Lost in translation? – Transport resistance in non-fullerene based organic solar cells

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With the advent of non-fullerene acceptors, organic solar cells have made impressive improvements in terms of power conversion efficiency, so that breaking the 20 % limit is within close reach. Understanding the efficiency-limiting processes of fresh devices and upon degradation remains important to optimise the solar cells effectively.

The impact of the most important loss mechanisms for state-of-the-art organic solar cells is schematically shown in Fig. 1. I will focus on a loss in fill factor due to the transport resistance.

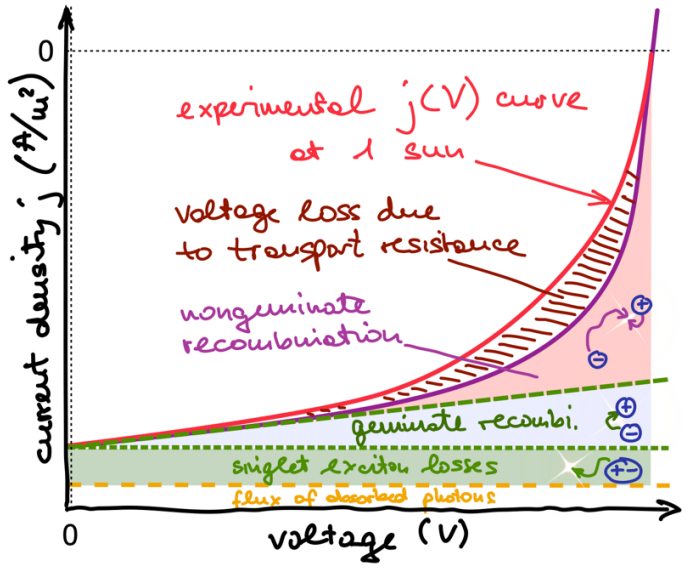

Fig. 1: Scheme of how efficiency-limiting processes determine the current density–voltage characteristics of organic solar cells.

The effect of transport resistance has been long known: it represents a voltage loss due to a low conductivity in the active layer! While its importance as loss for organic solar cells could have been forseen long ago (for instance by me as coauthor of a work published in 2008 about an analytic model for the open-circuit voltage of organic bilayer solar cells[1]) as result of the relatively low charge carrier mobility, its importance for organic solar cells as potentially major loss mechanism was only shown in 2014 by Uli Würfel and coworkers.[2] I will show results on fresh and thermally degraded PM6:Y6 solar cells (heated to 85°C, in the dark, under nitrogen atmosphere), a state-of-the-art system based on the „non-fullerene“ Y6. The increasing fill factor losses upon this degradation path are due to the transport resistance. The cause seems to be trap formation in the – possibly donor – tail states, which does not only decrease the active layer conductivity, but increase the intrinsic carrier concentration. I will relate what we (think we) know and what we do not… yet, and look forward to discuss this with you in person.

[1] D Cheyns, J Poortmans, P Heremans, C Deibel, S Verlaak, B P Rand, J Genoe. Phys. Rev. B 77, 165332 (2008)

[2] S Schiefer, B Zimmermann, U Würfel. J. Appl. Phys 115, 044506 (2014)