Optical design of all-perovskite tandem solar cells

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Abstract: We present a thorough analysis of the optical properties of $CH_3NH_3Sn_xPb_{1-x}I_3$ films, providing the field with definitive insights about the possibilities of these materials for perovskite solar cells of superior efficiency.
OCIS codes:

1. Introduction

Optical design of perovskite solar cells (PSCs) has been demonstrated to boost the performance of this emerging photovoltaic technology.[1, 2, 3] Recently, the research interest has put under the spotlight ABX_3 perovskites for their application in tandem solar cells that can surpass the Shockley-Queisser limit.

2. Discussion

Herein we discuss about the importance of optical modelling in order to optimize the performance of perovskite on perovskite tandem devices. In particular, we will analyze the potential of perovskite absorbers in which the lead cation is gradually substituted by tin. The tunability of their absorption onset in the spectral range from 780 nm to 1100 nm makes them ideal candidates for tandem applications. From the optical point of view, such cells are complex multilayered stacks in which both unwanted parasitic absorption and reflections need to be minimized to develop devices of improved efficiency. In this regard, we combine semi-analytical models based on the transfer matrix and genetic algorithms to find the ideal device architectures that fully optimize light harvesting within the active layers. We report a user's guide based on the first set of optical constants obtained for a series of tin/lead perovskite films, which was only possible to measure due to the preparation of optical quality thin layers. According to the Shockley–Queisser theory, $CH_3NH_3Sn_xPb_{1-x}I_3$ compounds promise a substantial enhancement of both short circuit photocurrent and power conversion efficiency in single junction solar cells. Moreover, we propose a novel tandem architecture design in which both top and bottom cells are made of perovskite absorbers. Our calculations indicate that such perovskite on-perovskite tandem devices could reach efficiencies over 35%. Our analysis serves to establish the first roadmap for this type of cells based on actual optical characterization data.

3. Conclusions

Pin-hole free dense layers of perovskite $CH_3NH_3Sn_xPb_{1-x}I_3$ films that are structurally and optically stable have been demonstrated and the performance of hypothetical solar cells based on these light harvesters is estimated. The bandgap tunability and optical quality of the solution processed films herein reported may allow the fabrication of perovskite-on-perovskite tandem solar cells of high efficiency.

4. References

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