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Review Article

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Cadmium chalcogenide thin films

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ABSTRACT

Cadmium chalcogenide thin films have been prepared by many deposition methods. The main benefit of cadmium chalcogenide materials is produce high power conversion efficiency solar cells compared with other chalcogenide thin films. Unfortunately, cadmium is highly toxicity and non-eco-friendly substance. Therefore, researchers must work harder in order to seek the less toxic materials to replace cadmium.

Keywords: thin films, cadmium; chalcogenide; solar cells

INTRODUCTION

In recent years, preparations of metal chalcogenide of various groups could be categorized into binary (Table 1), ternary (Table 2) and quaternary compounds (Table 3). These compounds have attracted considerable attention by many scientists due to their applications are possible in many areas of modern technology. They have a wide range of applications such as photovoltaic cell, laser screen, light emitting diode, sensor materials, thin films polarizers, thermoelectric cooling materials, infrared optoelectronic devices and memory switching devices.

Cadmium chalcogenide thin films are an attractive semiconducting material due to their variety of uses. These thin films have been prepared by many methods including chemical bath deposition[43-51], electro deposition [52-54], thermal evaporation [55-58], photoelectrochemical deposition [59], spray pyrolysis [60,61], screen printing method [62], close spaced sublimation [63,64], vacuum evaporation [65], polyol method [66], sol gel [67], electrochemical atomic layer [68], sputtering [69], electron beam evaporation [70,71], molecular beam epitaxy[72], chemical vapor deposition[73] and successive ionic layer adsorption and reaction[74].

Overview

In this review paper, preparation of cadmium chalcogenide thin films was discussed. These compounds have recently emerged as one of the most popular research activities. Up-to-date, there are a number of reports on the electrical, optical, morphological, structural and compositional properties of cadmium chalcogenide thin films prepared by different deposition methods.

For example, many scientists have reported synthesis of cadmium chalcogenide thin films using chemical bath deposition method due to some reasons such as a simple low cost method and easily set up their experiment in the laboratory. There are so many scientific papers present details of chemical bath deposition of thin films by using different cadmium sources such as cadmium sulfate[75-77], cadmium acetate[78-82], cadmium nitrate[83-84], cadmium iodide [85-86] and cadmium chloride[87].

On the other hand, a number of workers have prepared cadmium chalcogenide thin films using thermal evaporation technique. Jaber et al [56] studied the influence of substrate temperature from 25 to 300 °C on thermally evaporated CdS thin films. The XRD results show that the films have a cubic and hexagonal structure which prepared with low and higher temperature, respectively. For the data obtained, it is clear that the lattice parameter [88], grain size [89] and resistivity [90] were increased as the substrate temperature was increased. Also, Shah et al reported that the increase of temperature improves the surface morphology of CdS films and also diminishes cracks on the films according to scanning electron microscopy results. However, Salah et al have reported that the film thickness is reduced with increasing the temperature.

Electro deposition technique has many advantages such as simple, less monitoring required and requires less amount of starting materials. Therefore, much attention has been given in recent years to prepare various cadmium chalcogenide thin films. In order to develop a suitable condition for the deposition of films to occur, various parameters have to be optimized including the pH value of the solution, cathodic potentials and annealing temperature. CdS thin films have been deposited onto indium tin oxide glass substrate by Sasikala et al. [91] using electro deposition method under various cathodic potentials. They claimed that the good quality films were obtained at a cathodic potential of −0.6 V. Meanwhile, CdSe thin films have been deposited on the titanium substrate by Shen et al. using electro deposition technique. The authors claim that the nearly stoichiometric CdSe films were obtained at deposition potential of -0.7 V. [92] In terms of topography studies, the results showed the surface topography of electrodeposited CdSe films is smoother than that of the CdS thin films and crystal grains are smaller. [93]. Lastly, many researchers present the successful preparation of thin films deposited on substrate using different pH values, either from acidic [94-98] or basic medium [99].

As we understand, the cadmium is abundant and available anywhere. Therefore, cadmium is a favorite material for the preparation of thin films. Furthermore, the obtained films are good match with sunlight and can absorb sunlight at close to the ideal wavelength. The main advantage of cadmium chalcogenide materials is yield high efficiency solar cells compared with other chalcogenide thin films. Efficiency as high as 16.5% has been achieved in CdS/CdTe heterojunction structure in laboratory in 2001, and current techniques for CdS/CdTe solar cells gradually step toward commercialization [100]. On the other hand, Tetsuya et al have reported a photovoltaic conversion efficiency of 16.0% under Air Mass 1.5 conditions has been measured by the Japan Quality Assurance Organization[101].

Unfortunately, the major drawback of cadmium chalcogenide thin films, is toxic and non-eco-friendly substance. It is a heavy metal of considerable toxicity with destructive impact on most organ systems [102]. Its toxicity is known in its entire form included metal, vapor, salts, inorganic and organic compounds [103].

Second issue is difficult to obtain uniformity over a large area and stoichiometry especially when scientists prepare CdS thin film using thermal evaporation technique. It is due to the difference in vapour pressure between cadmium and sulphur elements. Bear in mind that in order to achieve uniformity of films, many deposition conditions such as chamber vacuum, rotation, temperature and substrate distance must be controlled carefully.

In future, researcher must work harder in order to looking for suitable materials to replace cadmium chalcogenide thin films. They should pay full attention to use more environmentally friendly photovoltaic materials.

Table 1 Binary thin films

Thin films	Reference
Ni_4S_3	[1]
CdSe	[2]
PbSe	[3]
Bi_2Te_3	[4]
NiS	[5], [6]
Cu_2S	[7]
CuS	[8]
SnS	[9]
ZnSe	[10], [11]
SnSe	[12], [13]
MnS_2	[14]
NiSe	[15]
FeS_2	[16]
Bi_2S_3	[17]
ZnS	[18]
In_2S_3	[19]

Table 2 Ternary thin films

Thin films	Reference
Cu_4SnS_4	[20], [21], [22]
$MoBi_2Se_5$	[23]
$ZnS_{0.5}Se_{0.5}$	[24]
$SnS_{0.5}Se_{0.5}$	[25]
$CuInS_2$	[26], [27]
Cu_3SnS_4	[28]
$CuAlSe_2$	[29]
$CuSbS_2$	[30]
$Pb_{1-x}Mn_xS$	[31]
$AgInS_2$	[32]
$Mg_{1-x}Ni_xS$	[33]
$Ni_3Pb_2S_2$	[34]
$CuInSe_2$	[35],[36]

Table 3 Quaternary thin films

Thin films	Reference
Ag-Zn-Sn-S	[37]
Cu_2ZnSnS_4	[38], [39], [40], [41]
$Cu_2ZnSnSe_4$	[42]

CONCLUSION

Cadmium chalcogenide thin films have been successfully prepared using various deposition techniques as shown in this work. However, due to its toxicity, researchers must work hard in order to looking for eco-friendly materials to replace cadmium.

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