**A cluster of bilayer diodes model for bulk heterojunction organic solar cells**

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Organic solar cells (OSCs) possess unique properties such as a low cost, flexibility, lightweight, semitransparency, and compatibility with roll-to-roll fabrication, which make them potential candidates for mass production. The rise in their power conversion efficiency (PCE) over the last few years has been driven by the emergence of new organic semiconductors and the growing understanding of morphological control at both the molecular and aggregation scales resulting in 18% PCE for single junction OSCs [1, 2].On the other hand, a basic physical concept that singles out dominant processes in these devices and quantifies them is still missing. The clarification of the device physics could open up an additional opportunity for a further PCE increase and the elimination of other shortcomings in OSCs.

The current-voltage (I-V) characteristic of OSCs is usually modeled by the standard drift-diffusion model (DDM) [3]. This model requires a numerical solution that makes it impossible to perceive the influence of individual processes (such as photogeneration, transport, recombination, contact phenomena, etc.) on the shape of the I-V curve. However, what is certain is that OSCs basically behave as photodiodes, implying that their work is based on the physics of heterojunctions. In a standard DDM, a bulkheterostructure active layer of an OSC is considered as a single semiconducting material, and the junction physics is not taken into account.

In this paper we present a new concept of treating the OSC bulkheterostructure as a cluster of spatially arbitrarily oriented small bilayer domains (bilayer diodes). The elementary bilayer domain is described by a one-diode model. The OSC I-V curve is calculated by summing the contributions of all bilayer domains. The resulting I-V dependence is the one-diode equation with parameters (the reverse saturation current and the ideality factor) related to the parameters of the elementary bilayer domain.

The one-diode parameters for the elementary bilayer domains are determined by fitting the one-diode equation to the measured I-V curve of bilayer ITO/PEDOT:PSS/P3HT:PCBM/Al solar cell. The I-V curves of ITO/PEDOT:PSS/P3HT:PCBM/Al bulkheterostructure solar cells with six different P3HT:PCBM thin film thicknesses are then simulated and compared to measured ones. The experimental data are successfully reproduced by the proposed model.

REFERENCES

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