Humidity Sensing Propertiesof PANI Doped Zinc Oxide Nanocomposites Thick Film Sensor

T R Ingle[1], R M Agrawal[2], G T Lamdhade[3], R J Gajbe[4]
1,3Department of Physics, Vidya Bharati Mahavidyalaya, Camp, C. K. Naidu Road, Amravati(M.S.)
2Department of Physics Shri R.L.T.College of Science, Civil Lines Road, Akola,(M.S)
4Department of Electronics, Vidya Bharati Mahavidyalaya, Amravati M.S. India
CorrespondingAuthors:Email:ingletr@rediffmail.com(T.R.Ingle),gtlamdhade@rediffmail.com, oumgajanan@gmail.com
(G.T.Lamdhade)Mob.+919403000509

Abstract

Over the last decades a variety of chemical sensors have been developed based upon semiconductors, which monitor different characteristic sensor properties such as conductivities for electronic conductivity sensors. In the present work Polyaniline is prepared by polymerizationof aniline under acidic condition. Zinc Oxide (ZnO) nanopartical prepaired by wet chemical method at room temperature using zinc nitrate and sodium hydroxide as starting material . ZnO nanoparticles were combined with conducting (PANI) polymer via polymerization in acidic aqueous solution to obtain a new type of inorganic – organic composites nanostructured . It is observed that PANI doped ZnO nanocomposites sensor shows a high response and sensitivity with good repeatability as compared to that of purePANI and ZnO nanoparticle.Theeffect of hysteresis is of the sensors, theeffects of pure and composite oxide on sensitivity of the sensors were studied. The crystallinity and the crystallite size were examined byX-Ray Diffraction technique.

Keywords: Polyaniline ,Zinc Oxide Nanocomposites,Humidity sensor.

1. Introduction

There is a growing demand for a sensing system that has high sensitivity, wide dynamic range, good stability, quick response, good reproducibility, simple structure and minimal cost. Metal oxide films sensitive to humidity have been reported earlier where sensing has been done using optical means. However, metal oxide humidity sensors depending upon measurements of electrical parameters require high temperature operation and consume significant amount of power.Humidity control and monitoring are of great interest to a wide area; these include moisture sensitive products, fresh and pack-age food, drug storage and environmental control for valuable Antiques or paintings etc. [1, 2]. Humidity sensors that are available in the market include dew point, infrared, catalytic and tin oxide-basedsensors, which may be expensive, or require high temperature operation and consume significant amount of power and high cost ofmaintenance [3].Much research has been focused on the development of humidity sensitive material [4–6]. Among these are the investigation of using conducting polymers such as polyaniline, polypyrrole, and polythiophene for humidity and gas sensing [7–9]. Advantages with polymers as sensing materials are light weight, flexible, low cost and simple fabrication process [10]. Pure polymer, polymer blends and polymer–inorganic composites have also been studied for the purposes, resulting in different degree of advancements in this area [11–16].

2. Synthesis of Material:

A) Synthesis of Polyaniline (PANI): In general is synthesized using two major polymerization approaches: electronic and chemical polymerization. In the present work polyaniline is synthesized by chemical polymerization method in which 0.2 M aniline hydrochloride is used as monomer unit. The synthesis is done by oxidative polymerization with 0.25 M ammonia peroxysulphate in aqueous medium. Bothsolutions kept 1 hour at room temperature then mixed in beaker, briefly stirred. And left at rest to polymerized , next day, the pani precipitate was collected on a filter , washed with three 100 ml portion of 0.2 M HCL and similarly with acetone . polyaniline hydrochloride powder was dried in air and then in vaccum at 60°c. Polyaniline prepared under these reactions and processing condition are further referred to as standard sample.

B) Synthesis of Zinc oxide (ZnO): It is prepared by the aqueous solution of zinc nitrate. And ispreparedbydissolving 0. 2M of zinc nitrate hexahydrate in 100 ml of distilled water .To this aqueous zinc nitrate solution 0.2 M sodium hydroxide is added and the reaction mixture was heated at 80°c along with stirring and the process is carried out for four hour after which the white precipitate was obtained. The formed oxide wet precipitate is centrifuged Then the wet precipitate is washed with de-ionized water to remove impurity ions present in it and further heated in the oven at 150°c to dry the precipitate formed.

Characterization :The above synthesized PANI-ZnO composites are structurally and surface morphologically characterized by using different technique like X- ray diffraction (XRD),the x-ray diffraction patterns of the prepared samples are obtained by Siemens D 5000 X-ray diffractometer using CuKα radition (λ =1.717 A°). The diffractograms are recorded in terms of 2ϴ in the range 40°-50° at ambient temperature with scanning rate of 2° per minute .The surface morphology of polyaniline and its composites are studied by using Leica's SEM (modal S 440) at 10kv.

