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Quantity and size dependence of Gas sensing properties for the SnO_2 nanofiber layer induced by the junctions between the layers

Wei Luo[1], Xiaohu Tong[1], Lei Xu[1], Qiuyun Fu[1,*], Honglang Li[2,*]
[1]School of Optical and Electronic Information, Engineering Research Center for Functional Ceramics of the Ministry of Education, Huazhong University of Science and Technology, Wuhan 430074, China,
[2] Institute of Acoustics, Chinese Academy of Sciences, 21 North 4th Ring Road, Haidian District, Beijing, 100190, P. R. China.
fuqy@mail.hust.edu.cn, lhl@ioa.ac.cn

Abstract

SnO_2 nano-material has been widely investigated for gas sensing in recent years. This research concerned about the unordered SnO_2 nano-fiber, which were prepared by far field electrospinning method. The nanofibers with diameters ranging from 54nm to 171nm were synthersized and showed excellant gas sensing properties towards H_2S at room temperature. The influences of both the quantity and size of nodes between SnO_2 nanofibers on the gas sensing response properties were investigated. It was found that the sensor response to H_2S increased with the thickness of the fiber membrane, which is different from the conventional nanocrystalline SnO_2 film. The mechanism was suspectred by the increase of the quantity of junctions in the nodes between the fiber connection part. Herein, the nodes diameter were varied by adjusting fiber diameter to verify the unique function of the nodes. The results indicated that the response to H_2S increased with the node size. From this, the unique effects of nodes on the gas sensing property of SnO_2 nanofibers were verified.

Key words: Electrostatic spinning, SnO_2, disordered nanofibers, nodes

Introduction

In recent years, the metal oxide semiconductor gas sensor has attracted great attention due to its wide application in gas detection and low cost property. One-dimensional nanostructures have unique advantages in improving SnO_2 gas sensing performance. The connecting nodes between the nano-fibers form the junction for electron transfer. The electrons must pass through these nodes when they are transferred in the stack of fibers. Therefore the quantity and size of nodes will inevitably affect the efficiency of electronic transmission.

J.Y.Park et al.[1] found that node density has a significant influence on the gas sensitivity of SnO_2 nanowires. D.Sun et al.[2] found that due to the existence of the y-type node with greater contact area, the gas sensing performance of carbon nanotube films has been greatly improved. In this work, the influence of nodes on gas sensitivity were studied by adjusting the number of nodes and the node size.

Experiments

The synthesis of SnO_2 precursor sol was accomplished according to previous literature [3]. First, the tin chloride powder was dissolved in DMF and the mixture was stirred for 10 min at room temperature to form tin chloride solution. Next, polyvinyl pyrrolidone(PVP) power was added into the solution with a continuously stirred for six hours. Then the precursor sol was aged for 24h before being used in the electrostatic spinning process.

After the nanofibers accumulated and deposited on the alumina substrate with a pair of interdigitated silver electrode， the as-spun fiber of $SnCl_2$/PVP were calcined to form the crystalline SnO_2 nanofibers.

Results and discussion

(1) Effect of the nodes quantity

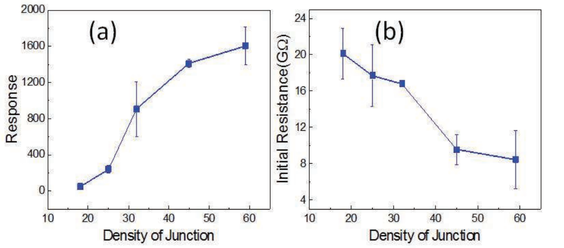

Fig.1 0.57mol/L disordered SnO_2 nanofibers (a)gas sensitive response, (b) initial resistance with different node quantities

Fig.1 shows samples of 0.57mol/L unordered SnO_2 nanofibers in the experiment. Analyzing the effect of node quantity on gas sensitivity（at room temperature）, it can be seen that the gas sensitive response increases with the quantity of nodes in the unit area, but the growth trend is slowing down. The initial resistance almost linearly decreases, with the increase of the junction points.

(2) Effect of the nodes size

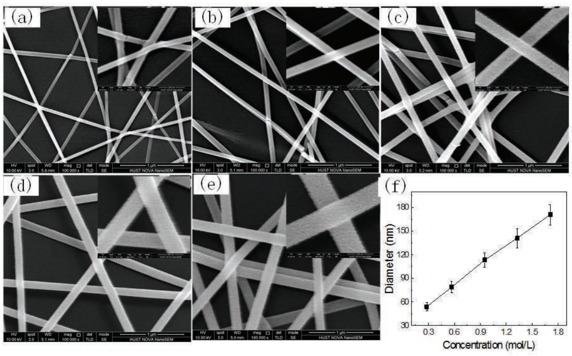

Fig.2 SEM images of (a)0.28mol/L,(b)0.57mol/L, (c)0.95mol/L, (d)1.33mol/L, (e)1.71mol/L precursor sol of the disordered nanofiber, (f)fiber diameter with diferrent precursor sol concentration at room temperature

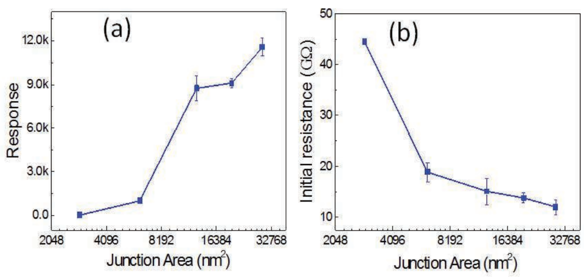

Fig.3 0.57mol/L disordered SnO_2 nanofibers (a)gas sensitive response, (b) initial resistance with different node sizes

Change in the size of the nodes were indicated in Fig.2. The nodes size increases with fiber diameter. The experimental results are shown in Fig. 3. It is clearly shown that both the response to H_2S of the fiber membrane and the initial resistance was affected by the size of the nodes. Gas sensitive response increases with the size of a node, and the initial resistance decrease with the nodes size.

Conclusion

Either the number of nodes increases or the nodes become larger, the gas sensitive response can be better.

Due to the influence of the nodes, the fiber film exhibits unique characteristics compared with the conventional nanocrystalline film.

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