physica status solidi a applications and materials science
2018, Vol. 215, Nr. 7, P 1700772

ZnAl2O4-Functionalized Zinc Oxide Microstructures for Highly Selective Hydrogen Gas Sensing Applications

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https://doi.org/10.1002/pssa.201700772

Abstract

In this work, a simple method of ZnAl2O4-functionalization of ZnO microstructures is presented. The different characterization methods (structural, chemical, and micro-Raman) demonstrated the presence of only ZnO and ZnAl2O4 crystalline phases. ZnAl2O4 nano-crystallites grow on the surfaces of ZnO 3D microstructures having diameters of 50–100nm and with high density. Transmission electron microscopy (TEM) and high-resolution TEM (HRTEM) results clearly show ZnAl2O4 crystallites functionalizing zinc oxide tetrapod arms. The individual structures (microwires (MWs) and three-dimensional (3D) tetrapods (Ts)) are integrated into functional devices, suitable for gas sensing applications. All devices show excellent hydrogen gas selectivity at relatively low operating temperature in the range of 25–100°C. The highest gas sensing performances are obtained based on individual ZnAl2O4-functionalized ZnO tetrapods (ZnAl2O4/ZnO-T, with an arm diameter (D) of ≈400nm) and a response of ≈2 at 25°C to 100ppm of hydrogen gas (H-2), while a ZnAl2O4/ZnO-MW (D≈400nm) shows only a response of ≈1.1. The Al-doped ZnO MW (D≈400nm) without ZnAl2O4 elaborated in another work, chosen only for comparison reason, shows no response up to 800ppm H2 gas concentration. A gas sensing mechanism is proposed for a single ZnAl2O4/ZnO-T microstructure based sensor. The obtained results on ZnAl2O4/ZnO-T-based devices is superior to many reported performances of other individual metal oxide nanostructures with much lower diameter, showing promising results for room temperature H2 gas sensing applications.