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Structural characterization and photoluminescence properties of pure and Ag(1–5%)-doped ($Cd_{0.95}Zn_{0.5}$)S phosphors synthesized by solid-state reaction methods

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Abstract

Pure and silver-doped cadmium zinc sulphide phosphors have been synthesized by high-temperature solid-state reaction methods under a nitrogen atmosphere. The influence of silver concentration on the crystal structure and the luminescence of solid-state synthesized ($Cd_{0.95}Zn_{0.5}$)S crystals were investigated by X-ray diffraction (XRD), energy dispersive analysis of X-rays (EDX) and photoluminescence (PL) emission spectroscopy. The powder X-ray diffraction (PXRD) pattern of silver-doped ($Cd_{0.95}Zn_{0.5}$)S revealed a hexagonal crystalline phase. The morphology of the samples was studied by scanning electron microscopy (SEM), which confirmed the microcrystalline behaviour and good connectivity with grain. The photoluminescence spectra were obtained by irradiating the samples with 345-nm UV light. The effects of silver concentration on the photoluminescence spectra of the prepared phosphors were investigated in detail.

Keywords: ($Cd_{0.95}Zn_{0.5}$)S:Ag; Solid-state synthesis; Photoluminescence

1. Introduction

Group II–VI semiconductor materials have been the focus of extensive theoretical and experimental studies for several decades. Moreover, these semiconductor materials are of great interest for both fundamental research and industrial development. Because of their nonlinear optical properties, electrical properties, tremendous luminescence quality, quantum cutting and other excellent physical and chemical properties, group II–VI microcrystalline semiconductors have potential applications as sensors, conductors, diodes and optical devices [1–4]. For numerous applications in the field of optics, the optical properties of materials are required to be tunable and thus controllable. The optical property tunability of these materials is imperative and would be beneficial to their applicability [2,5–7]. (CdZn)S is a high band gap material used for various optoelectronic

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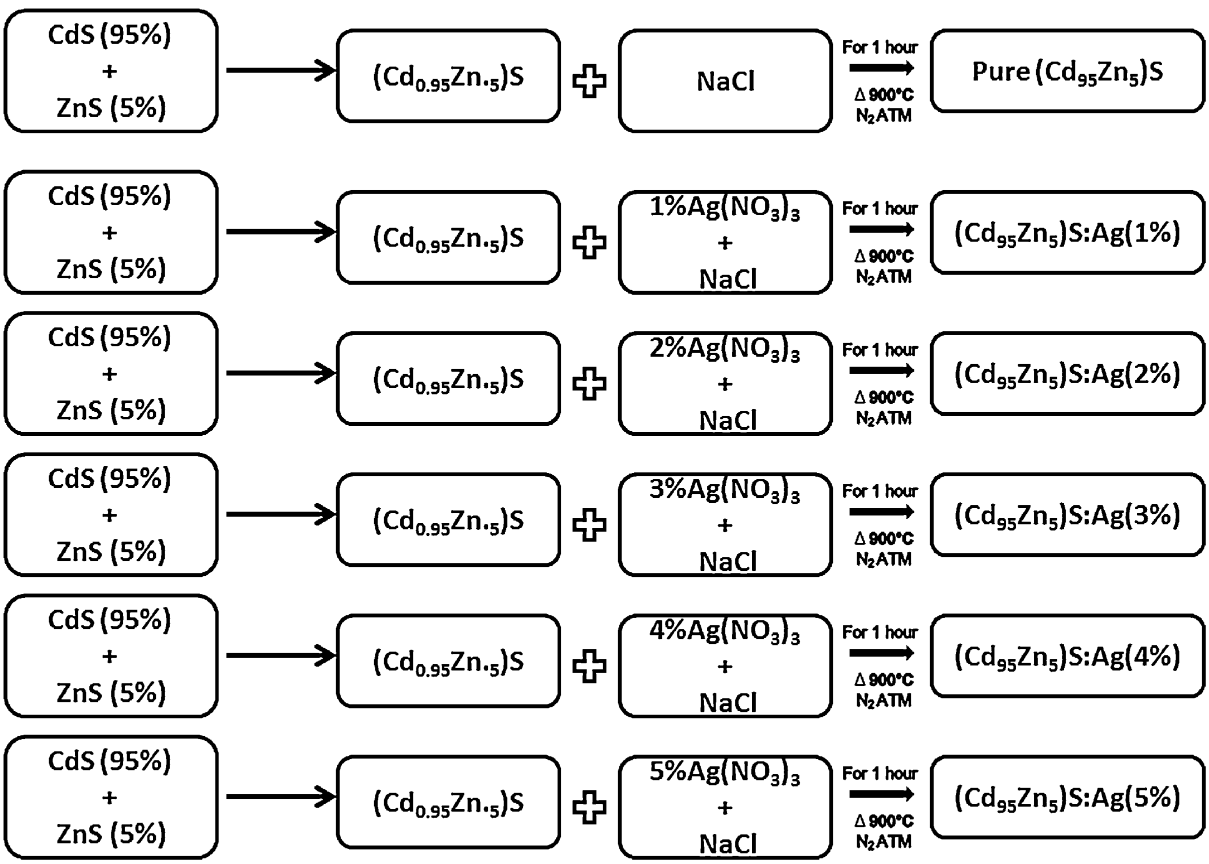
applications in the visible range of the electromagnetic spectrum. Because of its relatively high photoconductivity, high luminosity, tunability and morphological properties, it yields excellent results for various applications [2,8–13].

Among the various methods for the preparation of Ag-doped (CdZn)S materials, solid-state reaction techniques are effective. This technique can provide homogenous internal and volumetric heating. Moreover, the solid-state reaction technique is capable of producing uniform particle size distribution and high purity with fast processing at low cost [14]. The literature reveals that many authors have already studied different properties of (CdZn)S. Sao et al. synthesized Ag^+-doped $(Cd_{0.95}Zn_{0.5})S$ phosphors in an air atmosphere with KCl as a flux, and they also studied the ML and TL properties. Mechanoluminescence properties of $(Cd_{0.95}Zn_{0.5})S$ mixed nanoparticles doped with silver is already reported by Sao et al. (2012) and Ratnesh et al. (2014) [9,13]. The present work intends to study the effect of silver ion concentration on the structural and photoluminescence behaviour of $(Cd_{0.95}Zn_{0.5})S$ phosphors synthesized by solid-state reaction methodology under an N_2 atmosphere.

2. Experimental details

Pure and silver-doped $(Cd_{0.95}Zn_{0.5})S$ phosphors were prepared using solid-state reaction methods. Luminescence grade CdS and ZnS (Fluka, Switzerland) and silver nitrate ($Ag(NO_3)_3$; Merck) were acquired, as well as sodium chloride (NaCl; Merck) for use as a flux. The fixed CdS and ZnS contents (0.95% and 0.5%, respectively) were mixed with different Ag^+ ion concentrations (1–5 mol%) for preparation of the phosphors. The mixture was placed in an alumina crucible, and then heated in a silica tubular furnace maintained at 900 °C under an inert atmosphere of flowing nitrogen gas. After the completion of heating, the mixture was allowed to cool to room temperature in the same furnace. Following cooling, the sample was immediately crushed to convert it into a fine powder with uniform crystal size. (Scheme 1) [2].



Scheme 1. Mechanism of the solid-state synthesis of pure and Ag(1–5%)-doped $(Cd_{0.95}Zn_{0.5})S$ phosphors.