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Dielectric and *I–V* characteristics of high luminous CdS nanostructures with confined geometrical growth

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HIGHLIGHTS

- Preparation of CdS nanowires with length 2.6 μm at 1.5 h and nanoflakes.
- One step hydrothermal route by surfactant PEG.
- Dielectric behavior drastically changes with those different nanowires.
- *I–V* behavior also significantly changed.

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ABSTRACT

We have demonstrated in simple hydrothermal route a convenient way to design various nanostructural growth of cadmium sulfide (CdS) with various shapes and morphologies by using different ambient conditions. The synthesized CdS nanoflakes and the first reported large distributed nanowires with lengths of 2.6 μm whose diameters varied on the chemical compositional variation of surfactant poly ethylene glycol (PEG) under controlled extreme pressure in vacuum autoclave. We noticed a drastic change of dc conductivity of CdS nanostructures in confined geometry depending on its duration period of preparation. We can tune the band gap also which quite differ from bulk CdS value due to different structural behavior. The dielectric constant is higher for 3 h duration and we observed two relaxations, one at low frequency region and other, at higher frequency for 3 h duration system in compare to a single relaxation at low frequency region for 4 h duration system. From *I–V* characteristics we obtain an idea about different breakdown voltages and bi stable switching capability of such.

1. Introduction

Over the last decade, low-dimensional nanostructures have received considerable attention from the scientific and engineering communities. These structures exhibit distinct properties that are different from those of bulk materials due to their small size and large surface-to-volume ratios, and they are promising candidates for realizing nanoscale electronic, optical, and mechanical devices. The fabrication of semiconducting metal chalcogenide nanowires has attracted intense interest in the past several years because of their unusual optical and electric properties and potential applications in nanodevices [1]. Among these metal chalcogenides, CdS has been one of the most studied due to its extensive applications in photoelectric conversion in solar cells and light-emitting diodes in flat panel displays [2]. CdS nanowires have been synthesized by several techniques. For instance, the growth of thin CdS nanowires (20 nm thick) has been achieved by a laser ablation technique or chemical vapor deposition (CVD) process based on a gold nanocluster catalyzed vapor liquid–solid (VLS) growth mechanism [3]. Recently, our group reported that CdS nanowires with diameters of 31–53 nm and length 354–360 nm have also been synthesized simply by PEG assisted hydrothermal route [4–6]. Nevertheless, the abovementioned methods need some special instruments, harsh conditions, and/or relatively high performance temperature (over 800 °C). Uniform nanowires of CdS could also be obtained in the channels of various templates, such as anodic aluminum oxide (AAO) membrane [8], polymer gels [9], micelles [10] and so on [11]. Although the template-directed methods are effective in preparing nanowires with uniform and controllable dimensions, they usually lead to a complicated process and also impurities due to the incomplete removal of the templates, and the yields are relatively low. Moreover, CdS nanowires have also been prepared by a solvothermal process which may provide a more promising technique for preparing CdS nanowires, recently publish in our

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previous paper [4–7] than conventional methods in terms of cost and potential for large-scale production. Most of the efforts are aimed on the electro-optical characterization of LC [12,13], but no serious works have been done in understanding the dielectric properties of CdS like nano-composite materials. Newly, in this paper we work hard and tried to focus the main attention about the dielectric properties interestingly by changing diameters and lengths of various CdS nanowires/nanoflakes and also the dc conductivity depending on the suitable changes with various morphological growths of different size CdS nanostructures.

2. Experimental techniques and characterizations

To synthesize different structural variation of cadmium sulfide (CdS) nanowires/nanoflakes, we used chemical ingredients such as ethelynediamine ($C_2H_8N_2$), $C_4H_6O_4Cd{\cdot}2H_2O$ and sulfur powder, poly ethelyne glycol (all are purchased from Atlanta drugs chemical Reagent Co. Ltd., Merck). 0.58 g appropriate amount of analytically pure $Cd(CH_3COO)_2{\cdot}2H_2O$ and 0.078 g S powder put into a 100 ml stainless steel coated Teflon-lined autoclave which were dissolved into 75% of ethelynediamine (EDA) under vigorous

