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Structural and optical properties of CdTe thin films deposited using RF magnetron sputtering

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Abstract

In this work, we have studied the influence of RF power on structural and optical properties of CdTe thin films deposited by indigenously designed locally fabricated RF magnetron sputtering. Films were analyzed by using variety of techniques such as low angle X- ray diffraction, UV-Visible spectroscopy, Raman spectroscopy etc. to study its structural and optical properties. Low angle XRD analysis showed that CdTe films are polycrystalline and has cubic structure with preferred orientation in (111) direction. Raman scattering studies revealed the presence of CdTe phase over the entire range of RF power studied. The UV-Visible spectroscopy analysis showed that the band gap decreases with increase in RF power. However, CdTe films deposited at higher RF power has optimum band gap values (1.44-1.60 eV). Such optimum band gap CdTe can be use as absorber material in CdS/CdTe and ZnO/CdTe solar cells.

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Keywords: CdTe; RF sputtering; Raman spectroscopy; Low angle XRD, UV-Visible spectroscopy

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1. Introduction

Cadmium Telluride (CdTe) is becoming the most successful contender to Si photoactive material for the realization of solar cells due to its high efficiency and low cost solar cell applications. The material is gaining great interest among the researchers due to its crucial properties such as long term performance stability [1], direct band gap (1.44 eV) that is near the optimum for photovoltaic solar energy conversion [2] and high optical absorption coefficient (> 10^5 cm^{-1}) to achieve a nearly full absorption of solar spectrum for thicknesses below 800 nm [3, 4].

Various deposition techniques can be used to the preparation of CdTe thin films includes closed space sublimation (CSS) [5], molecular beam epitaxy (MBE) [6], electrodeposition [7], pulsed laser deposition (PLD) [8, 9], metal organic chemical vapor deposition (MOCVD) [10], successive ionic layer adsorption and reaction method (SILAR) [11], screen printing [12], physical vapor deposition (PVD) [13], vacuum evaporation [14], electron beam evaporation [15], RF sputtering [16] and spray pyrolysis [17] etc. Among these methods RF magnetron sputtering method is most commonly used technique for the deposition of CdTe films and has been established for industrial applications. The RF magnetron sputtering permits deposition at low temperature, and gives better adhesion, larger coverage and higher film density than other methods. The main advantage of RF magnetron sputtering is that the stoichiometry of the sputtering material is retained in the deposited film making it a suitable technique for depositing intermetallic compounds [18]. Another advantage of the sputtering technique is the use of low energy particle bombardment for achieving lower growth temperatures along with the use of excited species for improving the doping control during growth [19].

The physical properties of CdTe films deposited by RF magnetron sputtering strongly dependent on process parameters such as sputtering power, argon gas pressure, substrate temperature, target-substrate distance etc. Enormous work has been done on structure, optical and electrical properties of CdTe thin films deposited by RF magnetron sputtering. However, still it requires further investigation to optimize the optical and structural properties to use as a suitable candidate for solar cell applications. With this motivation we have initiated the detailed study of synthesis and characterization of CdTe films using RF magnetron sputtering method. In this paper, we present the detail investigation of influence of RF power on structural and optical properties of CdTe films deposited by RF magnetron sputtering method.

2. Experimental

2.1. Film Preparation

The CdTe films were deposited on corning #7059 substrates using indigenously designed locally fabricated RF magnetron sputtering system [20]. Fig 1 shows the schematic diagram of RF magnetron sputtering system.

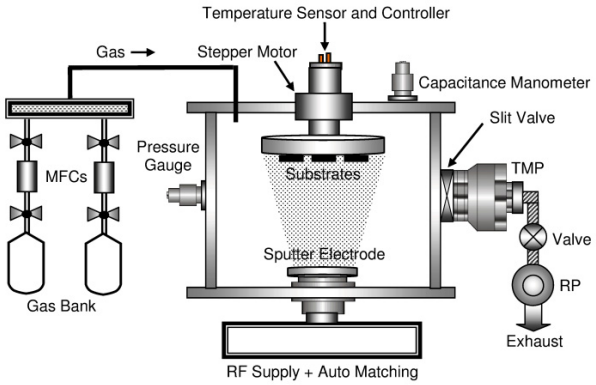

Fig. 1. Schematic diagram of indigenously designed locally fabricated RF magnetron sputtering system.

It consists of a cylindrical process chamber coupled with a TMP followed by a roughing pump which yields a base pressure less than 10^{-7} Torr. A target of 4 inch diameter (99.99 %, Vin Karola Instrument, USA) was used for