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Journal of Science: Advanced Materials
and Devices

Volume 8, Issue 2, June 2023, 100553

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Original Article

Enhanced photovoltaic effects of microwave-assisted polyol-synthesized Cu₂(Pd/Zn)SnS₄ kesterite nanoparticles

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<https://doi.org/10.1016/j.jsamd.2023.100553>

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Highlights

The suppression of the detrimental anti-site defect in the Cu₂(Pd/Zn)SnS₄ kesterite nanomaterial, by the replacement of Zn atoms with Pd atoms.

Pd-induced photoluminescence redshift emission ($\lambda_{max} = 755 \text{ nm}$) for CPTS nanomaterial.

Electrochemical double layer capacitance (EDLC) value of 0.5 F/cm² was obtained for CPTS nanomaterial.

CPTS-based photovoltaic cell device gave improved open circuit voltage (900 mV) and fill factor (83.4%) values.

Preliminary photovoltaic efficiency of 1.01% was achieved for CPTS-based device for a superstrate device architecture.

Abstract

Kesterite materials show excellent optical and semiconductive properties for use as p-type absorber layer in photovoltaic (PV) applications, but they have a high open circuit voltage deficit ($V_{oc,def}$) due to high antisite defect and secondary phase

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formation, resulting in poor device performance. This work reports a PV cell composed of Cu₂PdSnS₄ (CPTS) nanoparticles as an absorber layer yielding highly improved V_{oc} of 900 mV, which is two times that of fabricated pristine Cu₂ZnSnS₄ (CZTS) PV cell. Improved PV cell parameters such as fill factor (FF) of 83.4% and power conversion efficiency (PCE) of 1.01% were obtained for CPTS devices which are 3-fold that of pristine CZTS devices. Optical studies revealed enhanced redshift absorption for CPTS nanoparticles. Electrochemical studies show improved current production, high electron mobility and low charge resistance for CPTS nanoparticles. This study shows that the improved photovoltaic properties can be attributed to enhancement in the bulk properties when Zn atoms are replaced by Pd atoms in kesterite nanomaterials as absorber layer material for PV applications.

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Keywords

Antisite defects; Copper palladium tin sulfide (CPTS); Kesterite; Nanomaterial and photovoltaic cell

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Peer review under responsibility of Vietnam National University, Hanoi.

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