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Preparation and Characterization of Refractory ZnO Buffer Layers for Thin Film Solar Cell Applications

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Abstract

Zinc oxide thin films are widely investigated for optoelectronic and solar cell applications, due to its tunable physical properties. ZnO thin films were prepared by nebulized spray pyrolysis method using dry zinc chloride as the precursor of zinc by varying the substrate temperature and the precursor concentration. The samples were characterized through X-ray diffraction analysis, field emission scanning electron microscopy, UV-Vis-NIR Spectrophotometry, electrical measurement, to study the structural, surface morphological, optical and electrical properties of the prepared zinc oxide thin films. The results of the analyzes confirm that the films are highly crystalline in nature having preferred orientation along (002) plane. The optoelectronic analyzes show that the films are highly transparent having the resistivity in the range of insulators, which further confirms that the films can be used as the buffer layers in the thin films solar cells.

Keywords:ZnO, Buffer layer, thin film, solar cell, spray pyrolysis

1. Introduction

Photovoltaic (PV) cells are one of the most prominently used device for energy production in the present scenario in which thin film solar cells are having potential interest since its low cost and ease of production compared to single crystalline silicon PV technologies. Thin film solar cells are more flexible when compared to other type of solar cells and hence they are portable too. The thin film solar cells are separated into three different types of layers; they are window layer, buffer layer and absorber layer. Zinc oxide [ZnO] is one of the best direct wide band gap semiconductor which can be used for creating various nanostructures and nanoparticles. ZnO has a band gap of

3.37eV, this band gap is best suited for optoelectronic applications and its large exciton binding energy of 60 meV makes it a perfect material for various applications, such as window layers in solar cells, chemical sensors, light emitting diodes, thin film transistors etc., [1] ZnO can be prepared by various methods like physical vapour deposition, chemical vapour deposition, thermal evaporation, sputtering, spray pyrolysis. In the present study, the nebulizer spray pyrolysis method has been adopted to prepare ZnO thin films. The main advantage of using this method is that the average size of the droplets which are sprayed on to the substrate are in the range of 0.1-2 µm and droplet velocity is 0.2-0.4 m/s [1, 2]. This is an effiicient and cost effective pyrolysis method when compared to pressure, ultrasonic and electrostatic based spray pyrolysis for preparing high quality thin films.Present study deals with the preparation of ZnO thin films which can be used as window or buffer layers for thin film solar cells. The effect of substrate temperature and change in molarity has been completely studied by varying substrate temperature and the concentration of precursor.

2. Experimental procedures

Zinc oxide thin films were deposited onto the pre-cleaned microscopic glass substrates. The glass substrates were ultrasonically cleaned using acetone and ethanol and then were dried using normally blown air. The source of Zinc was zinc chloride [MERCK, India] and it was dissolved into 40ml of de-ionized water and was stirred till they completely dissolved in the solvent.

2.1 Effect of temperature

For the first set of depositions (which are denoted as A-series) the substrates were placed onto a heated substrate, where the temperature was varied from 473 K to 673 K, and the molarity of $ZnCl_2$ was 0.1 M, the carrier gas (atmospheric air) pressure was maintained at 1.6 kg/cm^3. The spray rate was kept constantly at 0.6 ml/min.

2.2 Precursor concentration

The second sets of depositions (which are denoted as B-series) were done with the optimized temperature that was obtained from the first set, which was set at 523 K. Now the concentration of precursor [$ZnCl_2$] was varied from 0.05 M to 0.15 M.

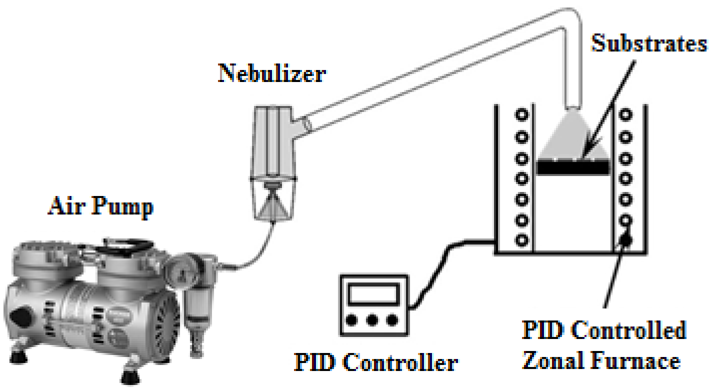

Fig.1. Nebulizer Spray Pyrolysis setup

The Fig. 1 shows the working setup of the nebulized spray pyrolysis, in which the nebulizer is connected to a L-shaped glass tube through which the aerosol particles are transported with the help of compressed air. The aerosol droplets are sprayed onto the substrates which are placed inside a zonal furnace. The temperature inside the furnace