NO_2 sensing propertiesof TiO_2/WO_3 thin film nano-heterostructures

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1. Introduction

Nitrogen dioxide (NO_2) is harmful to the environment and human. In order to detect the harmful gas, a large number of chemical gas sensors have been developed. Tungsten trioxide (WO_3) is considered to be one of the most popular applied sensors among NO_2 sensing materials because of its high sensitivity, fast response, and low cost [1]. Nevertheless, it is necessary to further improve the intrinsic selectivity and the overall performances of the materials. In recent year, the idea of combining different metal oxides materials, such as ZnO-TiO_2 [2], SnO_2-ZnO [3], TiO_2/SnO_2 [4] and TiO_2-WO_3 [6], forming a heterostructure would improve the selectivity and other important sensing parameters of resistive-type gas sensors [5]. Indeed, it would be of interest to investigate nano-crystal TiO_2-WO_3 composites. In this paper, TiO_2/WO_3 thin film nano-heterostructures were prepared by sputtering method. NO_2 sensing properties and gas sensing mechanism was also studied.

2. Materials and method

First, WO_3 thin films were deposited on the Al_2O_3 substrates with interdigitated Au electrodes by DC magnetron reactive sputtering. Then, TiO_2 nanofilms were deposited on top of WO_3 nanofilms also by DC magnetron reactive sputtering. Tungsten target and titanic target with a purity of 99.99% were used. The ratio of discharge gas-argon to oxygen mixture (Ar:O_2) was 4:1. The power was 100W. Substrate temperature was room temperature (RT). After deposition, the samples were annealed at 500°C in dry air for 4h with a heating rate of 2°C/min, then cool naturaly with the furnace. TiO_2/WO_3 thin film nano-heterostructures were obtained as Fig. 1.

Stylus profiler was used to measure the film thickness. X-ray diffraction (XRD) was used to investigate the crystallographic structure of sputtered TiO_2/WO_3 thin film nano-heterostructures. The morphologies were measured by a scanning electron microscope. NO_2 sensing properties of TiO_2/WO_3 thin film nano-heterostructures were measured using a static test system at different operating temperature. The results showed that, the addition of TiO_2 thin layer not only increased the response, but also decreased the operating temperature of WO_3 nanostructure towards NO_2. Such extremely good sensing properties of TiO_2/WO_3 thin film nano-heterostructures to NO_2 may be assigned to the formed interfaces.

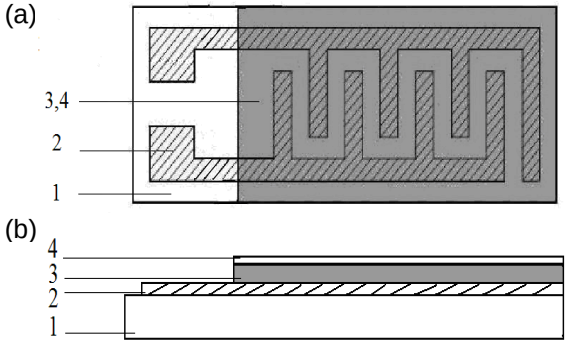

Fig.1 Schematic of TiO_2/WO_3 thin film nano-heterostructures (a: Top view, b: Side view, 1-Al_2O_3 substrate, 2-Au interdigital electrode, 3-WO_3 thin film, 4- TiO_2 thin film)

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