

# Design and Fabrication of Ammonia Gas Sensor Using Electrospinning Method for Industrial and Medical Applications

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## Abstract

Ammonia (NH<sub>3</sub>) is a very injurious gas, the part of nitrogen along with the mixture of other gases is present in our day today lives. Therefore, detection of greatly sensitive ammonia sensors plays an important role for environmental protection and also in human health and care. So in order to sense low concentrations of ammonia (<=50ppm) making use of conventional means at room temperature is required. Tin monoxide (SnO) is a member of metal monoxide, this has paid much attention to its low cost, environmental friendly and higher stability. When made comparison with other non-oxide ammonia detecting material, for this the expected outcome is to prepare ammonia gas sensor using efficient method for the purpose of sensing ammonia gas place an vital role and considering it to have applications in various field.

Keywords: Tin monoxide, Ammonia sensor, Electrospinning, PPM

## 1. INTRODUCTION

In recent years, the number of chemical industries are increasing therefore harmful gases are emitted which is very much hazardous to all kind of biodiversity, the variety of sensors are widely used in different applications like medical and industrial. Where some gases like ammonia above some level can be very harmful, a typical human nose can smell about 1 trillion different odours. But still many of us don't have the capacity to identify the type and concentration of gas present in our atmosphere. This is where sensors come into existence. The ammonia gas sensor is one which comes handy in applications where we have to detect the variation in concentration of ammonia (toxic gas), in order to maintain the system safe and avoid any unexpected threats in the environment. Much importance is given to the gas sensor due to their ability to detect harmful gases. Conducting polymers are very useful in fabrication of sensors due to their best chemical properties and low operating temperature. Use of electrospinning helps to get large surface area.

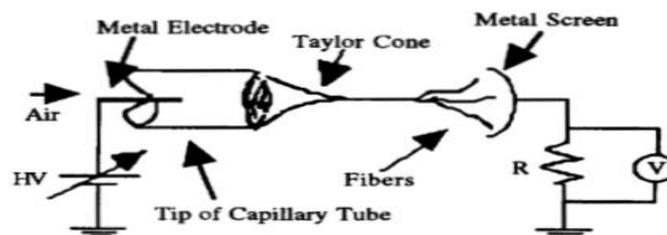


Fig 1: Design apparatus of electrospinning

## 2. LITRATURE SURVEY

Mahdieh et al [1] have reported to facilitate the ammonia gas sensor which is highly resistive at room temperature based on anN-doped quantum dots of graphene (N-GQDs) and conductive polymer dopant

which is spread on a translucent substrate with the presence of electrodes. The gas sensor designed and to be fabricated with conductive polymer resulted with a superior sensing response that is gradually increased by considering N-GQDs. The amount of gas sensing response of the poly (3, 4-ethylenedioxythiophene)-poly (styrene sulfonate) (PEDOT-PSS) to  $\text{NH}_3$  has rapidly increased from percentage range of 30.13% to 212.32% [1] at 1500 ppm of 50 wt. The timeresponse of the N-GQDs doped sensor decreased to minutes of 6.8 when compared with the sensor with the absence of N-GQDs and the firmness of the sensor is higher.

Susan et al [2] have studied the approach towards significant applicants for human health and biodiversity. Agricultural sector is the biggest sector which contributes to ammonia pollution. Ammonia itself and nitrogen deposition is badly affecting the biodiversity. For the nitrogen pollution ammonia is the main source. This deposition accumulates on plants species and dependent animals eat this plants and this may cause major bad effect on human and animals too, which may cause even death of a species. It is clear that ammonia is a threat to the environment and human beings. This paper also approaches for the reduction of ammonia emissions by various ways like manure storage, manure spreading, animal housing etc.

Monique et al [3] have explained the purpose to explore the methodologies used to measure the odour thresholds. The method used by the author is static and dynamic olfactometry. In static olfactometry the preparation to measure the odour by using some chemical formulas for the data which has to be regulated are untransformed. This is done to test-retest consistency valuations inside and amid approaches. When taken into consideration dynamic olfactometry method shows a robust correlation.

