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Fabrication of CdSe nanowires using template synthesis technique

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In this paper we reported the fabrication of CdSe nanowires using Template Synthesis technique. Ion track membranes having nanopores were used as templates. Simple electrochemical deposition technique was used for the synthesis of CdSe nanowires inside the pores of Ion track membranes. Scanning electron microscopy was used for morphological studies of CdSe nanowires.

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1. Introduction

There is enduring curiosity being exhibited towards production and categorization of one dimensional nanowires chiefly due to their prospective innumerable applications in diverse fields including magnetic, electronic and optical devices [1-2]. There are an assortment of procedures used in the production of nanowires but the template synthesis is elegant, adaptable and cost-effective for producing the variety of nanomaterials including metals, semiconductors, heterojunctions, conducting polymers, CNTs etc [3,4 and references therein, 5-7].

CdSe is one of II-IV semiconductors and for the reason that of elevated photosensitivity it has been extensively used in photoconductive devices [8-10]. CdSe nanowires have been produced by direct current (dc) as well as alternating current (ac) electrodeposition into the pores of Anodic alumina membrane(AAM) using $CdSO_4$ and Se dissolved in DMSO (dimethyl sulfoxide) at high temperature [11]. CdSe nanowires also have been genertated through the pores of AAM from alkaline solution containing $CdCl_2$ and SeO_2 by electrochemical deposition at room temperature [12]. Highly specific conditions like concentration, pH and cathodic potential are requisite to have fine stochiometry ratio for Cd and Se.

CdSe nanowires have also been produced by MOCVD technique [13], pulsed laser deposition technique [14], vapour-liquid-solid (VLS) technique [15], solution-liquid-solid (SLS) technique [16], sublimation of CdSe powders [17]. A non-galvanic method (chemical method) for preparing an ordered and crystalline array of CdSe nanowires using AAM as template has also been reported [18]. In the present paper pores in ion track membranes were used as templates for the synthesis of CdSe nanowires. Simple dc elcetrodeposition technique was used at 75±5 ºC.

2. Experimental

For CdSe deposition, 8 µm thick polycarbonate membrane (Whatman) with 80 nm diameter pores at a density of 10^8 pores cm^{-2} has been used. In general, a suitable cell design is required and the lay-out design of such a cell along with other relevant details of the technique has been used [4]. In the present case, two electrode cell made of Teflon was used. The electrolyte solution consisted of 0.05M $3CdSO_4.8H_2O$ and 0.1 Na_2SeO_3. Deionized distilled water was used for preparing the solution. The pH of solution was kept 2.5 using dilute H_2SO_4.

The galvanic replication was carried out for 50 min at 2 V (current 0.017 to 0.031 A) at 75±5 ºC with an anode of pure Cd. The optimum conditions e.g., temperature, voltage, time, stirring, etc. depend upon the cell dimensions, chemistry of the process and previous experience. After the deposition, the polycarbonate templates with CdSe nanostructures were immediately removed from the electrolyte, first rinsed with double-distilled water and ethanol and then dried in air at room temperature. The porous polycarbonate membrane was removed by dissolving it in dichloromethane and washing several times with double-distilled water.

The cleaned and dried samples were coated with a layer of gold-palladium alloy in Jeol, Fine Sputter JFC 1100 putter and subsequently mounted on specially designed aluminium stubs using double-sided adhesive tape. The samples thus mounted were then viewed under Jeol, JSM 6100 scanning microscope at an accelerating voltage of 20 kV. Fig. 1 shows the SEM micrographs of the CdSe nanostructures.

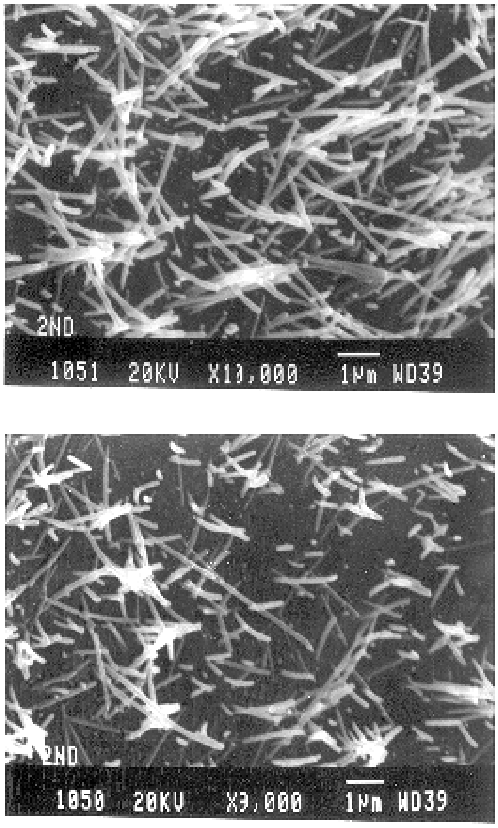

Fig. 1. SEM micrographs of the CdSe nanostructures

3. Results and discussion

In the present work we used the ion track membranes (Whatman) of 80nm. But after scanning through SEM we observed that electrodeposited nanowires were of 90nm. Due to their precise physical properties, cadmium chalcogenides such as CdTe, CdSe, and $CdSe_xTe_{1-x}$ are semiconducting compounds that can be used beneficially in various applications and in particular for the adaptation of solar energy in photovoltaic or photoelectrochemical cells. The pH was adjusted using dilute sulphuric acid. Deposition time is described as the time for reaching a constant charge per unit area at steady deposition potential.

The electrolyte composition, pH and the temperature effects on the deposition time, microstructure, crystalline orientation and surface composition of chalcogenide films also have been examined in detail [19]. The total charge passed through the plating circuit throughout deposition gives an excellent measure of the amount of materials deposited. The variables playing a significant role on plating competence may be observed by controlling the plating time at steady potential.

Among the various techniques, electrodeposition from aqueous solution appears to be particularly cheap, safe and easy to manage; especially plating for large areas. In order to electrodeposit alloy films, it is required that the single elements themselves be independently deposable. For the simultaneous codeposition of the elements, it should be feasible to bring the deposition potentials of the individual elements close adequate to each other by suitable adjustment of the electrolyte parameters. These parameters comprise stirring rate, pH and concentrations of ionic species in the electrolyte and elevated temperature. Many basic features of the electrochemical deposition of semiconductors are still not known accurately, in particular the deposition mechanism itself.

In conclusion, Ion track membranes act as ideal templates for the generation of nanowires.One-dimensional vertical nanowires can be fabricated simply by filling up pores in a substrate by means of electrochemical deposition. The structural design of the porous template or pattern describes the wire shape, direction and size. Because of high aspect ratio nanowires are created through nanopores in ion track membranes, “Template Synthesis” technique gained tremendous popularity. The electrochemical deposition is a route which involves charge transfer, diffusion, reaction and adsorption. Consequently, the organization of nanowires is strictly related to deposition parameters and growth means throughout the procedure [20].

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