Metal Oxides and Composites: Applications in Chemical Sensing

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In the field of advanced sensor technology, metal oxide nanostructures are promising materials due to their high charge carrier mobility, easy fabrication and excellent stability. In particular, most of them exhibit a reversible interaction between their surfaces and the surrounding atmosphere. This interaction may lead to a change of some different properties of the material, such as electrical conductance, capacitance, work function or optical characteristics. All metal oxides are in principle sensitive to gases if they are prepared in a sufficiently porous form (high surface to volume ratio and electrical properties controlled by surface states), but in order to be active material in chemical sensors they need to fulfill specific requirements such as sensitivity, selectivity, stability, fast response and recovery time.

Further conductometric sensors are the cheapest devices that could be integrated into portable olfaction systems, due to their easy readout, small size and low cost. Depending on the materials they are based on, they could offer high sensitivity, but they often lack selectivity between different chemical species. Moreover, they sometimes have stability issues, due to high temperature required during normal operation (200-400°C). Furthermore one dimensional (1D) semiconductor metal oxides such as nanowires (NWs) have been attracted great deal of attention in the field of chemical sensors due to their unique chemical/physical properties. In chemical sensor, surface of the active materials determines the sensor sensitivity toward specific gas analyte. The enhancement in the sensor response can be achieved by increasing the active surface area of the sensor. But there is still a lot of work going on regarding the preparation of nanostructured oxides, like controlling their morphology and position at the nanoscale level. Moreover, a major challenge is the reliable integration of quasi-1D nanostructures on specific transducers used to fabricate chemical sensors, assuring stable electrical contacts over long-term operation.

Various strategies have been used to increase the gas response and selectivity, including modulating the sensing temperature, morphological control, catalyst doping/loading and catalytic filtering of interference gases. Another effective strategy to enhance the sensor response and selectivity is to construct the heterojunction between two different oxides that enables the control of conductivity at p-p, p-n, and n-n interfaces, and synergistic catalytic effects between different materials.

The results of bringing together the properties of two different nanostructure materials into a single sensing platform by using a common, simple, low cost and high yield growth method will be presented. Herein, we report on the novel preparation and characterization of different nanostructures and hetrostructures morphologies such as NiO, WO_3, Bi_2O_3 and ZnO NWs, TiO_2 nanotubes and NiO/ZnO branched 1D-1D nano-heterostructures and NiO/SnO_2, CuO/ZnO Core-shell, SnO_2/Go and WO_3-doped with Nb. The surface morphology of the nanostructures was investigated by using scanning electron microscopy (SEM) while, for structural characterization GI-XRD, the transmission electron microscopy (TEM), and XPS, Raman spectroscopy, UV-Vis spectroscopy. Finally, heterostructures based conductometric gas sensing devices have been fabricated and tested towards different gases spices such as (NO_2, H_2, CO, VOC's) and their performance have been compared with literature and the host materials.