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A Review: Design and Fabrication of Gas Sensor using Sol-Gel Spin Coating Technique for the Detection of Ethanol

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Abstract

The sensor is an important part of daily activity. The sensor has already been commonly used for a variety of various applications such as medical technology, aerospace, etc. In manufacturing, on the other hand, the devices are used to analyze certain ambient parameters including temperatures, humidity, etc. Gas sensors are one of these groups, used to detect the existence of gases. Most factories manufacture ethanol as one of their bi-products. Ethanol induces skin inflammation and triggers asthma to people employed in business, and drug misuse influences the actions of consumers that intensify society's crime and injuries. The largest proportion of ethanol is present in alcoholic drinks. Therefore, it is important to keep track. Because of the tremendous motivation in nanotechnology over time, gas sensors are chosen to identify gases. In the paper, a survey has been done on various gas sensors and concluded that zinc oxide thin film has been structured and manufactured using a novel method of sol-gel to recognize ethanol vapors at RT. Thin-film deposition can be achieved in two ways i.e. chemical vapor deposition (CVD) and physical vapor deposition (PVD). CVD is favored in dealing with low-cost chemical solutions. Using Scanning Electron Microscope (SEM) the structural and morphological characteristics can be analyzed. Various sensing parameters such as reaction time, sensitivity and recovery period can be calculated at room temperature.

Keywords: Substrate, sol-gel, ZnO thin film, ethanol vapor, sensing parameters.

1. INTRODUCTION

Ethanol is a chemical compound derived from alcohol with formula C2H6O. Ethanol is an unstable, fuel-efficient and dreary fluid with a slight odour. Ethanol is produced by yeasts fermenting the sugar or by photochemical technique.

Heavy ethanol intake causes adverse effects on the human body. Ethanol contributes to obesity, hepatic and cardiovascular illness and lack of intellectual function that may end in accidents. Therefore, measuring the presence of ethanol in the human body plays a very important function.

Detection of ethanol may be performed using various techniques. Ethanol vapors in the soil can be quickly detected thanks to developments in nanotechnology and VLSI technologies. Gas sensors are the best choice of interest for those purposes. Owing to their large sensing capacities of specific analytes, metal oxide-based gas sensors have gained more popularity in recent years.

The ZnO sensors are commonly used to measure ethanol. ZnO thin film be able to synthesized using various methods such as chemical vapor deposition, sol-gel spinning, electrospinning, sputtering, and so on. It is established from previous studies that Zinc oxide (ZnO) possesses good electronic properties, good compatibility, and chemical stability which makes it suitable for application sense. Furthermore, numerous studies further detailed that at room temperature, ZnO is highly sensitive towards ethanol.

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2. LITERATURE SURVEY

H. Shokry Hassan et al [1] examined the synthesis of un-doped and in-doped ZnO like nano-particles and nanorods using the sol method were published. Here they have an optimized impact on the highest sensitivity of unusual doping ratios of indium as a dopant product. Using a scanning electron microscope, the morphological structures of prepared doped and undoped ZnO have been identified. For the produced gas sensor systems, the gas exposure for O2, CO2 H2 gases has been calculated.

Shashikant V et al [2] examined the creation of the current methodology for gas sensors by definition, evaluation and contrast. Detailed introduction to the sensing methods and stated sensing technology classification. Sensing equipment was used to track the petrol. Gas sensor manufacturing is progressing with material science and semiconductor innovations being developed in operation. In this paper, he analyzed different gas sensors in terms of their low strength, compact size volume, fairly low-cost capabilities.

Nilam B et al [3] worked on a ZnO thin film sensor formed by a sol-gel spin coating method on a glass substratum for detection of NO_2 was introduced. The developed sensor displays reactions when uncovered to NO_2 gas at operating temperatures of 200°C. They used the sol-gel spin coating technique because it has numerous advantages such as low expense, low annealing temperature, wide-area film production, easy working theory and modifications to the composition. They examined numerous parameters of gas sensing such as reactivity, stability, efficiency, time for response/recovery and responsiveness.

Brij Bansh Nath Anchal et al [4] studied to detect LPG gas by producing Zn 0.97 Fe 0.03 O nano-raw thin film utilizing high rpm electro-spin technique. LPG sensing is tested in the gas sensing device at varying concentrations of 100ppm, 300ppm and 500ppm at 50 ° C. They used zinc oxide doped with iron to layer thin film on the substratum. Thin-film deposition utilizing spin coating is standard smooth and minimal ruggedness. Due to this spin-coated, the adsorption sites of gas molecules increase in uniform and smooth thin film, which is ideal for developing a thin film on substrates at low cost and low power dissipation than the sputtering technique.

