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Electrochemical synthesis of zinc selenide nanowires and their characterization

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Abstract : In this paper, zinc selenide (ZnSe) nanowires are synthesized electrochemically using AAO template. Synthesis is done at 313 K temperature from an aqueous solution of selenium dioxide (SeO_2), and zinc sulphate ($ZnSO_4.7H_2O$). Nanowires of 100 nm diameters are synthesized on copper substrate using anodic aluminium oxide (AAO) template. Morphological and structural characterization was done that reveals the successful fabrication of ZnSe nanowires. Further investigation was done to study the effect of variation in dc current with respect to the change in voltage.

Keywords : Electrodeposition; Nanowires; One dimensional; Characterization; AAO; Template assisted.

INTRODUCTION

One-dimensional nanomaterials have gradually become important in recent era in the field of electronics and material science, because the nanostructure materials exhibit unique properties, i.e. electrical, optical, mechanical, thermal, chemical and magnetic properties as compared with their bulk counterparts[1,2]. In order to utilize the potentials offered by 1D nanostructures, one of the most important issues is to synthesize 1D nanostructures in large scales with a convenient method. Researchers in the field of nanotechnologies, have developed various techniques for synthesizing nanowires that includes lithographic patterning, vapour transport techniques, template based-synthesis and other synthesis techniques[3-12]. Among all these techniques most common technique used for the fabrication of nanomaterials is Electrodeposition/ Electrochemical technique. The template assisted electrodeposition is the simplest and versatile approach for the preparation of 1-D nanostructures/ nanomaterials[13-20]. Electrodeposition technique is cost effective and moreover the growth of nanomaterials can be controlled over the properties by changing the electrolyte, pH value, temperature, and applied voltage[21-27]. By using various templates such as Anodic Aluminium Oxide (AAO) and track-etch polycarbonate membrane various nanowires have been successfully synthesized using electrodeposition technique.

EXPERIMENTAL

In this work, we have successfully fabricated semiconductor ZnSe nanowires from a single solution precursor via template-assisted electrodeposition technique. In our experiment, we have used Anodic Aluminium Oxide (AAO) template (Whatman) 100 nm as mask for producing nanowires. The copper tape used as sub-

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strate for fabrication of ZnSe nanowires. The electrolytic solution was prepared in 20 ml double distilled water containing 0.2 M of $ZnSO_4.7H_2O$, and 0.001 M of SeO_2 at 40-50^0 C temperature. In our experiment we use platinum (Pt) electrode which act as an anode for the deposition whereas copper tape which is used as substrate act as cathode. Electrodeposition of ZnSe nanowires was carried out by applying 2.0 V dc to the electrodes at temperature range 40-50^{0}C for near about one hour. The lengths of the ZnSe nanowires were controlled by adjusting the deposition time. And finally the samples were dried at room temperature for further characterization. The schematic is shown in Figure 1.

RESULTS AND DISCUSSIONS

The morphological and structural properties of the as-deposited ZnSe nanowires have been studied by employing the characterization techniques such as scanning electron microscopy (SEM) and X-ray diffractometer (XRD). The electrical characterization has also been studied for ZnSe nanowires as resistor.

The morphology of as-deposited ZnSe nanowires was studied using scanning electron microscopy (SEM). Figure 2 shows the SEM image from the top of the deposited nanowires while as from Figure 3, SEM studies showed the non-uniform growth of ZnSe nanowires. The pores of the anodic aluminium oxide membrane have hexagonal shape so the nanowires formed were in hexagonal shape. In SEM micrograph the nanowires are found dispersed on the substrate due to under deposition of the materials.

The structural studies of as electrodeposited ZnSe nanowires were also done using X-ray diffractometer (XRD). The patterns were scanned for the scanning angle of 20 to 80 degrees with a step size of 0.0170 degree per second using wavelength (CuKa1) radiation 1.54060 Å. Figure 4 shows the XRD pattern of as-electrodeposited ZnSe nanowires with 100 nm diameter on indium tin oxide (ITO) substrate. The crystalline nature of ZnSe nanowires were ascertained by the diffraction peaks in the XRD Patterns.

The zinc selenide nanowires shows the hexagonal structure as the characteristic diffraction peak patterns match with the standard ICDD zinc selenium data (JCPDS Number: 80-0021)[28], which confirm the formation of zinc selenide nanowires. A high intensity peak in the XRD patterns indexed as (111) suggests that the zinc selenium material used for the nanowires. Besides this, number of XRD peaks are obtained and indexed as (220), (311), (400) and (331). ITO was used as substrate and is verified by matching with the ITO data (JCPDS Number: 32-0458). The '*d*' values observed are 22.509, 31.163 and 32.559 measured at wavelength 1.5418 Å.

An electrical characterization of the as-electrodeposited ZnSe nanowires has been also studied. The current (mA) is noted with respect to the corresponding dc voltage (V) and a graph is plotted as is shown in Figure 5.

