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Growth of Zinc Oxide Nanorods on Indium Tin Oxide and Silicon Substrate

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Abstract— ZnO is an important semiconducting material, which has a wide range of applications in optics, optoelectronics, sensors, actuators, energy, biomedical sciences and spintronics. ZnO exhibit the most splendid and abundant configurations of nanostructures that one material can form. Hence in this paper I put forward its synthesis and growth on ITO and silicon substrate. ZnO is one of the few dominant nonmaterials for nanotechnology. Based on bibliometric data from information-services, the number of publications and the cross- referenced areas based on ZnO nanostructures are as large and as important as literature in quantum computing carbon nanotube, semiconductor thin films, and dark matter. There are a few existing excellent reviews related to nanowire growth and characterization especially about ZnO. This paper gives the nature of growth of ZnO nanorods on a substrate.

Index Terms— **SEM, TEM, XRD.**

I. INTRODUCTION

ZnO, as an important semiconducting material, has a wide range of applications in optics, optoelectronics, sensors, actuators, energy, biomedical sciences and spintronics. ZnO has the wurtzite structure, which has a hexagonal unit cell with space group C6mc and lattice parameters a=0.3296 and c=0.52065nm. The oxygen anions Zn cations form a tetrahedral unit. The entire structure lacks of central symmetry. The structure of ZnO can be simply described as a number of alternating planes composed of tetrahedral coordinated O^{2-} and Zn^{2+} ions, stacked alternatively along the c-axis. One main advantage of wet chemical growth is that it can be achieved independent of the substrate by employing ZnO seeds in the form of thin films or nanoparticles. In this way, the nucleation step is bypassed and only the necessary conditions for growth are considered. Alignment of the ZnO nanocrystals occur on flat surfaces regardless of their crystalline or surface chemistry, including ZnO, transparent conducting oxides such as Indium Tin Oxide, Fluorine Doped Oxide, Amorphous oxides including glass and Si with it's native oxide, and the oxide-free processing. To improve the particle adhesion to the substrate and to improve the ZnO nanorod vertical alignment can be done by heating the ZnO seeds at 150^0C and 350^0C temperatures.

II. METHODOLOGY

A. Etching of Chromium from the Indium Tin Oxide Substrate

NaOH (25gram), K4FeCN6 (150ml), D.I Water (50ml).Make the solution of 200ml and put it inside the Petri dish. Put the strips for 20minutes inside the solution (Black part will be above). Now invert the strips and keep it for 20 minutes. Now clean the strips with D.I Water with pressure then take a beaker put some propane-2-ol and put the strips on the stand inside that beaker then ultrasonicate, again ultrasonicate it with acetone. Now dry the strips in a rotator (drier) for 2 minutes with a voltage less than 80V.Keep the strips in Oven at 120^0c for 1hours.

B. Etching SiO_2 from the substrate

NH_4F (40%), DEIONIZED WATER (D.I.WATER), 49% of HF (ACID) (2 part). Rinse the substrates in the solution for 10 minutes and then dry it with nitrogen gas. After that whether the circuit is open or closed circuited. If the silicon dioxide is etched then it will show short circuited.

C. Spin Coating Thin Film of Zinc Oxide on the Si Substrate

Make a solution of ZnO salt.10ml of ISOPOPANOL in 1gm ZINC ACETATE DIHYDRATE (Boil it at 84^0c).Boiling the solution atleast for ½ hours. A change in color will occur and the solution will turn milky white. Now add DIETHANOL AMINE (Add it drop by drop (9drops) until the solution turns transparent).Boiling the solution atleast for 2/3 hours at 120^0c.Now boil it for extra hours at 95^0c.

D. Take Zinc Nitrate (Hexahydrate) 50mm with Hexamethylene Tetra Amine (50mm)

Mix the two solutions and stir it**,** put the substrates with the thin film side upward and clean side downward inside the solution, heat it at 90^0c for 7hours**,**after that, take out the substrates with a quizzer and rinse it with DI water, Heat it at 60^0c inside the oven for 2hours.

