A.V.V.M. Sri Pushpam College (Autonomous)
Poondi– 613 503, Thanjavur-Dt, Tamilnadu
(Affiliated to Bharathidasan University, Tiruchirappalli – 620 024)

3.7.1 Number of Collaborative activities per year for research/ faculty exchange/ student exchange/ internship/ on –the-job training/ project work

Collaborating Agency:

Dr. M. Sridharan Associate Dean Centre for Nanotechnology & Advanced Biomaterials and School of Electrical & Electronics Engineering, SASTRA University, Thanjavur.

Dr. K. Ravichandran
Associate Professor & Head
PG &Research Department of Physics
AVVM Sri Pushpam College (Autonomous)
Poondi-613 503, Thanjavur-Dt, Tamil Nadu, India.

Dr. M. Sridharan
Associate Dean
Functional Nanomaterials & Devices Lab
Centre for Nanotachnology & Advanced Biomaterials and School of Electrical & Electronics Engineering
SASTRA University, Thanjavur – 613 401.

Date: 23.07.2019

LINKAGE

For the year 2019-2020

Between

1. Dr. K. Ravichandran
   Associate Professor & Head
   PG & Research Department of Physics
   A.V.V.M Sri Pushpam College
   (Autonomous), Poondi – 613 503.

&

2. Dr. M. Sridharan
   Associate Dean
   Functional Nanomaterials & Devices Lab
   Centre for Nanotechnology & Advanced Biomaterials and School of Electrical & Electronics Engineering
   SASTRA University, Thanjavur – 613 401.

Considering the significance of the noble cause for the student community, we have come forward to collaborate with each other to exchange research knowledge, expertise, laboratory and library facilities to the process of scientific research and education in the field of materials science. The parties (mentioned above as 1. & 2.) have had preliminary discussion in this matter and have ascertained areas of broad consensus. The parties now therefore agreed to enter in writing these avenues of consensus, under a flexible linkage, and this project aims to fill the gap between knowledge demand and subject expertise related to the mentioned field.

Joint Responsibilities

- Sharing of laboratory facilities, library resources, database etc.,
- Joint Publication of research articles, books, magazines, bulletins etc.,
- Jointly organizing conferences, seminars, symposia and workshops.
- Submitting joint proposals for research funding from agencies like UGC, CSIR, DST and TNSCST.

Dr. K. Ravichandran

Dr. K. Ravichandran Ph.D.,
Head, Department of Physics
AVVM Sri Pushpam College (Autonomous)
Poondi, Thanjavur - 613 503
Tamilnadu, India

Dr. M. Sridharan

Prof.M.SRIDHARAN, M.Sc.,Ph.D.,
Associate Dean Research - SEEE
SASTRA Deemed to be University
Thanjavur - 613 401. TN, India.

Journal of Materials Science: Materials in Electronics
https://doi.org/10.1007/s10854-020-03875-w

Effect of La incorporation on the NH_3 sensing behaviour of ZnO thin films prepared using low-cost nebulizer spray technique

A. Jansi Santhosam[1,2] · K. Ravichandran[2] · Mohd. Shkir[3] · M. Sridharan[4]

Received: 6 March 2020 / Accepted: 26 June 2020

Abstract
Lanthanum-doped zinc oxide (ZnO:La) thin films were deposited using a nebulizer spray technique with La concentrations 0, 1, 3 and 5 wt%. The structural, morphological and gas sensing properties were studied. All the film samples exhibit considerable ammonia sensing ability. The gas sensing results show that the ZnO:La film with 3 wt% of La doping exhibits remarkable sensing response and fast response/recovery times (39 s/11 s) for 100 ppm of NH_3 at room temperature. The reasons for the enhanced sensing ability of the doped films have been addressed with the help of the underlying mechanism, atomic force microscopy (AFM) and photoluminescence (PL) results.

1 Introduction

Ammonia is one of the toxic chemicals that cause severe health issues. For human being, the acceptable limit of ammonia inhalation is 50 ppm (Occupational Safety and Health Administration—OSHA) [1]. Chemiresistive gas sensors are widely used in the detection and control of such toxic gases at room temperature as these sensors are low in cost and can be prepared using simple techniques.

Metal–oxide semiconductors such as SnO_2, ZnO, TiO_2, NiO, WO_3 and CuO have been found to be promising materials for cost effective gas sensing [2–7]. Of these materials, zinc oxide (ZnO) can be used to detect various gases which include ammonia, acetone, ethanol, hydrogen and formaldehyde [8–12]. This material offers several advantages: low cost, available in abundance, non-toxic (GRAS—Generally Recognized As Safe by the U.S. Food and Drug administration) and can sense several gases at different operating temperatures [13].

Currently, several synthesis routes namely, sol–gel dip coating, atomic layer deposition, nebulizer spray pyrolysis, sputtering and solution combustion are employed to deposit thin-film gas sensors [14–18]. Among the various techniques, nebulizer spray pyrolysis offers several advantages such as large area deposition, low operating temperature, easy doping and flexible process parameters [19]. In the past few decades, many researchers have focussed on the addition of rare-earth elements with ZnO to achieve better gas sensing abilities.

Jeong et al. reported that La-doped ZnO nanopowders exhibit reasonable response and recovery times (90 s and 38 s) for 5000 ppm of CO_2 [20]. Similarly according to Kai fan et al., La_{1-x} Sr_x-doped FeO_3 nanocrystalline powders show considerable gas sensing response and recovery (11 m and 15 m) for 2000 ppm of CO_2 [21]. However, to the best of authors' knowledge, reports on La-doped ZnO thin-film sensor for ammonia sensing are scarcely available in the literature.

