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Photoluminescence Studies on Spray Pyrolysis Deposited ZnO-SnO_2 Mixed Thin Films

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Abstract. ZnO-SnO_2 mixed thin films were prepared by the spray pyrolysis technique using different molar ratios of zinc and tin in the starting solution. These mixed thin films were analysed by X-ray diffraction (XRD) and photoluminescence spectroscopy (PL). XRD patterns of mixed thin films indicate the presence of tetragonal casseterite structure of SnO_2 and hexagonal wurtzite phase of ZnO. The grain sizes of mixed films were calculated from XRD patterns and found to be in the range of 17- 84 nm. Mixed thin films exhibit smaller grain size compared to that of pure thin films. Ultraviolet and visible emission peaks were observed in photoluminescence studies of these thin films. The relative contribution of the emission bands occurring from different kinds of defects is described in detail. UV emission peaks were mostly affected by the influence of ZnO. Blue shift in UV emission peaks suggests a reduction in grain size in mixed thin film and bandgap modulation caused by SnO_2.

Introduction

ZnO and SnO_2 are wide bandgap semiconductor materials which are technologically useful in many application including sensors, photovoltaic devices, photocatalyst, lasers, transistors and generators in the recent years [1-3]. ZnO and SnO_2 have an optical bandgap of 3.3 eV [1] and 3.6 eV [4], respectively. They are attractive because of their good electrical properties, high stability and excellent optical properties [5]. Mixed thin films have been focused to better properties compared with pure single oxide thin film. Due to this reason, several groups have been studied a variety of binary mixed thin films compounds such as, SnO_2-ZrO_2 [6], ZnO-V_2O_5 [7], and SnO_2-ZnO [8, 9]. In the past decades, various techniques including pulsed laser deposition [10], RF magnetron sputtering [11], spray pyrolysis [12], and vacuum arc deposition [13] have been used in the deposition of ZnO-SnO_2 mixed thin films. In this work, we use tin (IV) chloride pentahydrate, and zinc acetate dihydrate to prepare ZnO-SnO_2 mixed thin films using spray pyrolysis approach. This is one of the most promising approaches to fabricate mixed thin films for large area production of low cost method among other processing techniques, and deposit a wide variety of films. Quality and properties of thin films prepared by spray pyrolysis is mostly influenced by the processing parameters such as deposition temperature, annealing temperature, type of substrate, concentration of solution, distance between substrate and spray gun, and rate of spray [14].

This work extensively focused on the fabrication of polycrystalline ZnO-SnO_2 mixed thin film and their photoluminescence studies. Complete studies of electrical and optical properties of mixed thin films may helpful to explain the complete photoluminescence spectra.

Experimental procedure

ZnO-SnO_2 mixed thin films were deposited on a glass substrate by spray pyrolysis. Zinc acetate dihydrate [$Zn(CH_3COO)_2.2H_2O$] and tin(IV) chloride pentahydrate [$SnCl_4.5H_2O$] were used as precursors to prepare 0.1 M solution individually. The glass substrates were cleaned by HNO_3, acetone, ethanol and finally rinsed by deionized water. Three different molar ratios of well mixed ZnO and SnO_2 solutions were prepared. Molar ratio of 3:1 thin film was prepared by spraying the mixed solution of Zn solution (15 ml) and Sn solution (5 ml). Similarly, Zn/Sn=1:1 and 1:3 thin