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Nanocrystalline nickel ferrite thick film as an efficient gas sensor at room temperature

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Abstract

Nanocrystalline $NiFe_2O_4$ known to exhibit inverse spinel structure was used as a gas sensing element at room temperature. Ni ferrite nanoparticles were prepared using chemical co-precipitation technique. Single phase formation of the cubic $NiFe_2O_4$ was confirmed by X-ray diffraction data. Fine powder resulted from the chemical co-precipitation reaction was used to prepare gas sensing elements in pellet and thick film forms. SEM technique was used to study the surface morphology of the sensing elements. The resistance measurements were carried out by exposing the sensing elements to various gases, namely O_2, LPG, ammonia and Cl_2 in a closed chamber at room temperature. It was found that the $NiFe_2O_4$ thick film sensor showed superior response than the pellet sensor. The sensing response was in the order Cl_2 > ammonia > LPG > O_2. The maximum response of the $NiFe_2O_4$ thick film to Cl_2 and ammonia was 96% and 68%, respectively, at room temperature.

Keywords: Ni ferrite; Thick film; Gas sensor

1. Introduction

Now-a-days the vast growing industries, various machines and an increasing large number of vehicles are responsible for spoiling the healthy life of human beings and all living organisms. Air pollution is found to be very dangerous as it is related to the respiratory system. Some gases like CO, CO_2, H_2S and Cl_2 evolved are found to be very toxic and create allergic and respiratory diseases like asthma, allergic bronchial asthma, and rhinitis [1–4].

The need for a novel gas sensor capable of providing reliable operation in harsh environments is now greater than ever. Such sensors find a range of applications, including the monitoring of traffic pollutants or food quality with specially designed electronic noses [5,6]. Gas sensors based on metal oxides are commonly used in the monitoring of toxic pollutants and can provide the necessary sensitivity, selectivity and stability required by such systems [7]. Commonly used oxides include zinc oxide, titanium dioxide, iron oxide, tungsten oxide and tin oxide. These materials have successfully been employed to detect a range of gas vapours, particularly ethanol, methanol and propanol [8–10]. Spinels of the type $M^{2+}M_2{}^{3+}O_4$ attract the research interest because of their versatile practical applications [5–7]. In the case of M^{3+} = Fe, the resulting spinel ferrites having a general chemical composition of MFe_2O_4 (M = Mn, Mg, Zn, Ni, Co, Cd, etc.) are widely used as magnetic materials. Currently it is a topic of increasing interest to study the gas sensing properties of ferrites [8–10]. Gas sensing at room temperature is of great interest; most of the currently available sensors, expect a few types of polymer-based gas sensor operate at elevated temperature [11,12]. Thick film technology is often used to fabricate such sensors and possesses many advantages: for example, low cost, simple construction, small size and good sensing properties [13]. In addition, this approach provides reproducible films consisting of a well-defined microstructure with grains and grain boundaries that can be studied easily [14]. The reports on use of nanocrystalline $NiFe_2O_4$ in bulk and thick film form for gas sensing at room temperature are scant. Therefore, in the present study attempts are made to use of nanocrystalline $NiFe_2O_4$ in bulk and thick film form as gas sensing elements to sense Cl_2, ammonia, LPG and O_2 at room temperature. The sensing response is found to be different for different gases.

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