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Correlation between Defect Suppression and Biosensing Capability of Hydrothermally Grown ZnO Nanorods

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Abstract : Biosensors are analytical devices with wide range of applications in biological, chemical, environmental and clinical analysis. It comprises of bio-recognition layer which has biomolecules (enzymes, antibodies, DNA, etc.) immobilized over it for detection of analyte and transducer which converts the biological signal into the electrical signal. The performance of biosensor primarily the depends on the bio-recognition layer and therefore it has to be chosen wisely. In this regard, nanostructures of metal oxides such as ZnO, SnO2, V2O5, and TiO2, etc. have been explored extensively as bio-recognition layer. Recently, ZnO has the attracted attention of researchers due to its unique properties like high iso-electric point, biocompatibility, stability, high electron mobility and high electron binding energy, etc. Although there have been many reports on usage of ZnO as bio-recognition layer but to the authors' knowledge, none has ever observed correlation between optical properties like defect suppression and biosensing capability of the sensor. Here, ZnO nanorods (ZNR) have been synthesized by a low cost, simple and low-temperature hydrothermal growth process, over Platinum (Pt) coated glass substrate. The ZNR have been synthesized in two steps viz. initially a seed layer was coated over substrate (Pt coated glass) followed by immersion of it into nutrient solution of Zinc nitrate and Hexamethylenetetramine (HMTA) with in situ addition of KMnO4. The addition of KMnO4 was observed to have a profound effect over the growth rate anisotropy of ZnO nanostructures. Clustered and powdery growth of ZnO was observed without addition of KMnO4, although by addition of it during the growth, uniform and crystalline ZNR were found to be grown over the substrate. Moreover, the same has resulted in suppression of defects as observed by Normalized Photoluminescence (PL) spectra since KMnO4 is a strong oxidizing agent which provides an oxygen rich growth environment. Further, to explore the correlation between defect suppression and biosensing capability of the ZNR Glucose oxidase (Gox) was immobilized over it, using physical adsorption technique followed by drop casting of nafion. Here the main objective of the work was to analyze effect of defect suppression over biosensing capability, and therefore Gox has been chosen as model enzyme, and electrochemical amperometric glucose detection was performed. The incorporation of KMnO4 during growth has resulted in variation of optical and charge transfer properties of ZNR which in turn were observed to have deep impact on biosensor figure of merits. The sensitivity of biosensor was found to increase by 12-18 times, due to variations introduced by addition of KMnO4 during growth. The amperometric detection of glucose in continuously stirred buffer solution was performed. Interestingly, defect suppression has been observed to contribute towards the improvement of biosensor performance. The detailed mechanism of growth of ZNR along with the overall influence of defect suppression on the sensing capabilities of the resulting enzymatic electrochemical biosensor and different figure of merits of the biosensor (Glass/Pt/ZNR/Gox/Nafion) will be discussed during the conference.

Keywords : biosensors, defects, KMnO4, ZnO nanorods
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