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Relationship between ZnO nano-heterojunction and its sensing performances

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Abstract:

ZnO nanorod arrays can be synthesized by a seed-assisted chemical reaction under ultrasonic spray pyrolysis. Several semiconductor oxides including n and p type can be composed outside of ZnO nanorod. The “oriented attachment” and “self-assembly” crystal growth mechanisms were proposed to explain the formation of the ZnO/MO (M=Fe, Sn, Cu, Ni) nanostructures. Sensors based on the ZnO/MO heterojunction nanostructure were fabricated and investigated for their gas sensing properties.

Key words: ZnO nanorod, heterojunction, gas sensor, nanostructure

Introduction

Zinc oxide, one of the most important functional semi-conductor materials, with a direct band gap of 3.4 eV and a large exciton binding energy of 60 meV, has attracted a wide range of research due to its unique properties and extensive applications in chemical sensors.

Hetero-nanostructures characterized by two or more metal oxides have attracted growing attention due to their great potential applications in gas sensors, catalysis, and lithium-ion batteries. In recent years, many studies have demonstrated that the performance of these composites is very good compared to those of their individual metal oxide counterparts. Therefore, great progress has been made in the synthesis of these hybrid composites with different nanostructure components and numerous hetero-nanostructures have been achieved. Among various metal oxides, ZnO, known as a famous wide-bandgap semiconductor (3.37 eV), has always been the research hotspot in the field of nanostructure synthesis. The design and synthesis of ZnO composites with novel architectures still have important scientific and practical significance. We prepared several ZnO/MO (M=Fe, Sn, Cu, Ni) nanostructures and investigated its sensing properties.

Experimental details

All chemicals in the experiment were of analytical reagent grade and used without further purification. First, ZnO nanorods were obtained by a ultrasonic spray pyrolysis (USP) method on the FTO substrate. Synthesis of hierarchical ZnO/MO nanoheterojunctions were obtained by a chemical bath deposits (CBD) method. Gas sensors were fabricated using conventional process of tube type gas sensors. The gas response (S) of the sensor is defined as the ratio of Rg/Ra, in which Rg and Ra are the electrical resistance of the sensor in the target gas and atmospheric air.

Results and discussion

The SEM of the ZnO/MO (M=Fe, Sn, Cu, Ni) nanostructures were shown in Fig1 to Fig.4.

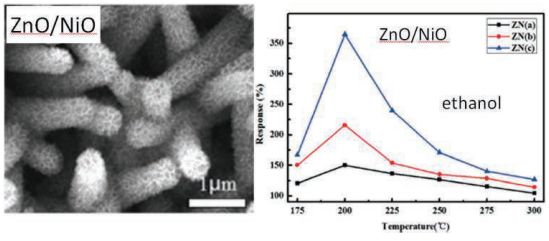

Fig. 1.SEM ZnO/NiO and its properties

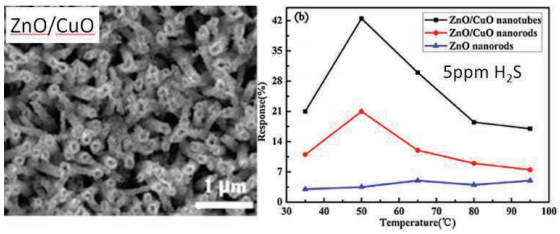

Fig2. SEM i ZnO/CuO and its properties

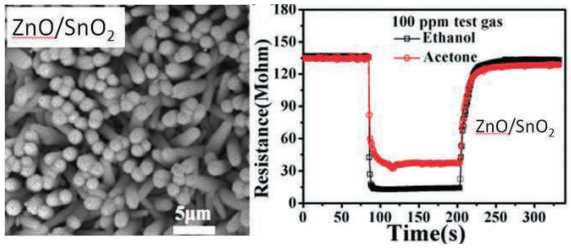

Fig3.SEM of ZnO/$ZnFe_2O_4$ and its properties

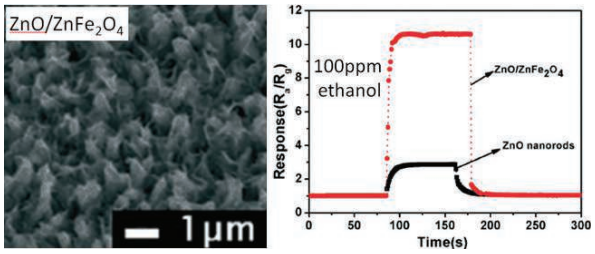

Fig4. SEM of ZnO/SnO_2 and its properties

The nanostructures of ZnO/MO heterojunction are different and its sensing performances are different too. A possible formation process and growth mechanism was proposed as the ZnO nanorods were partly dissolved during the CBD period. The growth approach in this work offers a new technique for the design and synthesis of transition metal oxide hierarchical nanoarrays which are promising for gas sensing applications. The sensing performance is affect by the materials nanostructure.

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