Jayesh and Darrell [4] have studied that an electric pasture is made worn to produce a electric spurt of polymer resolution. He as explained that, as this jet movement in atmosphere, solvent is evaporated parting following a fibre which is indicted, that can be electrically composed or deflected on a display of metal. Fibres among variability of fractious sectional extents and shapes which were made as of variety of polymers. These fibres are in the width choice of 0.05 to 5 microns [4]. This document defines the development of electrospinning, fiber structure, the dispensation situations and various utilizes of electrospun fibres. Biopolymers, liquid crystalline polymers and soluble polymers. Electrospun fibres may have remarkably small widths, fluctuating sliding from 5 microns to 0.05 microns [4]. The minute width provides a great ratio of outside region to volume. This stuff is useful in departure membranes, coiled dressing materials, and many other uses. Fibres with a variability of shapes and differences laterally their length may be formed.

Thomas and Parks [5] have discussed the properties of ammonia in this paper, Ammonia has several necessary features that propose its use as an intermediate to stock hydrogen. Initially, it can be dissolved under very mild situations. The vapour anxiety of ammonia at RT is 9.2 bar [5]. Its physical properties are analogous to those of propane. This indicates to facilitate ammonia container placed within a modest, low-cost vessel where ammonia has to be contained. Second, ammonia has an excessive heaviness element of hydrogen. Hydrogen institutes 17.65% of the bulk of ammonia. When these two features are pooled, the effect is shown to be simple. Ammonia can be broken more than a mechanism to yield the wanted fuel-hydrogen ( $\text{H}_2$ ) alongside with nitrogen ( $\text{N}_2$ ) a non-toxic. In addition, the author as quoted that ammonia is a very decent evolution fuel.

Ruthenbar [6] have proposed a genuine technicalities of replicated annealing, and an easy example as of an Integrated Circuit (IC) design is used toward demonstrates how these thoughts can be useful. The difficulties and trade-offs implicated in offensing a truthfullymultipart intend quandary is proved via dividing two incredibly diverse annealing algorithms for VLSI fragment floor planning. Several existing research problems intended at determining more precisely how and why annealing algorithms workare observed. Some logical issues are raised by the overview of annealing are discussed.

Zain et al [7] have studied in the recent decade's nanostructured material have attracted due to their flair of purposes in nanotechnology and nanoengineering. The accessibility of new resources with novel and engineered morphology are powerfully dependent if the developments in nanotechnology. In recent years' composite nanofibers have fascinated for the extensive attention. For the progress of gas sensors metal oxides have a great prospective. Using the composite NFs, they are developed, more responsive and selective gas sensors due to their huge exterior region and elevated quantity of grains limitations. This paper describes about the properties of complex NFs synthesized by an electrospinning approach. Here structure shows very good sensing presentation, these all are explained using the ES principles. Overall result is high sensitive and selective gas sensors.

Ganesh and John [8] have done the research on ammonia gas sensing individuality of undoped as well as cobalt (co)-doped nanostructured ZnO thin layerd films. It is established by the X-ray diffractogram were elevated crystalline excellence among foremost (0 0 2) plane direction of Co-doped ZnO film and polycrystalline environment with hexagonal wurtzite configuration. The undoped film exhibited the homogeneous deposition of circular -shaped elements for scanning electron micrographs. However, in favor of the Co-doped ZnO thin films were having the minor elements with no clear particle limitations. Undoped and Co-doped ZnO thin films they have the group space values to be establish as 3.26 eV and 3.22 eV. The concentration of ammonia gas sensing behavior of Co-doped ZnO film were studied in RT ranging from 15-100 ppm. Here, in the result pure ZnO lean films and difference within the sensing performance of Co-doped has been examined as well as evaluated. It is confirmed that one of the greatest aspirants for sensing ammonia at RT like response, permanence, reproducibility, rapidity of response, improvement and broad range of exposure.

Jian et al [9] have explained the research of this paper gives report as the ultrasensitive nanostructured sensor with the purpose of detects 50 ppt of NH<sub>3</sub> gas in atmosphere. In the electrospun n-type semi conductive TiO<sub>2</sub> filament exterior gives specifically, there are enchased the polyaniline (PANI), very small structured grains of a p-type conductive polymer. The main purpose is to electric current toggles when NH<sub>3</sub> gas is immersed by discussed nanoparticles using conflict of the p-n heterojunctions merging among the immensity confrontation of PANI very small structured grains (nanograins). As an outcome, the compassion of the sensor can be enhanced. In the literature it says that, it is more insightful than the most excellent PANI because sensor made-up into this work is 1000 times susceptible. The main function is nanoswitches to turn current path when it is associated with NH<sub>3</sub> gas.

