

Charge-Transport Materials Impact on the Perovskite Solar Cells Stability

Artyom Novikov^{1*}, ^{**}, Marina Tepliakova¹, Olga Yamilova¹, Lyubov Frolova², Gennady Shilov², Nadezhda Dremova², Ivan Zhidkov^{3,4}, Ernst Kurmaev^{3,4}, Pavel Troshin², and Keith Stevenson¹

¹*Skolkovo Institute of Science and Technology, Nobel St. 3, Moscow 121205, Russia.*

²*IPCP RAS, Semenov Prospect 1, Chernogolovka, 141432, Russia.*

³*Russia Institute of Physics and Technology, Ural Federal University, Mira 9 str., Yekaterinburg 620002, Russia*

⁴*M. N. Mikheev Institute of Metal Physics of Ural Branch of Russian Academy of Sciences, S. Kovalevskoi 18 str., Yekaterinburg 620108, Russia*

^{*}, ^{**} E-mail: Artyom.Novikov@skoltech.ru

Perovskite solar cells (PSCs) represent one of the most promising photovoltaic technologies now reaching power conversion efficiency (PCE) values more than 25%. However, their commercialization is still hindered by the poor stability of complex lead halides comprising their active layer. It was shown repeatedly in previous works that charge-transport materials (CTMs) employed in PSCs can affect their operational stability significantly by reacting with the perovskite materials or, in contrast, protecting the perovskite. Yet, to date, there have been no systematic investigation of this issue.

This work presents a systematic study of the impact of both hole-transport (HTMs) and electron-transport (ETMs) materials on the photochemical stability of bulk of the perovskite films and finished perovskite solar cells. A large set of primarily inorganic and hybrid organic-inorganic bilayer charge-transport layers was investigated. An array of complementary physicochemical characterization techniques such as UV-vis absorption spectroscopy, X-Ray diffraction, X-Ray photoelectron spectroscopy, and scanning electron microscopy was employed to assess the rate of active layer degradation in contact with various CTMs under continuous illumination. Additionally, the PCE of the finished devices comprising different CTMs was tracked as function of exposure

time to estimate the solar cells lifetime under operation conditions.

The obtained results demonstrate a significant CTM influence on the perovskite stability. Among the HTMs it was shown that there is a strong correlation between the HTM's reduction potential and both bulk material and device stability, suggesting that redox reactions are the major source of HTMs adverse effect on PSCs stability.

In ETMs, however, a significant discrepancy between bulk material and device stability was observed, implying that more complex interfacial processes such as charge carrier trap formation or chemical processes in a very thin layer determine ETMs effect on the PSC stability.

Thus, in this work the crucial importance of proper CTM selection to achieve high PSC stability is demonstrated, several most promising CTMs are identified, and an important selection criterion for HTMs related to their redox properties is suggested.