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III. RESULTS

SEM RESULTS, as we can see the SEM images of 3 samples with their lateral and cross sectional view. Nanorods formed at 95^0c range from 54.6nm to 70nm in its diameter for the 1st sample. While the diameter range for 2nd sample is above 100nm but less than 150nm, 3rd sample gives the similar range as the 1st sample. Now the outer cross-section appears to be hexagonal in shape while the length appearing to be in the range of 50nm to 100nm. Thus the shape appears to be like a nanorods or nanotubes. As the substrate was placed for 8 hours in the solution at 95^0c the growth occurred to be small. We can increase the growth of nanorods if we increase the time period. ZnO nanorods grown on a Si substrate using thin layer of ZnO shows an aligned growth of ZnO nanorods. These nanorods are uniformly distributed at the centre, along the edges and at the corner of the substrates. Starting six images show the top view SEM images of vertically aligned ZnO nanorods while last five are the cross sectional images of SEM images which show the length of nanorods through particular angle.

A. SEM IMAGES

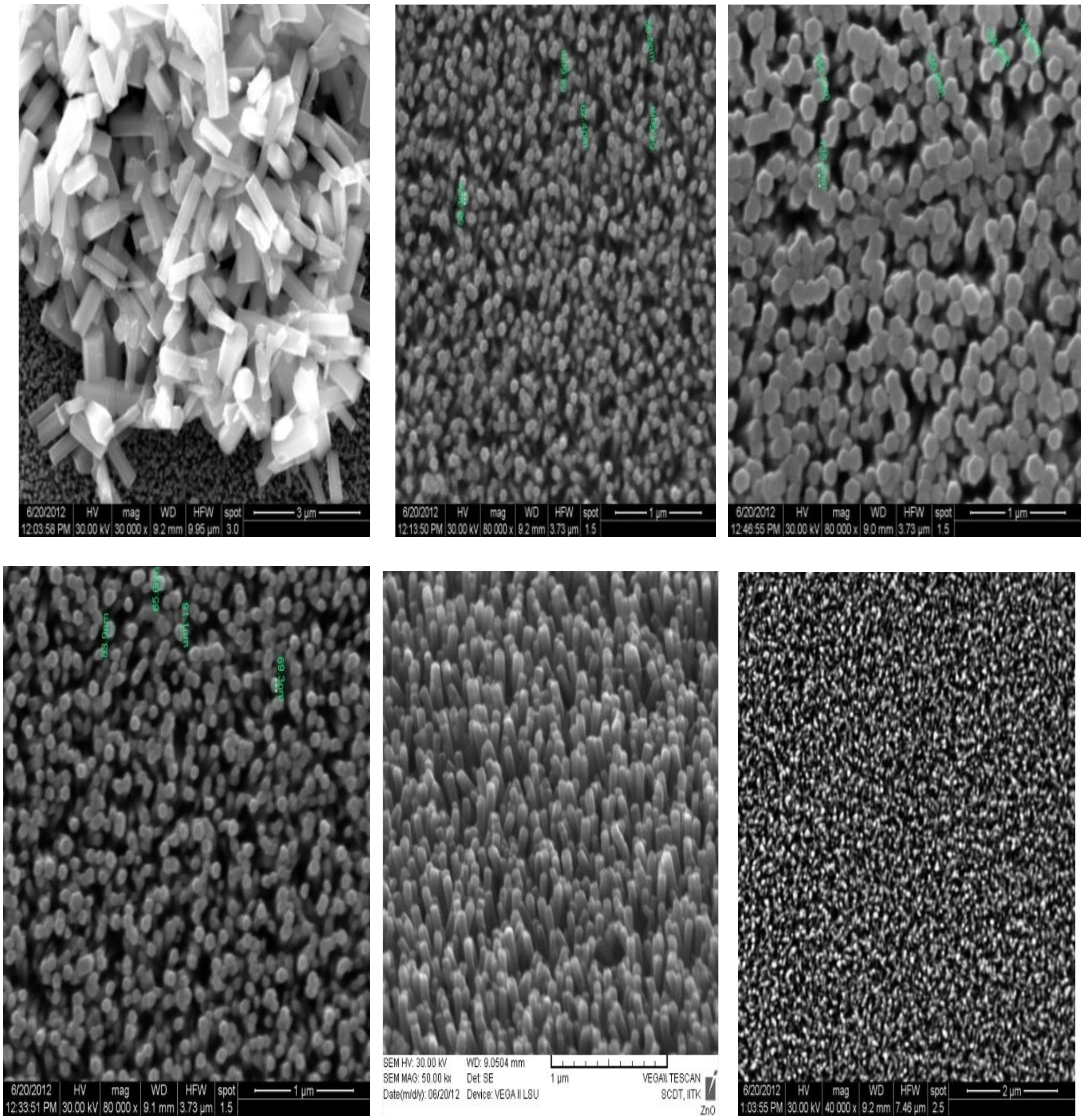


Fig 1. Top View Images

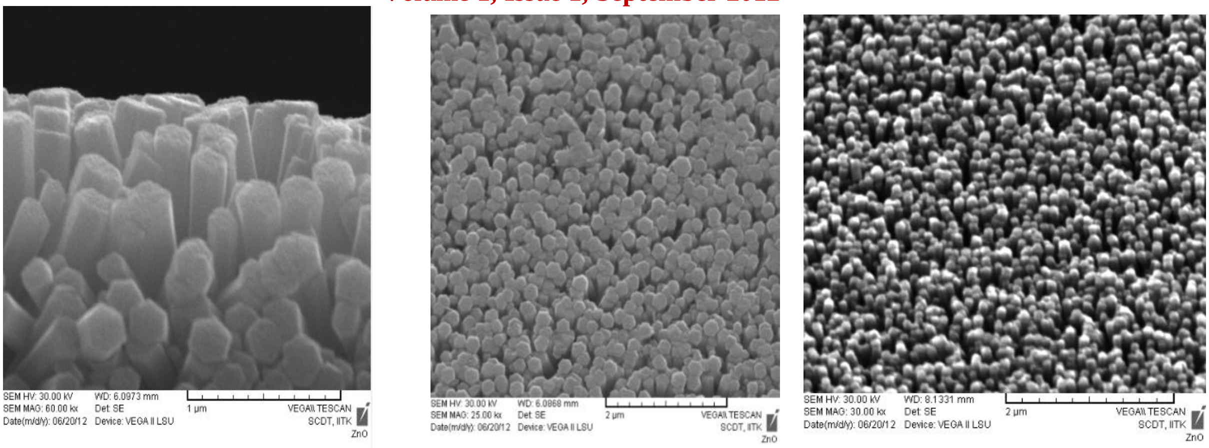
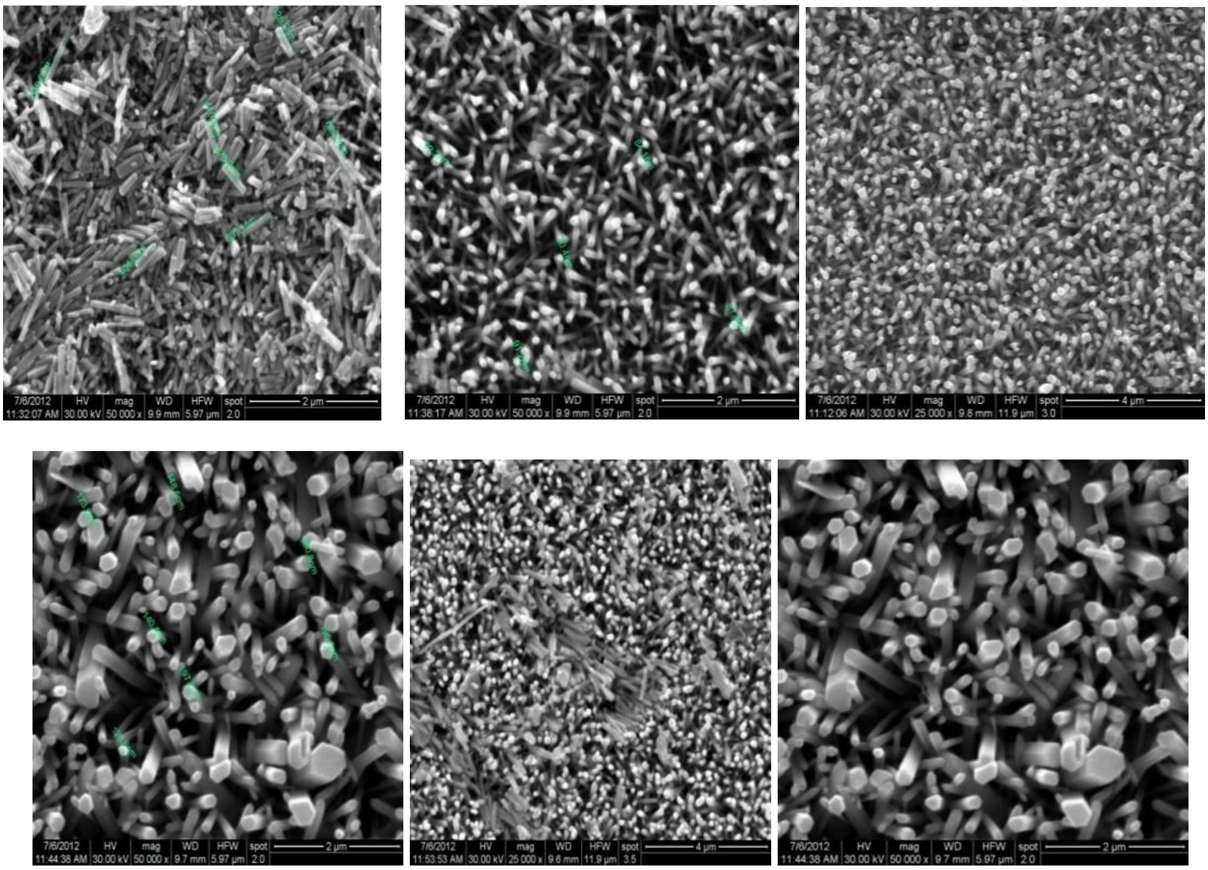


