The interface of technological advancement, utilizing hidden scientific principles to the real world has been the preoccupation of present day scientists and technocrats. The use and development of newer sensing devices as an aiding extension of the sensing capability of human beings provide the real interface of technology with the world. As the universe is limitless, as the applications and possibilities of exploring the physical, chemical and biological variables are limitless, so is the field of research and development of sensor devices. The research and development of electronic sensing devices serve the purpose of scientific exploration as well as the technological applications to improve the standard of living and surely to make the world in real sense the “abode” of “Supreme Energy”, heightened to supreme perfection.
Sensors play vital role in an instrumentation system. In order to keep pace with the rapid process-technological advancement of the instrumentation system, the development of more accurate, viable and reliable sensors is of utmost importance. Chemical sensors, mainly gas and vapour sensors are the devices which involve the interface of gaseous phase of matter with the solid surface and the principles of the exchange of electrons through electronic and chemical processes, with applications ranging from domestic, industrial, defense, food processing technology, clinical and medical analysis, aviation, space and environmental protection.

The development of semiconductor vapour sensors as direct, online measuring and portable devices to detect the presence of hazardous, toxic or technologically important vapours and odourants has been very much in demand. The field of the research and development in chemical sensors using semiconductor devices and technologies is one of the fastest growing areas.

Most of the research work in this field is concentrated towards the performance improvement of the sensors, which is: (i) identification and quantification of multiple species with enhanced efficiency, (ii) reducing the size of the semiconductor sensors, and (iii) making the device integratable. Also, quick response, minimum hardware requirement, low temperature operation, good
reversibility, enhanced sensitivity and selectivity, along with good stability are the main important qualities expected of an excellent semiconductor sensor.

Despite good number of chemical sensors now available in the market, selection and design of a suitable sensor for a newer application is a difficult task. Careful selection of the sensing material, the surface platform, and the sampling system are very important because such parameters are responsible for the proper and required functioning of the device. Therefore, in designing a semiconductor thin film chemical sensor, developers have to answer questions like (i) whether the application requires high sensitivity or a broader range of detection, (ii) does the careful choice of operating parameters of sensors satisfy the applications, needs and importance, or will a combination of technologies be needed to sort out the contributions of various other techniques (iii) what are the needs of operating environment as fare as the fabrication procedure is concerned ? (iv) if there is a trade-off in the characteristic parameters of the sensors, is there a solution to solve?

This branch is interdisciplinary, interlinking electronics, physics, chemistry, materials science, sometimes biology due to the varied applications of sensors and also computer science, for designing a suitable pattern recognition technique. In general, semiconductor thin film sensors are the
devices, which convert physical or chemical quantities into electrical signals.

The semiconductor sensor research and development have therefore been of paramount importance to any instrumentation system.

Oxide semiconductor based thin film gas sensors play vital role in detecting, monitoring and controlling the presence of hazardous and harmful gases /vapours in the environment. In order to keep pace with rapid process-technological advancement of instrumentation system and the applications in demand, the development of accurate, viable and reliable vapour sensors are the need of the hour. An important aspect of Vapour Sensors is its use in the development of electronic nose, which will bring the next breakthrough in Electronic Communication System, apart from their stand alone applications of providing detection to the range of odourous compounds.

The Indium Tin Oxide (ITO) \((\text{In}_2\text{O}_3:10\%\text{SnO}_2)\) is a well known oxide semiconductor material showing many applications in modern electrical and optical engineering and science. The ITO is a potential semiconducting material for fabrication of various types of thin film gas or vapour sensors due to its excellent stability as compared to other materials used for gas sensing. It is attempted here to explore the applications of ITO thin film sensors for many other vapours not reported so far. The test gases or vapours used in present
studies are Formaldehyde (HCHO), Toluene (C\textsubscript{7}H\textsubscript{8}), Benzene (C\textsubscript{6}H\textsubscript{6}) Carbon Tetrachloride (CCl\textsubscript{4}) and Hydrogen Peroxide (H\textsubscript{2}O\textsubscript{2}).

The thesis comprises of four parts:

**PART–A** deals with an introduction to vapour sensors. Chapter 1 describes the need and importance of the semiconductor thin film vapour sensors, the factors affecting their performance parameters, the importance of ITO thin film sensors with a literature review and an the need of the development of an e-nose.

**PART–B** deals with the Fabrication and Optimization of Deposition parameters of ITO film. Chapter 2 comprises of the instrumental part, used for the fabrication of ITO thin films. It describes the deposition technique used for the fabrication of the device. Different types of characterization methods such as Transmission Electron Microscope (TEM), X-Ray Diffraction (XRD), Chemical analysis using Energy Dispersive Analysis of X - Rays (EDAX) and Scanning Electron Microscope (SEM) are described in this chapter. The Data Logger used for recording of the data from the output of the array sensors has also been described. Chapter 3 deals with preparation and growth of Indium Tin Oxide (ITO - In\textsubscript{2}O\textsubscript{3}:10\%SnO\textsubscript{2}) semiconductor thin film. It highlights the
structural, electrical and optical properties of ITO thin films. The growth conditions are optimized for the development of the resistive sensor.

**PART – C** comprises of studies on application aspects. The response of ITO thin film sensors to the various vapours under test which are main contributors to indoor pollution, namely, Formaldehyde (HCHO), Toluene (C\(_7\)H\(_8\)), Carbon tetrachloride (CCl\(_4\)), Benzene (C\(_6\)H\(_6\)) and Hydrogen Peroxide (H\(_2\)O\(_2\)) vapors have been described in Chapters 4-6. **Chapter 4 deals with the development of the Formaldehyde Sensor operating at room temperature.** The study of the ITO sensor at elevated temperature has also been discussed. Chapter 5 describes a detailed study on the development of sensitive and selective sensors for Toluene and Benzene. Chapter 6 deals with the study of the response of ITO sensor to Carbon tetrachloride and Hydrogen peroxide.

**PART–D** consists of Novel additions in the work. **Chapter 7** deals with a preliminary study on Chemical Vapour Transport technique, which enabled us to **deposit SnO\(_2\) based thin film sensor with microstructure having nano clusters, which showed a drastic enhancement in the sensitivity to benzene vapours at room temperature.** A review of the research work on flexible substrates used for the sensing devices is also discussed. The last part of the
chapter was the fabrication of an array of three sensors to detect the mixture of three vapours. The output of the array was analysed by principle component analysis. As a further outstanding attempt, an intelligent electronic nose was fabricated by the array associated with neural network. A pilot study on the design of a feed forward neural network, trained by the error back propagation algorithm was successful in training the network, which made the array of sensor – system intelligent in quantifying the unknown vapours.

All earth shall be the Spirit's manifest home,
Hidden no more by the body and the life,
Hidden no more by the mind's ignorance;
An unerring Hand shall shape event and act.
The Spirit's eyes shall look through Nature's eyes,
The Spirit's force shall occupy Nature's force.

*Sri Aurobindo*