ZNO Nanostructures & Microstructures: Synthesis using Different Materials
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Abstract: Thermal decomposition and heat treatment method is used for the preparation of ZnO and the precursors are used for this is zinc oxalate, zinc nitrate and zinc sulfate after preparation of ZnO study on its optical and electrical properties has also been performed then its photoconductivity in air and two minutes rise and fall curve also measured. Which is very useful in study of switching characteristic of materials. XRD clearly shows that prepared material has good quality of ZnO, SEM indicates that synthesized materials are of wurtzite structure. Two minutes rise and fall curve shows that zinc oxalate has the best switching time among all three materials.

Keywords: Zinc Oxide, XRD, Photoconductivity, Rise and decay

I. INTRODUCTION

Zinc Oxide play an important role among various industries in electronics the potential applications of ZnO are photodetector, electrodes, thin film transistor and many more. In electronics industry the classification of ZnO is as semiconductor and in material group it belongs to II-VI group. Peculiar chemical and physical property of zinc oxide make it particularly important for many different applications. The synthesis of ZnO with different precursor has been done in several dimension structures. The size of synthesized material could fall in between few nanometers to several thousand micrometers. In terms of dimensions we can say the synthesized material could be of single dimension, two dimension and three dimension nano or microstructure [1-4].

In nanoscience the dimension begins with 0D (All dimensions in the nanoscale), 1D (Two dimensions at the nanoscale one dimension at the microscale), 2D (one dimension at the nanoscale 2 dimensions at the macroscale) and 3D (No dimensions at the nanoscale all dimensions at the macroscale).

At nano dimensions we can clearly see the difference in properties like when the particle size decreases it will produce different color for different size similarly other property of nanomaterial’s are also changed at nano dimension which make them unique and the reason behind it that greater number of atoms is found on the surface of nanomaterial when it is compared to the atom that are present inside the nano and micro dimensions this is the reason why nanomaterials are so unique and going to play important role in future in design from airplane to space elevator.

In this paper we have synthesized ZnO with different precursors and then study its optical and photoconductivity properties. There are number of techniques are available for preparation of ZnO but here the method chosen heat treatment and thermal decomposition method for preparation of ZnO. Since these technique provide ZnO of different shapes as per our requirement.

The photoconductivity study for the synthesized ZnO nanostructures & microstructures prepared by different precursors has been performed. The materials which is synthesized could play major role in design of photodetector which is the main outcome of this work [5-7].

II. EXPERIMENTAL SECTION

A. Chemicals

The different types of chemicals used in synthesis of ZnO nano and microstructure are zinc-nitrate, zinc Sulfate and zinc oxalate for which chemical formula are Zn(NO$_3$)$_2$, 6H$_2$O, (ZnSO$_4$, 7H$_2$O) and (ZnC$_2$O$_4$, 2H$_2$O) respectively. These materials are used directly in the form which is available in the market after procuring it from company like Merck Ltd. etc.

B. Sample Preparation

The Zinc Oxalate, Zinc nitrate and zinc sulfate is used to prepare zinc oxide nano & microstructures. First we have taken small quantity of these three material around 3 to 4 g of each then put it in a crucible and fired it in a furnace at the temperature of 500 °C for three to five hours or even more.

Obtained zinc oxide nano and micro structures were obtained in powder form and this sample is to be used for further Characterizations. Similarly we have obtained ZnO from each of above materials.

C. Instrumentation

For characterization of obtained Synthesized ZnO nano & microstructures there are different techniques used such as for study of the surface of the material the technique used is scanning electron microscopy which gives the idea of morphology of the prepared material and then we can judge the synthesized material is of nano dimension or micro dimension.

Then X-ray diffraction technique is used to find out that the obtained material is pure zinc oxide or not actually the peak in x-ray diffraction give us the information about purity of the synthesized material that’s why in material characterization x-ray diffraction plays a key role, It’s also gives the idea of obtained crystal structure.

Synthesized ZnO UV-vis.
Spectroscopy is also performed in which light has passed through the material then we see the possible transition of electrons from one state to other state it also identify if any organic compound is present in the material.

The photoconductivity measurement which has performed in lab for that taken the small quantity of synthesized material on a special kind of cell which has a space of 1nm between two copper electrodes and the after pressing it with a glass and connected to computer via Rish multimeter we start measuring the photoconductivity in which we are going to measure rise and decay curve which gives important idea of Switching characteristics of the synthesized material. The fig. 1 shows the basic cell which we are using for the measurement of the photoconductivity. This cell is put inside the dark chamber till the dark current stabilized.

Fig. 1. Cell for measurement of photoconductivity.