Fig 2. Cross Sectional Images

B) As we can see the SEM images of 3 samples with their lateral and cross sectional view. Nanorods formed at 95^0c range from 100nm to 200nm in its diameter for the 1st sample. While the diameter range for 2nd sample is above 70nm but less than 100nm with the length in the range of 400nm to 900nm, 3rd sample gives the similar range for its diameter as the 1st sample but length in the range of 800nm to 2micrometer. Now the outer cross-section appears to be hexagonal in shape while the length appearing to be in the range of 400nm to 2000nm. Thus the shape appears to be like a nanorods or nanotubes. As the substrate was placed for 70 hours in the solution at 95^0c the growth occurred to be small. We can increase the growth of nanorods if we increase the time period. ZnO nanorods grown on a Si substrate using thin layer of ZnO shows an aligned growth of ZnO nanorods. These nanorods are uniformly distributed at the centre, along the edges and at the corner of the substrates. All the images shown in the SEM result are top view of the substrate were ZnO nanorods are appearing to be aligned, tilted or lateral to the substrate.



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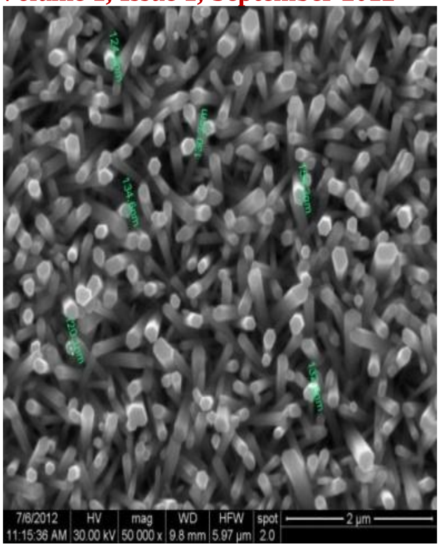