M. R. Alfaro Cruz et al [5] presented thin films collected using a sol-gel process. The thin film may be collected by different methods of deposition, be it by chemical or physical processes. The most critical aspect of thin-film research is morphology that defines the properties of a thin film. Thin-film morphology varies according to deposition techniques employed.The synthesis is conducted using spin coating and dip coating techniques using a sol-gel process. They used Atomic Force Microscopy (AFM) to do the surface study.Here they provided the CuO-SiO 2, Fe- SiO 2 and ZnO surfaces collected by the sol-gel process and coated by the techniques of spin and Dip coating.

Gaurav Bahuguna et al [6] analysis thin film coating by sol-gel method, showcasing coating technologies utilizing sol-gel driven precursor, offering strong homogeneity, low-temperature processing and numerous other benefits. We addressed different methods of thin film deposition such as spin-coating, dip-coating and their use. The synthesizing process of the materials is based on a phase transfer of the sol derived from precursors of metallic organometallic or alcoxides. At low temperatures, the sol collected is polymerized. Throughout exposure to normal ventilation, the solvent is removed to create a dry gel.

Yusnita Yusuf et al [7] Presented thin-film processing of Nickel Zinc Nano ferrite (Ni 0.3 Zn 0.7 Fe 2 O 4) utilizing the spin-coating technique. This paper describes a basic technique of the sol-gel precursor system

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for the manufacture of NiZn Nano ferrite (Ni 0.3 Zn 0.7 Fe 2 O 4) thin film and spin-coating system in a chemical solution coating cycle. This approach can be extended to thin films of NiZn Nano ferrite both for low-temperature deposition and crystallization. They had the framework shaped in the thin film which is a natural feature of the sol-gel-derived film. Sol-gel spin-coating process has been able to generate specific ferrite thin film patterns and behaviors, among others.

Amit Kumar et al [8] explained about uses of sol-gel related nanomaterials.This analysis includes the sources, manufacturing, applications and advantages of sol-gel techniques. Through this step, the monomers are converted into a sol, i.e., a colloidal solution that is the precursor to more gel-forming. They also clarified phases including blending, spinning, gelation, aging, drying and densification of sol-gel processes.

Aslim Jilani et al [9] reported on advance thin film and coating deposition techniques. In specialized applications such as optical devices, environmental technologies, telecommunications devices, energy storage devices and so on, thin films play a significant role. Based on their shape and durability the problems around thin-film manufacturing emerge. In this study, they addressed in depth the strategies of vacuum thermal evaporation, evaporation of electron beams, deposition of pulsed membranes, sputtering of direct current/radio frequency magnetrons and deposition of chemical paths.

K. M. Wibowo et al [10] suggested the impact of annealing temperature on aluminum thin film structural and electrical properties. Small AI films are deposited by thermal vacuum evaporators on the glass substrate. Then they annealed the films for 1 hour at 100 °, 200 °, 300 °, 400 ° and 500 °. Using the atomic force microscope (AFM), and field emission scanning electron microscope (FESEM), the surface morphology of AI thin films after annealing was described. When the samples become annealed, which relies on roughness, from 100 ° to < 400 ° C. If annealed from 400 ° to 500 ° C the resistivity shows depend on the scale of the plant.

Q. Nguyen Minh et al [11] worked on Interdigital nanogap electrodes with gaps of 50-250 nm that were developed and processed at a maximum wafer scale as discussed in this research. Such nanogap IDEs were then coated with poly as a flexible layer for shaping low concentration gas sensors for acetone detection. This technique may also produce addressable, large-scale, high-density nanogap electrodes through traditional micro-manufacturing methods. Growing the region in which the nanogap IDEs framework was processed could further improve sensitivity.

J.Q. Wang et al [12] examined Chemiresistive gas sensors with low power consumption, fast response and efficient manufacturing processes for a particular target gas for many applications. They need both responsive nanomaterials for heating and electrical addressing and an effective substratum device. Here, the construction of gold (Au)-loaded ZnO / SnO2 core-shell nanorods successfully manufactured a near-room working temperature and quick reaction triethylamine gas sensor. With a cost-effective hydrothermal technique, ZnO nanorods formed directly on the Al2O3 flat electrodes.

