

Preparation of ZnO Nanorods by Hydrothermal Process at Different Temperatures

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Abstract— Here for the synthesis of ZnO (Zinc Oxide) nanorods we have used hydrothermal process. Seed layers were deposited on FTO (Fluorine doped tin oxide) glass substrates using electro deposition method with zinc nitrate dehydrate. ZnO nanorods were synthesized on annealed seeded layer by hydrothermal method using hexamethylenetetramine as a precipitant and zinc nitrate dehydrate as source at different temperatures 50°C, 65°C, 75°C, and 85°C. The crystal surfaces were investigated by Scanning Electron Microscopy (SEM). SEM produces image by using electrons rather than light photons. A beam of electrons is sent by electron gun which follows the vertical path and after travelling through the magnetic lens it hits the sample. After the beam hits the sample, electrons and X-rays are ejected and collected by detector to give final image. It is found that the dimension of ZnO nanorods changed with different temperature. SEM images show that the average diameters of ZnO nanorods are about 10-15 nm by changing growth temperature. The smallest diameter of ZnO nanorods is observed while the growth temperature is equal to 50 °C. ZnO nanorods have applications in Quantum Dot Sensitized Solar Cells (QDSSC).

Keywords—Nanorods , Hydro thermal , SEM images , Nano struture , Zinc Oxide

I. INTRODUCTION

ZnO nanostructures have great importance in nanotechnology as nanotubes, nanowires, nanorods, nano belts, nanocables etc. ZnO is the material of the family of II-VI semiconductors. Binding energy of ZnO is 60 meV and band gap energy is 3.37 eV besides this it has high breakdown strength, cohesion and excitation stability for which it has greater importance in nanotechnology. For its vertical geometry this is suitable for filling with hole transporting materials [1-4]. There are various methods of preparing ZnO nanostructure such as vapour-liquid-solid growth, Template-based methods, chemical vapour deposition, and hydrothermal process [5-10]. Cobalt nanoparticles were prepared by modified Polyol process [11].

In this work, we have used the hydrothermal growth of ZnO nanorods on FTO substrates, and investigated them by scanning electron microscopy (SEM) at different temperatures. These ZnO nanorods are widely used to prepare QDSSCs. The hydrothermal method is used because of its advantages—it is a simple, can be performed at low temperature (60–100 °C), has high efficiency and greater controllable process with respect to other methods performed which are highly power consuming and highly expensive [12–16].

Scanning Electron Microscope (SEM) creates an image when electron beam is focused over a surface. When the electrons

in the beam interact with the sample that gives signals which gives information about the surface structure and composition. SEM analysis is nondestructive in the sense that the X-rays emitted during the interaction do not cause any volume loss of the sample. So the same material can be analyzed repeatedly. SEM is an instrument which produces image by using electrons rather than light photons. A beam of electrons is sent by electron gun and follows vertical path. Then the beam travels through the magnetic lens (this focus the beam down to the sample) and hits the sample. After that electrons and X-rays are ejected which are collected by detectors to give final image as shown in fig.1. In our knowledge the hydrothermal method used here is old technique but our experimental results obtained is purely different from the similar work done in past. In our future work we will study the optical and electrical properties of the prepared ZnO nanorod thin films.

This paper has been written into four distinct sections- Introduction, Experimental procedure, Results and discussion and conclusion. Introduction section gives the brief review of literature related to our present work. Experimental procedure contains the preparation of ZnO nanorods at different temperatures by hydrothermal method. Results and discussion section shows SEM images of ZnO nanoparticles at different temperatures and includes analysis and

discussion of our results. Conclusion part gives the major conclusion drawn from our results.