Keeping these points in mind, in the present study, lanthanum-doped ZnO thin films have been prepared using nebulizer spray method, and the effects of La doping

✉ K. Ravichandran
kkr1365@yahoo.com; kkravi1365@gmail.com

1 Research Department of Physics, Kunthavai Naachiyaar Govt. Arts College for Women (Autonomous), (Affiliated to Bharathidasan University, Tiruchirappalli.), Thanjavur, Tamil Nadu 613 007, India

2 Materials Science Research Laboratory, PG and Research Department of Physics, A.V.V.M Sri Pushpam College (Autonomous), (Affiliated to Bharathidasan University, Tiruchirappalli.), Poondi, Thanjavur, Tamil Nadu 613 503, India

3 Advanced Functional Materials & Optoelectronic Laboratory (AFMOL), Department of Physics, Faculty of Science, King Khalid University, P.O. Box 9004, Abha, Saudi Arabia

4 Functional Nanomaterials & Devices Lab, Centre for Nanotechnology & Advanced Biomaterials and School of Electrical & Electronics Engineering, SASTRA Deemed To Be University, Thanjavur, Tamil Nadu 613 401, India

Published online: 07 July 2020

Surfaces and Interfaces 18 (2020) 100412

Contents lists available at ScienceDirect

Surfaces and Interfaces

journal homepage: www.elsevier.com/locate/surfin

Effect of tungsten doping on the ammonia vapour sensing ability of ZnO thin films prepared by a cost effective simplified spray technique

K. Ravichandran[a,*], A. Jansi Santhosam[a,b], M. Sridharan[c]

[a] Materials Science Research Laboratory, PG and Research Department of Physics, AVVM Sri Pushpam College (Autonomous), Poondi, Thanjavur, Tamil Nadu 613 503, India

[b] Research Department of Physics, Kunthavai Naachiyaar Govt. Arts College for Women (Autonomous), Thanjavur, Tamil Nadu-613 007, India

[c] Functional Nanomaterials & Devices Lab, Centre for Nanotechnology & Advanced Biomaterials and School of Electrical & Electronics Engineering, SASTRA Deemed to be University, Thanjavur-613 401, India

ARTICLE INFO

Keywords:
ZnO
Spray pyrolysis
Ammonia
Vapour sensor

ABSTRACT

Tungsten (W) doped zinc oxide films (WZO) are deposited using a simplified spray technique with perfume atomizer for gas sensing application. Tungsten doping concentration is varied as 0, 0.5, 1 and 1.5 at.%. Ammonia vapour sensing ability of the prepared samples is studied at room temperature using chemi-resistive method. The results reveal that all the films have good ammonia sensing behaviour. Amongst all the films 1% WZO sample shows the fast response, recovery and high sensing response even towards low concentration of ammonia. The AFM results reveal that 1% WZO sample has maximum roughness and porosity and PL results demonstrate that 1% WZO sample possess more number of oxygen vacancies and zinc interstials which are the major causes for the enhancement of sensing ability.

1. Introduction

Air pollution affects not only the human health but also the ecosystem. Health issues caused by pollution in air include respiratory related problems such as suffocation and asthma as well as cardiac problems. By "World Health Organization 7 million premature deaths are caused by air pollution in the year 2012" [1]. Therefore, it has become essential to monitor and control the harmful gases. Hectic research activities on gas sensors are hence going on globally. Semi conductor oxide based chemi resistive vapour sensors are the most widely used devices for sensing the harmful gases.

Zinc oxide is one of the important semiconductors generally used for effective gas sensing as it offers several advantages such as chemical stability, high exciton binding energy, non toxicity, bio compatibility and higher number of oxygen vacancies to adsorb more electrons [2,3]. Due to these advantages, ZnO based gas sensors are used to detect harmful gases such as CO, ethanol, NH_3, H_2S and NO_2. Among these gases, ammonia (NH_3) is problematic to human body which gives coughing, nose and throat irritation even at low concentration. Therefore, it is important to control leakage of ammonia gas in air [4].

Even though ZnO has several advantages, there is a need to enhance its performance by doping with different metals such as noble or transition metals or with some other metal oxides. Doping of transition metals such as Mn, Cr, W, Co and Ta can constructively change the properties related to stoichiometry of ZnO and increases the surface defects such as carrier density and oxygen vacancies which can enhance the gas sensing performance [5].

ZnO thin films has been prepared by methods such as sputtering, hydro thermal, spray pyrolysis and sol-gel [6–9]. Of these perfume atomizer spray technique is one of the simple methods due to its advantages: simple, easy doping, low cost, adjustable parameters and risk free while preparing the samples [10].

In the present work, perfumed atomizer spray was employed to deposit tungsten (W) doped ZnO thin films (WZO) which could detect ammonia vapour even very low concentrations at room temperature.

2. Experimental details

2.1. Film deposition

Pure and WZO thin films (doping percentage 0.5, 1 and 1.5 .at%) were prepared using spray pyrolysis with the help of perfume atomizer reported in our previous study [11]. The deposition parameters are given in Table 1.

* Corresponding author.
E-mail address: kkravi1365@gmail.com (K. Ravichandran).

https://doi.org/10.1016/j.surfin.2019.100412
Received 25 August 2019; Received in revised form 25 September 2019; Accepted 19 November 2019
Available online 20 November 2019