Manikandan et al [10] have proposed that the very important materials are metal oxide heterostructure for mounting the various toxic gas/chemical exposure sensor methods. For the realistic equipment applications of sensors still require to be optimized using the most important features like permanence, sensitivity, response, high selectivity towards ammonia than others and improvement time. In many papers there are some problems owing to their exterior chemistry than that of their immensity form is

a best part of the critical issues to solve this with not high-dimensional resources contain exposed incredible prospective to decipher. Here, exploration is done on ammonia sensor at room temperature (RT), the responsibility of nanostructured n-ZnO/p-NiO heterostructure. In this overall study, it gives the polyvinyl alcohol fibers of the electrospinning technique were engaged towards organize heterostructure metal oxides merged through nanofibers. There are some characteristics such as heterostructure were executed via SEM, photoluminescence (PL) spectrophotometer and XRD. And also for the further need of RT ammonia gas sensing characteristics was examined since configuration demonstrated the response of 67 for 250 ppm [10] of ammonia at RT.

Korotcenkov et al [11] have developed in this research paper, author has achieved by comparing both the structural and gas sensing possessions of the SnO<sub>2</sub> and In<sub>2</sub>O<sub>3</sub> films dumped through the cover pyrolysis technique, these all are based on the investigational outcome. And evaluating the pressure of crystallite volume taking place factors of SnO<sub>2</sub>- and In<sub>2</sub>O<sub>3</sub>- based lean film frozen circumstances gas sensors. The ceramic-kind sensors activities evaluation were measured along with it. In exacting, the compassion of sensor indication towards atmosphere moisture, the enormity of sensor indication, thermal stability, and the velocity of sensor reaction. There are factors of conductometric-type gas sensors and grain size is observing the association among these gas sensors. Here very important role is having the grain size finding confirmed that one of the most essential equipment of metal oxides, also frozen condition gas sensors made-up by together ceramic and emaciated film equipment's these are controlling almost all working characteristics. For the grain size it exposed like there is no single collective necessity, because it's outcome is may give the alterations into particle volume might also progress, otherwise exacerbate of working behaviour of gas sensors. Hence, only depends on their pressure on the constraints of sensors deliberated the variety of best particle volume must be based on the exhaustive deliberation of the entire potential conditions.

Penghong et al [12] have explained the preparation of nanofiber yarn with a chemical polymerization and electrospinning method is an extremely organized polypyrrole layered polyacrylonitrile nanofiber thread. It is illustrated among chemical structure and morphology of polypyrrole polyacrylonitrile nanofiber thread by Field Production Scanning Electron Microscopy which signifies that the exterior of PAN nanofiber PPy as consistently polymerized and homogeneously in the shell layer. Here, examination is done using nanofiber thread sensor were property of special deliberation of doping acidic taking place the reactions. As well as the electrical response of gas sensor is based on the PPy-PAN nanofiber thread to ammonia were studied at RT. Here the response instance was less than 1s, one-dimensional formation demonstrated a temporary response is the nanothread sensor composed of uniaxially associated PPy-PAN nanofibers. Hence, the outcomes are exceptional sensing properties and it increase to excellent potential purpose prospects in the pasture of ammonia sensor.

Norbort et al [13] have proposed poly acrylonitrile nanofibers are prepared through photo -assisted and ES technique. The composite nanofibers which are obtained are texted as gap sensor (ammonia) at room temperature with a lower detected range i.e. 400ppb – 200ppm and the response time are compared which were produced by the same used technique. The obtained results show that a PAN/Ag fibre produces a higher response values, selectively and time of recovery. It also gives informative that increases in Ag, the response time will not increase or will not show any change. Ag will just act as dopant where the content of Ag is not too high, if the content is very high within the sensors, the electrical conductivity is highly depended taking place the silver.

Zengyuan et al [14] have studied about ES process that helps in the continuous fanatics of nanoparticles on smooth fibres in single step layer of the nanofibers are deposited uniformly over long area substrates. How the nanoparticles are obtained through the electrospinning process is initially explained with key process parameter. The results are shown by plotting the graph of ES-electrospinning time with respect to deposited material on diameter. The methods which is carried while preparing a solution, ES setup and procedure, followed by physical and electrochemical characteristics. The presence of nanoparticles on the fibre surface yields composite with increase in surface area of electrolyte which is been exposed. The higher cell voltages produced are compared to fuel cell which is fabricated with state of the electrodes.