N. D. Khoang et al [13] worked on nanostructured materials to improve gas-sensing performance is a significant key for sensor systems of the next decade. A hierarchical SnO 2/ZnO nanostructure architecture for the efficient manufacture of high-performance ethanol sensors is built in this paper based on a combination of two basic synthesis pathways. High-quality single-crystalline SnO 2 nanowire (NW) backbones were first synthesized using the thermal evaporation process, while branches of ZnO nanorod (NR) were subsequently grown perpendicularly to the SnO 2 NW axis using the hydrothermal approach.

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May Ali et al [14] explained about the detailed analysis of three distinct process variables was performed to maximize the optimal production of multilayer graphene (MLG) thin films grown over a Co-Ni catalyst backed by alumina substrate. The three parameters considered were the temperature of the reaction, the structure of a catalyst and the flow rate of ethanol. The optimization approach was used to ensure good efficiency in the experimental ranges used and to test the interactive effects of the three parameters for future gas-sensing applications on the MLG yield of the ethanol-based chemical vapor deposition (CVD) system.

Aleem Anwaar et al [15] explained that plasma spray physical vapor deposition (PS-PVD) is a popular strategy for the development of strain-tolerant and non-linear thermal barriers (TBC) coatings. This fills the difference between traditional plasma spraying and actual vapor deposition via electron beams (EB-PVD). Throughout this analysis the influence of different Ar / He plasma compositions on 7~8 wt particle properties and coating morphologies. Partially stable zirconia (YSZ) yttria percent is examined. The plasma properties at different gas concentrations were determined by reducing free energy from Gibbs under conditions of chemical equilibrium.

Darius Gailevicius et al [16] explained the concept of angular, or equivalently – spatial, filtering by photonic crystals (PhCs) is based on selective diffraction of the light propagating across the photonic system of the double-time. The angular components of incident light at equilibrium with the structure's transverse and longitudinal periodicities essentially diffract and are excluded from the emitted beam's zero-diffraction sequence.

Awani Khodkumbhe et al [17] analyzed Acetone makes up 58 percent of the volatile organic compounds of human blood. Acetone at breath is a biomarker for type I diabetes. A portable and flexible metal oxide semiconductor-based gas sensor with thin-film Tungsten Oxide (WO3) as the sensing layer was used to calculate acetone concentration in air. When acetone gas is a reducing chemical, the resistance of thin-film reduces as the sensor falls in contact.

Sugato Ghosh et al [18] analyzed the Commercially accessible sensors that were found to be immune to their target gases but less precise. The authors also developed ZnO dependent sensing materials to selectively detect methane, carbon monoxide, and hydrogen sulfide from a mixture of gases to enhance selectivity. The materials were considered extremely reactive and stable at either room temperature or about 1000C at low operating temperatures against their target gases. Various surface stimulation methods such as plasma treatment were used to improve the selectivity of the sensing materials utilizing composite materials.

Khue T. Lai et al [19] worked on thin films of varying thickness of beta-gallium oxide (Ga2O3) that may be produced through a process of physical vapor deposition, utilizing suitable annealing conditions. This helps one to compare the variance of optical properties in such phases as clarity, band distance. Our study of the transmittance spectra of beta-Ga2O3 revealed a decrease in structural abnormalities (amorphous to crystalline) with a rise in the temperature of the annealing.

Przemysław Płociennik et al [20] examined innovations require in thin films for different applications. Throughout the areas of optoelectronics, photonics, photovoltaics, and magnetic systems, thin-film films are critical components of scientific advancement. Content processing into thin films allows for fast incorporation into various forms of products. While analyzed in the context of thin films the material's properties vary greatly. Thin-film techniques allow the use of the assumption that the properties can be

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effectively managed by layer thickness. Thin films are created through physical or chemical methods mainly by deposition.

Artur Rydosz et al [21] suggested that the gas sensing applications, thin films of CuO and CuO / TiO2 were deposited through medium frequency magnetron sputtering on a variety of substrates. Film analysis was achieved by X-ray diffraction, XRD, electron microscopy scanning, SEM, and optical spectrophotometry. Gas sensing experiments were conducted at a steady temperature of 200-400 ° C in the NO2 and H2 atmosphere. For CuO / TiO2 thin film heterostructures, improvement in sensor response has been observed.

Jeong-Ho Park et al [22] examined the device for a three-electrode metal-oxide gas sensor with CMOS Interface IC. The suggested device adopts a switching scheme utilizing pulse-width modulation signals to monitor the heater temperature and simultaneously calculate the sensor's resistance in real. Also, the switching approach will solve the sensor's electro-asymmetry problem. The mode-adjustable integrater protects a large range in the sensor resistance. The proposed device achieves temperature stability up to 250 ° C and the sensing material's observable resistance range from 80 ohms to 2 Mohms with a relative error of less than 1.5%.

