Recent Trends in Thin Film Ammonia Gas Sensor for Medical Applications

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***Abstract*— Ammonia is corrosive in nature, effects the soil acidification, throat and respiratory tract infection, lungs damage or death. Ammonia gas sensor plays vital role in detecting ammonia concentrations. Ammonia gas detectors are an essential part of workplace safety. A thin film is a layer of material ranging from fractions of a nanometer to several micrometers in thickness. The gas sensor based on thin films is a low-cost fabrication and portable device to measure the ammonia concentration. The spray pyrolysis is a process in which thin film is deposited by spraying a solution on heated surface, where the constituents react to form a chemical compound. Interdigitated electrode is made up of two individually addressable interdigitated comb like electrode structures using silver paste. The analysis of body fluids like blood, sputum and urine for disease diagnosis and monitoring is routine clinical practice. Human breath analysis methodologies that exploit the non-invasive of such approach are still underdeveloped. The ammonia smell in the mouth of the kidney failure patients is associated with high levels of blood, urea and nitrogen. When the kidneys are not functioning properly, blood nitrogen will accumulate into the body.**

Index Terms: Ammonia gas sensor, thin film, V_2O_5, Spray pyrolysis, Inter digitated electrode.

I.INTRODUCTION

Ammonia gas sensor using vanadium pentoxide (V_2O_5) thin film for medical applications, the project is all about ammonia breath sensor which is used to detect only ammonia. To detect ammonia at a concentration of 1 ppm, use a source meter to measure the smallest amount of current while maintaining the voltage constant and the resistance changing. Arduino is an open-source electrical platform that uses simple hardware and software to make it easy to use. Light on a sensor can be read by Arduino boards. Arduino UNO with integrated development environment (IDE) tool is used for programming. The main benefit of an Arduino board is its speed and ease of use. Also, it can be used as a quick tool in the development of very large scale integration (VLSI), particularly for sensors, and it can make complicated things appear simpler and more interesting.

When Laviseir discovered carbon dioxide (CO) in the exhaled breath of guinea pigs in 1784, The invented the first breath testing instrument. Spray pyrolysis is a method of depositing a thin coating on a heated surface by spraying a solution on it. The ingredients react to generate a chemical product. Vanadiumpentoxide is a fascinating substance because it exhibits a high specific energy density, a high electrochemical activity, and a reversible to potactic reaction with lithium. A surface profile meter was used to measure the films.

II. LITERATUE SURVEY

Tariq Abdul et al [1] Optical devices with high gain and low noise are being developed. A gas sensor detects various gases in various atmospheres and converts chemical reactions into observable signals that can be analysed. For optoelectronic applications, there is a limit of low sensitivity and high operating temperature that is currently being investigated. Because of its layered structure and various valence states, the practical alternative semiconductor V_2O_5 was chosen. Spray pyrolysis was used todeposittheV$_2$O$_5$nanostructuresonwarmedglasssubstrates.Thermalevaporation,thesol-gelprocess, magnetron sputtering, chemical vapour deposition, electron beam evaporation, and spraypyrolysis are just a few of the processes used to make V_2O_5 thin films. X-ray diffraction (XRD) and FESEM characterisation are used to investigate the V_2O_5nanoparticles.

Aurangabad B et al [2] Zinc oxide (ZnO) is a semiconductor with outstanding chemical and thermal stability, low cost, abundant supply, environmental friendliness, non-toxicity, strong oxidising power, high photosensitivity, and radiation resistance. Spray pyrolysis is used to make thin zno films, both doped and undoped. ZnO thin films changes the properties of doping. ZnO is an appealing material for applications in hardware, photonics, acoustics, and detecting. Slender movies of ZnO may be fabricated by splash pyrolysis strategy. Doping of ZnO meagre movies changes the properties of ZnO slight movies.