Result And Disscusions:

XRD Pattern of ZnO

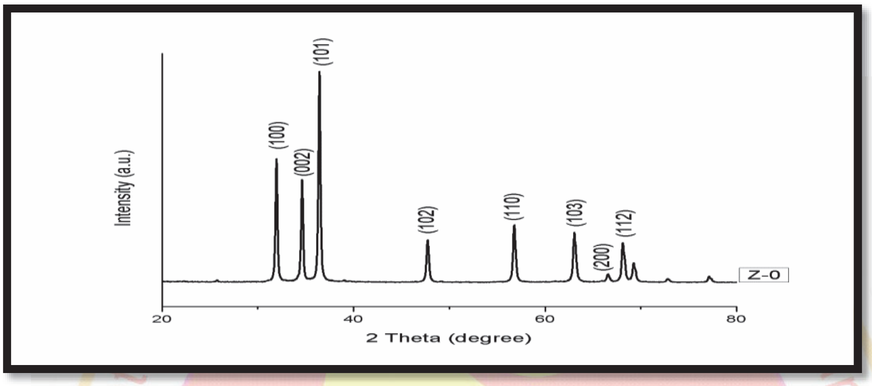

Fig. 1 XRD of Pure ZnO

XRD pattern of pristine zinc oxide (ZnO) nanostructure synthesized by liquid phase method via chemical wet reaction method were calcinated at 800°C as shown in figure 1.The crystalline nature with 2θ peak lying at (100), (002), (101), (102), (110) and (103) planes. All the peaks match well the standard hexagonal wurtize structure of zinc oxide (ZnO) with lattice constants a = b = 0.3249 nm and c = 0.5206 nm [JCPDS card no. 36-1451]. All the peaks are perfectly match with pure ZnO structure, which indicates the high purity of the obtained ZnO nanoparticle. The average crystalline size was found to be 37.38 nm calculated by Deye-Scherrer formula.

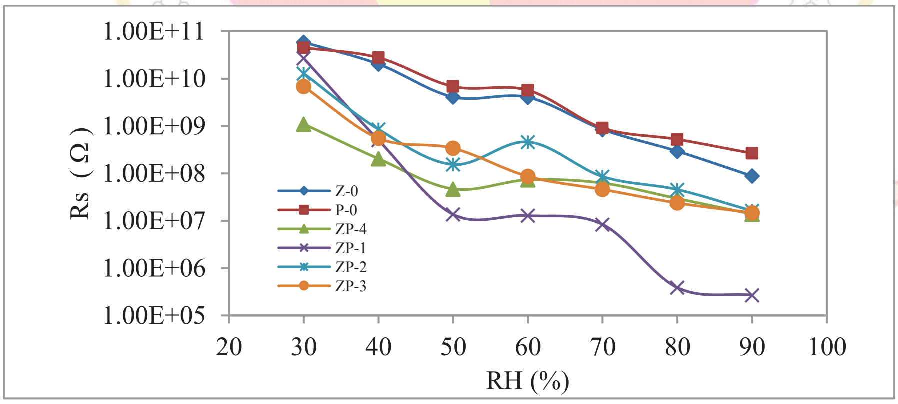

Figure: 2 Hysteresis plot

Hysteresis plot shows the variation between resistances of sample with respect to the relative humidity in increasing and decreasing order from 30 to 90 % RH as shown in the fig. 2. A very small hysteresis present during forward and reverse cycle of relative humidity, where as a very significant average change observed in the value of resistance of sample, in the sample ZP-1 (10ZnO – 90PANI) the change in value of resistance is from $10^{11}\Omega$ to $10^{5}\Omega$, these is a remarkable change in the value of resistance.

Sensitivity

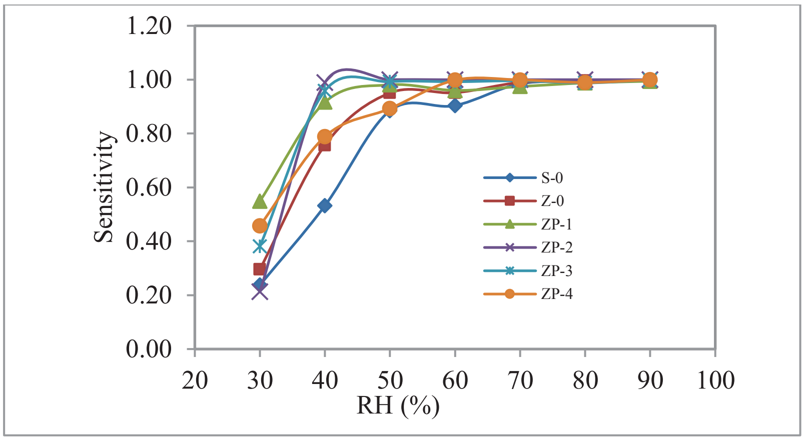

Figure: 3 Variation of sensitivity with Relative Humidity

In the above samples the sensitivity is found to be increasing with the RH for all the samples of thick films and it is increasing up to some particular RH and then afterward it remains constant as shown in fig. 3 For higher RH the sensitivity is found to be higher in case of all samples of thick films. The sensitivity of ZP-1 (10ZnO-90PANI) is more than ZP-2, ZP-3, and ZP-4 samples and also from the pristine samples P-0 and Z-0. The (ZnO-PANI) composite sensors exhibits significantly higher sensitivity than sensor constructed specially from ZnO nanoparticles and PANI itself due to the formation of heterogeneous interface between them and more adsorption site was created to absorbed more water vapours.

5. Conclusions:

Nanostructured ZnO was successfully prepared via chemical precipitation method and PANI with IUPACpolymerization technique. Minimum crystallite size was found to be for ZnO is 37.38 nm. The Hysteresis plot shows very significant average change in the value of the resistance from$10^{11}\Omega$ to $10^{5}\Omega$during forward and reversed cycles of sampleZP-1(10ZnO-90PANI). The sensitivity is found to be increasing with the RH for all the samples of thick films and it is increasing up to some particular RH and then afterward it remains constant.Amongst all the prepared samples ZP-1 is more sensitivity than other prepared composite samples.

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