

Characteristics of cadmium selenide: Cuprous selenide photovoltaic cells

I Radhakrishna, K R Murali and K Nagaraja Rao

Central Electrochemical Research Institute, Karaikudi - 623 006, INDIA

Thin films of cadmium selenide were cathodically deposited on ITO, molybdenum and stainless steel substrates by short circuiting the substrates to an easily oxidisable metal like aluminium or cadmium in a bath containing cadmium sulphate and selenium dioxide at a pH around 2. The as-deposited films were characterised by X-ray diffraction studies and their composition analysed by EPMA. These films were etched in hydrochloric acid-acetic acid mixture and cuprous selenide layers were grown topotaxially on CdSe layers. The effect of heat treatment on the output of the CdSe:Cu_{2-x}Se cells as well as their stability is presented.

Key words: Photovoltaic cell, cadmium selenide, cuprous selenide

INTRODUCTION

Although considerable efforts, extended over many years, have been devoted to the study of photovoltaic cells based on CdS, relatively little attention has been paid to cells based on the related II-VI compound, CdSe, which has very similar properties like CdS. Most studies of the photovoltaic application of CdSe have been concerned with MIS structures based on evaporated films. Investigations of CdSe-Cu_{2-x}Se heterojunction sublimed Cu_{2-x}Se on to thin films [1] and single crystals of CdSe [2,3] have been reported. In the present paper, the characteristics of CdSe:Cu_{2-x}Se photovoltaic devices based on electrodeposited CdSe films are presented.

EXPERIMENTAL

Thin films of CdSe were deposited on ITO, molybdenum and stainless steel substrates. The bath for deposition normally contained CdSO₄ and SeO₂. The pH of the bath was adjusted to a value of 2 by adding 10% H₂SO₄. In a typical deposition run, the bath was first thermostated at the required temperature. The temperature of the deposition bath was varied in the range 333-358K. After the desired temperature was attained the substrates were suspended in solution and shorted to an aluminium sheet. The aluminium sheet serves as a source of electrons for the redox reaction. Deposition was done for a period of 5 hours to get a thick film. The deposited films were characterised by X-ray diffraction studies and morphology of the surface was studied by SEM. Optical absorption measurements were made at room temperature using a spectrophotometer. Thickness of the films was measured by the weighing method. The as-deposited CdSe films were etched in 1:3 hydrochloric acid for a few seconds to open grain boundaries, washed with distilled water dipped in

a hot solution of cuprous chloride, sodium chloride and hydrazine (363K) at a pH 2-3 for 5-10 seconds. A topotaxial growth of Cu₂Se takes place wherein cadmium atoms are replaced by copper while the chalcogen lattice remains unaltered [4]. The layers were washed with distilled water and dried.

For junction formation, these CdSe-Cu_{2-x}Se devices were heated at various temperatures for different periods of time. ITO served as the bottom contact and evaporated silver served as contact to the p-side layer. The devices were heat treated in air at 493K for various periods in the range 5-15 minutes. Longer heat treatment resulted in decrease of layer thickness.

RESULTS AND DISCUSSION

Films of varying thicknesses in the range 0.5-2 μm were routinely grown on ITO substrate. X-ray diffraction patterns of as-deposited CdSe films exhibited broad peaks corresponding to (111), (220) and (311) orientations. Films deposited at a bath temperature of 353K exhibited sharper diffractograms compared to films deposited at lower temperatures. Surface morphology studies indicated that large grained (>1.5 μm) films were obtained on stainless steel substrates. EPMA analysis of the films indicated the presence of Cd and Se in stoichiometric quantities. Analysis of the optical absorption spectrum has indicated a direct bandgap around 1.65 eV. This value is comparable to those reported for CdSe films deposited by other techniques.

For the CdSe/Cu_{2-x}Se devices, ITO served as the back contact and "Ag" served as the top contact. After heat treating the devices in air at 493K for various periods, it was observed that the cells heat treated for 12 minutes

yielded good rectification ratio. An open circuit voltage (V_{oc}) of 220 mV and a short circuit current of 0.03 mA were observed under an illumination of 40 mW.cm^{-2} . The low current output is due to the non-ohmic "Ag" contact on the Cu_{2-x}Se layer and also the high resistance of the CdSe. Stability studies were also made on the cells and only about 10% reduction was observed in I_{sc} after about 15 days; a CdS/ Cu_{2-x}S cell usually has a 50% reduction in I_{sc} during the same period, hence the CdSe based cells seem to be more stable. Further work on the growth of low resistance CdSe layers to obtain higher photovoltaic output is in progress.

REFERENCES

1. V N Komashchenko, N B Lukyanchikova, G A Fedorus and M K Sheinkmana, *Proc Int Conf Phys and Chem Semiconductors, Heterojunction Layer Structure*, Akademic Kiado, Budapest (1971) p 213
2. V N Komashchenko and G A Fedorus, *Sov Phys Semiconductors*, 1 (1967) 411
3. IEE Ture, GJ Russell and J Woods, *6th EC Photovoltaic solar Energy Conf*, (Ed) W Palz and F C Treble, D Reidel Publishing Co (1985) p 861
4. H E Nastelin, J M Smith and A L Gombach, Final Rep Contract No NAS 3-13467, Clevite Corp, June (1971)