The graph clearly indicates that the current initially increases slowly with respect to the change in voltage and after certain knee voltage (1.25 V), the current increases in a linear way with respect to the small in-

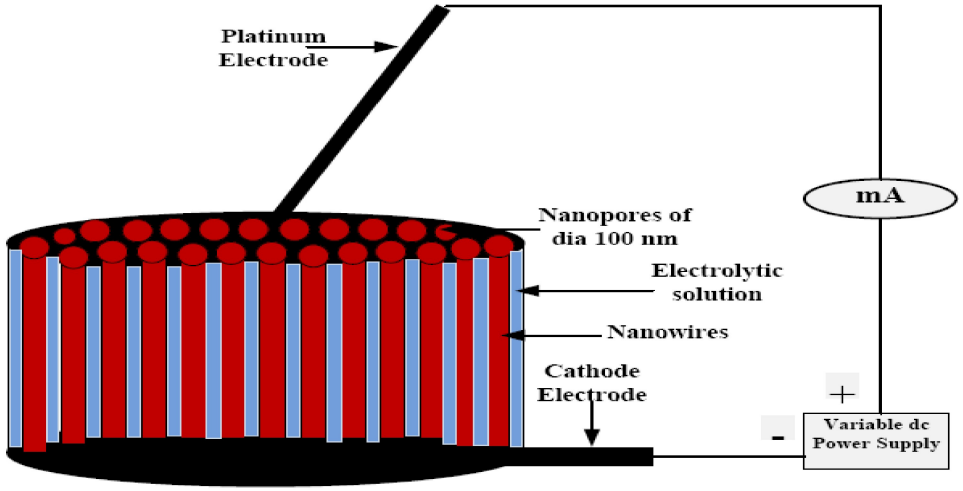

Figure 1

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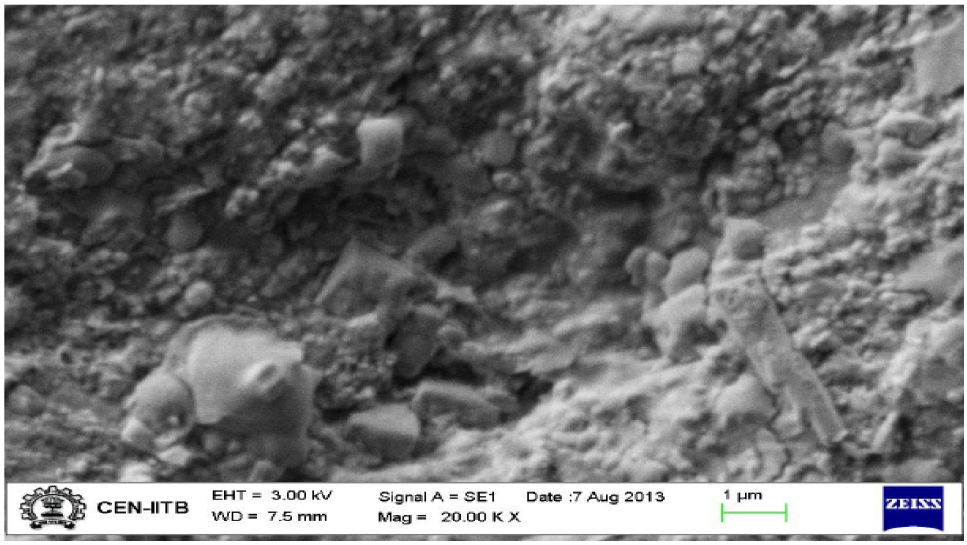

