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Highly Sensitive and Selective Ethanol Sensor Based on ZnO Nanorod on SnO_2 Thin Film Fabricated by Spray Pyrolysis

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This work reports the fabrication of mixed structure of ZnO nanorod on SnO_2 thin film via spray pyrolysis followed by thermal annealing and their gas sensing properties. ZnO/SnO_2 nanostructures are successfully prepared on a gold interdigitated alumina substrate by spraying varying mixed precursor concentrations of zinc acetate and tin (IV) chloride pentahydrate solutions in ethanol and thermal annealing. The morphology of the nanostructures is controlled by tailoring the Zn:Sn ratio in the precursor solution mixture. Unique ZnO crystals and ZnO nanorods are observed under a field emission scanning electron microscopy (FESEM) when the Zn/Sn ratio in the precursor solution is in between 13:7 and 17:3 after thermal annealing. The fabricated nanostructures are tested for ethanol, methane and hydrogen in air ambient for various gas concentrations ranging from 25 to 400 ppm and the effect of fabrication conditions on the sensitivity and selectivity are studied. Among the nanostructure sensors studied, the film fabricated with molar ratio of Zn/Sn =3:1 shows better sensitivity and selectivity to ethanol due to high sensing surface area of the nanorod. The response to 25 ppm ethanol is found to be as high as 50 at an operating temperature of 400°C.

Keywords: spray pyrolysis, ZnO, nanorod, SnO_2, thin film, gas sensor, ethanol, nanocomposite

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INTRODUCTION

Gas sensors based on metal oxide nanostructures have been widely studied and used in applications ranging from health and safety to emission control (Comini et al., 2002; Lin et al., 2015; Yao et al., 2016; Kwak et al., 2018; Liu et al., 2019a). These sensors are attractive because of their high sensitivity, low cost, simplicity and compatibility with modern electronic devices due to direct electrical readouts (Miller et al., 2014). Until now, several metal oxides including TiO_2, In_2O_3, WO_3, ZnO, TeO_2, CuO, SnO_2, and NiO are used in resistive-type metal oxide gas sensors (Dey, 2018). However, these single metal oxide gas sensors generally have the disadvantage of low sensitivity, high operating temperature, and poor selectivity between gases (Arafat et al., 2014).

Ethanol sensors are being used in numerous applications, such as, to monitor chemical reactions, breath analysis, biomedical productions, and quality control of foods (Kolmakov et al., 2003; Timmer et al., 2005). Augmented usage of ethanol increases the issues of explosion hazards