Effect of thickness on H2 gas sensitivity of SnO2 nanoparticle-based thick film resistors

1. Introduction

The use of resistive, adsorption-based sensors has been increasing over the past few years for purposes such as detection of smoke. oxidizing or reducing gases (O_2, CO, CH_4, CO_2. etc.) and humidity [I-4]. A variety of materials have been used For gas sensing, including ceramics that often consist of a combination of metal oxides, SnO_2 is one of the semiconducting materials very widely used for sensing oxidizing/reducing gases due to its high sensitivity to small concentrations of gas (at p.p.m. level).

These sensors are not able to differentiate the gases in a mixture. So selectivity is a serious problem. There are [4] several ways of improving the selectivity of gas sensors. The commonly used methods are (1) temperature control (2) catalysts on the surface of sensing elements and (3) thickness variation. The temperature effect is due to the reaction between hydrocarbon and oxygen. For hydrocarbon molecules (RH 1) adsorbed on the sensor surface. The reaction between the hydrocarbon molecules and the surface oxygen is RH; +2()' -—~ RO+H;O +2e' The rate of this reaction is ii function of temperature. When the sensor is operated at low temperatures. The reaction is slow. When the sensor is operated at higher temperatures, the reaction occurs so rapidly that the sensor is not able to detect the combustion reaction. Therefore, a maximum is exhibited on a sensitivity versus temperature cur\-‘c. As the reaction rates for the various gases are different, the maximum for each gas occurs at different temperatures [4]. The Catalyst on the surface of the basic material acts as an intermediate layer, creating extra sites for adsorption. The thickness dependence is because of the space charge layer which varies with thickness and oxygen chemisorption [14]. The sensitivity variation is caused by the variation in space charge. The space charge is ii function of the adsorption of the reactive gases. ln general, these semiconductor sensors detect low concentrations of gases and convert the gas concentmlions directly to the change in electrical conductance of the sensor material. With the aid of a simple electrical circuit, a portable inexpensive solution is achieved.

For this work, nanoparticles of SnO_2 are synthesized by a sol-gel method and are used in the form of thick film along with the lead borosillicate glass for better adhesion. We reported the H_2 gas-sensing properties of the films in an earlier paper [5]; it shows that the use of nanoparticles increases the sensitivity of the sensor by orders of magnitude and it gives a higher value than previously reported by others [6 I0]. In this paper we will concern ourselves with the sensitivity of thick film resistors based on SnO_2 nanoparticle gas sensors. mainly for H_2, with thickness variation
for 300 p.p.m. gas concentration.