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Synthesis of highly pure single crystalline SnSe nanostructures by thermal evaporation and condensation route

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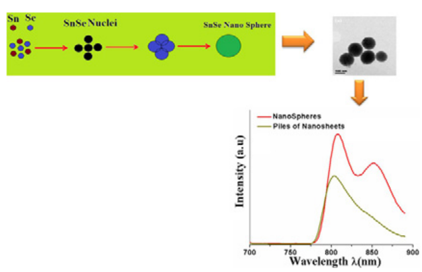
HIGHLIGHTS

► Synthesis of SnSe nanospheres for the first time via CVD technique.
► NH_3(aq) controls the preferred growth orientation as well as the morphology of SnSe.
► A facile route for growth of SnSe nanospheres without any toxic or complex reagents.

GRAPHICAL ABSTRACT



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ABSTRACT

Here we report the synthesis of highly pure single crystalline tin selenide (SnSe) nanospheres by pretreatment of precursors with aqueous ammonia. In this work we have demonstrated that aqueous ammonia not only controls the preferred growth orientation but also controls the morphology of SnSe. Chemical vapor deposition technique was used for the growth of SnSe nanostructures. The optical properties were studied using UV–vis–NIR spectroscopy and Photoluminescence (PL) spectrum.

1. Introduction

Semiconducting nanomaterials have gained considerable attention due to their expected low dimensional quantum effects. These nanostructures are thought to be suitable for advanced optoelectronic devices [1,2]. Among the family of 1D nanostructure metal chalcogenides have attained considerable interest due to their potential applications for photovoltaic cells, infrared detectors and optoelectronic devices. Cadmium telluride is a promising material for solar cells with excellent conversion efficiencies. On the other hand lead sulfide is used in infrared detectors. Due to increasing concern over energy crises, need for solar energy production and suitable materials for producing solar energy is becoming inevitable. The need for proficient and cost effective photovoltaic materials has stimulated a new research in the field of metal chalcogenides synthesis [3–5]. Although cadmium and lead based chalcogenides have better conversion efficiencies, they are toxic and environmentally hazardous. The feasibility to use copper and indium based

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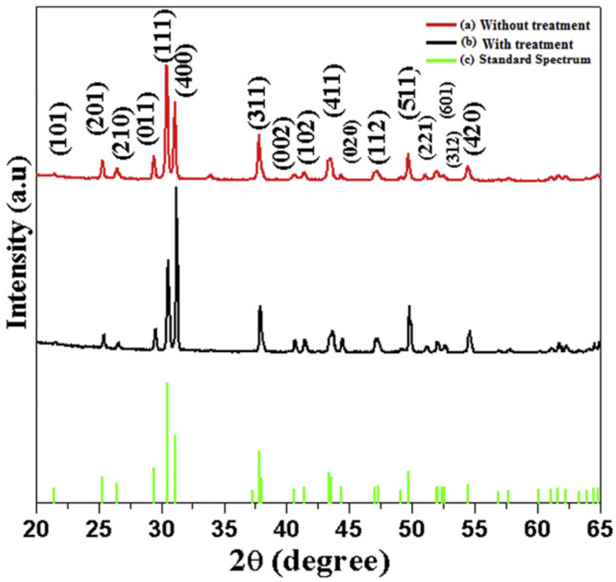

Fig. 1. XRD spectrum of SnSe nanostructures (a) without and (b) with pretreatment. The standard XRD pattern of SnSe (c).

photovoltaic devices is put into question due to increasing cost and scarcity [6,7]. Therefore it is crucial to find alternatives which are economical and environment friendly with high conversion efficiency. SnSe have been explored as an economical, nontoxic and environment friendly material for photovoltaic applications [8–10]. It is a p-type layered semiconductor, with narrow band gap ~1 eV, desirable for optical and electronic devices [11]. It also exhibits multi-exciton generation which allows them to generate more than one electron-hole pair per absorbed photon thus increasing their potential use in solar cells [12]. Other applications of SnSe include memory switching devices [13], Holographic recording material [14–16], infrared production and detection [17], as anode material to improve lithium diffusivity [18] sensors and laser materials [18–21].

