MASTER

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1. ABSTRACT

This report contains reprints of two papers. The first describes the results of a study on the grain structure of CdS and (CdZn)S films. The other paper is a study of the band structure in heterojunctions between Cu₂S and Cd_{1-x}Zn_xS. Ongoing material studies are focused on the optical properties of Cu₂S as influenced by oxidation-reduction heat treatments. A set of high efficiency Cu₂S/(CdZn)S cells stored in hydrogen are being monitored for changes in efficiency and nine cells have been put on test under continuous illumination.

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Appendix A

E. Eser and R. B. Hall. Grain Structure of Cadmium Sulfide and Cadmium-Zinc Sulfide Films. Submitted to Thin Solid Films.

Appendix B

B. R. Bennaceur, R. B. Hall, and A. Rothwarf. Heterojunction Energy Band Lineups in $\text{Cd}_{1-x}\text{Zn}_x\text{S}/\text{Cu}_2\text{S}$ Solar Cells. 1980 Photovoltaic Solar Energy Conference. October 1980, Cannes, France.

3. INTRODUCTION

The major features of the heterojunction between Cu_2S and CdS or $(\text{CdZn})\text{S}$ have been determined and are fully described in the recent annual report⁽¹⁾. Portions of this work have been prepared for publication in the open literature and a reprint is attached as Appendix A.

The results of a theoretical study of band structures in the $\text{Cu}_2\text{S}/\text{Cd}_{1-x}\text{Zn}_x\text{S}$ was presented at the 1980 European Photovoltaic Solar Energy Conference and is reprinted as Appendix B.

Experiments to identify the principal degradation modes have continued. An enclosure to allow continuous illumination testing of nine cells has been constructed and preliminary testing initiated. Four cells from the group of $\text{Cu}_2\text{S}/(\text{CdZn})\text{S}$ cells that exceeded 10% efficiency are being stored in static hydrogen. They are degrading slowly, in large part as a result of the periodic exposure to air for testing. After about three months their efficiencies range from 7.4 to 8.5%.

4. STRUCTURAL AND MATERIAL ANALYSIS

The results of the metallographic studies on the grain structure of CdS and (CdZn)S have been prepared for publication. A preprint of the paper is reproduced in Appendix A. In addition an analysis of the energy band configuration has been prepared and was presented at the European Photovoltaic Solar Energy Conference in October. A preprint of this paper is given as Appendix B.

Optical analysis of Cu₂S film has been continued. The free carrier absorption as influenced of oxidation and reducing heat treatments is being determined so that the band to band absorption near the edge can be accurately determined.

The etching behavior of non-centrosymmetric crystals such as CdS⁽²⁾ are known to be different on the cadmium rich basal face (0001 A) and the sulfur rich face (000 $\bar{1}$ B). The rate of reaction to CuCl is also likely to be different. A sample of typical CdS substrate material was polished through the copper backing and the exposed CdS then etched in the standard texturing solution, 25% HCl at 60°C. The reaction rate on the normally exposed CdS surface is more rapid than on the "back" surface. A highly textured, pyramidal structure results on the exposed surface and a flatter, etch-pitted structure on the back surface. This is illustrated in Figure 1. Judging from the published literature, it is concluded that cells are normally constructed on the sulfur rich, 000 $\bar{1}$ B surface of vapor deposited CdS. While generally not of significance, this asymmetry could be important in cell designs which result in the Cu₂S being in contact with the A face of CdS.

(a)

(b)

FIGURE 1. CdS surface etched in dilute HCl.
(a) Exposed surface during film growth.
(b) Surface towards film substrate. x 10,000

5. DURABILITY

The high efficiency $\text{Cu}_2\text{S}/(\text{CdZn})\text{S}$ cells that have been stored in static hydrogen since 8/26/80 have declined in efficiency as shown in Figure 2. Most of the loss is believed to be related to oxidation as a consequence of removing the cells for testing at the intervals shown.

A set of nine matched cells have been placed on test. Three each are held at V_{oc} under AM1 and $\sim 1/4$ AM1 and at J_{sc} under AM1. I-V characteristics are being recorded at intervals and the results of this testing will be given in the next quarterly report.

FIGURE 2: Degradation of cells stored in static hydrogen.

6. ACKNOWLEDGMENTS

The continuing cooperation of Dr. S. DiZio, President, S.E.S. Inc. is gratefully acknowledged.

7. REFERENCES

1. IEC Annual Report XS-9-8310-04, January 1981.
2. M. V. Sullivan and W. R. Bracht, J. Electrochemical Society 114, pp 295-297, 1967.