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WO_3 Nanotubes/SnO_2 Nanoparticles for Ultrasensitive NO_2 Detections

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Abstract

Gas sensors based on metal oxide heterostructures have been widely studied for gas sensing applications with functionalization and modification of structure, which significantly enhanced the number of reactive sites and dangling bonds on the sensing surfaces, resulting in the improved gas-sensing properties [1]. In this research, SnO_2 nanoparticles with high specific surface area were synthesized by flame spray pyrolysis [2, 3], which could effectively produces low dimensional nanostructures in one step and the WO_3–SnO_2 heterostructures were fabricated by thermal decomposition of WS_2 nanotubes with varying WS_2 contents ranging from 0.5–10 wt%. The phase and structural characterizations by X-ray analysis, thermogravimetric-differential thermal analysis, nitrogen adsorption, and electron microscopy further confirmed that the hexagonal WS_2 nanotubes can be completely converted to orthorhombic WO_3 nanotubes. Moreover, the tetragonal SnO_2 nanoparticles were well-dispersed on WO_3 nanotubes led to *n-n* heterointerfaces which can significantly enhance accessible surface areas of highly active sites for chemisorbed NO_2 species with concentration ranging from 0.125−5 ppm in dry air. The NO_2-sensing measurements revealed that the addition of WO_3 nanotubes to SnO_2 nanoparticles can substantially enhanced the sensing properties. It was noticed that the optimal 5 wt% WO_3 loaded SnO_2 sensor exhibited an ultra-high response of ~12,800 to 5 ppm NO_2 with good recovery stabilization at a low optimal working temperature of 150°C. The response was increased by more than 5 times compared with the unloaded SnO_2 sensor. Hence, SnO_2 nanoparticles-WO_3 nanotubes heterostructure based sensor is a promising candidate for highly sensitive detection of NO_2 at low working temperatures.

Keywords: WO_3-SnO_2, Heterostructures, WS_2, Flame spray pyrolysis, NO_2 sensor.

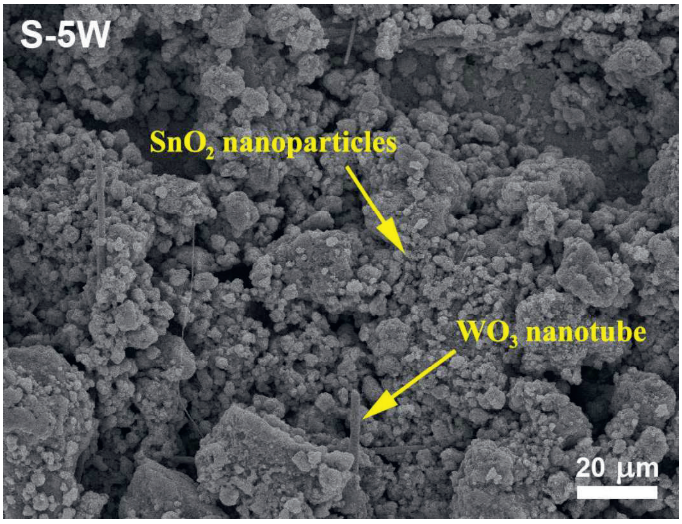

Fig.1. A typical top–view SEM image of 5 wt% WO_3 nanotubes-loaded SnO_2 sensor (S–5W).

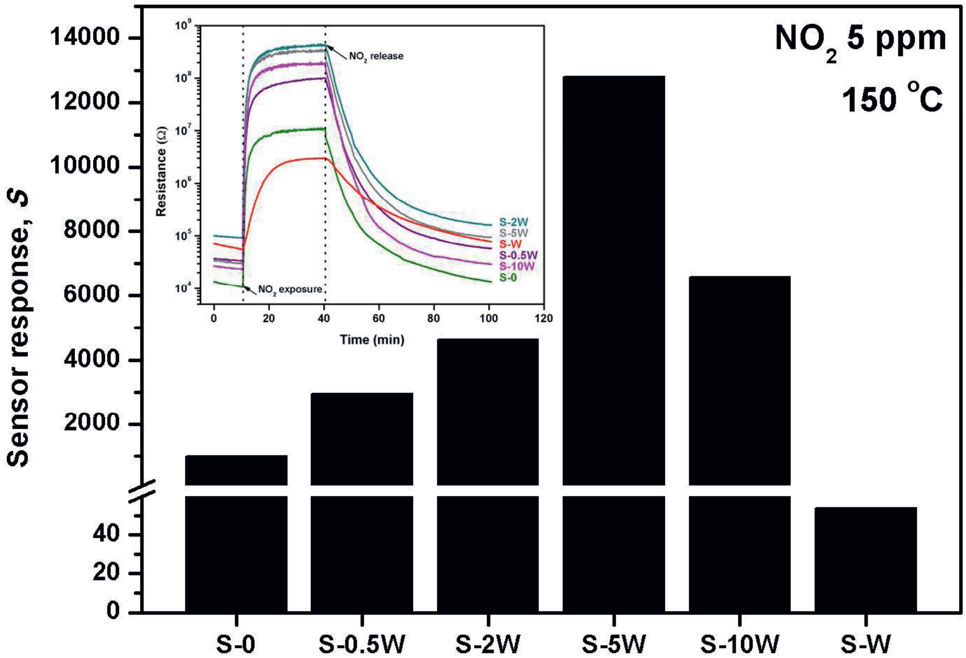

Fig. 2. The histograms of typical sensor response with corresponding change in resistance (inset) of WO_3 (S-W), undoped SnO_2 (S-0), and 0.5–10 wt% WO_3-loaded SnO_2 sensors (S-0.5W to S-10W) towards 5 ppm NO_2 at optimal operating temperatures of 150˚C in dry air.

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