Fig 3. Top View Images

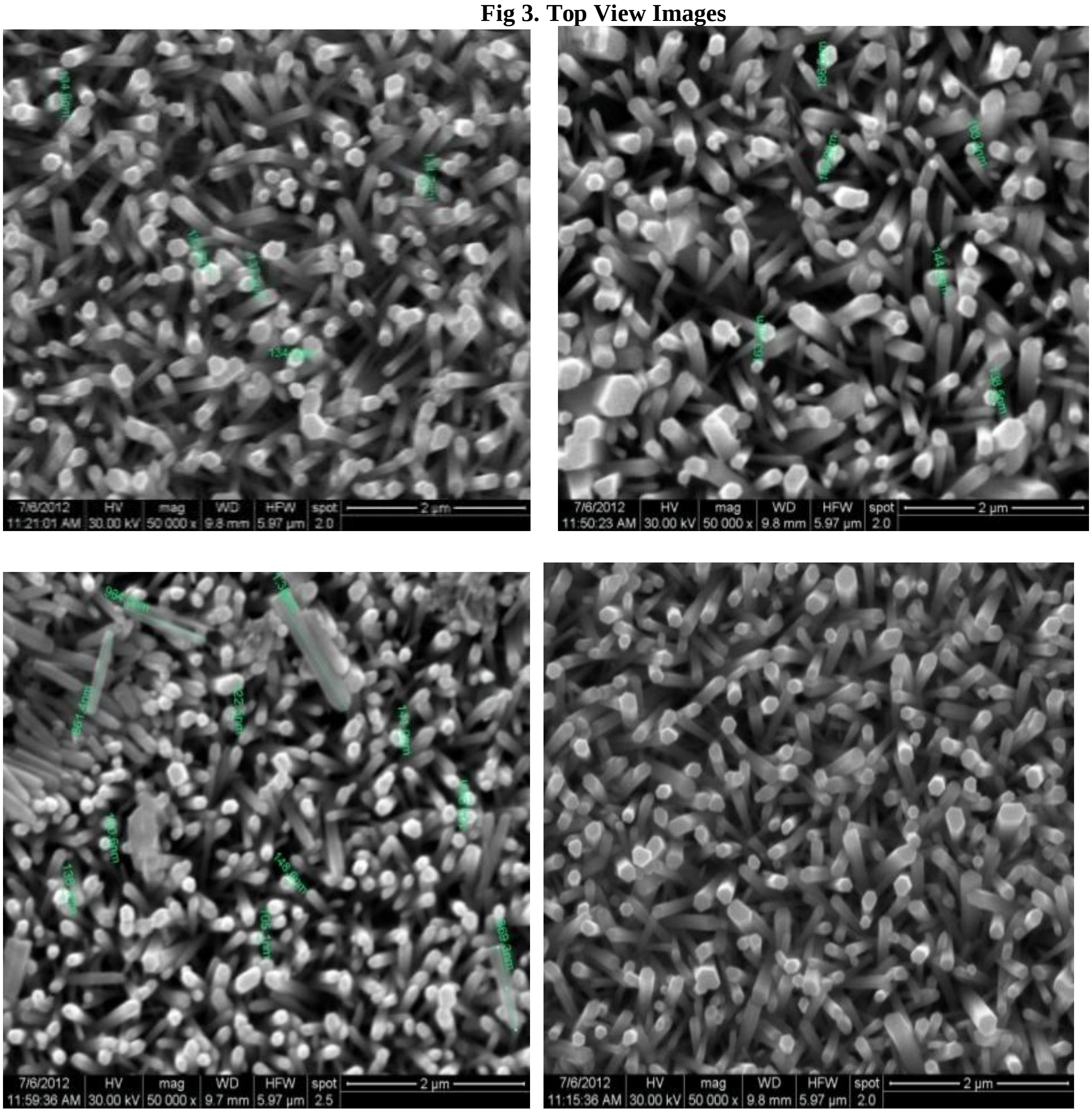

Fig .4. Cross Sectional Images

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PL RESULT

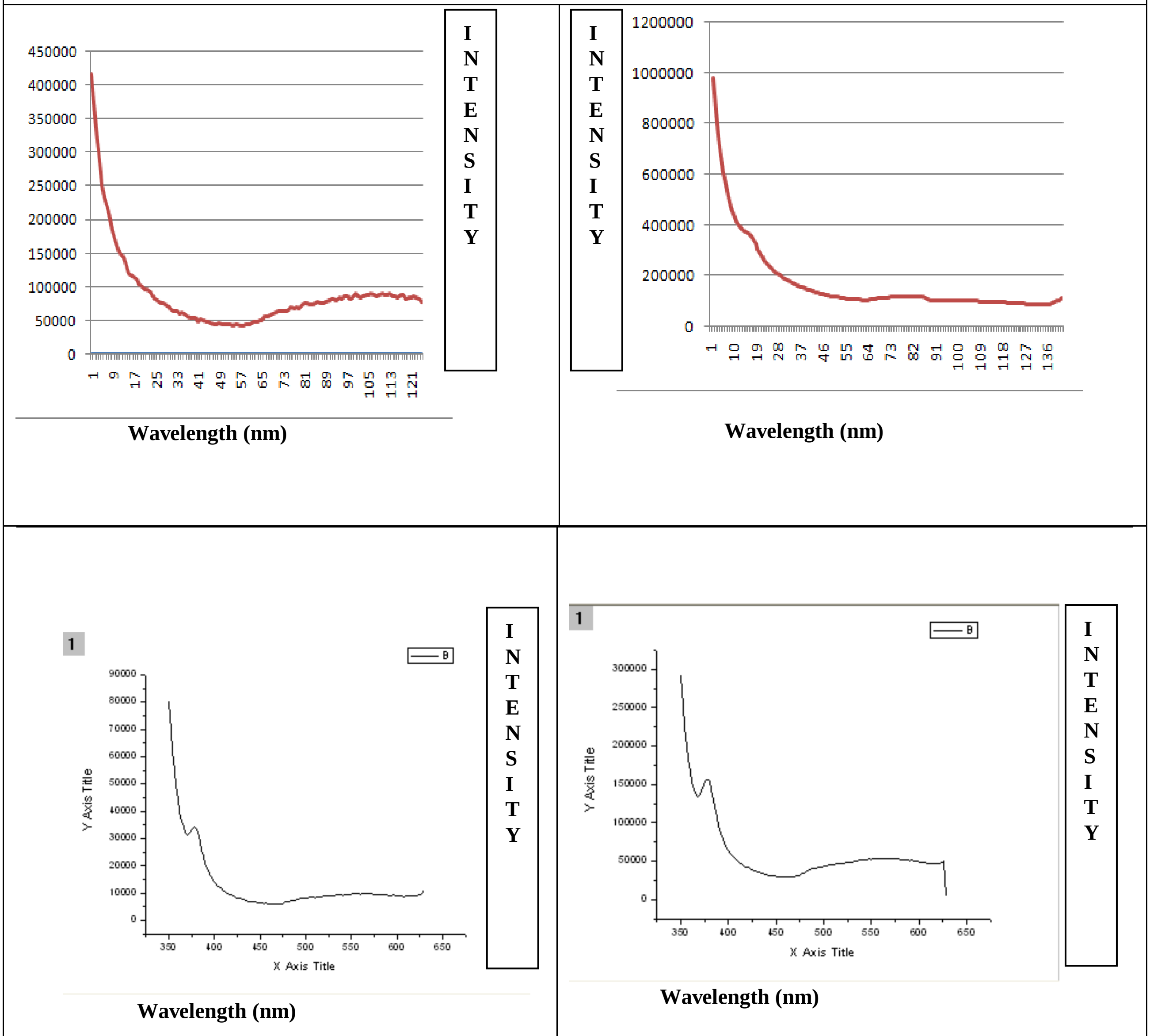

Fig.5. Results Graph

The room temperature photoluminescence (PL) of the ZnO nanorods was examined with a He–Cd laser (325 nm) as the excitation source and the result was shown in Figure. In the PL spectrum, weak and broader emissions situated in the yellow–green part of the visible spectrum have been observed. The UV emission peaked around 386nm is attributed to the near band-edge transition of ZnO, namely, the recombination of free excitons through an exciton–exciton collision process. The strong UV emission in the PL spectrum indicates that the ZnO nanorods have good crystal quality.

