Gas Sensors using Hierarchical and Hollow Oxide Nanostructures

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The gas sensing reaction in n-type oxide semiconductors is an oxidative or reductive interaction between the target gas and the charged oxygen adsorbed on the surface. The gas response increases abruptly when the particle size becomes comparable or smaller than the Debye length (typically several nm). However, the aggregation between the nanoparticles is very difficult to avoid because the van der Waals attraction is inversely proportional to the particle size. This retards the diffusion of the target gas toward the surface of the sensor as well as the counter diffusion of the product gases to the ambient atmosphere, which greatly reduces the sensor response speed. Hierarchical nanostructures are the higher dimensional structures that are assembled from low dimensional, nano-building blocks such as 0-D nanoparticles, 1-D nanowires, nanorods, and nanotubes, and 2-D nanosheets. Hierarchical nanostructures show well-aligned porous structures without scarifying high surface area. Hollow nanostructures with thin shell layers are also very attractive to achieve high surface area with a less agglomerated configuration. Thus, both a high gas response and a fast response speed can be accomplished simultaneously by using well-designed, hierarchical and hollow oxide nanostructures as gas sensor materials. The presentation will cover the preparation of hierarchical/hollow oxide nanostructures, the principal parameters to determine the gas sensing reaction, and the mechanism for enhancing the gas sensing characteristics.