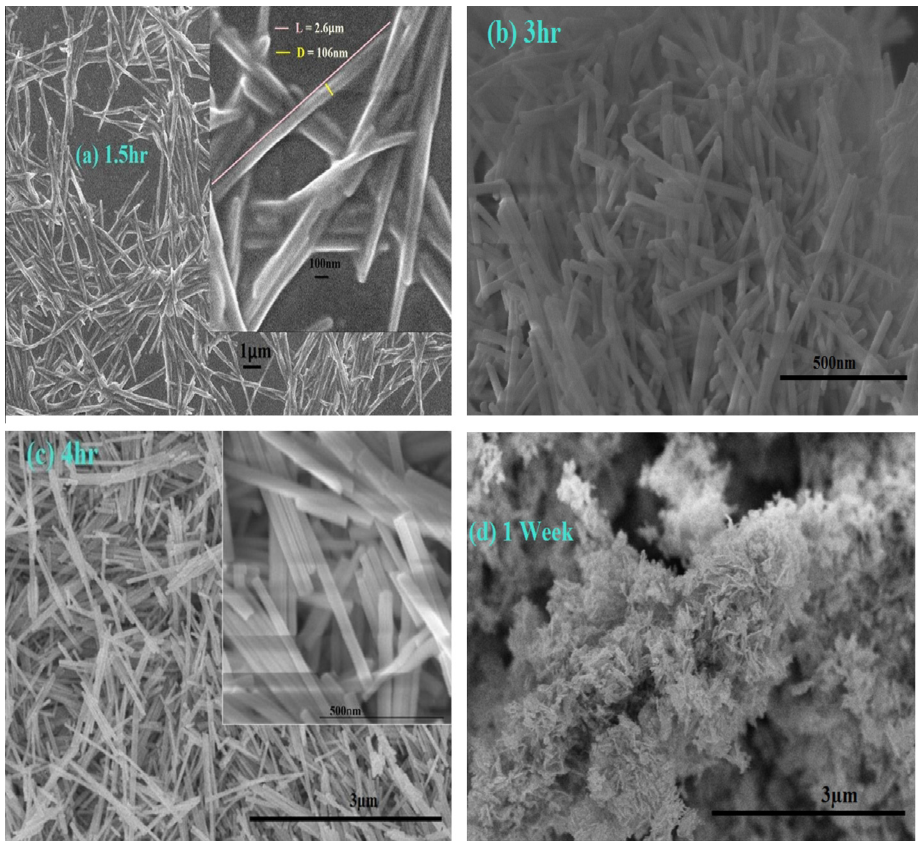

Fig. 1. FESEM images of CdS nanowires with PEG at 1.5 h, 2 h, 3 h and 4 h.

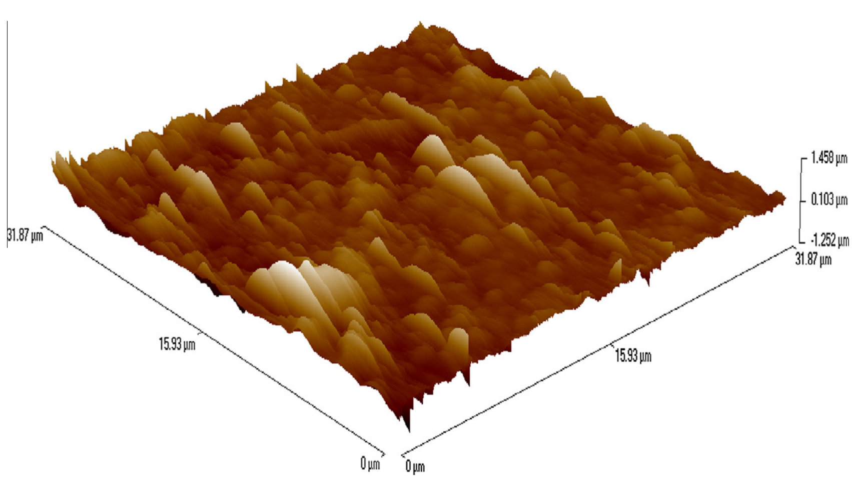

Fig. 2. Atomic force microscopic (AFM) behavior of the surface of thin film deposited CdS nanowires at 3 h.