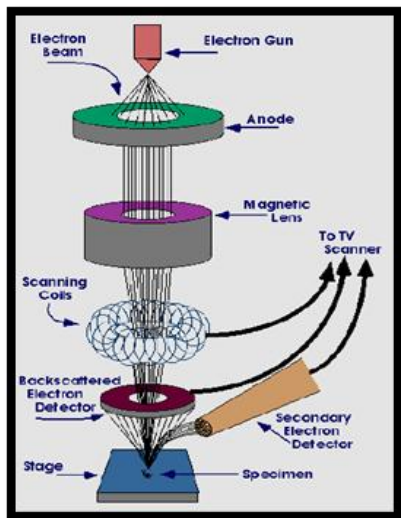


Fig1:Schematic diagram of SEM

II. EXPERIMENTAL PROCEDURE

ZnO nanorods were grown on FTO substrates via a two-step process. In the first step, a thin seed layer was prepared on FTO substrates by using electrodeposition technology. In the second step, ZnO nano rods were grown on seed layer coated FTO substrates by hydrothermal technique. 0.074 (2.5mM) gram of zinc nitrate powder and 0.026gram (2.5mM) of di-ethanolamine & 100ml of de-ionized water were added to prepare the solution. This solution was stirred continuously for 2 hours at room temperature for obtaining clear homogenous solution. The stirred solution was taken in a beaker and the well cleaned FTO substrates were electrodeposited for five minutes at room temperature. Then these films were annealed in a furnace at a temperature of 200°C for 1 hour. The diagram shown in Figure.2 shows the detailed preparation procedure of ZnO seed layers.

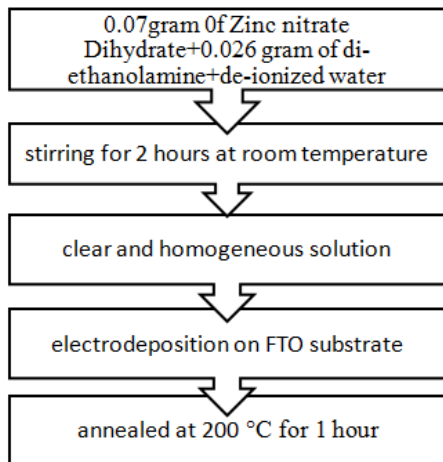


Figure 2: Flow chart showing the preparation of ZnO seed layer thin film

Hydrothermal method was used by suspending the ZnO seed coated FTO substrates. ZnO nanorods were grown using hydrothermal method by immersing a seeded FTO substrate in a glass beaker to containing 10 mM of zinc nitrate and 20 mM of hexamethylenetetramine in a hot air oven and maintained at 90°C for 4 hours (HMTA) solution, which is the optimized ratio to grow ZnO nanorods. The solution was heated in a hot air oven and maintained at 90°C for 4 hours.

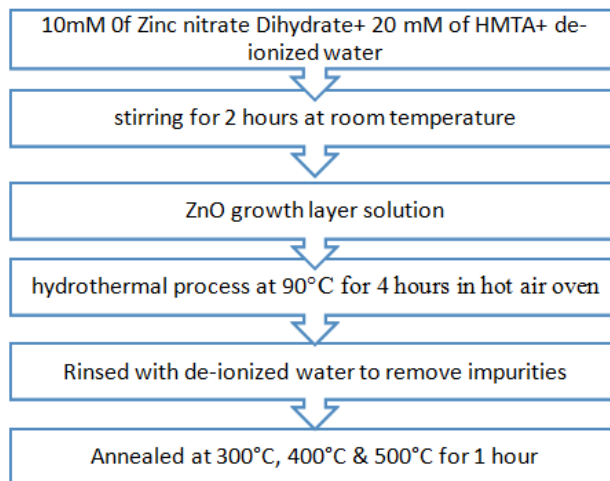


Fig3: Preparation of ZnO Nanorods

III. RESULTS AND DISCUSSION

SEM was used to investigate the nanostructure of ZnO nano needle. Below Figures show the SEM images of ZnO nanoneedle obtained under different growth temperatures. They show that a ZnO nanoneedles having a diameter of from 10-15nm are formed under different growth temperatures at 50°C, 65°C, 75°C and 85°C. So the dimensions of ZnO nanorods are changed with different temperature. The smallest diameter of ZnO nanorods is observed when the growth temperature is equal to 50 °C. From Fig.4, the best growth temperature of ZnO nanorods is at 85 °C.