Hslao wen Zan et al [3] Pentacene-based organic thin film transistors for ammonia sensing non-invasive ammonia sensors are attractive alternatives for the diagnoses of a variety of chronic diseases such as liver cirrhosis and renal failure. The presence of ammonia is a key indication of uremia and chronic liver disease. Cirrhotic individuals had much higher breath ammonia levels (0.745 ppm) than healthy people (0.278 ppm).Renal failure patients even exhale 4.8 parts per million of ammonia. Cirrhotic patients had a higher ammonia level of0.775 ppm. As indicated above for cirrhotic and renal failure patients, anadequate ammonia sensor for biomedical applicationsshouldbeabletodetect ammonia from roughly 0.5 to 5 ppm at room temperature. Because of its low-cost fabrication technique and excellent sensitivity to gas molecules, organic thin-film transistors (OTFTs) have been described as a non-invasive, inexpensive, portable, and disposable diagnostic device. OTFTs have a molecular active channel that allows them to respond quickly in both gaseous and aqueous sensing environments.

Rajendra kumar R T et al [4] V_2O_5 films are deposited on silicon substrates by vacuum evaporation technique at various deposition temperature of x-ray characterization. The influence of deposition temperature on the growth of the V_2O_5 films has been studied by Raman scattering spectroscopy. The films deposited on the silicon substrates maintained at 573K. Experiment by using vacuum evaporation technique, deposition of V_2O_5filmsonsiliconsubstratesandatvariousdepositiont emperatures of 300, 573, 623 and 673 K. Growth of V_2O_5 films has been studied by Raman scattering spectroscopy. Powder of V_2O_5 was used for deposition. In Raman spectra of orthorhombic V_2O_5 has vibrations are possible in 21 nodes. At the substrate temperature, the V_2O_5 films deposited of 573 K have better quality of structure.

GaneshanSetal[5] From the view point of novel electronic and optical characteristics in the formation of thin films, V_2O_5 is one of the important materials when compare to other metal oxides. The system of vanadium oxygen has studied intensively by theoretical and experimental techniques. The V_2O_5 thin film was created utilising a variety of physical and chemical processes, including thermal evaporation, electron beam evaporation, sol-gel, electrochemical deposition, and pulsed layer ablation.

Ukoba K.O et al [6] Metal oxide semiconductor films are commonly utilised in gas sensors. The film microstructure has a significant impact on the selectivity, response time, and sensitivity of such sensors. Several studies have looked into the formation of ZnO films. In the study, the effect of post annealing on the characteristics of ZnO films demonstrates that annealing improves film quality by reducing structural defects by aggregation of tiny particles. The influence of temperature on the structure of ZnO films has been explored, with results indicating that such films crystallise better at temperatures above 400°C. Metal oxides are mixed in sensor performance and thermal stability.

Tharsika T. et al [7] Based on the metal oxide nanostructures, the gas sensors have been used to emission control for applications ranging from health and safety. Sensors are more attractive because of high sensitivity, low cost, simplicity and compatibility. In numerous applications, the ethanol sensors were used, such as, to monitor chemical reactions, breath analysis, biomedical productions, and quality control of foods. For selective ethanol sensing sensor, lower sensitivity is one of the major drawbacks of the metal oxide-based sensors. With controllable morphologies, a simple spray pyrolysis and heating routet of abricateZnOnanorodonSnO_2 thin film.

Patil J.M. et al [8] The nano structured metal-oxides give a high surface area to volume ratio while preserving good chemical and thermal stabilities with minimal power consumption and low weight. Nanostructures were also used in the creation of gas. Nanostructures include metal-oxide nanorods, nanowires, and nanobers. Metal-oxide semiconductors have demonstrated good detection sensitivity, robustness, and the ability to with stand higher temperatures, and the method is widely used in a variety of air pollution monitoring systems, the food industry, medical diagnosis equipment, gas leak alarms to detect various types of toxic gases.

