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Bouras Mounir

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Improve efficiency of Perovskite-Based Solar Cell by photon recycling

Mounir Bouras, Abdelhafid Benyounes, Salah khennouf

Department of Electronics, Faculty of Technology, University of M'sila, University Pole, Road Bordj-Bou- Arreridj, M'sila 28000, Algeria

Department of Electronics, Faculty of Technology, University of M'sila, University Pole, Road Bordj-Bou- Arreridj, M'sila 28000, Algeria

Department of Electronics, Faculty of Technology Mohamed Boudiaf University of M'sila (28000) Algeria, Speech Communication and Signal Processing Laboratory (LCPTS-USTHB)

Abstract

In recent years, significant advancements have been made in thin-film planar heterojunction solar cells, emerging as cost-effective photovoltaic devices with high power conversion efficiency. Among the materials utilized, organometal trihalide perovskite (CH3NH3PbI3) stands out as a promising absorber material. Its appeal lies in the affordability of organic-inorganic perovskite compounds, readily available in nature, ease of fabrication, and compatibility with large-scale processing at low temperatures. In addition to its effective absorption in the ultraviolet range, this material exhibits captivating optoelectronic properties, including high crystallinity, elevated carrier mobility, and extensive carrier diffusion lengths. Despite these advantages, the highest reported power conversion efficiency for perovskite solar cells is currently at 26.1/100 , as of 2022. This study introduces a thin-film organometal trihalide perovskite solar cell featuring hybrid interfaces between carefully chosen materials. These selections are the result of an in-depth study aimed at minimizing recombination and optimizing performance. Furthermore, we enhance the absorption of the incident solar spectrum by incorporating a 1D photonic crystal at the cell's bottom, facilitating the photon recycling process. The proposed solar cell parameters are numerically computed using the rigorous coupled wave algorithm through the SYNOPSYS RSOFT CAD tool. The thickness of each layer in the structure is optimized using the MOST scanning and optimization module of the RSOFT CAD tool, achieving the highest power conversion efficiency at a minimal device thickness (approximately 2.5 m). Remarkably, the power conversion efficiency achieved is 27.5/100, with a fill factor of 87.4/100 at AM 1.5, showcasing great promise. This demonstrates the remarkable potential of the proposed design to achieve efficiencies exceeding 5/100, positioning it as a competitive contender in the existing crystalline silicon photovoltaic market.

Keywords: Recycling photon; Solar cell; R-Soft.
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