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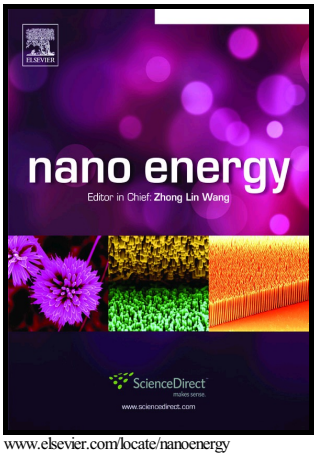


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# Dual interfacial modifications by conjugated small-molecules and lanthanides doping for full functional perovskite solar cells

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## Abstract

Power conversion efficiency (*PCE*) of perovskite solar cells (PSCs) was reported to be over 23% with a variety of configurations including the optimization of photoactive material, selection of carrier transport layers and interface engineering. Critical concerns pertaining to the instability, hysteretic effects, reproduction, flexibility, large area and transparency, which may potentially hinder their commercialization still remain. In this work, an effective low-temperature electron beam (E-beam) approach for depositing lanthanides ($Y^{3+}$, $La^{3+}$, $Ce^{3+}$, $Nd^{3+}$, $Sm^{3+}$, $Gd^{3+}$, $Tm^{3+}$, $Yb^{3+}$, $Lu^{3+}$) doped $TiO_2$ as electron transport layer was developed for planar PSCs application. The lanthanide dopants, especially for $Gd^{3+}$, could facilitate the charge transport behaviour and band gap optimization of $TiO_2$. Additionally, small molecule DRCN5T was selected as an effective additive in anti-solvent to fill grain boundary and modify the quality of the perovskite film with a grain size of 1.3-2.0 μm. The modified PSCs exhibit a noticeably increased *PCE* from 19.0% to 20.53% with excellent long-term and light stability. More importantly, flexible, large area and transparent PSCs were also achieved. The flexible devices show more than 20% of their initial *PCE* values after 1000 bending cycles. The dual interfacial modification mechanism represents an attractive approach to achieve full functional PSCs.