III. RESULTS AND DISCUSSIONS

STRUCTURAL STUDY

From fig. 2 XRD pattern of synthesized zinc oxalate nanoparticles is observed. The major peaks are indexed as (202), (002), (402) and (021) at 19°, 23°, 30° and 35° respectively. Peak broadening indicates formation of nanoparticles. Crystallite size calculated for the peaks (202), (002), (402) and (021) is 18 nm, 29 nm, 15 nm, and 28 nm respectively.

In fig. 3 XRD plot of ZnO is shown, this ZnO has been synthesized using Zn(NO$_3$)$_2$ thermally decomposed at 500°C for 3 hours. The maximum peak is observed at 36° of intensity 1000 (a.u.).

Fig. 4 shows XRD of synthesized ZnO nanoparticles. From XRD we can say that the microstructures synthesized by zinc sulfate are of good shape crystalline structure.

Fig. 2: X-ray diffraction (XRD) pattern of ZnO synthesized by thermal decomposition of zinc oxalate.

Fig. 3. XRD of ZnO synthesized by zinc nitrare

MORPHOLOGICAL STUDY

Fig. 5, Fig. 6 and Fig. 7 shows the ZnO Synthesized by different precursors. From these figures it can been seen that synthesized ZnO particles are from nano to microdimensions. These structure look is like a diamond shaped in Figure 6 and 7 whereas it looks like rice particles in Figure 5.

Fig. 4. XRD of ZnO synthesized by zinc sulfate.

Fig. 5. SEM image of synthesized ZnO by zinc sulfate.
UV VISIBLE ABSORPTION STUDY

Fig. 8 shows UV-visible spectrum of zinc oxide nano and micro structures at the room temperature. These molecules are thermally decomposed using catalyst as zinc oxalate. These ZnO particles have band edge at 370 nm as Blue shift can be seen in figure.

Fig. 9 shows UV-visible spectrum of prepared using Zn(NO$_3$)$_2$ thermally decomposed at 500°C for 3 hours which shows peak at 381 nm. Almost the same absorbance was observed by Singh et al. [10].

PHOTOCONDUCTIVITY STUDY

Figure 10 shows the setup used for measurement of photoconductivity for obtained ZnO nanostructures and macro structures from different precursors. The equivalent circuit can be seen in figure. The circuit comprise of voltage source $V_a$ that connected to light intensity (bulb) focusing on the ZnO particles thereafter load resistance is connected across with photoconductivity is measured using RISH multi-meter.

Fig. 11 shows the rise and fall curve of when light is in switched on and switched off state. This occurs because as UV light fall on the proposed ZnO particles the UV light is focused on the ZnO nano and microstructures since the water and oxygen molecules play important role in governing the internal mechanism of the synthesized material. After stabilizing the current in dark when the light particles (photons) suddenly fall on synthesized material there will be large number of generation of electron and hole pair occurs and phenomenon of absorption takes place generated photons is absorbed after attaining a peak rapidly there is fall in the current due to the presence of oxygen molecules.

Fig. 12 shows the rise and fall curve for two minutes while switching on and off UV light over synthesized zinc oxide particles prepared using zinc oxalate, zinc nitrate and zinc sulfate has been measured. Since photoconductivity give the idea of the conductivity which happens from absorption of the ligh, It give the idea how electrons are moving from one band to other which is very important phenomenon in optoelectronic devices because this switching characteristic play major role in reponse time which is the key principle behind many electronics devices.
ZNO Nanostructures & Microstructures: Synthesis using Different Materials

The current paper gives the various methods for preparing of ZnO by different precursors. The synthesized ZnO is inexpensive, reproducible and mass yielding method used is thermal decomposition method for various precursors. The zinc oxalate particles are prepared using heat treatment then XRD was performed on it. The XRD shows high peak at 35° for zinc oxalate. The SEM results are from nano to micro dimensions which is good for analysis the morphological behavior of particles. The photoconductivity of the proposed particles was done that has shown in rise and fall curve with UV spectrum of light. Here we have compared the response time of all three prepared materials and the best material could further used for photodetector based application.

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REFERENCES


AUTHORS PROFILE

Dr. Ravi Shankar saxena, Professor GMRIT, RAJAM Completed M.tech from MNNIT then D.Phil from university of Allahabad in the field of optoelectronics and devices. His area of research is design of photodetector with ZnO nanostructure with good response time. Already published papers in several SCI Publications.

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Fig. 11. Rise and decay curve of Synthesized ZnO structure by zinc nitrate.

Fig. 12. Two minutes rise and decay curve of synthesized ZnO prepared by zinc oxalate, zinc nitrate and zinc sulfate.

IV. CONCLUSION & FUTURE SCOPE

The zinc oxalate particles was synthesized by using zinc oxalate, zinc nitrate and zinc sulfate. This work is further used for photodetector based application.