Nano-Structures & Nano-Objects 16 (2018) 1–8

Contents lists available at ScienceDirect

Nano-Structures & Nano-Objects

journal homepage: www.elsevier.com/locate/nanoso

Self-assembled Cu doped CdS nanostructures on flexible cellulose acetate substrates using low cost sol–gel route

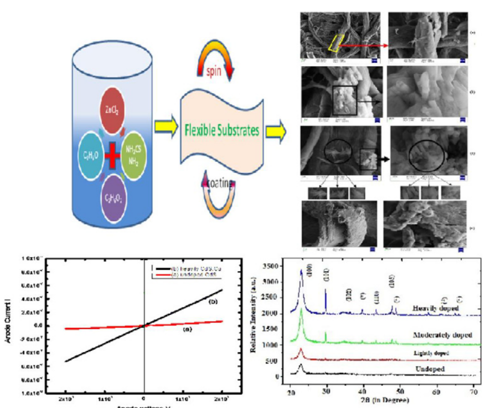
Nitin Kumar [a], Trilok K. Pathak [c], L.P. Purohit [a], H.C. Swart [c], Y.C. Goswami [b,*]

[a] Department of Physics, Gurukula Kangri University, Haridwar, UK, India
[b] Department of Physics, ITM University, Turari, Gwalior, MP, India
[c] Department of Physics, University of the Free State, Bloemfontein, South Africa

HIGHLIGHTS

- Self assembled highly transparent Cu doped CdS nanostructures on flexible cellulose acetate substrates.
- Shape dependent growth in the form of rods is controlled by Doping of Copper.
- Electrical conductivity with optical transmission in visible region makes them suitable for various flexible optoelectronic applications.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 12 June 2017
Received in revised form 20 February 2018
Accepted 5 March 2018

Keywords:
Sol–gel
Flexible substrate
Crystallinity
Nanofibers
Self-assembly
Nanocrystals

ABSTRACT

Copper doped Cadmium sulfide (CdS) nanostructures were assembled on flexible cellulose acetate substrates using low cost sol–gel route. The effects of doping concentrations of copper (Cu) on the CdS nanostructures were studied. The sol was prepared in ultrasonic environment and used for the growth of films using spin coater. The particles and films were characterized by structural, morphological, elemental, optical and electrical studies. Micrographs obtained by field emission scanning electron microscopy (FESEM) reveal the rod shape formation in the presence of Cu with increasing doping concentrations Williamson Hall plots obtained using x ray diffraction (XRD) studies indicate the presence of stress in the lattice due to copper doping. The reduction in crystallite size is observed from 7.29 nm to 5.66 nm. Current–voltage curves exhibit ohmic behavior with an appreciable increase in the conductivity with increasing Cu doping concentrations. Samples show excellent photoluminescence behavior with good absorption spectra in the visible region.

1. Introduction

Since last decade, optically important semiconductor nanomaterials are gaining lot of attention by researchers from various disciplines like Physics, Chemistry, Biology, Engineering and medical sciences. Multidisciplinary potential of such nanoparticles is useful [1–4] to carry out research in various areas of human welfare and comfort. Out of various materials Cadmium Sulfide (CdS) is an II–VI chalcogenide wide band gap semiconductor having band gap about ∼2.42 eV at room temperature [5]. It is a good luminescence material at the nanoscale in the visible region [6–8].

* Corresponding author.
E-mail address: y_goswami@yahoo.com (Y.C. Goswami).

