Cent. Eur. J. Chem. • 8(2) • 2010 • 331-340
DOI: 10.2478/s11532-009-0137-5

Central European Journal of **Chemistry**

Effect of alumina incorporation on restricting grain growth of nanocrystalline tin(IV) oxide

Research Article

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Received 17 February 2009; Accepted 20 October 2009

Abstract: In this project, nanocrystalline SnO_2 powders were successfully prepared by (a) citrate sol-gel and (b) direct precipitation methods. Powders were characterized using thermal analysis techniques (DTA-TG-DSC), X-ray powder Diffraction (XRD), surface area (BET) and electrical conductivity measurements. XRD patterns showed the presence of the cassiterite structure. SnO_2 particles, prepared through sol-gel method exhibit crystallite sizes in the range from 3.1 to 22.3 nm when the gel is heat treated at different temperatures up to 900°C. SnO_2 nanocrystallites prepared by the precipitation method are comparatively larger in size. The higher specific surface area was obtained for the powder prepared using sol-gel method and the obtained average grain size (*d*) is relatively large compared with that of the average crystallite size. The powders show a semiconducting behavior with increasing temperature. The higher conductivity obtained for SnO_2 prepared by sol-gel method can be attributed to their smaller average crystallite size. XRD of alumina doped powder exhibits finer particles than pure SnO_2. TEM images showed that the particles are spherical in shape and consist of a core of SnO_2 surrounded by a coating of alumina. The calculated surface area was found to decrease with temperature increases. Due to the effective role of Al_2O_3 additive as a grain growth inhibitor for the matrix grains, the observed surface area for the coated materials are predominantly higher than for the uncoated materials.

Keywords: *SnO_2 • Surface are • Conductivity • Grain growth inhibition*

1. Introduction

SnO_2, is one of the most widely used semiconductor oxides. It can be used as transparent electrodes for solar cells, liquid crystal displays, catalysts for methanol conversion and CO/O_2, CO/NO reaction in the control of noxious emissions, transistors, catalyst supports, nano and ultra-filtration membranes and anticorrosion coatings [1-7]. More recently, attention has been paid to its potential use as anode for lithium-ion batteries because of its high gravimetric and volumetric capacity which increases with using very fine particles [8]. The most important use is for gas sensors. The sensing properties of SnO_2 sensors depend on several factors, mainly crystallite size and specific surface area [7].

The microstructure of materials depends upon the method of preparation. Tin oxide nanoparticles were prepared by many different methods, such as hydrothermal [6], precipitation [9], solvothermal [10], sol–gel [11], gel-combustion [12], spray pyrolysis [13], polymerized complex [14] and amorphous citrate [15] methods.

SnO_2 nanocrystals were synthesized by a precipitation process [16]. The samples were characterized by means of X-ray diffraction (XRD), high-resolution transmission electron microscopy (HRTEM) energy-dispersive X-ray spectra (EDS) and X-ray photoelectron spectroscopy (XPS). The influence of calcination temperature on SnO_2 was investigated.

Bose *et al.* [1] synthesized nanocrystalline tin(IV) oxide (SnO_2) by chemical precipitation method. The nanoparticles are of 5–20 nm in size as observed by transmission electron microscopy (TEM). The electrical properties of the consolidated nano-structured SnO_2 are studied using an impedance spectroscopic technique.

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