Abstract

In the past decades, organic solar cells (OSCs) have surpassed noticeable development in terms of device optimization, material evolution and industrial implementation towards commercialization due to the advantages of light-weight, flexibility and ability of solution processing and large-scale manufacturing at low-cost. In comparison to the traditional fullerene commonly used in OSCs, non-fullerene acceptors (NFAs) have been shown promising features in their molecular design. Their tunable optical and photophysical characteristics marking high-performing NFAs as promising candidates for the future industrial organic photovoltaic (OPV) field. Maximum power conversion efficiencies (PCEs) of over 19 % for NFA OPV have been reported already. Nevertheless, these efficiencies have not been achieved on industrial scale yet. The processing for these small-area devices is mainly based on non-industrial compatible techniques (e. g. spin-coating), non-scalable materials (e. g. evaporated molybdenum oxide MoO_3) and conditions such as an oxygen-free environment. With the use of rigid substrates, this discrepancy towards their practical application will be limiting their future commercialization.

This work focuses on the large-area solution-based production of NFA devices by using roll-to-roll (R2R) processing and taking industrial requirements and standards into consideration. With a commercially available NFA-based material system and optimized device architecture, morphology and coating processes, device performance of over 12 % on cell level and close to 7.0 % on module level *via* slot-die coating and screen-printed top electrodes, was achieved. The thermal and photo-induced impact on the NFA has been carefully investigated so far as well. The NFA-based devices feature excellent photostability, even after 1000 hours of continuous light illumination and under open-circuit condition. However, these devices exhibit performances losses under high continuous heat. The thermal stability limiting factors were studied by means of optical and grazing incidence wide-angle x-ray spectroscopy (GIWAXS). Approaches for the potentially improvement of the inherent thermal instability will be presented as well. The successful transfer to the upscaling line presented in this work, demonstrate the great potential of NFAs as the next generation of high-performing industrial OPV.