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Characterization and Processing of CdS/ZnS Thin Layer Films Deposited onto Quartz for Solar Cell Applications

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Abstract

In this work, synthesis and processing of CdS/ZnS multilayer thin film systems are studied; compositional changes within these thin films structures are investigated by the Rutherford backscattering (RBS) technique to determine the depth distributions of the mixed region and stoichiometry according to Rump simulation which is used to estimate layer thickness and compositions even for complex samples; depth profiling using this program is also determined. The RBS data reveal a more homogeneous film could be obtained after annealing in 400°C and stoichiometric film structures with composition $Cd_{1-x}Zn_xS$, where x=0.6 are synthesized in ZnS/CdS bilayer.

Keywords: Thin film; ZnS/CdS; Chemical treatment ; Thermal treatment; RBS; Depth profiles; Vacuum deposition; Solar cell

1. Introduction

Over the years, CdS and ZnS thin films have been intensively investigated mainly for their applications in large-area electronic devices such as thin-film field-effect transistors and solar cells. Among several n-type semiconductor materials, it has been observed that the large band gap n-type window material CdS is the most promising hetero-junction partner for the well-known photovoltaic

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materials, e.g. ZnS [1, 2]. This latter thin film has a vast potential for use in short-wavelength optoelectronic such as electroluminescent devices due to his band gap which is of 3.66eV [3, 4]. So by the addition of ZnS, the band gap energy of CdS can be increased, hence combination of the two thins films produce $Cd_{1-x}Zn_xS$ thin film which has a larger energy gap make it transparent to practically all wavelengths of solar spectrum [5] also by using this higher band gap materials i.e. $Cd_{1-x}Zn_xS$ as a heterojunction partner to CdTe can improve the window band gap then improve the short wavelength spectral response of CdTe solar cell.

$Cd_{1-x}Zn_xS$ can be prepared by a variety of techniques, including spray pyrolysis, ion beam deposition, molecular beam epitaxial growth, chemical bath deposition, thermal evaporation, and screen printing methods [7].

The Rutherford Backscattering technique (RBS) is one of the most powerful methods to investigate the composition, stoichiometry and depth profile of solids and consequently any structural changes in their composition as a result of ion beam modifications. This technique has been considered for the measurement of dose accumulation in a semiconductor substrate during an implant. The RBS involves measuring the number and energy of ions in a beam (usually He ions) that backscatter after colliding with atoms at surface and near-surface regions of a sample at which the beam was targeted. With this information and the scattering geometry, it becomes possible to determine quantitatively mass information and elemental concentrations versus depth below the surface [8].

The most extensive use of the RBS technique finds itself in various fields of electronic and optical materials and applications, e.g. special coatings and in the study of various physiochemical processes on solid surfaces [9].

Our goals in this work are to study mixing effects of synthesized CdS/ZnS multilayer thin film systems deposited on quartz substrate by using vacuum deposition method, chemical and thermal treatment will be used to achieve homogeneous $Cd_{1-x}Zn_xS$ thin films, also compositional changes within the thin films structures will be investigated by the RBS technique to determine the depth distributions of the mixed region and stoichiometry.

2. Experimental methods

In the preparation of CdS/ZnS thin film layer, a ZnS film was first deposited on Quartz substrate with thick of 700A° by vacuum deposition with a typical working pressures of 10^{-4} Pa were used during evaporation, this was then dipped in 1% $CdCl_2$ methanol solution for about 30 s, then dried with an infrared lamp, and then rinsed in the Deionized water. This was followed by an additional deposition of CdS thin film with thick of 500A°; finally the samples were annealed in air at 400 °C for 15min.

Rutherford backscattering (RBS) was used to characterize the films, using 2 MeV α-particles beam supplied from the Jordan University Van de Graaff accelerator (JOVAC). Detection of backscattered particles was done using normal incidence and a scattering geometry with angle 135° relative to the incident beam and the reflected particles were collected using a silicon surface barrier detector of 12keV resolutions and 50 active area. To assist in the evaluation, Rump simulation was used in order to estimate of the layer thickness, compositions and determine the depth profile of our samples [10].

3. Results and discussion

Typical and theoretical results of Rutherford backscattering (RBS) experiment for our multilayer ZnS\CdS samples are reported in figure 1 for two cases: before and after chemical treatment, the calculated (theoretical) spectrum which is obtained from Rump simulation and is shown as a solid curve appear to be in good agreement with the measured spectrum (experimental) which is represented by open