Numerous techniques have been employed for synthesis of SnSe such as chemical bath deposition [22,23], vacuum evaporation [7], electro-deposition [24,25], molecular beam epitaxy (MBE) [26,27], migration-enhanced epitaxy (MEE) [28,29], electrochemical atomic layer epitaxy (EC-ALE) [30], thermal evaporation [31], solid state reactions [32], reactive evaporation [5], laser ablation [33], hot wall deposition [34] and solvo-thermal method [35].

All the aforesaid methods are rather complicated or require the presence of toxic reagents like H_2Se. In the present work SnSe nanospheres have been synthesized by pretreatment of Sn and Se powders with aqueous ammonia. We believe that aqueous ammonia plays important role in the formation of nanospheres. Chalcogenides nanocrystals have shown promising applications in the fields of luminescence and non-linear optics [36]. To account for the potential applications of nanosized chalcogenides for solar cells and photovoltaic devices it is important to study and investigate their optical properties. In this work SnSe nanospheres were synthesized for the first time via CVD technique without the presence of any toxic material or complex reagents. We have devised a facile and less complicated route for the preparation of SnSe nanospheres. Room temperature optical characteristics such as UV emission and photoluminescence (PL) were also studied.

2. Experimental

In a typical experiment 1 g of each tin (99%) and selenium (99.99%) powders were used as starting materials. The mixture was

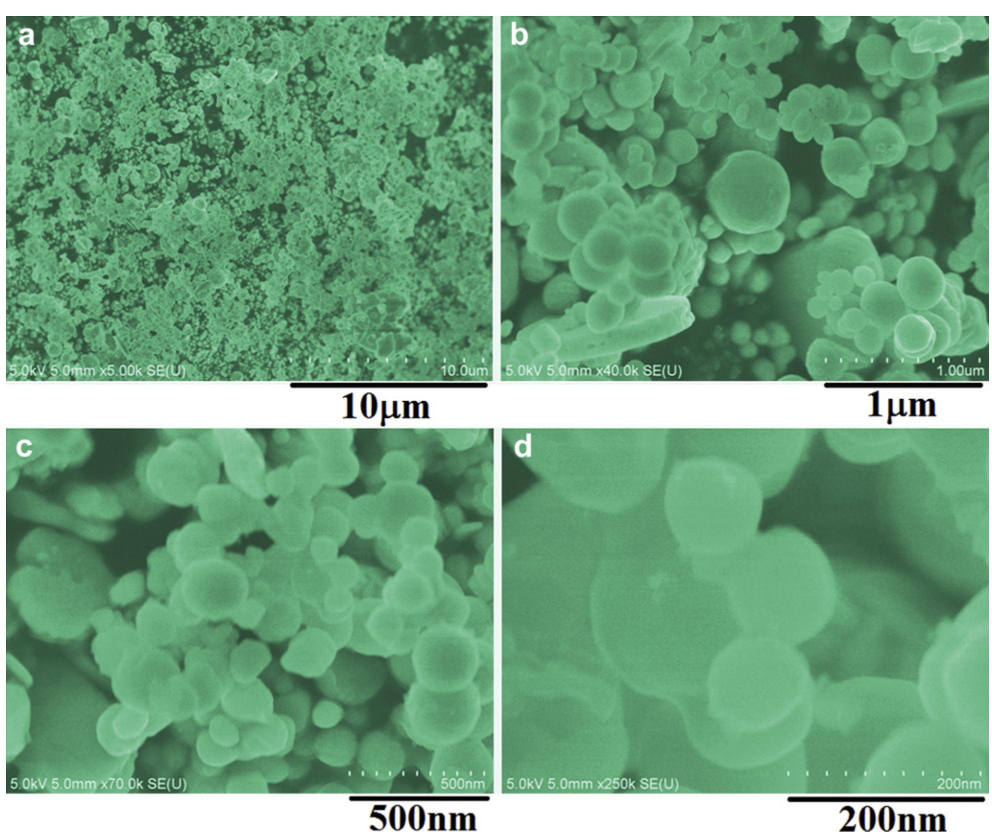

Fig. 2. Low (a and b) and high (c and d) magnification SEM Images of SnSe nanospheres.