ORGANIC PHOTOVOLTAICS: FROM THIN FILM SYNTHESIS TO LARGE SCALE MANUFACTURING

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Organic photovoltaic (OPV) devices have recently experienced a fast rise in power conversion efficiency (PCE) with the introduction of new non-fullerene acceptor (NFA) molecules, reaching today PCE values above 18 %, placing device stability and large-scale manufacturing as the focus areas for this technology. In this presentation, recent progress on active layer molecule and interlayer systems as well as device architecture and up-scaling routes will be presented. Transition metal oxides have been demonstrated as an important class of materials for OPV devices, where they serve as charge carrier selective interlayers for efficient electron and hole extraction. However, interlayer related instabilities have recently been reported as a main degradation route for NFA OPV devices, making a thorough understanding of such interface effects highly important for the further development of this field and technology. Recent progress made within sputtered metal oxide electron [1,2] and hole [3] transport interlayers for thin film organic photovoltaics will be presented. Supported by a variety of surface science characterization techniques, the role of e.g. microstructure, work function, oxygen vacancies and energy band alignment, on the performance of such interlayers in organic photovoltaic devices is discussed. This includes a focus on their positive impact on non-fullerene acceptor based OPV device stability, as compared to conventional metal oxide interlayers. Here, new results focusing on the integration of 2D materials in NFA OPV will also be elaborated on.

In addition, routes for Roll-to-Roll (R2R) up-scaling and manufacturing of OPV will be presented, including metal oxide interlayers and full modules using industrial-compatible techniques. This includes (R2R) UV Nanoimprint Lithography (UV NIL) for improving the light absorption in fully scalable OPV. Nanoscale structures are formed on flexible substrates using R2R UV nanoimprint lithography and integrated in fully scalable OPV devices to form efficiency-enhanced ITO-free OPV [4]. The nanostructured OPV are based on the non-fullerene acceptor system PBDB-T: ITIC, and made in a back contact nanostructured grating architecture. All the processes are made in an ambient condition from non-toxic solvents, and can easily be adapted to the industrial standard. Using optical modelling, the effect of the nanostructured grating on the performance of OPV devices is investigated and optimized. Due to combined effects of improved charge carrier extraction and enhanced optical path lengths, these industrial compatible nanostructured OPV reach device power conversion efficiency enhancements of above 20%.

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