XRD RESULT

X-RAY diffraction was employed to determine the phase structure, performed on a XRD diffraction spectrometer with a monochromatic at 40kv and 40mA. Scanning electron microscopy was used to observe the surface

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morphology of samples. All diffraction peaks can be indexed to hexagonal wurtzite ZnO with the lattice constants a=3.249A^0 and c=5.206A^0 and no diffraction peaks from any other impurities have been detected in the spectrum, indicating that the as synthesized products are pure wurtzite ZnO structure.

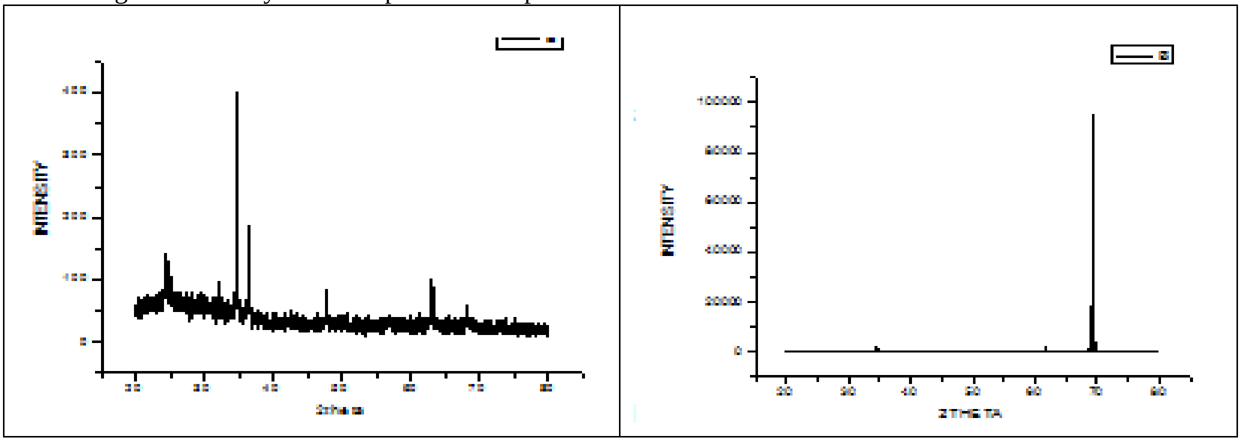

Fig.6. Results Graph

IV. CONCLUSION

ZnO nanorods were successfully synthesized through thermal evaporation method. The average diameter and length of the nanorods are **50nm to 150nm** and **0.05-2micrometer**, respectively. XRD results demonstrate that the-grown ZnO nanorods have a wurtzite ZnO structure. The growth process of ZnO nanorods can be controlled through the five chemical reactions. All the five reactions are in equilibrium and can be con rolled by adjusting the reaction parameters, such as precursor concentration, growth temperature and growth time, in order to push the reaction equilibrium forward and backward.PL behavior shows that ZnO nanorods show a broad curve near 450nm to 600nm range. XRD shows (0001) type of growth.

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