. METHODOLOGY:

The sol-gel technique is a process that has gained much attention in recent years in the field of glass and ceramics. The sol-gel process is a wet-chemical technique that is widely used to deposit nanocomposite films. Such methods are used primarily for the fabrication of materials (typically a metal oxide) starting from a chemical solution (or sol) that acts as the precursor for an integrated network (or gel) of either discrete particles or network polymers. The precursor sol can be deposited on a suitable substrate for thin film preparation by spin coating, dip coating or other technique. Spin coating allows the preparation of thin films on flat substrates using spin coater. Dip coating allows the preparation of thin films on substrates using dip coater.

In the fabrication of ZnO and Copper (Cu) doped ZnO thin films following chemicals are used, Zinc acetate dihydrate, Methanol or Ethanol, Copper for dopant and Acetone.

Here, in this study sol-gel method is utilized because of it synthesizes almost any material, co-synthesize two or more materials simultaneously, coat one or more materials onto other materials, produce extremely homogeneous composites, synthesize high purity materials, control microstructure of the final products and control the physical, mechanical and chemical properties of final product but these properties depends on such parameters like pH of solution, stirring speed, sintering temperatures, time period etc. Sol-gel technique meets all these requirements and many reports have been already published.

The different properties of ZnO and Copper (Cu) doped ZnO thin films are investigated by using, X-ray diffraction studies using diffractometer, by varying the diffraction angle 2θ from 10° to 100° and compare the observed and standard ‘d’ values taken from JCPDS card. Particle size was estimated using Scherrer’s equation,

\[ d = \frac{0.9 \lambda}{B \cos \theta} \]

Where \( \lambda \) is the wavelength, B the full width at half maximum of the peak, and \( \theta \) is the Bragg angle.

Optical absorption and transmission of the ZnO and Copper (Cu) doped ZnO thin films is analyzed using Ultraviolet visible Spectrophotometer within the wavelength range of 200 to 1000 nm. The ac-dc electrical resistivity, conductivity measurements were carried out by using four probe methods. The IR spectrum of undoped zinc oxide (ZnO) films and Copper (Cu) doped zinc oxide (ZnO) are recorded by using infrared spectroscopy (FTIR).

The graphs of ac-dc electrical resistivity, conductivity and UV–vis, FTIR were made by using Microsoft office excel and Origin software. The surface morphology of the ZnO films
was studied with the help of scanning electron microscope (SEM) attached with an energy
dispersive x-ray spectroscope (EDX).

The working principle for gas detection of these sensors based on changes in work function,
resistance, dielectric constant, mass of the sensing element due to adsorption of gas etc. the
resultant change in any one of these properties is measured to determine the presence and
percentage of the gas in the surrounding with measuring response time and recovery time.
The variation of the film resistance noted with time for different gases is used and sensitivity
(S) of films is evaluated using following formula,

\[
S = \left(\frac{R_a - R_g}{R_a}\right) \times 100,
\]

Where, \(R_a\) is resistance in air, \(R_g\) is resistance in testing gas.

To achieve the objectives in the research proposal:

Step I
The undoped zinc oxide (ZnO) films and Copper (Cu) doped zinc oxide (ZnO) films prepared
by using the sol–gel spin-coating technique.

Step II
The thin films are characterized by using physiochemical techniques such as X-ray
diffraction (XRD), Scanning Electron Microscopy (SEM), Energy Dispersive x-ray
spectroscope (EDX), Infrared spectroscopy (FTIR) and UV–visible Spectroscopy.

Step III
Test the gas sensing properties of the composites films.

5. LIMITATIONS:

1. Metal oxide gas sensors can be detecting only one gas at a time.
2. The sensitivity of metal oxide gas sensors reduces with high temperature, so they cannot operate at high temperature.

6. WORK PLAN:

i) First six month
   • Literature survey.
- Setting of problem.
- Provision of chemicals for preparation of samples.
- Preparation of ZnO thin films.
- First Course work.

**ii) One Year**
- Preparation of Copper (Cu) doped ZnO thin films.
- Characterization of thin films by X-ray diffraction technique and analysis for the calculation of various parameters.
- Scanning electron microscopic (SEM) and Elemental analysis (EDAX) study of the thin films.
- Second course work and theory paper.

**iii) One year and six months**
- Study the electrical A.C. and D.C. conductivity properties of the thin films.
- Ultraviolet-visible (UV-Vis) study of fabricated material.
- Characterization of thin films by infrared absorption technique and analysis.
- Study the gas sensing properties of the thin films.
- Analysis of Result and conclusions.

**iv) Two year**
- Writing of research papers and publication of research papers.
- Thesis Writing.
- Typing and binding of the research thesis.
- Submission of thesis.

**PROPOSED WORK PLAN:**
1. Introduction
2. Relevant Literature Review.
4. Synthesis, structure, morphology, electrical and optical studies on Copper (Cu) doped ZnO thin films.
5. Gas sensing properties of ZnO and Copper (Cu) doped ZnO thin films.
7. References