S. Santra et al [9] has explained about a room temperature ammonia gas sensor which can also be built with the help of carbon nanotube thin films. According to the transmittance measurement, the film is transparent to the visible spectrum when compared to air. As a result, a single-walled carbon-based nanotube ammonia sensor might be used to create a low-cost, flexible, foldable, and disposable sensor system. Ammonia in the environment must be maintained. This is where you'll find the sensing data. In order to stabilise the baseline signal, the sensors are routinely cleaned with nitrogen before being exposed to ammonia. This demonstrates that when the concentration of ammonia rises, so does resistance. As a result, CNT films' responses to ammonia are selective and rapid. As a result, the CNT sensor on flexible substrates might be used to create low-cost, disposable ammonia sensors.

Nagare A et al [10] has studied about Branched nanofibers polyaniline thin films are used to create achemi resistive ammonia gas sensor. Among the several poisonous gases, ammonia is one of the most toxic. This author emphasises the need for high-performance gas sensors. Using a dip approach, PANI films will be made by in situ oxidative polymerization of aniline monomer with variable oxidant concentrations on glass as a substrate. The deposited film will be later exposed to various tests such as FESEM, XRD and many other. At room temperature, the PANI thin film exhibits a selective response of up to 10 ppm. The sensitivity, response-recovery time, and selectivity of PANI film's gas sensing properties for various concentrations of NH3 gas are investigated. X-ray diffractometer will be used to identify structural analysis of PANI thin film. The resistance is evaluated in the pressure of air and the gas sensing performance of the PANI thin films is assessed using a computer controlled static unit.

Wu H et al [11] has given a detailed study and research related to highly sensitive ammonia sensor based on Tin Monoxide nano shells. Ammonia plays a vital role in the nitrogen cycle hence it is very essential to have ammonia sensors for the environmental protection as well as human health. It is well known that detecting ammonia concentrations of less than 50ppm is a difficult operation. Tinmonoxide is a member of the IV-VI metal monoxides, and its low cost and environmental friend lines smake it an attractive material for ammonia gas detection applications. The ammonia sensors in this study are made by self-assembly SnO nano shells using a solution technique and annealing at 3000Cfor an hour. Because of its curved form and wide surface area, the nano shell structure aids in the absorption of additional ammonia molecules. Compared to other metal oxide ammonia sensing materials, it has a higher oxygen vacancy. When compared to tin monoxide and tin dioxide, tin oxide is the most widely employed for ammonia gas detecting applications. Tinmonoxide is more stable and absorbs ammonia since it is manufactured at a low temperature.

P. Kathirvel et al [12] has made a spectral investigation of chemical bath deposited Zinc oxide thin films of ammonia gas sensor. In thin film transistor development, Zno thin films are known as an active channel material because they contain an n-type semiconductor with a band gap of 3.3eV and good thermal stability. Semiconducting oxide films are made using the chemical bath deposition process. In this approach, metal oxide is only formed when the substrate comes into contact with a chemical bath containing metal ions. When the solubility of the ions exceeds the solubility of the ions, a film is created. The chemical bath deposition method creates a layer on a substrate by allowing the material to precipitate in a controlled manner. Powder X-ray diffraction revealed that the film had a hexagonal structure with a C-axileorientation, according to the researchers. The properties of photoluminescence and gas sensing were also investigated.

Martins LD S et al [13] Because they can handle the light and heat that enter and leave a structure, electrochemical materials are a slim invention with a close relationship with ecological sustainability. Vanadium oxide films are electro- synthetically dynamic for lithium and electron counter coalition, resulting in minimal optical variation in low-energy apparent light, making them suitable for use asalatent anode in electro chromic devices. Although the spectrum two-fold ting of Vanadium oxide films has been examined, the monochromatic, specifically for high photon energy, has not. Heat treatment in an idle climate saved the electron shaft and modified the movies. The crystallographic stage transition should result in a monochromatic two-fold tint.