https://doi.org/10.1016/j.nanoso.2018.03.001
2352-507X/

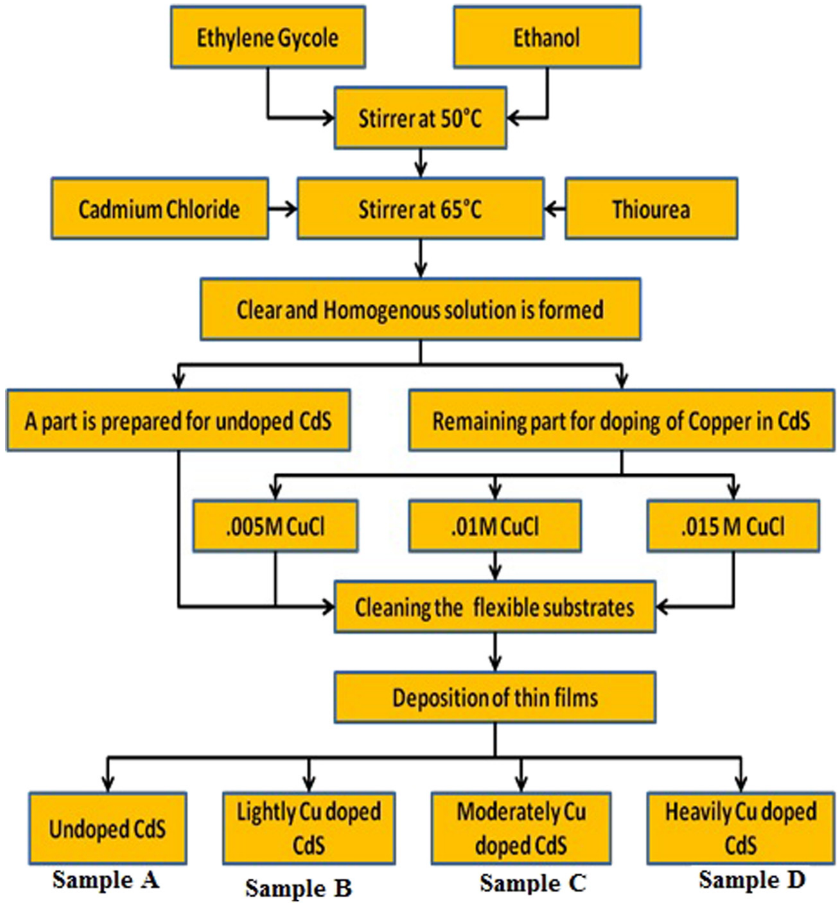


Fig. 1. Flow chart of growth process of undoped and CdS: Cu nanostructures on flexible cellulose acetate substrates.

It has been considered as a multifunctional optoelectronic material having various potential applications in nonlinear optical devices, flat panel displays, light emitting diodes, solar cells and photoconductors etc. [9–13].

Due to the ease of preparation and versatile properties of CdS nanomaterials a large amount of research is reported on CdS, however doping of transition elements such as Cu, Mn, Ni etc. to modify the morphological, optical and structural properties of CdS nanostructures [14–16] is a new and less reported area of research. Recently Zein *k*. Heiba et al. [17] were reported Mn^{2+} doped CdS quantum dots via a simple chemical synthesis. Mn^{2+} doping in CdS increased the band gap of CdS to around 3 eV which is greater than the bulk CdS. As an application, Malik et al. [18] reported efficient light driven photo catalysts using morphology controlled CdS nanostructures. CdS nanoparticles based liquid crystal device is also been reported by Kaushik et al. [19]. Ghosh et al. [20] also investigated structural and optical characterization of CdS nanofibers, However growth parameters are still to be optimized for desired output. To enhance photo catalytic hydrogen evolution a new charge carrier modulation pathway was suggested by Choi et al. [21] using integration of MoS_2 and Ni_2P.

Mechanical flexibility of the devices is also a thrust area where Cu doping may be a good candidate for research [22–25]. Low temperature nanofilms deposition on flexible cellulose acetate was recently reported for organic electronic devices [26,27]. Flexible substrates are versatile and free from damage to glass and metal based electronic devices [28,29]. Rolling based direct transfer printing of nanostructures on flexible substrates paved a new ways for preparation of flexible devices [30].

Numerous methods have been developed to prepare chalcogenide nanocrystalline films are chemical bath deposition [31–33], spray pyrolysis [34], vacuum evaporation [35], pulsed laser deposition [36], sol–gel spin coating method [37,38] and biologicalroutes [39]. In compare to others methods, spin coating with sol–gel is found to be more suitable to grow the nanostructures on flexible substrates [40]. Sol–gel processing is advantageous because of its high purity and low temperature fabrication route and easy doping process, [41] on flexible substrates.

In this paper, we have reported low cost synthesis of undoped and Cu doped CdS on flexible, cellulose acetate substrates. The doping dependent structural, optical and electrical studies were investigated.

2. Experimental details

All the chemicals were of analytical grade supplied by Ranbaxy and measured by analytical balance without any further purification. Undoped and Cu doped CdS layers on flexible cellulose acetate substrates were obtained using different precursors various atomic concentrations. Ethylene glycol ($C_2H_6O_2$, 99%), ethanol (C_2H_6O, 99%) were used as the solvent and Cadmium chloride ($CdCl_2$, 99.99%), thiourea (NH_2CSNH_2, 99.99%), Cuprous chloride (CuCl, 99.99%) were used as the source for Cd, S and Cu respectively. For deposition of layers an APEX spin coater (NXG) was used. Square pieces (area 1 cm^2) of cellulose acetate sheets supplied by Grafix plastics were used as the flexible substrates.

In a typical route for the preparation of samples by the chemical route sol–gel method, the sol was prepared by continuous mixture of ethylene glycol and ethanol in the ratio of 1:2 (although initially various ratios have been tried however based on results, 1:2 was found the best ratio for synthesis). Firstly 50 ml ethylene glycol was