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Preparation of $ZnSnO_3$ nanoparticles by solid state method and its gas sensing properties

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Abstract

$ZnSnO_3$ nanoparticles were successfully synthesized using solid state method. The morphology and gas sensing properties were investigated. The results shows that the particles are cubic and the diameter is 150-200 nm. The sensor based on $ZnSnO_3$ nanoparticles exhibits an good response of about 26.6 to 1000 ppm ethanol at optimum operating temperature of 400oC. The response and recovery time is 16 s and 24 s respectively, showing excellent response and recovery characteristics.

Keywords

$ZnSnO_3$ nanoparticles; solid phase method; gas sensing properties

1. Introduction

In recent years, as a perovskite type gas sensing material, $ZnSnO_3$ have attracted wide attention because of its excellent performance and been used to detect formaldehyde, hydrogen sulfide, ethanol, hydrogen, acetone and other toxic and harmful gases [1-5]. At present, the preparation methods of $ZnSnO_3$ include self-assembly method [6, 7], sol-gel method [8], precipitation method [9, 10], hydrothermal method [11, 12] have been reported. In this experiment, nanosized $ZnSnO_3$ was prepared by hydrothermal method and its gas sensing performance was studied.

2. Experimental Section

2.1 Chemicals and reagents

$Na_2SnO_3 \cdot 4H_2O$, NaCl, $Zn(NO_3)_2 \cdot 6H_2O$ were purchased from Sinopharm Chemical Reageat Limited Corporation. NP 10 were purchased from Linyi Lanshan Lvsen Chemical Co., Ltd. All chemicals were analytical grade and without further purification process. All solutions were prepared with deionized water.

2.2 Preparation of ZnSnO3 nanoparticles

$ZnSnO_3$ nanoparticles were prepared by high temperature solid state method. 2 mmol $Zn(NO_3)_2 \cdot 6H_2O$, 2 mmol $Na_2SnO_3 \cdot 4H_2O$, 2 g NaCl and 2 mL NP 10 were milled for 30 minutes in a agate mortar and formed homogeneous paste. The mixture were washed with distilled water and anhydrous ethanol and dried for 8 hours at 80°C.

2.3 Fabrication and measurement of gas sensor

$ZnSnO_3$ nanoparticles were mixed with terpineol to form a paste. The paste was coated onto a ceramic tube with a pair of gold electrodes to and dried at 80°C for 2 h. Then the sensor was annealed at 500°C for 2 h in air. Finally, a Ni-Cr alloy coil was inserted and fixed into the ceramic tubes for controlling the operating temperature. The gas responses were defined S = Ra/Rg for reducing gas, where Ra is the resistance of sensor in gas, Ra is the resistance in test gases.

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3. Results and discussion

3.1 Morphology analysis of sample

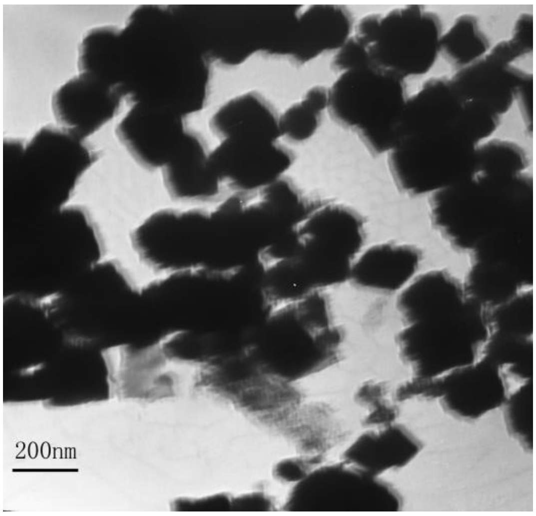

Fig. 1 TEM photographs of $ZnSnO_3$ nanoparticles

Fig. 1 shows the TEM micrograph of the $ZnSnO_3$ sample. It can be seen that Most of the particles are cubic and the diameter of the cubic particle is about 150-200 nm.

3.2 Gas sensing performance analysis

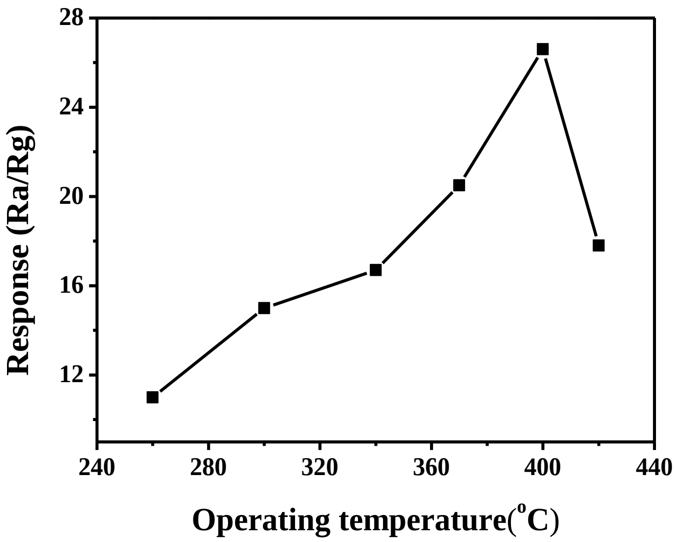

Fig.2 Responses of the $ZnSnO_3$ sensor to 1000 ppm ethanol at different temperature