III. METHODOLOGY

Using pure V_2O_5 powder and a spray method, 423 nm thick V_2O_5 nanostructures were created on glass substrates. The spraying nozzle was 28 cm distant from the substrate, and the spraying solution included 0.1 M V_2O_5 powder dissolved in deionized water. X-ray diffraction (XRD) analysis was used to investigate the structural features of the thin films, while field- emission scanning electron microscopy was used to characterise their surface shape (FESEM, MIRA3 model, TESCAN). Spraypyrolysis was used to create V_2O_5 thin films. The films were homogenous and comprised V_2O_5phase with nanostructure grain size, according to structural and morphological characterisation.(particularly). V_2O_5 nanostructures on an oxidised p-type silicon substrate (SiO_2/Si) were used to create a highly sensitive V_2O_5/SiO_2/Si gas sensor. It was also established the properties of vanadiumpentoxide nanostructures with and without illumination of the sensing method. One of the applications of vanadiumpentoxide (V_2O_5) nanostructures is detection of both ethanol and acetone at low working temperatures. The indicated results in higher sensitivity in dark conditions under light illumination. V_2O_5 nano structures for detection of ethanol at low operating temperatures[1].

For both detection of acetone and Fe (iron) doped Zno (zinc oxide) thin films Fe is chemically stable and exists in two possible oxidation states, Fe^{2+} and Fe^{3+}, it is closed to ionic radius of Zn^{2+} without disturbing the crystal structure of Zno it can easily enter into Zn lattice sites either substitutionally and interstitially. For improved conductivity, Zno can contribute more charge carriers. Sol-gel, spraypyrolysis, hydrothermal process, electro deposition, and dip coating technique are some of thephysical and chemical procedures used to make Fe-doped Zno films. A simple, vacuum-free, andcost-effective spray pyrolysis technique is deposited using Fe-doped ZnO thin films. Both the undoped and doped Zno thin films exhibited x-ray diffraction patterns. Both undoped andAl doped films are transparent in the visible range, according to an optical analysis. With increasing doping concentrations, the conductivity of Al doped sheets increases by three orders of magnitude.[2].

OTFTs were fabricated on silicon substrates A highly doped p-type silicon wafer with 100-nm- thickSiO_2 was used as the gate electrode and gate insulator, respectively. Part of the SiO_2 with PMMA was exposed to UV-light. Electric properties of OTFT devices were measured by using a semiconductor analyzer (Keithley4200-SCS) in a sealed chamber. The inside total chamber-volume was 42L. To begin a measurement, the chamber was initially vacuumed to be less than 1 torrand then purged with high-purity (99.99%) nitrogen (N2) to 1 atm. Then, NH_3 gas (Air product, >99%) was injected through a mass flow controller (Brooks, MFC 5850E, USA) into the chamber during a controlled time period. The concentration of NH_3 gas in the chamber was calculated according to the chamber dimension as ppm unit (mg/L). Due to the simple fabrication processes of the devices, OTFTs are promising to be developed to a portable and disposable gas sensor [3].

Deposition is done with V_2O_5 powder. Thermal evaporation technique was used to deposit a V_2O_5 thin film. The films were deposited at temperatures of 300, 473, 573, 623, and 673 K on diverse substrates. Surface profile meter and multiple beam interferometry were used to determine the thickness of the films. With the help of Philips, the deposited films' X-ray diffraction (XRD) patterns were recorded. The surface roughness of as-deposited V2O5 films was measured using a profilometer and revealed a smooth surface with an average roughness of 3–4 nm. At varied deposition temperatures, V2O5 was deposited. Using XRD and RamanScattering data, a comprehensive structural investigation was carried out.AtTs = 573 K, the film was found to be highly oriented, with planes parallel to the substrate. The findings show that V_2O_5 films formed at a substrate temperature of 573 K have higher structural quality, andthat the structural degradation observed as the substrate temperature was increased beyond 573 K was likely attributable toan increase in non-stoichiometry[4].

The V_2O_5 film were prepared by electrode position method. The powder of V_2O_5 was mixed with hydrogen pentoxide and is used as a stock solution. The process of electrode position has follows three electrode system, one is ITO coated plate acting as working electrode, the second one was platinum electrode as counter electrode and the third one was the saturated calomel electrode (SCE) as the reference electrode[5].

