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Sensing Characteristics of Nanostructured SnO_2 Thin Films as Glucose Sensor

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Abstract

Thermal evaporated Sn thin film was deposited followed by atmospheric oxidation annealing at 550ºC for 1 h to fabricate nanostructured SnO_2thin film sensor. The nanostructures were characterized through X-ray diffraction, scanning electron microscopy (SEM) and electrochemical amperometric glucose ($C_6H_{12}O_6$) sensing. The obtained film was strongly c-axis oriented along (100) direction and has other low intensity towards the directions 101, 200 and 211, indicating polycrystalline characteristics. The film exhibited high dense porous nature has been indicated in the SEM images. Furthermore, the glucose sensing properties of the as-prepared SnO_2 thin film were investigated for various glucose concentrations (50, 100, 150 and 200) mg/L. The nanostructured SnO_2 thin film exhibited a higher response, fast rise time 8s and suitable recovery time 53s upon working at room temperature. Linear relative response with the glucose concentrations for SnO_2 thin film biomedical sensor was obtained.

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Keywords: *Thermal evaporation, SnO_2thin films, Glucose sensing, Amperometric biosensors.*

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1. Introduction

Wide band gap metal oxide semiconductors as SnO_2, CdO, ZnO, TiO_2, ..etc. have been investigated during recently ten years ago [1- 8] . Among these materials, SnO_2 has more attractive for biomedical sensing based on the different types of nanostructured thin film synthetization as; nanoparticles [5], nanorods [6], nanowires [7], nanosheets [8], and others. Nanostructured SnO_2 thin film has been used in many applications as, transparent conducting electrodes [9], Li batteries [10], optoelectronic devices [11,12,13], photovoltaic energy converter [14], toxic gas sensors [15], heat reflecting mirrors [16], aqueous salts solution [17] SnO_2 thin film has been prepared by various techniques such as thermal evaporation [18-20], chemical vapor deposition (CVD) [21,22], chemical bath deposition (CBD) [23,25], pulse laser deposition (PLD) [26-28], sputtering [29,30], spray pyrolysis [31,32], sol gel coating [33-35], etc. Among them thermal evaporation is very attractive technique for the growth of SnO_2 due to its simplicity and more homogeneity Several different metal-oxide systems have been utilized as gas sensing materials, such as tin oxide (SnO_2)[36] , tungsten trioxide (WO_3)[37], titanium oxide (TiO_2)[38] and zinc oxide (ZnO)[39], thin films and nanomaterials are suitable for gas sensors because the sensing properties are related to the material surface where the gases are adsorbed and surface reactions occur. Surface reactions change the concentration of charge carriers in the material, creating a depletion layer and surface dipole at the interface, which results in a change in electrical resistance [40].

Here, in presence investigations, we focused on the prepared nanostructured SnO_2 thin film via PVD technique through optimum conditions and examined these prepared films to the glucose solution at different concentrations bases on the electrochemical reaction.

2. Experimental

2.1 Preparation and sensitization

The SnO_2 thin films prepared by deposited Sn on the Cr-glass substrates followed by atmospheric oxidation at 500 ^oC for 1 h. Prior to deposition the substrates were cleaned by the following sequence; detergent and rinse under tap water; acetone, ethanol, distilled water; ultrasonic bath of acetone and ethanol for 15 min followed by the further cleaning steps in distilled water; finally the substrates dried in the flow of hot air for 1 min, then the substrates were ready for deposition. Prior to the fabrication of SnO_2 nanostructured films, chromium metal (Cr) was deposited by the electron beam (e-beam) method on the glass substrate as a buffer layer to improve the film adhesion. In the next step the Sn film was deposited on the Cr-glass substrates through thermal evaporation. A molybdenum boat was used as the evaporation heating source, and the precursor was tin granulate with a purity of 99.999%. The deposition parameters are listed in table (1):

Table 1: The Deposition Parameters

Deposition parameters	Data
Boat to substrate distance	12 cm
Weight of tin in boat	0.5 g
Pressure through deposition	1 x 10^{-6} mbar
Deposition rate	0.5 Å/s