, which uses an enzyme to breakdown the blood glucose/sugar into its metabolites. In this process, it transfers an electron to the electrode and this is used as a measure of blood glucose concentration. Most of the glucose biosensors are based on the glucose oxidation catalyzed by glucose oxidase. The amperometric response of either the produced H_2O_2 or consumed O_2 can be monitored for glucose sensing. The first generation of electrochemical biosensors was based on the oxidation or reduction of enzymatically produced H_2O_2, or depletion of oxygen monitored at an oxygen-sensitive electrode (Arica et al., 1998; Clark and Lyons, 1962; Lin and Brown, 1997; Gill et al., 1999; Lee et al., 2005; Liao et al., 2007; Ma et al., 2004; Patel et al., 2003; Rajesh et al., 2005).

Large market demand of such sensors has generated interest in researchers and technologists to explore this multidisciplinary and growing field. In last few decades, the development of enzyme-based biosensors has been a topic of considerable interest due to their potential applications, since the spectroscopic methods are laborious and often not useful in online monitoring system. The inconvenience was overcome by the use of electrochemical methods for bio-sensing. The electrochemical biosensors play a leading role in this direction, since the enzyme-immobilized surfaces help in rapid and direct electron transfer. Distinct advantages of enzyme over conventional chemical catalysts are specificity and selectivity, not only for a particular reaction but also in their discrimination between similar parts of molecular or optical isomers. These enzymes catalyze only the reaction of very narrow range of reactants. The stable immobilization of enzyme on the electrode/host material surface with better retention in addition to the cost would be a crucial problem for the development.

An important part of biosensors construction is to immobilize biomolecules on the transducer without changing their structural conformation and activity. There are various methods to immobilize biological elements such as self-assembled monolayers

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