Semi-transparent and tandem organic solar cells

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Very recently, a number of companies announced organic solar cells with power conversion efficiencies well exceeding 10% on lab scale opening pathway towards a cost-efficient exploitation of this young technology, thereby widely exhausting the efficiency potential for common single junction solar cells. Reasons for the strong efficiency limitations in organic solar cells are among others the spectrally limited absorption of organic semiconductors as well as thermalization losses during charge carrier relaxation after the absorption of highly energetic photons. A widely discussed concept to overcome this limitation is the use of tandem solar cell architectures, i.e. the (monolithic) integration of two solar cells in series in a single device stack. Their working principle relies on two different light absorbing semiconductors with different band-gap and hence complementary absorption in order to ensure a broader absorption of the solar spectrum and to reduce the energy losses upon the absorption of highly energetic photons. In fabrication processes, the sophisticated tandem solar cell multilayer-architectures offer many degrees of freedom such as choices for materials and layer thicknesses. Hence, understanding their working principle and optimizing their efficiency is one of the most challenging tasks in organic photovoltaics. Besides carefully chosen complementary absorbers there is a strong need for charge carrier transport layers that allow for the fabrication on an ohmic intermediate contact with low resistivity. Both require advanced solutions in particular when low-cost solution deposition processes are considered with respect to future printing processes.

As the front cell of an organic tandem solar cell needs to be transparent for a certain part of the visible spectrum in order to provide light for the back cell, this technology is closely related to a key application for organic photovoltaics: Semi-transparent devices for building or automotive integration.

In this work general concepts are presented for the solution fabrication of both semi-transparent and tandem organic solar cells and how to realize devices with decent power conversion efficiencies. In particular, promising concepts for charge carrier transport layers for advanced device architectures and solutions how to overcome solubility limitations will be discussed.