Endeavors to design photo-stable perovskite solar cells and perspectives on the enhancement of nano-photovoltaics performance through polymer-perovskite down-conversion composite materials implementation

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ABSTRACT

Light-induced degradation of metal halide perovskite solar cells (PSCs) is considered a major hurdle to cross for their future commercialization, with scientists endeavoring to develop more photo-stable photovoltaic materials and designs toward technological maturity for real-world applications. On the other hand, low-cost and straightforward strategies to break nano-photovoltaics performance limits have seized increasing attention in our days, with the renaissance of luminescence solar concentrators gaining an emerging role among unconventional solar energy conversion devices. The present work demonstrates new insights on both under-consideration topics. At first, the photo-stability of scalable carbon-based hole-transport-material-free PSCs (encapsulated devices) developed under different manufacturing protocols was assessed using accelerated aging (according to ISOS protocols). Herein, the dependence of the degradation of the devices performance developed using different electron-transport-materials (ETMs) (mesoscopic or planar TiO_2, planar SnO_2), substrates (glass or plastic) and perovskite active materials (one- or two-step solution deposition) is determined and post-mortem analyzed. The results showed that the PSCs composed of planar SnO_2 ETM and two-step deposited perovskite active layer are the most robust devices to light-induced degradation amongst the studied ones, while the use of plastic substrates in the studied solar cell design decreased photovoltaics lifetime almost to half compared to the rigid glass-based devices. On the other hand, the development of new low-cost polymer-perovskite luminescent films is demonstrated for their intended application on spectral-engineered nano-photovoltaics. Noteworthy, the proposed material showed well-controlled down-convention characteristics, with the Stokes shift being adjustable between 50 to 200 nm depending on the perovskite material composition. Both studies presented herein are important since they provide new insights into cutting-edge technologies to develop high-performance and stable light-to-electricity conversion devices, which would constitute the future competitors of the already mature crystalline silicon photovoltaics for new and niche applications.

KEYWORDS: perovskite solar cell; luminescent solar concentrator; photo-stability; efficiency enhancement.

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