Solution processed multijunction polymer solar cells

Martijn Wienk, Jan Gilot, and Rene Janssen

Polymer solar cells bare the promise of becoming an alternative to the regular photovoltaic solar cell devices that are based on inorganic semiconducting materials like silicon and cadmium telluride. The main advantage of organic over inorganic semiconductors is the possibility to deposit these materials in a reel-to-reel fashion by printing methods. However, currently the efficiency of polymer solar cells is not sufficient for most applications. One important loss mechanism in all solar cells is related to the large variation of photon energies in the solar spectrum. For any single junction device this will inevitably lead to a trade off between current and voltage, limiting the maximum efficiency. Multijunction solar cell concepts can partly overcome this problem by converting photons of different energy in separate dedicated subcells, to maximize the power conversion of both high and low energy photons. For example, tandem solar cells can combine a wide band gap subcell that converts high-energy photons, providing a high voltage with a narrow gap subcell that converts lower energetic photons.

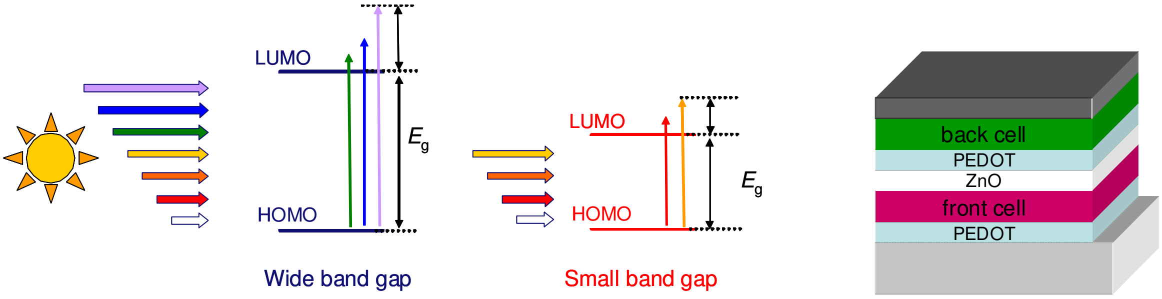

Fig. 1. *(left) Schematic representation of a tandem cell comprising two subcell with different absorbers, minimizing thermalization losses.(right) Device layout of a polymer tandem solar cell with a wide gap front cell and a narrow gap back cell.*

In order to take advantage of the higher voltage of the wide gap subcell, the subcells must be connected in a series configuration. This can be achieved by connecting the subcells with an transparent intermediate contact that can effectively collect holes from one subcell and electrons from the other and let them recombine with a minimal energy loss.

An intermediate contact, consisting of a thin layer of nanocrystalline ZnO, collecting electrons from one subcell and a highly doped polymer semiconductor, PEDOT:PSS to collect holes from the other subcell, are sequentially processed in between two polymer:fullerene solar cells. In order to achieve ohmic contact between these layers, the ZnO needs some additional doping, which is easily achieved after completion of the complete tandem device by exposure to UV-light. By combining subcells with distinctly different band gap polymers, tandem cells are constructed that outperform each of the individual single junction analogues.

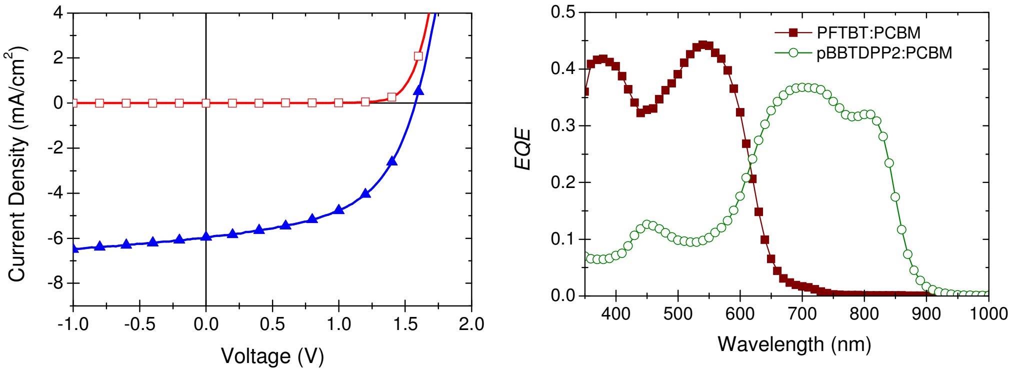

Fig. 2. *(left) JV curves of a ~5% efficient polymer tandem solar cell; dark and under illumination with simulated solar light. (right) EQE of the two subcells.*

External quantum efficiencies of both subcells have been determined, carefully considering relevant light intensities (AM1.5 equivalent) and the electrical biases the subcells experience during the measurement. These data reveal that each subcell performs as well a similar single junction device. Moreover, the electrical characteristics of the tandem device perfectly matches two ohmicly connected subcells, indicating that the ZnO PEDOT:PSS intermediate contact imposes no electrical losses.

J. Gilot, M. M. Wienk, R. A. J. Janssen, *Adv. Mater.,* **2010**, *22*, E-67
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