Abstract

In this work, organic semiconductor devices, namely organic light emitting diodes (OLEDs) and organic solar cells (OSCs), were examined regarding their photovoltaic properties. Standard measurement techniques as well as a newly developed method were used. A focused laser beam is used to scan a device while the resulting photocurrent is concurrently measured, allowing for local photocurrent mapping (LPM). In addition this system also allows to apply arbitrary bias voltages, so that the crucial characteristic photovoltaic parameters (short-circuit current I_{SC}; open-circuit voltage V_{OC}; compensation voltage V^*) can be mapped. The capabilities of this measurement device were tested on state-of-the-art model OLEDs and OSCs. While, SuperYellow (SY), a poly-vinylene-phenylene (PPV) derivative, was chosen as electroluminescent material for the OLEDs, the OSCs were based on a blend of poly-3-hexylthiophene (P3HT) and [6,6]-phenyl-C61 butyric acid methyl ester (PCBM).

In OLED research, LPM is a supplemental tool, while it represents a powerful imaging technique to visualize the performance distribution of OSCs. Generally, the amount of generated photocurrent is mainly determined by the properties of the active layer, while V_{OC} and V^* can be influenced by both, active layer and electrode interfaces, depending on the device type. However, the measurement of V^* seems to be more promising, as it allows the separation of bulk material and interface properties to a certain extent. In addition, also shorted devices can be investigated. The phenomenology of a short allows a differentiation regarding other defects.

For degradation monitoring, LPM was included in lifetime measurements of model OLEDs. Using appropriate experimental conditions, the decay processes regarding the electrodes and intrinsic degradation could be separately investigated, and a degradation mechanism for the metallic cathode could be proposed. After oxidation the cathode de-laminates from the polymeric film. Intrinsic degradation, is commonly attributed to degradation of the active material itself due to a reduction of the length of the conjugated electronic system and trap formation. After catastrophic failure of model OLEDs due to electrical short formation, the device were examined

further by field-dependent LPM. Shorts in OLED devices can be automatically located. Presumably, the formation of shorts is related to electro-migration of contact material. It was demonstrated that shorts can develop at any location of the active device area. The results of this measurement can probably be generalized to polymeric OLED devices.

Poly(3,4-ethylenedioxythiophene) (PEDOT) is commonly used as anode in solution-processed OLEDs and OSCs. A derivative with a perylene-di-imide based side-chain (PDI-PEDOT), was used as anode in P3HT/PCBM solar cells. By manipulating the workfunction of the PDI-PEDOT layer prior to depositing the active layer, it was possible to manufacture inverted cells. PDI-PEDOT acted as a semi-transparent polymeric cathode in this case. However, the performance seemed to be limited due to a fundamental origin, which has to be investigated further.

In addition, the fabrication of a small OSC panel with four single cells in series was carried out. It was examined under various illumination intensities and color temperatures. Since an incandescent lamp was used, the results cannot be compared to common solar simulator experiments, due to the large spectral mismatch. Usually, P3HT/PCBM solar cells exhibit power conversion efficiencies of approximately 5%. However, the yielded characteristic values matched the calculated maxima relatively well. The relative efficiencies showed an increase towards higher color temperatures, because the spectral mismatch was reduced. It is assumed, that the efficiency of the panel is reduced compared to a standard device due to a higher series resistance, which results in a lower fill factor. Presumably the efficiency of the panel amounted approximately 3.0% to 3.5%, when the poor fill factor is taken into account.