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A Screen Printed $CdS/CuInSe_2$ Solar Cell

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Ternary chalcopyrites have gained a considerable technological interest in recent years due to their utility in various optoelectronic devices and in particular in solar cells. A $CdS/CuInSe_2$ solar cell with the CdS epitaxially grown on single crystal $CuInSe_2$ has demostrated an efficiency of 12%.[1] Recently an all thin film $CdS/CuInSe_2$ cell, fabricated entirely by vacuum deposition and sputtering onto inexpensive substrates, was reported having an AM-1 efficiency of 9.5%.[2] In the search for low cost processes $CdS/CuInSe_2$ and $ZnO/CuInSe_2$ cells have been prepared by spray pyrolysis.[3,4] Other cells containing $CuInSe_2$ and CdS or $Zn_xCd_{1-x}S$ have also been reported showing a potential for high conversion efficiency.[5] Similarly the inexpensive method of screen printing has been utilized to produce efficient CdS/Cu_xS and CdS/CdTe solar cells.[6,7] The present work demonstrates the feasibility of producing $CdS/CuInSe_2$ heterojunctions by using the screen printing method. The potential of this method of fabrication could mean a reduction in the cost of the $CdS/CuInSe_2$ solar cell and the possibility of depositing several cells in the form of an integrated module.

The structure of the experimental cells is shown in Fig. 1. The $CuInSe_2$ paste used in printing was prepared by mixing previously crushed P-$CuInSe_2$ powder with 3wt% indium chloride and 3wt% copper chloride, to act as a flux, and mixing this with an appropiate amount of binder (propylene glycol). The paste is then printed on gold-plated substrates, dried at about 110°C for 25 min. and sintered in an inert atmosphere for one hour at 710°C, producing a film of about 20 microns thickness. The CdS paste was obtained by mixing CdS powder with 5wt% cadmium chloride (flux) and about 1wt% indium chloride (dopant) together with propylene glycol. After printing the paste was dried at about 120°C for 30 min. and sintered at 650°C for about 30 min. The resulting CdS film had a thickness of 30-35 microns. The CdS and $CuInSe_2$ films showed resistivities of about 10^{-2} ohm.cm and 1.5×10^3 ohm.cm respectively. Scanning electron microscope studies show that the grain sizes of these two films are around 5 microns for CdS and 2 microns for $CuInSe_2$. To improve the contact to the gold substrate a P^+ layer of $CuInSe_2$ was produced by printing a paste containing about 5wt% of dimethyl diselenide.

Fig. 2 shows the current-voltage characteristics of one of these devices illuminated with ELH light of 80 mW/cm^2 intensity. Typical short-circuit currents obtained are 17 mA/cm^2 with an open circuit voltage of 0.33 volt and fill factor of 0.43, giving an efficiency of about 3% for a device of 1 cm^2 area.

The simple printing and sintering method seems to be viable in the production of low process cost CdS/$CuInSe_2$ solar cells and modules. Further work is underway to optimize the fabrication parameters such as the introduction of ZnS in the CdS film, and to utilize the practical structure formed by: glass substrate, tin oxide transparent front electrode, CdS film, $CuInSe_2$ film, screen printed back electrode.

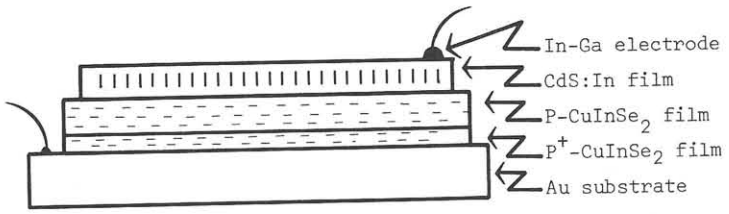

Fig.1: Schematic structure of experimental cell.

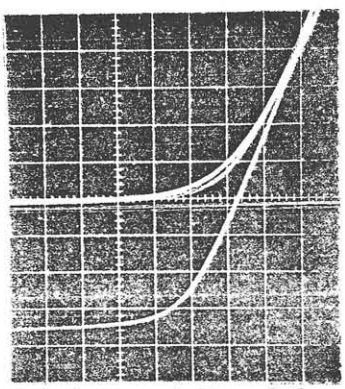

Fig.2: I-V characteristics of the cell.
Vertical: 5mA/div
Horizontal: 0.1 volt/div

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