Development and Modeling of Low-Cost Tandem Perovskite/Silicon Solar Cells

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Abstract

Keywords: Perovskite, Tandem Solar Cells, SCAPS, Efficiency, Environmental Impact, Temperature Influence.

Introduction and Objectives:

The increasing demand for electricity, the instability of oil prices, and the ongoing climate change crisis necessitate a transition towards renewable energy sources. Current solutions, despite their maturity, face efficiency limitations. To address these challenges, our project aims to develop and model tandem perovskite/silicon solar cells to enhance their efficiency and economic viability. Specifically, we aim to identify perovskite materials that meet predefined criteria for efficiency and stability, develop effective and economical synthesis methods, master all fabrication and testing stages of tandem perovskite/silicon photovoltaic cells, identify and overcome technological barriers, and create and test a prototype cell to validate our research and development efforts

Methodology

We utilized SCAPS (Solar Cell Capacitance Simulator) for modeling, testing various types of perovskites and adjusting parameters such as temperature, thickness, and bandgap to optimize performance. SCAPS simulations guided the physical experiments by predicting the most promising material configurations

Molecular Structure of $FASnI_3$:

The molecular structure of $FASnI_3$ (Formamidinium tin triiodide) is characterized by the following composition: FA ($CH(NH_2)_2$) is the organic cation, Sn is the metal cation, and I_3 is the anion .

Results

$FASnI_3$ Photovoltaic Cell Parameters:

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Influence of Temperature on $FASnI_3$ Performance:

The performance of $FASnI_3$ perovskite was analyzed at different temperatures (300K, 400K, and 500K);

The data indicates that with increasing temperature, the open-circuit voltage (Voc) decreases significantly, directly impacting the overall efficiency (η). The fill factor (FF) also drops, further reducing the efficiency. The short-circuit current density (Jsc) remains relatively stable, suggesting that the carrier collection is less affected by temperature changes.

300 K

400 K

500 K

Figure 1. Influence of Temperature on J-V Characteristics for FASnI3 Photovoltaic Cell

Conclusion

$FASnI_3$ demonstrates promising potential for use in tandem perovskite/silicon solar cells due to its lead-free composition and reasonable efficiency. Despite the challenges posed by temperature variations, $FASnI_3$ remains a viable and environmentally friendly alternative to lead-based perovskites. Future research will focus on optimizing these parameters to enhance overall cell efficiency, reinforcing $FASnI_3$'s position as a sustainable solution in the development of high-performance tandem solar cells.

References

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