Proceedings of the

NATIONAL CONFERENCE ON MULTIDISCIPLINARY RESEARCH 2020

VIRTUAL POSTGRADUATE SYMPOSIUM

"Inspiring Sri Lankan Youth for Tomorrow's Science"

NCMR 2020

08th October 2020

ORGANIZED BY THE YOUNG SCIENTISTS' ASSOCIATION, NATIONAL INSTITUTE OF FUNDAMENTAL STUDIES, SRI LANKA

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NCMR 2020

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ISSN 2756-9063

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Published by:
Young Scientists' Association (NIFS-YSA),
National Institute of Fundamental Studies,
Hanthana Road, Kandy,
Sri Lanka
www.nifs.ac.lk
Tel: +94 (0) 812 232 002
Email: ysa@nifs.ac.lk

Cover page Design & Page setup:
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ACKNOWLEDGEMENTS

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ISSN 2756-9063
Proceedings of the National Conference on Multidisciplinary Research-2020
Young Scientists' Association, National Institute of Fundamental Studies, Sri Lanka
October 08, 2020

Numerical modeling of hybrid 3D/2D organic-inorganic halide perovskite solar cell under low light conditions and AM1.5G full sun spectrum

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Hybrid organic-inorganic halide perovskite solar cells (PSCs) have acquired significant research attention because of their low cost and high performance. We have numerically modeled p-i-n structure perovskite solar cells with intrinsic layers of 3D-$CH_3NH_3PbI_3$ (3D-MAPI) and 2D sheets of $CH_3NH_3PbI_3$ (2D-MAPI) hybrid organic-inorganic halide perovskites. 2D-MAPI layer is mainly used in the simulation to enhance the stability of the 3D-MAPI layer. Poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT: PSS), which is an organic hole transporting material (HTM), has been used as a p-type layer. The fullerene derivative material, (6,6)-phenyl-C61-butyric acid methyl ester (PCBM), which is an organic electron transporting material (ETL), has been used as an n-type layer. The performance of this p-i-n type perovskite solar cell model was studied by employing Solar Cell Capacitance Simulator (SCAPS-1D) software under indoor low light conditions and outdoor AM1.5G full Sun spectrum. The indoor low light intensity produced by the artificial light source is about 20 W/m^2 as compared to the outdoor light intensity of 1000 W/m^2. In this study, Tungsten Halogen lamps were used as low light illumination sources to model the indoor low light conditions. We have numerically obtained, the power conversion efficiencies of the baseline model of PSCs underlow light intensities of 10 W, 20 W, 50 W Tungsten Halogen lamps, and AM 1.5G full Sun spectrum as 11.47%, 12.04%, 12.16%, and 24.71% with the open-circuit voltages (V_{OC}) of 1.07 V, 1.09 V, 1.12 V, and 1.26 V respectively. Due to the high absorption properties of the 3D and 2D halide perovskite materials, the hybrid organic-inorganic halide perovskite solar cells can be used for indoor applications. Our findings revealed in this work can be useful to practically develop indoor applications of solar cells in the future.

Keywords: *perovskite-based solar cell, power conversion efficiency, light intensity, SCAPS-1D, low light conditions*