CdS BASED THIN FILM SOLAR CELLS

by

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Thesis submitted
in fulfilment of the requirements
of the degree of
DOCTOR OF PHILOSOPHY

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

JUNE, 1978

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ACKNOWLEDGEMENT

It is a pleasure to thank Professor K.L. Chopra for his inspiring guidance. His deep involvement and critical evaluation at all stages of the work has contributed greatly in lending to the thesis its present form and content.

I have had the privilege of being associated with Mr. A. Banerjee, Dr. Prem Nath and Dr. V.D. Vankar whose active collaboration in various facets of this work is deeply appreciated.

A project of this nature necessarily calls upon the technical resources and expertise in a variety of disciplines. In this context, this work has benefited considerably from the unstinted cooperation of all my colleagues and the technical staff of the Thin Film Laboratory. In particular, I wish to record my gratitude to Mr. Bhanwar Singh and Mr. A.K. Tyagi for developing the photolithography techniques necessary to fabricate grids and masks of the desired specifications, Mr. Viresh Dutta for his help with the electrical measurements and Dr. P.J. George for the many intensive discussions which have helped to clarify several ideas. Thanks are also due to Dr. D.K. Pandya and Dr. P.K. Bhat for incorporating refinements in the fabrication of the cells and providing valuable feedback on the process. The help extended by Dr. A. Hepworth and Mr. Lal in scanning electron microscopy, Mr. V.D. Arora in transmission electron microscopy and Dr. A. Mukerjee with the electronics is gratefully acknowledged.

The award of a fellowship by the National Council of Educational Research and Training and the financial assistance provided by the DST is acknowledged.

Finally, in the preparation of the manuscript, I am indebted to Mr. N.S. Gupta for drafting the figures and Mr. V.N. Sharma for his skilful typing.

(S.R. DAS)

ABSTRACT

The work reported in this Thesis has been directed toward the following aspects of CdS based Thin Film Solar Cells: (a) Investigation of an alternate method of reproducibly preparing Cu_2S films of well controlled thickness and composition with stable structural, electrical and optical properties; (b) Modification of the base CdS by alloying with ZnS to realise higher open circuit voltage and hence enhanced efficiency; (c) Development of a new cell design to minimise degradation and (d) Characterisation of $Cu_2S/Cd_xZn_{1-x}S$ heterojunctions in terms of various functional junction parameters and correlation of cell performance with material properties.

Single phase alloy films of $Cd_xZn_{1-x}S$ have been prepared over the entire composition range by vacuum evaporation of a mixture of CdS and ZnS powder in the desired proportion. The crystallographic structure of these films depends on the deposition conditions, particularly the substrate temperature and also on the composition. The lattice parameter of these structures exhibit a strong dependence on temperature of deposition. The electrical resistivity increases by several orders of magnitude with increasing zinc sulphide concentration. The optical bandgap varies from 2.4 eV for CdS to 3.4 eV for ZnS.

Stoichiometric Cu_2S (chalcocite) thin films of well controlled thickness have been prepared by a solid state reaction between CdS and CuCl films. Detailed investigations

of the growth process reveal that Cu_2S grows topotactially on CdS and the chalcocite phase is obtained on reaction with both wurtzite and sphalerite structures of CdS. The Cu_2S films exhibit optical and electrical properties consistent with the Cu_2S composition and are suitable for fabricating solar cells.

$Cu_2S/Cd_xZn_{1-x}S$ solar cells have been fabricated utilising the solid state reaction with efficiency $> 6.5\%$ for CdS. Enhanced open circuit voltage has been obtained for increasing ZnS concentration up to 0.65 V for $Cd_{0.7}Zn_{0.3}S$ composition. However, the higher open circuit voltage has generally been accompanied by lower short circuit currents and lower efficiency. Analysis of cell performance has revealed the factors limiting efficiency. Design changes have been proposed to enhance efficiency to $\gtrsim 10\%$.

Junction characterisation has brought to light significant results. The cell performance is limited by interface recombination. However, the density of interface states, contrary to popular belief, does not depend on the extent of lattice mismatch between Cu_2S and $Cd_xZn_{1-x}S$. The increase in open circuit voltage has been related to an increase in the diffusion voltage corresponding to an increase in the band-gap of $Cd_xZn_{1-x}S$. An energy band diagram has been proposed to explain the cell operation.

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