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Influence of Deposition Parameters on the Morphology, Structural, and Optical Properties of ZnSe Nanocrystalline Thin Films

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Zinc selenide (ZnSe) nanocrystalline thin films were prepared by using chemical bath deposition at different ammonia concentrations and different deposition temperatures. The structural and optical properties of ZnSe nanocrystalline thin films were investigated as a function of the ammonia concentration in precursors or the deposition temperature using scanning electron microscopy, energy-dispersive spectrometry, x-ray diffraction measurements, and ultraviolet (UV)–visible spectrophotometry measurements. The results reveal that the ZnSe thin films are composed of a large number of uniform spherical particles. Each spherical particle contains several nanocrystals 5 nm to 7 nm in crystallite size. An increase in both the average diameter of the spherical particles and the crystallite size of the nanocrystals occurs with an increase in ammonia concentration and/or deposition temperature. The Se/Zn atom ratios in the ZnSe thin films increase and the optical band gaps, E_g, of the ZnSe thin films decrease with an increase in ammonia concentration or deposition temperature. The kinetics and reaction mechanism of the ZnSe nanocrystalline thin films during deposition are discussed.

Key words: ZnSe thin films, chemical bath deposition, optical properties, structural properties, reaction mechanism

INTRODUCTION

Because zinc selenide (ZnSe) is an intrinsic *n*-type semiconducting material with a wide band gap of 2.7 eV, it has a very wide application area for devices such as green–blue light-emitting diodes, laser diodes, thin-film transistors, photovoltaic devices, and photoelectrochemical cells.[1–3] At present, ZnSe thin films are used as an *n*-type buffer layer material for high-efficiency Cu(In,Ga)Se_2 (CIGS)-based thin-film solar cells.[4,5] High-efficiency CIGS solar cells have been achieved by the use of a CdS buffer layer grown by chemical bath deposition (CBD). However, Cd is toxic, and there are absorption losses in the CdS buffer layer of CIGS solar cells. Therefore, it is very important to search for new alternative, nontoxic, environmentally friendly, and wider-band-gap buffer materials that are suitable for industrial production and environmental protection. ZnSe is a promising candidate for replacement of toxic CdS in the buffer layer for CIGS thin-film solar cells, due to its environmentally friendly materials, wide band gap (2.7 eV), and good lattice match with Cu(In,Ga)Se_2 absorbers.[6]

There are several methods used to synthesize high-quality ZnSe thin films, including physical vapor deposition,[7] metalorganic chemical vapor deposition,[8] pulsed laser deposition,[9] molecular beam epitaxy,[10] electrochemical deposition,[11] and chemical bath deposition.[12] The ZnSe thin films deposited by physical methods are well known. However, physical deposition processes do not allow uniform coverage over the absorber layer. In recent years, the CBD method has been used for deposition of buffer layers of Cu(In,Ga)Se_2-based solar cells. A thin buffer layer with thickness in the range of 20 nm to 50 nm deposited by the CBD method can achieve uniform coverage over the surface of the absorber layer. In chemical bath deposition, there is

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