Xiping Song et al [23] worked on Magnesium nanowires with various morphologies were effectively prepared using the process of physical vapor deposition, and the factors of effect on the creation of these magnesium nanowires were addressed.

Stephan Schroder et al [24] described a novel and very easy manufacturing approach for using modern wire bonding technology to realize amperometric gas sensors. Working and counter electrodes are constructed of 360 vertically standing bond wires, fabricated entirely by a regular completely automatic wire bonding device. Our procedure allows for 1,24 mm long-standing bond links, resulting in an incredibly large aspect ratio of 50, thereby significantly expanding the surface area of the operating electrode. Both electrodes for gas sensors are mounted in a solid electrolyte dependent on polymers.

S.K. Speransky et al [25] demonstrate the presence of fractal structures on the thermal oxidized air, with specific quantitative parameters. By utilizing neural networks in the control loop, we suggest a modern solution to the automation of such systems. It will allow manufacturers to decide the parameters of the coating method to achieve different profile roughness, and the required output of experimental samples was produced from titanium VT1-00. The resulting formulation of oxide coatings was performed on titanium samples utilizing the air-thermal oxidation process.

A. Zawadzka et al [26] explain the procedure of physical vapor deposition and its application to the chosen method of deposition of organometallic thin films. We analyze tests of the structural and optical properties of metal-containing thin films (M = Zn, Cu and Al) and bis- or tris (8-hydroxyquinoline). Physical vapor deposition (PVD) technique successfully grown the films in the high vacuum on translucent (quartz) and semiconductor (n-type silicon) substrates held at room temperature throughout the deposition process. After processing in an atmospheric environment selected films are annealed for 24 hours at temperatures equivalent to 50 ° C, 100 ° C and 150 ° C.

Kai Zhang et al [27] worked on the globular black-white catalytic gas sensor that has been getting the problems of assembled, large-element dispersion, and matching difficulties for decades. To address these issues, a concept of combining responsive components with catalytic sensors and mitigation components

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together into a chip is suggested using the combination with silicon-based MEMS technology and nanometer technology. Active carriers are produced using chemical co-precipitation methods and ThO2+CeO2 stabilization modifications using cheating technologies (Pd and Pt as catalysts).

Xiping Song et al [28] Many unknown variables impact Body-centric Wireless Contact (BCWC). The purpose of accessible propagation models is to describe the conduct of radio propagation for a specific scenario; the model selection is focused on the a posteriori awareness of previous experience. In this paper, the 41-norm probability propagation model, which is independent of a posteriori information, was developed to generalize established parametric propagation models. In the time-domain estimation of finite-difference, Duke phantom was used as the carrier to test the concept centered on 41.

Claudio Zuliani et al [29] reports on the usage of a thermoelectric catalytic (TE) gas sensor based on CMOS for specific hydrogen and carbon monoxide detection. Using inkjet printing, palladium and platinum oxidation catalysts were used and sprayed onto substrates. The dissertation examines the impact on sensing efficiency particularly with gas sensitivity and selectivity of the catalyst and the operating temperature of the microheaters.

K.L. Foo et al [30] suggested a clear ZnO thin-film semiconductor was prepared using a sol-gel process, utilizing ethanol as solvent. The thin film was then placed on the interdigital electrode. Over 2 hours the accumulated thin ZnO film was annealed in the furnace at 350 ° C. The ZnO thin film studied the effects of surface morphologies and substrate properties. Using FESEM they studied the morphologies of the annealed ZnO video. The XRD result shows that the thin film ZnO was similar to a single crystalline structure which, after annealing, focused at the surface.

3. CONCLUSION

The ZnO sensor is fabricated using sol-gel spin coating technique working at room temperature. The substrate used is non-conducting material thereby, the fabricated sensor is not affected by external temperature. The influence of catalyst and surfactant, in prepared sol-gel, reduces surface tension and enhances the chemical reaction. The ZnO sensor is sensitive to ethanol and also to other analytes, but the ratio of sensitivity is high for ethanol. Ethanol exhibits a response of 50.1% at 100 ppm concentration. The sensor detects the low concentration of ethanol. As a result, the ZnO sensor is used in many applications like drink-drive cases, industries, etc. The sensor is working at room temperature, so no requirement of the heating circuit. Therefore, the power consumption is less. Thus, the sol-gel synthesized ZnO sensor may be used for ethanol sensing applications at room temperature.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interest.

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