Development of Multi-dimensional Metal-oxide Nanostructures for Environmental Gas-Sensing Applications

A. Wisitsoraat[1], K. Jaruwongrangsee[1], C. Sriprachuabwong[1], A. Tuantranont[1], S. Phanichphant[2], C. Liewhiran[3]

[1]*National Science and Technology Development Agency, Pathumthani, Thailand*
[2]*Materials Science Research Center, Chiang Mai University, Chiang Mai, Thailand*
[3]*Dept. of Physics and Materials Science, Chiang Mai University, Chiang Mai, Thailand*

Abstract

Metal oxide composites comprising multi-dimensional nanostructures are attractive for various gas-sensing applications due to their large effective specific surface area, unique electronic/chemical characteristics and high environmental stability. Over the past several years, we have developed highly sensitive gas sensors based on multi-dimensional metal-oxide nanostructures prepared by different methods. For instance, 1D carbon-nanotubes (CNTs)-0D metal oxide (SnO_2, WO_3 and MoO_3) nanocomposites are developed by means of powder mixing and electron beam evaporation. Appropriate compositions of the nanocomposites lead to enhance responses towards gases such as NO_2, ethanol, acetone and H_2. In addition, carbon-doped 1D metal oxide nanostructures such as WO_3 nanorods were produced by sputtering with glancing angle deposition and demonstrated to offer a significantly higher gas-sensing response compared with conventional undoped dense thin film prepared by conventional sputtering method. Moreover, carbon-coated 3D ZnO nanotetrapods fabricated by two-step vapor phase transport shows considerably enhanced response towards NO_2 compared with uncoated ZnO nanotetrapods. Additionally, graphene-metal oxides (SnO_2, WO_3, CuO and Bi_2WO_6) composite thick film gas sensors are fabricated based on one-step flame spray pyrolysis (FSP), electrolytic exfoliation and spin coating. The gas-sensing characteristics towards ethanol, acetone and NO_2 gases of the composite were found to be significantly improved with optimal graphene loading concentrations in the range of 0.5–5 wt%. Furthermore, 1D WO_3 nanorods-0D SnO_2 nanocomposites produced by fluidized bed reaction and FSP followed by thermal oxidation offered high selectivity and sensitivity towards NO_2.

Keywords: Metal oxide nanostructures, Multi-dimensional nanocomposites, Gas sensor.