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Fabrication and characterization of a miniaturized pH potentiometric sensor based on a nano Bismuth Oxide film deposited on a Fluorine doped nano Tin Oxide (FTO) glass substrate using spray pyrolysis technique.

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KEYWORDS

Nanoscale bismuth oxide, Fluorine doped nano tin oxide, pH monitoring

SHORT SUMMARY

Conventional glass electrodes are commonly used for pH monitoring due to their high sensitivity, long-term stability, high selectivity and wide operating range, but they have other drawbacks such as mechanical fragility, difficulty in miniaturization, high cost and conditional storage which hinder their application in miniaturized systems and some other applications. Since nano, metal oxides have gained increasing attention due to their unique characteristics specially the high surface area. Hence, Metal oxides have gained increasing interest in incorporating them into potentiometric sensing electrodes such as pH sensors due to their high sensitivity to change in pH as well as their nanoscale size and high surface area.

EXTENDED ABSTRACT

In this work, a thin film of bismuth oxide Bi_2O_3 deposited on a fluorine doped tin oxide glass substrate (FTO) using the spray pyrolysis technique at three different temperatures (450, 500 and 550 °C) for a total deposition time of 10 min have been examined. The deposited Bi_2O_3 was characterized using X-ray diffraction (XRD), field emission scanning electron microscope (FESEM) and energy-dispersive X-ray spectroscopy (EDS). The results revealed the presence of the tetragonal phase of Bi_2O_3 (Fig.1) with a porous and high roughness film surface with nano cracks for Bi_2O_3 deposited film at 550 °C (Fig.2&3). The fabricated Bi_2O_3/FTO film was used as a miniaturized potentiometric sensor for monitoring a wide range of pH (pH 2 – 12). The Bi_2O_3/FTO based electrodes fabricated at 500 and 550 °C displayed an ideal Nernstian slope of -59.4 ± 0.517 and -62.05 ± 0.342 mV/decade, respectively with a lower response time using Bi_2O_3/FTO (550 °C). while Bi_2O_3/FTO (450 °C) showed a non-Nernstian slope of -41.5 ± 0.979 mV/decade.

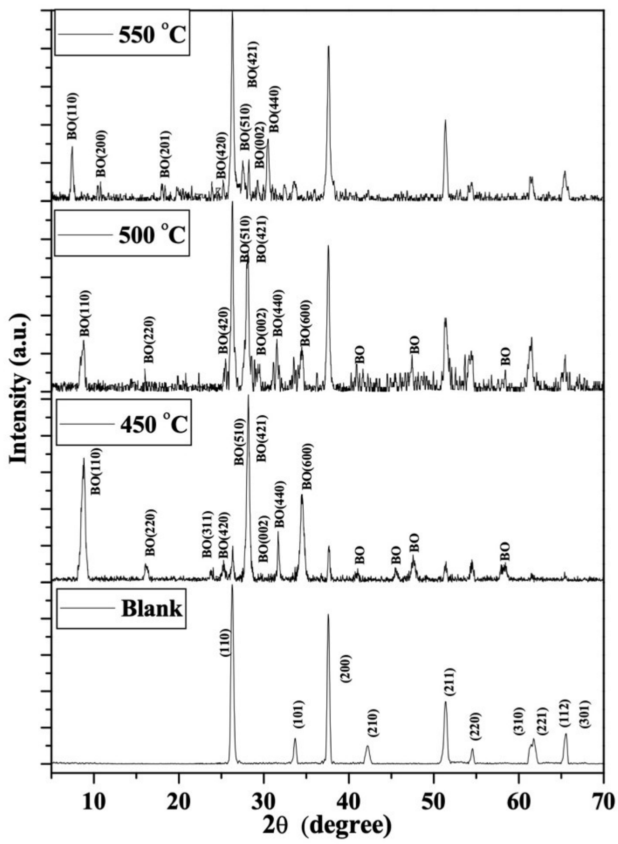

Fig. 1. XRD patterns for the FTO before and after deposition of the Bi_2O_3 films at different temperatures.

This attributed to the effect of temperature in forming a porous and high roughness thin film of Bi_2O_3 with nano cracks on the FTO substrate, which improved the sensitivity in pH monitoring.

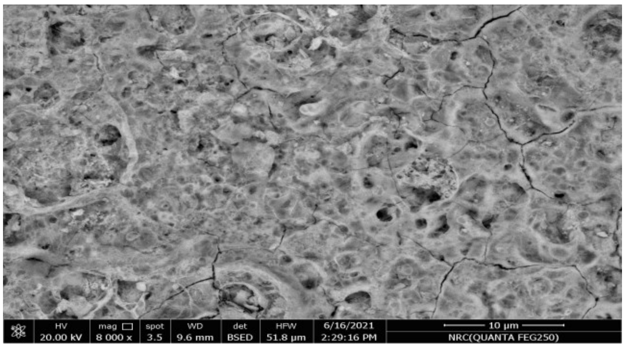

Fig. 2. FESEM image of the nano Bi_2O_3 film.

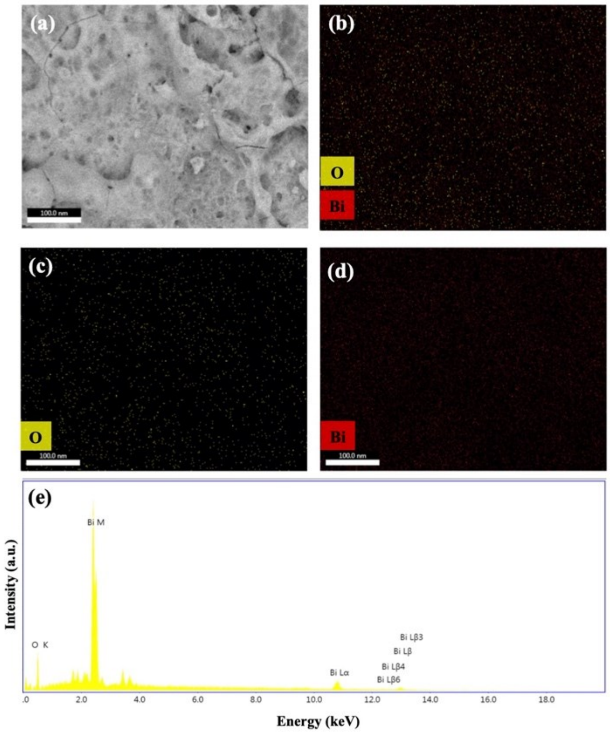

Fig. 3. Energy dispersive x-ray spectroscopy (EDS) analysis of the deposited Bi_2O_3 (550 ºC), scale bar 100 nm. (a) High-angle image; (b) O and Bi ; (c) O K-edge ; (d) Bi M-edge and (e) EDS sum spectra for the deposited Bi_2O_3 film.

The selectivity was tested toward some common interfering ions using the two solutions method (TSM) and results indicate that the proposed electrodes can accurately monitor the pH as the selectivity coefficient values are < 1. These Bi_2O_3/FTO based electrodes were satisfactorily applied for monitoring the pH of many real water samples. The obtained results showed an excellent agreement between the pH values obtained with the proposed sensor and those measured using the conventional pH glass electrode with a recovery close to 98%. Therefore, it is demonstrated the possibility of using the Bi_2O_3/FTO based electrodes to measure the pH of real samples.