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SrS:Ce^{3+} thin films for electroluminescence device applications deposited by electron-beam evaporation deposition method

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ABSTRACT

The strontium sulfide (SrS) thin films doped with different concentrations (0.1, 0.5, 1 and 1.5 mol%) of cerium (Ce^{3+}) ions are synthesized by electron-beam evaporation deposition (EBED) method. The SrS:Ce^{3+} thin films have been deposited on glass substrates. It is interestingly witnessed that both the structural and optical properties of as-deposited thin films are strongly influenced by the concentration of Ce^{3+} ions. The utmost photoluminescence (PL) emission intensity in visible region at 476 and 529 nm is observed for SrS:Ce^{3+} (0.5 mol%) thin film when excited suitably by an ultraviolet (UV–369 nm) light which is well supported by afterglow behavior of SrS:Ce^{3+} thin film for the same composition.

1. Introduction

Alkaline earth sulfide (AES) phosphors are well known for their wide-range industrial applications [1]. Strontium sulfide (SrS), a potential member of AES family acts as a good insulator due to indirect band gap of 4.2 eV in its bulk form [2]. However, SrS doped with suitable activator such as rare earth ions, exhibits excellent and versatile luminescent properties [3,4]. SrS is frequently chosen due to its large band gap, which allows it to create appropriate luminescence centers and emit visible light without self absorption [5]. Cerium (Ce^{3+}) is considered to be an important doping element in the rare earth family due to its remarkable property as a variable electronic structure [6].

Phosphor materials deposited in form of thin films offer significant advantages over conventional bulk powders for display applications because of higher resolution, more uniform density and increased thermal stability [7]. Ce^{3+} doped SrS as a blue luminescent phosphor with superior chromaticity has attracted noteworthy attention recently due to its potential application in the fabrication of full color electroluminescent (EL) displays [8]. SrS:Ce^{3+} thin films can be used to develop optoelectronic devices [9,10], solar cells [11], civil and military applications [12]. These films have been grown using a variety of deposition techniques such as; pulsed laser deposition (PLD) [13,14], radio frequency (RF) sputtering [15], atomic layer epitaxy (ALE) [16], metal organic chemical vapour deposition (MOCVD), etc.

In the beginning of last decade, many research groups including Warren et al. [15], Barth et al. [17] and Xu et al. [18] have synthesized SrS: Ce^{3+} thin films by popular methods like ALE and MOCVD and reported their structural and optical properties in terms of electron paramagnetic resonance (EPR), X-ray diffraction, atomic force microscopy (AFM), photoluminescence (PL) and EL. Later, Fukada et al. [19] studied stabilization of bluish-green luminescent Ce^{3+} centers by Rb doping in SrS:Ce thin film EL devices but structural and optical properties of SrS thin films deposited by electron beam evaporation at varied concentration of dopant (Ce^{3+}) are remaining unaddressed for long time. The novelty of present work lies in the very less film thickness and low roughness profile, smaller average size of particles, low operating voltage of EL device and positions of PL peaks falling in blue and green regions.

2. Materials and methods

The SrS:Ce^{3+} (0.1, 0.5, 1.0 and 1.5 mol%) phosphor powders taken as source materials were synthesized by solid state diffusion method (SSDM) [6]. Strontium sulfate ($SrSO_4$) and activated charcoal were taken in a stoichiometric ratio, while sodium thiosulfate ($Na_2S_2O_3$) used as flux was 15% of the amount of strontium sulfate. The solution of cerium nitrate [$Ce(NO_3)_3.6H_2O$] in ethanol (C_2H_5OH) was preferred to maintain the uniform dispersion of

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