Electrical properties of Tin Oxide Nanoparticles Synthesized with Mesoporous Silica Templates

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Nanoparticle science and its applications are generating increasing interest in recent years. Side by side, there is an urgent need on developing reliable synthesis methods to dispose of nanoparticles with controlled physical properties, being optical, catalytic and electrical characteristics strongly dependent on particle size, surface states, shape and agglomeration.

Tin oxide nanoparticles has attracted much attention in the field of optoelectronics, catalysis and chemical sensors. These are usually obtained by sol-gel processes, which fail on producing narrow size distributions of stabilised material.

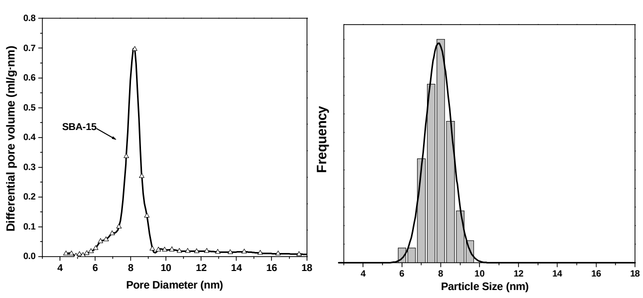

Fig. 1 a) Pore size distribution of the mesoporous silica used for synthesis of tin oxide nanoparticles; b) Size distribution histogram of the tin oxide nanoparticles obtained from TEM micrograph.

Material encapsulation on template structures has been recently reported as a promising way to obtain small diameter monodispered nanostructures[1]. Stabilisation treatment of the material can be also done inside of the silica template. Thus template synthesised and stabilised materials have particle size determined by pore diameter distribution of the framework structure. Dispersion is accomplished by the isolation of the nanostructure into the template channels, although final agglomeration also depends on the template elimination procedure and posterior treatments[2].

In the present work we detail the characterisation of template synthesised tin oxide nanoparticles with controlled narrow grain size distributions. Varying template pore size in the range between 2nm and 30nm different semiconductor nanoparticle diameters are easily obtained[3]. This allow to obtain a set of samples with narrow and predefined different particle size distributions, which are the basis for a comprehensive study of the particle size influence on semiconductor electrical properties and on surface related phenomena such as catalysis and chemical sensing.

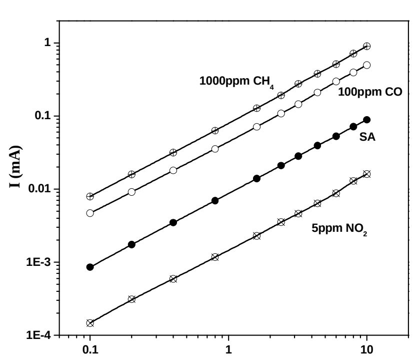

Fig. 2 Intensity vs. applied voltage for different gas atmospheres.

Figure 1 shows particle size distribution of a tin oxide material with a mean grain crystallite diameter of 8nm, obtained by encapsulation inside SBA-15 mesoporous silica. Pore size distribution of the template silica, as measured by corrected BJH method[4], is also plotted for comparison.

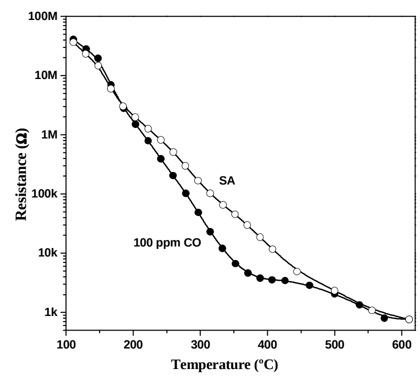

Fig. 3 Dependence of the electrical resistance with the material temperature in two different gas atmospheres, synthetic air and when adding 100ppm of CO.

For electrical characterisation, materials are deposited on silicon and alumina based hot plates with Pt or gold electrodes. On figure 2 the dependence of the intensity flowing between both electrodes with the applied voltage is plotted for different gas atmospheres.

Figure 3 shows the dependence of the tin oxide electrical resistance in synthetic air and when adding 100ppm of CO with the material temperature. It shows the reliability of the proposed procedure for SnO_2 nanoparticles fabrication with homogenous size distribution. Besides, it offers a methodology, based on the template channel size, for the analysis of the metal oxide grain size influence on the gas sensors performances.

References

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