Small Molecule based OPV: from Single to Tandem Heterojunction Devices

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Organic solar cells OSCs have the potential to become a low-cost alternative to conventional solar cells due to low material consumption, simple processing methods as well as the possibility for flexible and lightweight devices. One very promising approach for OSCs is based on thermal evaporation of small molecules in vacuum to create an organic stack in the p-i-n concept, i.e. a concept in which intrinsic absorber layers are sandwiched between p- and n-doped transport layers(see figure 1)[1]. The key to this concept is the controlled molecular doping. It allows for an active control of the Fermi level in the doped layers, making transport materials highly conductive and creating ohmic contacts to the electrodes. Using doped and transparent materials as transport layers, the p-i-n concept comes close to the ideal solar cell structure proposed by Peter Würfel[2]. Furthermore, small molecules can be easily be purified, the thickness and composition of each layer can be controlled well and multilayer stacks are easily accessible, e.g. for tandem solar cells.

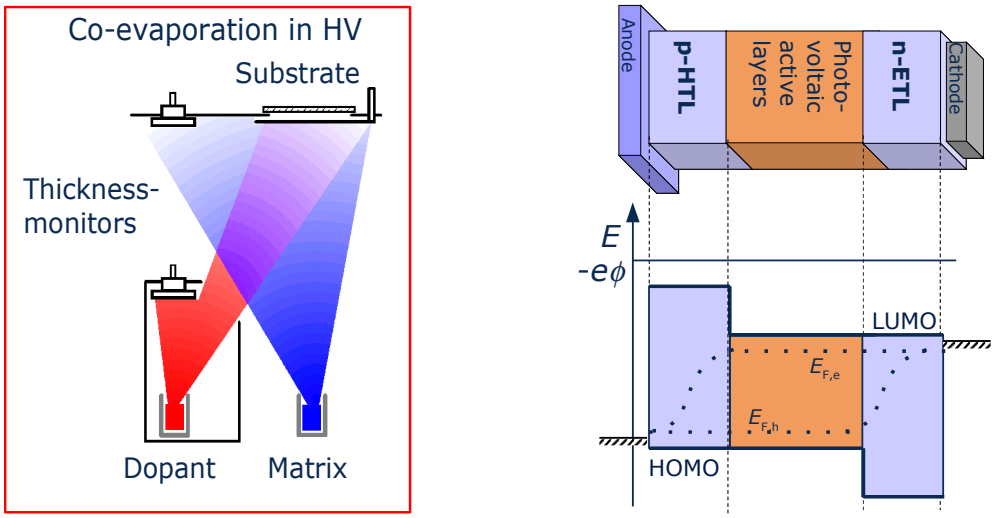

Figure 1: Preparation of organic layers in vacuum (left) and a schematic drawing of the p-i-n concept under illumination with split quasi Fermi levels $E_{F,e}$ and $E_{F,h}$ (right). The photovoltaic active layers are sandwiched between doped hole and electron transport layers (p-HTL/n-ETL).

As such, the p-i-n concept offers a solid basis both for studies on the working principles of OSC, for screening of new materials and for device optimisation. There has been good process in recent years and the important developments in the field of small molecules OSC, especially based on the p-i-n concept, will be presented and discussed. One central issue remains the control of the morphology in the photovoltaic active layers, because it has significant influence on the device performance. For vacuum-deposited OSCs, substrate temperature is shown to be crucial for efficient single heterojunction devices. Still, to eventually achieve efficiencies above 10%, the threshold usually considered as lower limit for large scale commercial success of OSCs, most likely tandem concepts are required. Thus, much effort has been devoted to developing these concepts and currently vacuum deposited tandem device show the highest efficiency. The main requirements of tandem concepts (efficient recombination contact, current matching and complementary absorption) and steps towards realising optimised devices will be discussed.

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