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Potential of CdS/CdTe-based Multi-Junction Photovoltaic Cell for Indoor Light Harvesting: A Simulated Study

In recent years, there has been a noteworthy surge in interest surrounding indoor photovoltaic (IPV) devices due to their promising potential for powering small, portable electronics and self-powered Internet of Things (IoT) devices. Cadmium Telluride (CdTe) solar cells stand as a significant player in the global photovoltaic (PV) technology landscape, ranking as the second-fastest-growing PV technology after crystalline silicon. CdTe-based photovoltaic (PV) cells have demonstrated remarkable efficiency under outdoor sunlight conditions. However, their potential for indoor light harvesting remains relatively unexplored. This work presents a comprehensive study on the application of CdTe-based multi-junction photovoltaic cells in indoor environments. In this work, a multi-junction photovoltaic structure "ITO/SnO2/CdS/CdTe/Au"was modelled and analysed for its photovoltaic performance using SCAPS-1D modelling software. The simulations were conducted under LED light conditions, with a power density of approximately 60 W/cm2 and a temperature of 300 K. The primary focus of this study was the impact of donor concentrations and layer thicknesses on cell performance, with an emphasis on optimization rather than the optical and morphological properties of the layers.
Through systematic optimization of each layer, the study achieved an outstanding efficiency of 20.70% under indoor LED lighting. The optimized device exhibited a high open-circuit voltage (VOC) of 0.945 V, a current density (JSC) of 2.13 mA/cm2, and a fill factor (FF) of 64.02%. These results were obtained at the doping concentration of 1017 cm-3 (SnO2), 1015 cm-3 (CdS), 1015 cm-3 (CdTe), and at the thickness of 50 nm (SnO2), 70 nm (CdS), 900 nm (CdTe). These results highlight the substantial potential of CdS/CdTe-based multi-junction PV cells for efficiently harnessing indoor light sources, paving the way for their integration into a wide range of portable and IoT devices. This research not only contributes to the advancement of indoor photovoltaics but also underscores the importance of tailored device design and optimization for specific lighting conditions

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