A Self-Heating Gas Sensor of SnO2-Based Nanoparticles Electrophoretic Deposited

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Abstract : The contamination of the environment has been one of the biggest problems of our time, mostly due to developments of many industries. SnO_2 is an n-type semiconductor with band gap about 3.5 eV and has its electrical conductivity dependent of type and amount of modifiers agents added into matrix ceramic during synthesis process, allowing applications as sensing of gaseous pollutants on ambient. The chemical synthesis by polymeric precursor method consists in a complexation reaction between tin ion and citric acid at 90 °C/2 hours and subsequently addition of ethyleneglycol for polymerization at 130 °C/2 hours. It also prepared polymeric resin of zinc, cobalt and niobium ions. Stoichiometric amounts of the solutions were mixed to obtain the systems (Zn, Nb)-SnO_2 and (Co, Nb) SnO_2 . The metal immobilization reduces its segregation during the calcination resulting in a crystalline oxide with high chemical homogeneity. The resin was pre-calcined at 300 °C/1 hour, milled in Atritor Mill at 500 rpm/1 hour, and then calcined at 600 °C/2 hours. X-Ray Diffraction (XDR) indicated formation of SnO_2 -rutile phase (JCPDS card nº 41-1445). The characterization by Scanning Electron Microscope of High Resolution showed spherical ceramic powder nanostructured with 10-20 nm of diameter. 20 mg of SnO_2 -based powder was kept in 20 ml of isopropyl alcohol and then taken to an electrophoretic deposition (EPD) system. The EPD method allows control the thickness films through the voltage or current applied in the electrophoretic cell and by the time used for deposition of ceramics particles. This procedure obtains films in a short time with low costs, bringing prospects for a new generation of smaller size devices with easy integration technology. In this research, films were obtained in an alumina substrate with interdigital electrodes after applying 2 kV during 5 and 10 minutes in cells containing alcoholic suspension of (Zn, Nb)-SnO_2 and (Co, Nb) SnO_2 of powders, forming a sensing layer. The substrate has designed integrated micro hotplates that provide an instantaneous and precise temperature control capability when a voltage is applied. The films were sintered at 900 and 1000 °C in a microwave oven of 770 W, adapted by the research group itself with a temperature controller. This sintering is a fast process with homogeneous heating rate which promotes controlled growth of grain size and also the diffusion of modifiers agents, inducing the creation of intrinsic defects which will change the electrical characteristics of SnO_2 -based powders. This study has successfully demonstrated a microfabricated system with an integrated micro-hotplate for detection of CO and NO_2 gas at different concentrations and temperature, with self-heating SnO_2 - based nanoparticles films, being suitable for both industrial process monitoring and detection of low concentrations in buildings/residences in order to safeguard human health. The results indicate the possibility for development of gas sensors devices with low power consumption for integration in portable electronic equipment with fast analysis. Acknowledgments The authors thanks to the LMA-IQ for providing the FEG-SEM images, and the financial support of this project by the Brazilian research funding agencies CNPq, FAPESP 2014/11314-9 and CEPID/CDMF- FAPESP 2013/07296-2.

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