Preparation and Gas Sensing Characteristics of Mesoporous In_2O_3 Nanofibers

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Recently, one-dimensional nanostructured materials such as nanowires, nanofibers, nanorods, and nanotubes have received a great attention for their potential applications in numerous areas due to their special properties, which are distinct from conventional bulk materials. Since the first reported nanobelt structure of In_2O_3 [1], there have been a large number of studies on one-dimensional In_2O_3 nanostructures[2,3]. In_2O_3 nanowires have also been demonstrated to work as ultra-sensitive chemical sensors for NO_2 and NH_3, exhibiting significantly improved chemical sensing performance compared to existing thin film-based sensors due to their enhanced surface to volume ratio [4]. Thus, gas sensors based on one-dimensional In_2O_3 are very sensitive to low concentrations of oxidizing gases like O_3, NO_x and Cl_2.

In this work, a simple process is described for forming In_2O_3 nanofibers by thermal oxidation of polymer/indium precursor nanofibers that were prepared by electrospinning. Electrospining has been found to be a unique and cost-effective route for fabricating large surface area nanofibers for a variety of applications. Here, mesoporous In_2O_3 nanofibers with high surface area were synthesized by calcinations of electrospun polyvinyl alcohol (PVA)/indium acetate composite fiber. A PVA solution and indium acetate were mixed and electrospunned. After calcinations of these precursor PVA/indium acetate composite nanofibers, the mesoporous In_2O_3 nanofibers were successfully obtained. The mesoporous In_2O_3 nanofibers were characterized by thermogravimetric analysis, X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, and physical adsorption/desorption isotherms. The mesoporous In_2O_3 nanofibers with diameters in the range of 150 ~ 200 nm consisted of nanoparticles with a primary particle size of 10 nm ~ 20 nm and showed the cubic indium oxide crystals. The BET surface area of mesoporous In_2O_3 nanofibers was strongly affected by calcinations temperature. The sensitivity of these mesoporous In_2O_3 nanofibers to CO in air was high rather than commercial In_2O_3 nanopowder. The highly elevated sensitivity of In_2O_3 nanofibers calcined at 400 ˚C to CO in air could be attributed to the high surface area. The results demonstrate that the electrospinning approach is an easy and useful method to synthesize the metal oxides with mesopores and high surface area, which could be responsible for enhancing the gas sensing properties.

References

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Figures

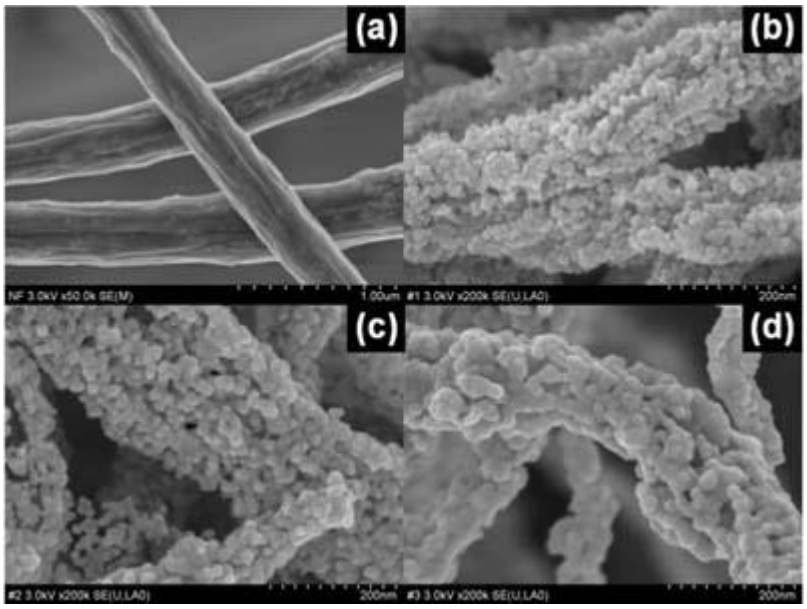

Figure 1. SEM images of (a) PVA/indium acetate composite nanofibers as-prepared, (b) INF-400, (c) INF-500, and (d) INF-600.

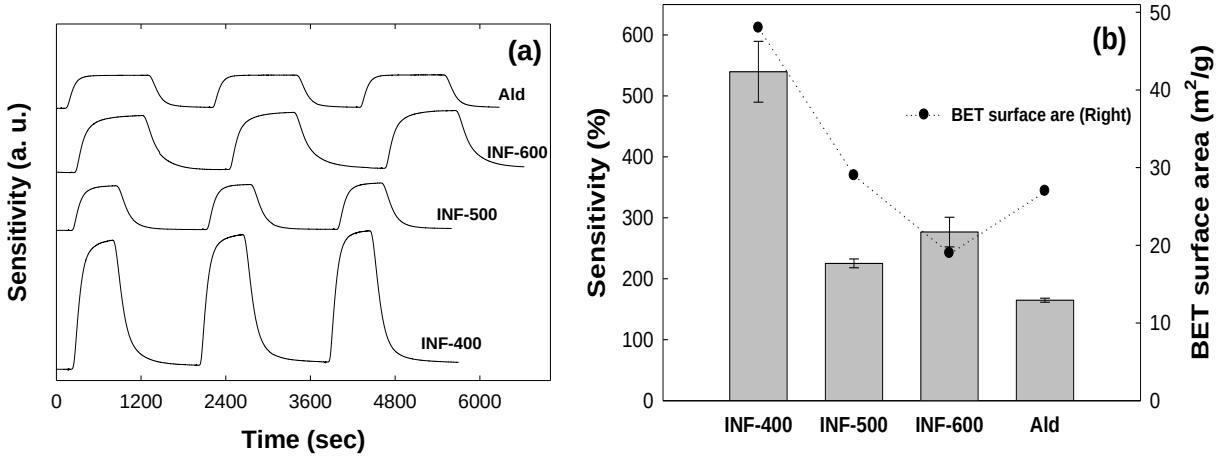

Figure 2. (a) Sensor response and (b) Sensitivity and BET surface area of INF-400, INF-500, INF-600, and commercial In_2O_3 (Ald) to 100 ppm of CO in air at 300 ˚C.