Modeling of CdTe Solar Cells

Md Shahnawaz Anjan , S. Asif Mahmood and M. Zahangir Kabir

Electrical and Computer Engineering, Concordia University, 1455 de Maisonneuve West, Montreal, Quebec H3G 1M8, CANADA

The most successful second generation solar cell material is Cadmium telluride (CdTe) which offers significantly cheaper production costs. CdTe has a band gap which is very close to the theoretically-calculated optimum value for solar cells under unconcentrated AM1.5 sunlight. Since CdTe has a high absorption coefficient approximately 99% of the incident light is absorbed by a CdTe layer thickness of only 1µm (compared with around 10µm for Si). CdTe is a material that is particularly well suited for thin film photovoltaic solar cell. It has a direct band gap Eg = 1.45 eV, which is well within the high intensity region (1.2eV to 1.5eV) of AM1.5. In CdTe based solar cells, a very thin layer of CdS is used as a buffer layer, which acts as n^+ material. The CdTe layer behaves as lightly doped p-type material. Although there is a large lattice mismatch, the energy bands of the buffer and the absorber are matched quite well. As a result, the solar cells based on CdS/CdTe combination without any interface passivation layer show a very good performance.

There has been an active research both theoretically and experimentally to improve the performance of these devices. Several theoretical models have been proposed to describe the J-V characteristics in CdTe solar cells. Crandall [1] developed a model for calculating photocurrent considering carrier generation near the radiation-receiving electrode and utilizing Hecht collection efficiency formula. Demtsu and Sites [2] described the effect of back contact on J-V characteristics considering full charge collection. In this paper we solve the continuity equation for both electrons and holes considering exponential carrier generation, carrier trapping and carrier drifting through the CdTe layer. We obtain an analytical expression for voltage dependent photocurrent. The overall load current is calculated considering the effect of CdTe/CdS contact and the actual solar spectrum. We analyze J-V characteristics, fill-factor, power, efficiency with varying material properties. The model is fitted with the published experimental data on several CdTe solar cells. The model shows a very good agreement considering carrier lifetime as a fitted parameter. The fitted values of carrier ranges are matched with reported experimental values [3].

The modeling work in this paper identifies the important factors that limit the CdTe solar cell performance, which can ultimately lead to the increase of power output consistent with better efficiency. The quantitative analyses presented in this paper show that the solar cell structure is just as important to the overall performance of the solar cell as the material properties of the photoconductor itself.

[1] R. Crandall, “Modeling of thin film solar cells: uniform field approximation,” J. Appl. Phys., 75, 577, 1983.

[2] S.H. Demtsu and J.R. Sites, “Effect of back-contact barrier on thin-film CdTe solar cells,” Thin Solid Films 510, 320-324, 2006

[3] P. J. Sellin, A. W. Davies, A. Lohstroh, M. E. Özsan, and J. Parkin, “Drift Mobility and Mobility-Lifetime Products in CdTe:Cl Grown by the Travelling Heater Method,” IEEE Transaction on Nuclear Science, 52, 3074, 2005.

*E-mail: m_anja@encs.concordia.ca