Aghamkar et al [15] have proposed the consequence of thermal annealing on  $Nd_2O_3$  doped silica dust by sol gel method. Using sol gel method  $Nd_2O_3 - SiO_2$  binary oxide system was manufactured, when the catalyst which is used in HCL. The obtained from is transformed to crystalline phase with the heat application. The time, temperature of the effect of annealing is discussed in details. In order to obtain neodymium silicate and  $Nd_2O_3$  annealing temperature and heat action take part in a vital position. For about on the sample was sintered at temperature  $1200^\circ C$  and  $Nd_2O_3$  nanocrystallites with size  $\sim 18nm$  is obtained.

Valizadeh and Farkhani [16] have developed electro spinning and Electro spin fibers less than 1 ppm fibres are defined as nanofibers. These Nano fibers can be proved by using different several techniques. The author as coated that electro spinning method is one of the best method is one of the best method. The complete process of electro spinning method is explained thoroughly electro spinning as so many advantages and application that is it is simple and less cost for preparing Nano fibers during the synthesis process, many factors effect on the properties of synthetic Nano fibers. The author as discussed basic level of electro spinning and the various polymers for preparation of nanofibers. The main properties of ES are its type, molecular weight, solvent properties, additives, polymers concentration, solution properties, electric fields etc....

Mingxu et al [17] have explained a high performance ammonia gas sensor which works in RT which is based on hydroxyapatite film which is comprised of 3D system configuration is detailed in this document. The gas sensor made-up is on the indium tin oxide glass through very simple electrochemical deposition technique. The author as not used the electrospun technique here. The HAP film gives a very appropriate selectivity, sensitivity and reproducibility at RT. The response time of gas sensor is 1000ppm at 23s and 14s in dry condition and 4s as least and 11s as max under air condition. This gas sensor shows executant selectivity when there is a chemical use of ace tow and ethane under dry and air condition. All the mechanism of sensing has been studied in this particular paper.

Parinaz et al [18] have studied the appropriate element for application of sensing a gas is owing to their substance and electrical characteristics. The electrodes which are produced are gold comb like electrodes by using the standard deposition technique and photolithography methods. The graphene nanoribbon quality is investigated using different approaches. The result indicates that AUGNR and GNR is best choice for  $NH_3$  at RT shows the response for 25ppm is 34% and 12.1%. The response time is comparability high by all the test are carried and worked at room temperature. Finally the AUGNR and GNR sensor are detecting  $NH_3$  were fabricated and examined successfully with a significant response.

Stephanie et al [19] have proposed the micro-gas sensor is designed and fabricated. The study of process and working polymerization, deposition technique of thin films, process of ES and its characteristics are reported. The sensor signed used is the change in conductance of thin polymer layer. All behavior response is studied and investigated. The gas concentration of various range ranging from 8ppm to 1000 ppm are examined. The study and experimental results indicate that  $NH_3$  is efficient and best because they show charecteristics of a sensor which is responsive, reversible as well as reproducible by the side of RT. Main gaol of this paper is to check the use of poly prole related gas sensor for sensing ammonia at different concentrate. Sensitivity was lower than 10ppm which is known by conduction of various test and comparison at RT.

Sajjadi and seyed pooyan [20] have proposed the sol-gel method may be a flexible arrangement handle for making advanced materials, counting ceramics and organic-inorganic half breeds. Within the later a long time essentially more advances were made with development and commercialization of this innovation and presently it's one of the foremost promising generation strategies in nanotechnology. It gives may be an audit of applications of sol-gel prepare. This overview demonstrates that sol-gel processes continue to develop in numerous regions. Since sol-gel technology could be a handle, an assortment of the Applications in the shape of filaments, coatings, powders, stone monument, thin films and coatings, permeable gels, composites can be exploited. One of impediments of the sol-gel prepare is its moisture affectability, which comes about in brief rack life of the arrangements, consistency and coating thickness variations with surrounding conditions.

### 3. CONCLUSION

This chapter summarizes the major contributions and survey of existing systems and its applications in real world. The following major points are considered from literature survey. Most of the people who are staying near chemical industries and people working in industry inhales large concentration of ammonia but no particular measures taken for the detection which causes irritation. At present there are many sensors are designed which detects ammonia but there is no particular sensor which detects ammonia at room temperature and for small concentration. Since sol-gel process is adaptable solution for making progressive materials sol-gel can be made used of electrospinning is a technique of uniform deposition of sol-gel in form of electrospun fibres which has its own application and advantages. An ammonia detection gas sensor is the one which can be designed to measure the small amount of concentration of ammonia.

### DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interest.

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