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THE INFLUENCE OF THE ABSORBER LAYER THICKNESS ON THE EFFICIENCY OF CDTE/CDS/ZNO HETEROSTRUCTURE

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Abstract. *The modeling results of CdTe-based photovoltaic heterostructures performed in the SCAPS software package are presented. It is shown that thin CdTe layers provide high optical absorption and a conversion efficiency of approximately 17 %. Increasing the absorber thickness to 2–3 µm leads to a pronounced rise in efficiency; however, any further thickening yields no significant gain, while it increases recombination losses, lowers the fill factor (FF), and raises the fabrication cost of the device.*

Key words: *solar cell, CdTe solar cell, CdTe absorber layer, second generation solar cell*

Introduction.

Photovoltaic converters based on cadmium telluride (CdTe) absorber layers exhibit a high optical absorption coefficient across the visible and near-infrared spectral regions, making them one of the most efficient thin-film solar-energy technologies. Their ability to absorb light intensely even in films only a few micrometers (µm) thick allows CdTe devices to dramatically reduce material usage during fabrication. At the same time, precise control of the absorber-layer thickness is critical: layers that are too thin cannot capture the full incident photon flux, whereas excessively thick layers impede charge-carrier transport and increase recombination losses [1]. Optimizing the CdTe layer thickness therefore achieves an optimal balance between effective light harvesting and minimal carrier losses. Moreover, the choice and fine-tuning of deposition techniques influence film crystallinity, defect density and overall structural quality, directly impacting device efficiency and long-term stability.

Main text

For the analysis of the absorber-layer thickness effect in CdTe/CdS/ZnO heterostructures (superstrate configuration), the SCAPS software package [2] was employed. During the simulation, the CdTe layer thickness was varied from 0.5 to 4 µm (Figure. 1). Heterostructure parameters were set in accordance with [3,4]. Simulation results are presented under standard test conditions (STC): irradiance = 1000 W/m² and cell temperature = 25 °C, while all other layer parameters remained unchanged.

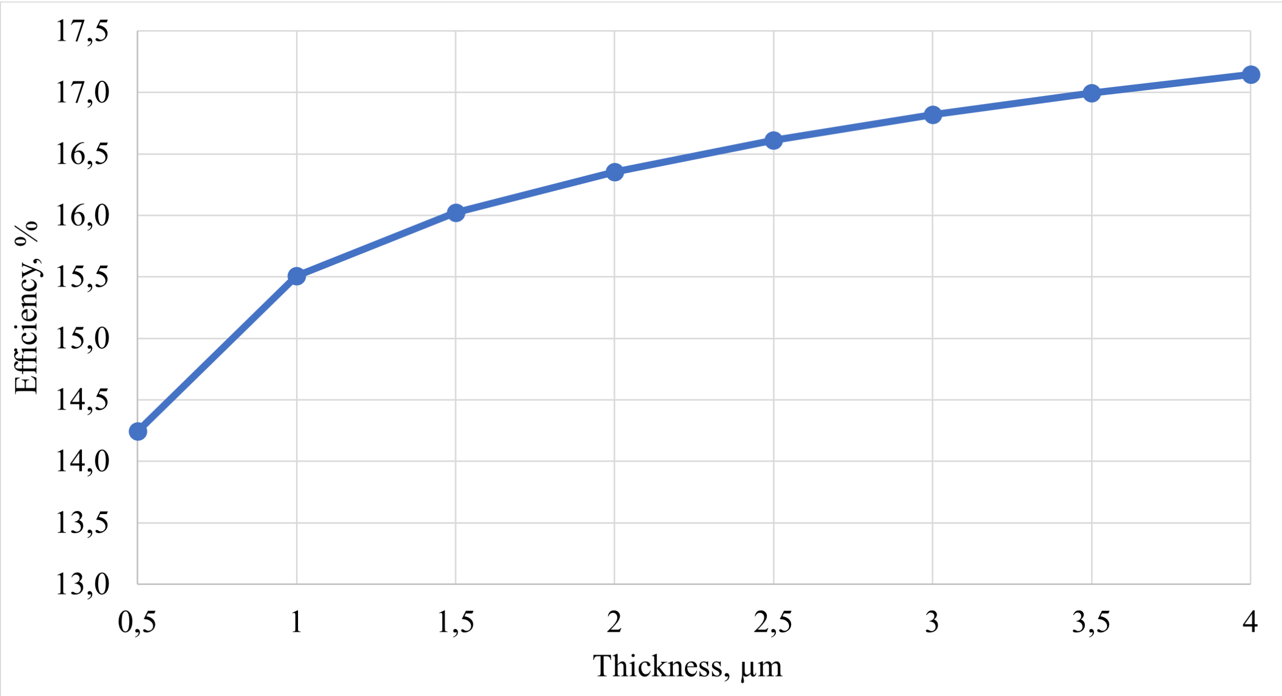

Figure 1 – Dependence of photovoltaic cell efficiency on CdTe layer thickness

The simulation results indicate a clear dependence of solar-cell efficiency on CdTe absorber thickness. Increasing the layer from 0.5 to 2 µm produces a marked rise in efficiency, reflecting the limited light absorption of thinner films. Concurrently, thickening the CdTe layer from 0.5 to 3 µm causes a sharp increase in short-circuit current density (J_{sc}), with J_{sc} values saturating at approximately 3 µm and above. The open-circuit voltage (V_{oc}) remains essentially unchanged throughout this thickness range, showing only minimal variation as the layer approaches ~3 µm.

Conclusions.

The numerical modeling carried out in the SCAPS environment demonstrated that the optimal CdTe absorber-layer thickness is approximately 2–3 μm, at which an optimal balance between photon-absorption coefficient and recombination-loss minimization is achieved. Simulation of the proposed heterostructure yields a power-conversion efficiency of 16.5–17 % under standard test conditions.

These results can serve as a technological guideline for the optimization of CdTe film deposition and for improving the performance of thin-film photovoltaic cells.

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