A solution of precure which contains compounds of constituent reactant is atomized in a nozzle to tiny droplets and sprayed onto a preheated substrate. Between the precursors in the solution of droplets, the surface of the substrate must be sufficient hot to initiate reaction in chemical[6].

By spray pyrolysis, the ZnO/SnO_2 nanostructures were deposited on substrate of gold interdigitated alumina by using zinc acetate. A spray pistol was used to spray the combined solution directly onto the substrate after it was ultra sonicated for aminute. The sprayed films were annealed at 3500C for one hour. Thin films of ZnO and SnO_2 were also deposited [7].

Cleaning the substrate is critical for depositioning thin films. With a size of 25nm x 25nm x 1nm, they were cleaned with a soap solution, then maintained in hot chromic acid before being rinsed with deionized water. The substrate has previously been cleansed with deionizedwater[8].

The dip approach was used to make single wall carbon nanotubes (SWCNTs). 5mg of SWCNT powder is dissolved in aqua regia, rinsed with distilled water until the pH value reaches 7.0, and thenadded totheacetone. Finally, a transparentsheetwasused[9].

PANI film made by altering molar concentrations of ammonium persulphate in a chemical oxidativepolymerization technique. An X-ray diffractometer is used to examine the structural integrity of deposited PANI films, and a computer-controlled static gas sensing device is used to assess gas sensing capability[10].

A solution technique and annealing at 30°C are used to build a highly sensitive ammonia sensor.SEM, XRD, XPS, and Raman tests are used to characterise the sample. Under gas concentrations of5ppm, 20ppm, 50ppm, 100ppm, 200ppm, the SnO nano-shell responds with a high response of 313percent, 874 percent, 2757 percent, 3116 percent, 3757 percent. Redox processes have a role in the ammonia sensing system. The huge surface area and larger oxygen vacancy of the SnO nano-shell contribute to the high sensitivity[11].

Ammonia gas sensor made on zinc oxide thin film deposited in a chemical bath. At various bath temperatures, such as 40°C, 60°C, and 80°C, zinc oxide thin films are produced on glass substrates. The deposition of thin films happens in the chemical bath deposition process when the substrate is kept in contact with metal ions. The glass substrate is micro corning glass. Prior to deposition, the solution is brought to a consistent temperature by a breaker[12].

The optical conduct of vanadium oxide films was investigated opto-electrochemically at high photonenergies (E>2.0eV) in order to better understand their optical conduct. The charge limit of produced films is roughly 6MC, but it is multiple times greater for films heat treated at 1000 C. Reversible Liintercalation was seen in the vanadium oxide sheets, resulting in a two-fold other worldly, monochromatic hue. It was assumed that the small polaron model perfectly clarifies the uniqueness of two-fold tinge for low energy photons[13].

IV. APPLICATIONS

Ammonia detection by breath for early detection of renal disease. It assesses the effectiveness of treatment for severe liver diseases like cirrhosis. Additionally, it aids in the detection of a childhood disorder known as Reye syndrome, which can cause liver and brain damage. Ammonia testing aids in predicting the prognosis of a Reye syndrome diagnosis. Aids in the prediction of the outcome of an acute liver failure diagnosis.

V. CONCLUSION

Ammonia plays a vital role in nitrogen cycle. Hence, ammonia is considered as one of the very important things to have ammonia gas sensor for environmental protection as well as human health. Design of ammonia gas sensor is proposed by various techniques using a different precursor and doped metaloxides for the formation of thin films. Characterization is performed to study the morphology, structure and thickness of a thin films using FESEM, XRD, Profilometer, UV-V is spectroscopy and many other. Now a days ammonia gas sensor is not only designed by using a semiconducting metal oxide, potentiometric electrode and surface acoustic but also concentrated on thin films as well. Nowadays thin film ammonia gas sensor has got much higher demand because of the size, low-cost fabrication and lifetime.

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