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Surfactant-assisted spray pyrolyzed SnO_2 nanostructures for NO_2 gas-sensing application

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Abstract

Well-defined morphologies of tin oxide (SnO_2) nanostructures assisted by cationic surfactant such as cetyl trimethyl ammonium bromide (CTAB) have been obtained by simple and cost-effective spray pyrolysis technique (SPT) for NO_2 gas detection. The effect of concentrations of CTAB on the structural, morphological, electrical, optical, and gas-sensing properties of SnO_2 nanostructures was investigated using X-ray diffraction, field-emission scanning electroscope microscopy, two probe resistivity, and photoluminescence techniques. The XRD results revealed that high concentration of CTAB in the precursor solution leads to decrease in crystallite size with significant changes in the morphology of SnO_2 nanostructures. Photoluminescence studies of the SnO_2 nanostructures showed the emissions in visible region, which exhibit marked changes in the intensities upon variation of surfactants in the precursor solutions. The calculated crystallite size was found to be 10.78–24.57 nm. The optical band-gap energy was found to be in the range of 3.95–2.78 eV. Using indigenously built gas-sensing unit, the gas-sensing properties of synthesized thin film were studied. For NO_2 gas at 150 °C as an operating temperature and for 20 ppm concentration of the gas, the gas response for CTAB4 thin film is found to be 19.43.

1 Introduction

Last many decades, the role of nanostructure-based materials plays considerable attention in the field of research and research-oriented technology because of their novel properties, such as smaller size, size or shape related characteristics, good sensitivity, and better stability as compared to conventional microcrystalline. The most challenging research interest before the people is that to synthesize the controllable nanostructured materials with specific morphologies and pure crystalline phases [1, 2]. Nowadays, most of the countries aware about the environmental protection policy which helps to regulate, proper measurement, detection, and control of the toxic and harmful gases such as hydrogen sulphide (H_2S), ozone (O_3), carbon monoxide (CO), hydrogen (H_2), and nitrogen dioxide (NO_2) in the atmosphere. Atmospheric air, which is polluted by the oxides of nitrogen (NO_x), is generally nitric oxide (NO) and nitrogen dioxide (NO_2). The volatile organic compounds always associated with nitrogen dioxide are responsible for the formation of ozone (O_3) in the lower part of atmosphere, smog in urban areas, and formation of acid rain due to chemical reaction of NO_2 gas with water vapor [3, 4].

That is why, to detect such toxic and harmful gases, it is very necessary to fabricate NO_2 gas sensor for environmental monitoring and controlling. However, due to its wide range of applications, the attention is focused on the studies of nanostructured thin, thick films, and powder of the metals and metal oxide semiconductors. There is variety of metal oxide semiconductors (MOS), but *n*-type non-stoichiometric wide band-gap tin oxide (i.e., SnO_2) is mostly used as a best candidate from many years because of its large wide band-gap ($E_g = 3.6$ eV at room temperature) and very excellent electrical and optical properties. Beside gas sensing, it is also used in solar cells, transparent conducting electrodes, transistors, lithium batteries, and supercapacitors [5–9]. Modern research shows that this type of materials has proven its applicability very popular in the research communities

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