Invited

Towards the optimization of the performance of Organic Photovoltaics by sophisticated optical sensing

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During the last years there has been a tremendous effort for the development of Organic Electronic (OE) devices onto flexible substrates by solution methods (e.g. gravure and inkjet printing, spin coating, etc.) as well as by vacuum deposition methods. The advantage of this technology is that it can provide a wide range of electronic devices by using low-cost and high-throughput manufacturing processes, for example by roll-to-roll (r2r) printing processes. Among the main applications of OEs is organic photovoltaics (OPVs) that will have a significant impact in the generation of electricity from renewable resources.[1], [2] Although the power conversion efficiencies have exceeded the 10%, most of the research efforts are focused on the understanding and the control of the photoactive blend morphology. Other applications include organic light emitting diodes - OLEDs, organic thin film transistors -OTFTs, sensors, and biosensors.

In this presentation, we discuss about the latest advances towards the optimization of the performance of OPV devices by using a combination of state-of-the-art analytical techniques including the sophisticated optical sensing. Among the main factors that define the performance of OPVs is the interfacial composition of the bulk heterojunction (BHJ) photoactive layer that consists of a blend of a polymer electron donor and a fullerene electron acceptor.[2] We will discuss about the blend morphology and the vertical distribution of the polymers and fullerene components in the BHJ blend and its evolution with the thermal annealing applied after the film deposition.[3], [4], [5] The material systems will include polythiophene (P3HT) or polycarbazole derivatives (PCDTBT and Si-PCPDTBT) as electron donors, and fullerene derivatives ($PC_{60}BM$, $PC_{70}BM$) as electron acceptors. Spectroscopic Ellipsometry (SE) working in the near infrared to visible and far ultraviolet spectral region provides significant information on the vertical distribution of donor and acceptor in the blend. The above were correlated with the device electrical characteristics. In addition, we will discuss on the implementation of metallic plasmonic nanoparticles in the blend and its effect on the optical and electrical properties and performance of OPVs.

Finally, we will describe the implementation of in-line SE system working in the visible-far ultraviolet spectral region on a r2r printing system for the real-time monitoring and analysis of the optical properties, and nano-scale morphology of gravure printed nanomaterials for OE devices.[5], [6] These include barrier layers (inorganic and hybrid barriers), and Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) transparent electrodes and BHJ blends that are deposited onto flexible polymer substrates (e.g. PolyEthylene Terephthalate-PET) in the form of web rolls.[6], [7] Also, we discuss on the analysis of the measured pseudodielectric function spectra and the stability of measurements and final properties of the gravure printed OE nanomaterials. The proposed methodology will open the way for the in-line robust determination of the optical properties and quality of other nanolayers for several OE applications (e.g. OLEDs, OTFTs, sensors, and biosensors). Finally, it emphasizes the potentiality of in-line SE to become a standard technique for the r2r manufacturing of flexible organic electronic materials and devices.

References

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