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Cadmium Telluride Solar Cells

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14.1 INTRODUCTION

Thin-film cadmium telluride (CdTe) solar cells are the basis of a significant technology with major commercial impact on solar energy production. Large-area monolithic thin-film modules demonstrate long-term stability, competitive performance, and the ability to attract production-scale capital investments. This chapter reviews the status of CdTe thin-film solar cells, with emphasis on the properties that make CdTe a favorable material for terrestrial photovoltaic solar energy conversion, their historical development, methods for device fabrication, analysis of device operation, and the fabrication strategies and technical challenges associated with present and future development of thin-film CdTe cells and modules.

Calculations of the dependence of ideal solar cell conversion efficiency on band gap show that CdTe is an excellent match to our sun, a G2 spectral-class star with an effective black-body photosphere surface temperature of 5700 K, and a total luminosity of 3.9×10^{33} erg/s. CdTe is a group II^B-VI^A compound semiconductor with a direct optical band gap that is nearly optimally matched to the solar spectrum for photovoltaic energy conversion. The direct band gap, $E_g = 1.5$ eV, and high absorption coefficient, $>5 \times 10^5$/cm, of CdTe means that high quantum yield can be expected over a wide wavelength range, from the ultraviolet to the CdTe band gap, $\lambda \sim 825$ nm. Short-wavelength photons, with energy greater than E_g, are absorbed near the CdTe surface, making CdTe an attractive absorber-layer material for thin-film solar cells. The theoretical solar cell efficiency versus band gap for CdTe and the optical absorption coefficient versus energy for CdTe and other selected photovoltaic materials are compared in Figure 14.1 [1, 2]. The high CdTe absorption coefficient, $>5 \times 10^5$/cm, for photons with $E > E_g$ translates into 99% absorption of the absorbable AM1.5 photons within 2 μm of film thickness.

Handbook of Photovoltaic Science and Engineering. Edited by A. Luque and S. Hegedus
 ISBN: 0-471-49196-9