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Electrical response analysis of doped tin oxide gas sensors under different gases atmospheres

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Abstract

Semiconductor gas sensors based on tin oxide have been widely accepted for detecting and monitoring oxidizing or reducing gases. The electrical resistance of $Ti_xSn_{1-x}O_2$ sensors under diferent atmospheres was analyzed. Possible mechanisms responsible for the found responses, under different gases conditions, are proposed (1-4). The influence of temperature on the oxygen diffusion into the grains annihilating oxygen vacancies was studied. To fit the experimental results, a simple circuit model that considers a capacitance and a resistance in parallel was employed. An explanation for the resistance variation considering spherical grains with different characteristics is proposed.

Description

It is well known that the most studied sensor system, being currently used for commercial purpose, is based on a SnO_2 semiconductor oxide [1-4]. Doped SnO_2-based sensors have many advantages such as fast response and good reproducibility including a long-term stability, and are not much affected by ambient disturbances, at least compared with other kinds of sensors. Thick film pastes were obtained by mixing powders of TixSn1-xO_2 ($0.1 < x < 0.9$) and a suitable organic vehicle. A sensitive pastes thus achieved were screen-printed onto 96% alumina substrates (2mm × 2mm) covering interdigital electrodes of Pt. Heater element and temperature sensor were also printed. Two sets of films were then fired, respectively, at 650 or 950 ◦C in air for 1 h. The gas sensing properties of the sensors were measured in a flowing gas system at a flow rate of 530 ml/min at various concentrations of CO (Fig. 1). All the electrical resistance measurements were performed in the temperature range 250-350℃ in a sealed Teflon chamber of 650ml (Fig. 2).

An explanation for the gas sensor response in the case of completed depleted grains is proposed. To this aim the Poisson Equation has been analitically solved in spherical coordinates with the proper boundary conditions and the probability of tunnel current calculated. A rapid decrease in the density of surface states when the grain radius becomes smaller than a critical length is then derived from the continuity equation. The decrease in the density of surface states accounts for the necessity of a lower surface barrier height. It was possible to estimate the depletion region width of these materials. The crucial role of this quantity in gas sensing has been highlighted.

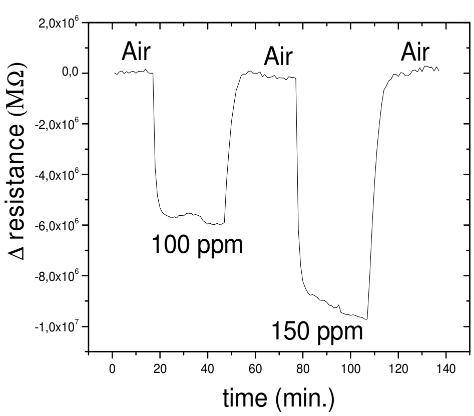

Figure 1: Sensor response to CO/air at 300ºC.

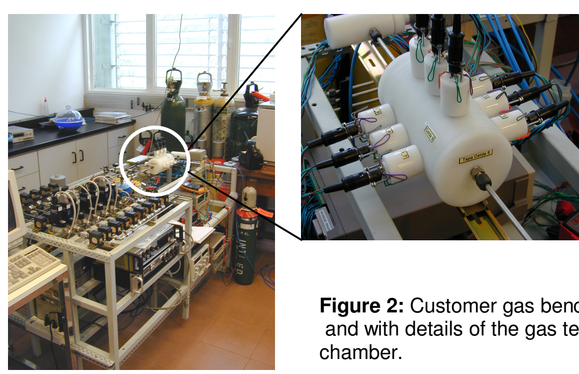

Figure 2: Customer gas bench and with details of the gas test chamber.

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