

Development of SnO₂:Sb and SnO₂:Nb films to obtain gas sensors.

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Abstract – This work aimed the development of films based on tin oxide (SnO₂) doped with antimony and niobium, for to be applied as gas sensors. The films were prepared by the mixture of solutions, obtained by two different methods: polymeric precursor and alcoholic suspensions of the oxides. The solutions were deposited in substrates by spin coating technique. The films were characterized by Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS).

Semiconductors based on metal oxides have been extensively used as gas sensors [1] and the films based on SnO₂ can detect a wide variety of gases with high sensitivity, good stability and low cost [2]. The detection mechanism is given by changes in conductivity, caused by adsorption of gases on the oxide surface. This way occurs charge transference between the surface and adsorbate, varying the electrical behavior of the material. Depending of the adsorbed species, different behaviors are observed and this difference can be used to draw a profile in terms of chemical species present and their concentrations.

The particle size, morphology and composition are key parameters for the study of sensors properties. Thus, the oxide systems based on semiconductor oxides, for example, SnO₂ pure and doped, are of great interest for the development of gas sensors. In different molar ratio of components, these systems could be differing in structure, redox properties and acidity/basicity in the surface. These parameters determine the sensing properties of the oxide. The performance of the material can be improved by incorporation of some additives, in order to change the activation of the film's surface.

The literature reports two important methods to obtain films: alcoholic suspensions [3] and polymeric precursor [4]. However, there aren't works in the literature that report films obtained by the mixture of the two solutions above mentioned. This way, the main purpose is to obtain films with different compositions, so that later can be applied as gas sensors.

The mixture of solutions used to the film's deposition was done by two different ways: by the SnO₂ pure and doped colloidal suspensions and starting the mixture of solutions obtained by two different methods: polymeric precursors and alcoholic suspensions. In the colloidal suspension, the solid concentration was 30% (w/v), and the molar ratio of dopants (Nb⁵⁺ and Sb³⁺) was 5, 10 and 14 mol %. In the polymeric solution, the molar ratio among citric acid and metallic salt was 4:1 for Nb and 5:1 for Sb, and the proportion among citric acid and ethylene glycol was both 40:60 (w/w). The films were deposited by spin-coating, and their heat treatment was performed at 550 °C for 120 min, with heating rate of 1 °C.min⁻¹ and inertial cooling.

The result shows that the films obtained by colloidal suspensions (Fig. a) presented interesting surface morphologies to a film to be used as a sensor, which have high roughness and porosity (presence of holes), contributing to the increase in surface area. Besides, the films obtained from the polymeric resin had no covering regions, where the substrate is visible (dark area in Figure 1.b). EDS spectrum shows that in less covered areas the presence of Sn and Nb is lower (not shown). These films will be better studied to improve the coating uniformity, for then later be tested as sensor of gases.

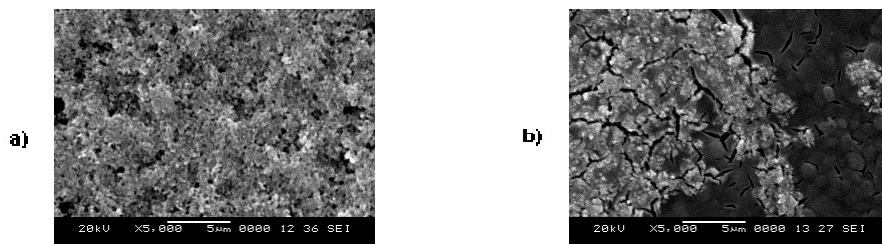


Figure 1: SEM images of SnO₂:5% Nb⁵⁺ films obtained by a) suspensions; b) suspension + polymeric resin.

[1] J. Grace Lu, P. Chang, Z. Fan, *Materials Science and Engineering R* 52 (2006) 49–91.

[2] H.C. Wang, Y. Li, M.J. Yang, *Sensors and Actuators B* 119 (2006) 380–383.

[3] I.T. Weber, E. Longo, E. Leite, *Materials Letters* 43(2000) 166–169.

[4] M.P. Pechini, U.S. patent 3,330,697 (1967).