Fig. 2 shows the responses of the $ZnSnO_3$ sensors as at different operating temperature from 260 to 420°C. It can be found that the response increases with increasing operating temperature and reaches Maximum value of 26.6 at 400°C, then decreases above 400°C. Therefore, 400°C is chosen as the optimum operating temperature in the subsequent testing measurements.

Responses of the $ZnSnO_3$ sensor to different concentration ethanol at the optimum operating temperature of 400°C was presented in Fig. 3. In the low concentration range, the response of the sensor increases rapidly with the increasing of concentration. When the concentration reaches a certain value, the increasing trend of response slows down, which shows the adsorption of sensor to ethanol tends to be saturated.

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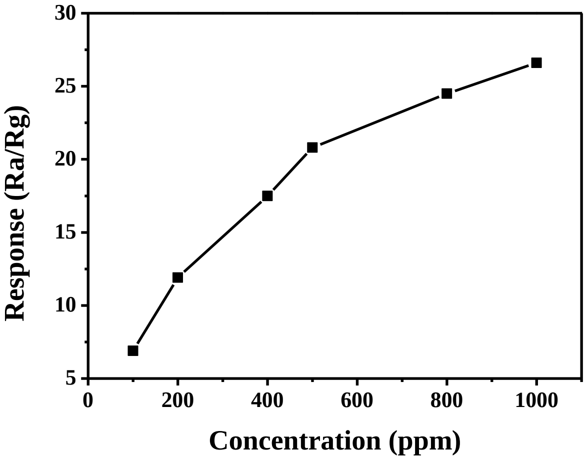

Fig. 3 Responses of the $ZnSnO_3$ sensor to different concentration ethanol at 400°C

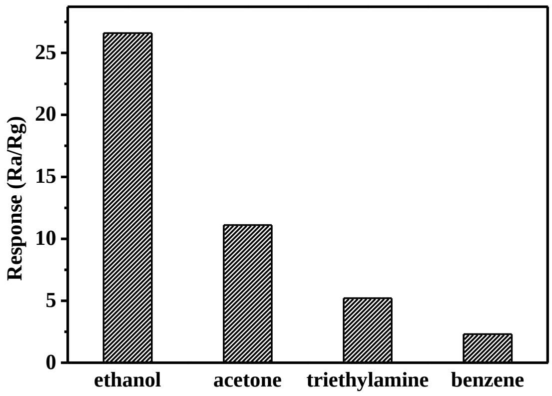

Fig. 4 Responses of the sensor to different VOC gases at 400°C

Fig. 4 shows the responses of the sensor to different VOC gases of ethanol, acetone, triethylamine and benzene at 400°C. It can be seen that the ZnSnO3 sensor exhibits good selectivity to ethanol.

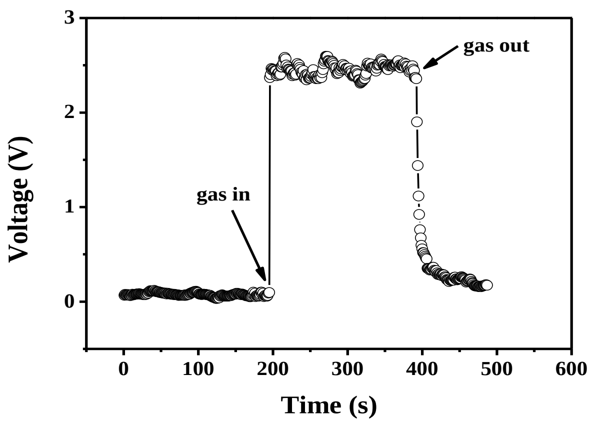

Fig.5 Response and recovery time of $ZnSnO_3$ sensor to 1000 ppm ethanol at 400°C

Fig.5 shows the response and recovery time of $ZnSnO_3$ sensor to 1000 ppm ethanol at 400°C. It can be seen that the response time of sensor to ethanol is 16 s and the recovery time is 20 s at the optimum operating temperature of 400°C, exhibiting good the response and recovery characteristics.

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4. Conclusion

Cubic $ZnSnO_3$ nanoparticles was successfully synthesized via solid state method. The sensing performances of the sensor based on the $ZnSnO_3$ were investigated. The sensor exhibits high response, good selectivity and fast response and recovery to ethanol at 400°C. These results suggest that the sensor might have great potential to be used to detect ethanol gas.

Acknowledgements

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