Figure 2

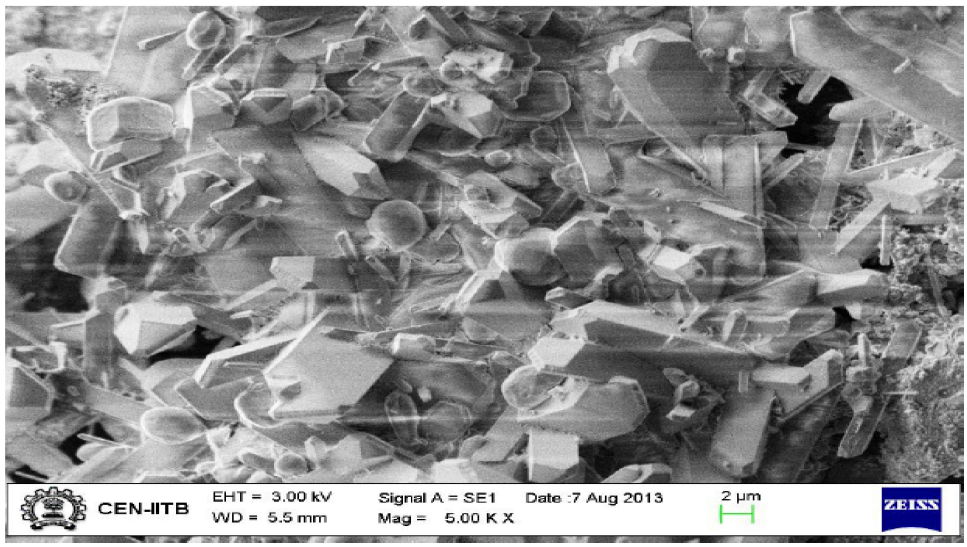

Figure 3

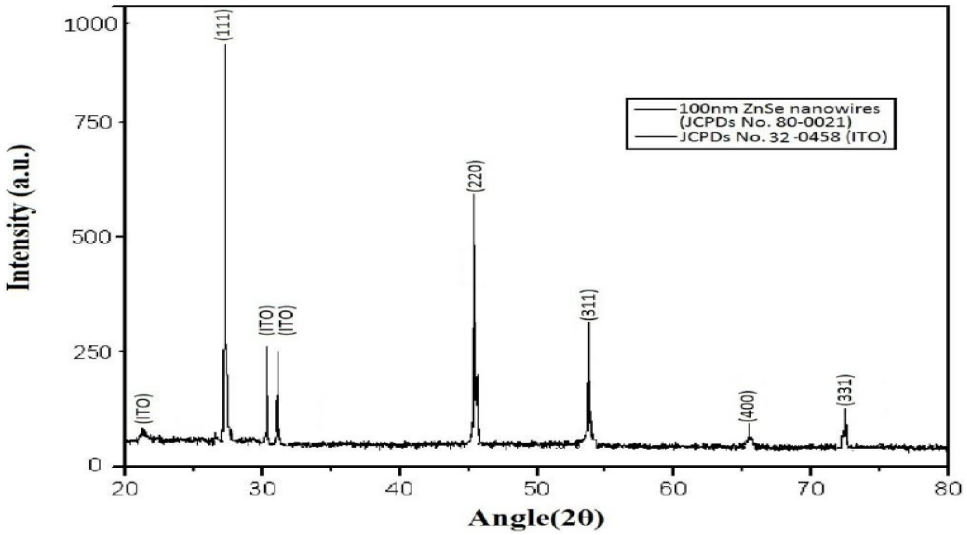

Figure 4

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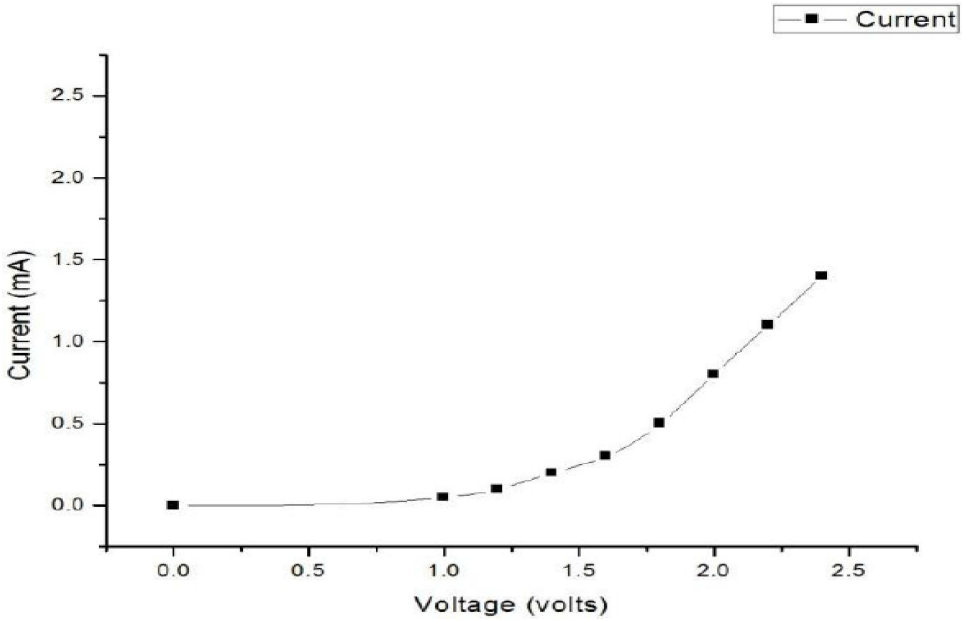

Figure 5

crease in voltage upto 2.5 volts. Thus the plot for VI characteristics reveals the non-linear behaviour of ZnSe nanowires for dc analysis.

CONCLUSION

The hexagonal shaped ZnSe nanowires of 100 nm diameter have been successfully synthesized using chemical electrodeposition technique at 40-50 degrees temperature. The morphological and structural confirms the formation of ZnSe hexagonal structure of non-uniform growth with good aspect ratio. Further, the ZnSe nanowires have been studied for dc analysis that shows non-linear behaviour. The future work will be studied for ZnSe nanowires as chemical sensor.

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