WO3 Nanotubes/SnO2 Nanoparticles for Ultrasensitive NO2 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, SnO2 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 WO3–SnO2 heterostructures were fabricated by thermal decomposition of WS2 nanotubes with varying WS2 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 WS2 nanotubes can be completely converted to orthorhombic WO3 nanotubes. Moreover, the tetragonal SnO2 nanoparticles were well-dispersed on WO3 nanotubes led to n-n heterointerfaces which can significantly enhance accessible surface areas of highly active sites for chemisorbed NO2 species with concentration ranging from 0.125–5 ppm in dry air. The NO2-sensing measurements revealed that the addition of WO3 nanotubes to SnO2 nanoparticles can substantially enhanced the sensing properties. It was noticed that the optimal 5 wt% WO3 loaded SnO2 sensor exhibited an ultra-high response of ~12,800 to 5 ppm NO2 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 SnO2 sensor. Hence, SnO2 nanoparticles-WO3 nanotubes heterostructure based sensor is a promising candidate for highly sensitive detection of NO2 at low working temperatures.

Keywords: WO3-SnO2, Heterostructures, WS2, Flame spray pyrolysis, NO2 sensor.
Fig. 1. A typical top–view SEM image of 5 wt% WO₃ nanotubes-loaded SnO₂ sensor (S–5W).

Fig. 2. The histograms of typical sensor response with corresponding change in resistance (inset) of WO₃ (S-W), undoped SnO₂ (S-0), and 0.5–10 wt% WO₃-loaded SnO₂ sensors (S-0.5W to S-10W) towards 5 ppm NO₂ at optimal operating temperatures of 150°C in dry air.

References