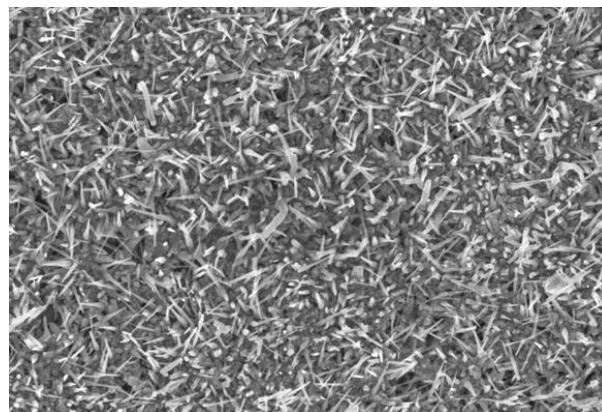


Fig.4:SEM Image showing ZnO nanoneedles grown at 85°C

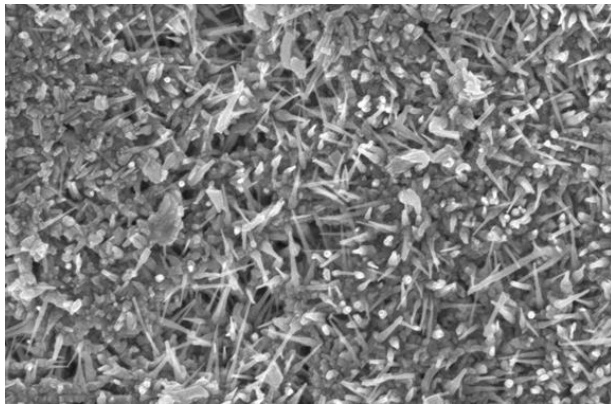


Fig.5: SEM Image showing ZnO nanoneedles grown at 75°C

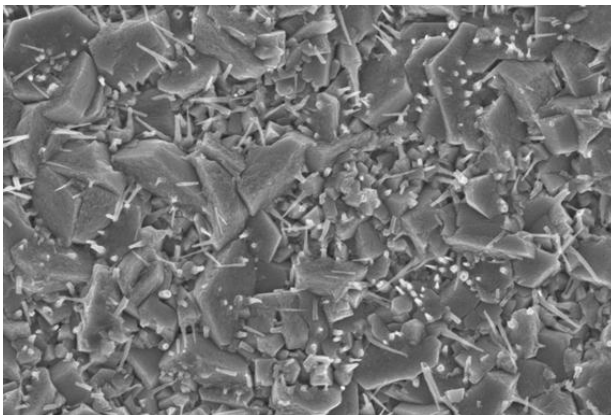


Fig.6: SEM Image showing ZnO nanoneedles grown at 65°C

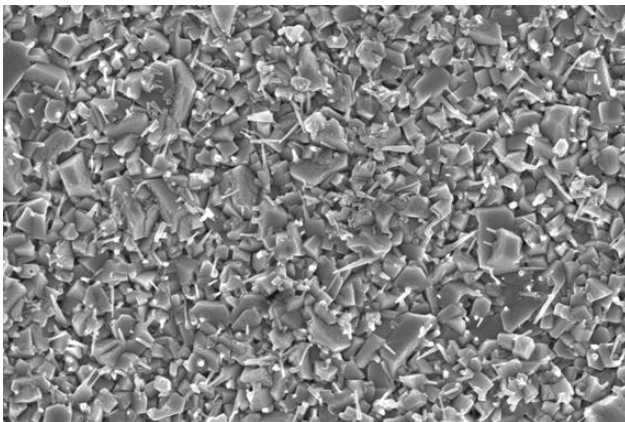


Fig.7: SEM Image showing ZnO nanoneedles grown at 50°C

IV. CONCLUSION

In summary, ZnO micro and nanostructure needles were synthesized by hydrothermal solution technique. ZnO rods grown at 85°C had a large aspect ratio than those obtained at 50 °C. Our procedure allows the growth of ZnO nanorods with seeds layer. The controlled synthesis of ZnO nanorods

opens new applications in the fabrication of nano devices in nanotechnology. The results presented in this report demonstrate that growth temperature, and deposition time have influence on the shape and ordering of ZnO nanoneedles. In our future work we will study optical and electrical properties of prepared ZnO nanorod thin films at different temperatures.

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Author Profile



Mr. R.K. Das has completed B.Sc from St. Paul's Cathedral Mission College under university of Calcutta. He has completed M.Sc in physics from Calcutta University. He has been working (Lecturer and Assistant Professor Stage II) with Department of Physics, Charuchandra College, Kolkata which is affiliated to Calcutta University for 15 years. He has 6 research publications and 4 papers have been communicated till now. And his research topic is basically electronics. He has taught Physics for 15 years and basically the topics are Electronics, Quantum Mechanics, Classical Mechanics, Electrodynamics, Magnetism, Thermodynamics, Electromagnetic Theory, Solid State Physics, Relativity. Presently he is continuing in his teacher job.
