The photoshunt in organic solar cells and how it is connected to the transport resistance

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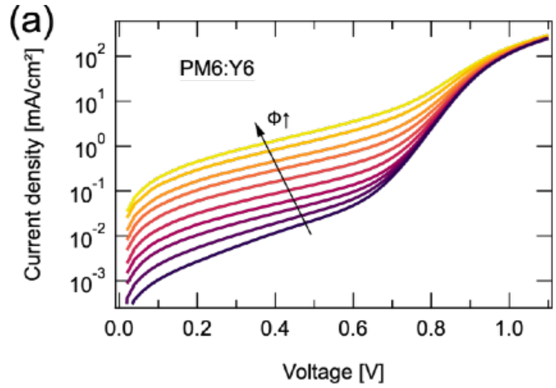
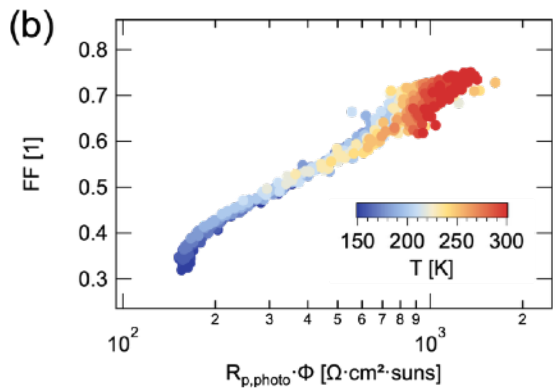
One of the major limiting factors of the organic solar cell performance is the impact of the low active layer conductivity on the transport resistance that, in turn, limits the fill factor. In literature, there are different approaches that describe the same effect in different ways. Central to them is that the superposition principle of the diode equation – the shifting down of the dark curve by the short circuit current to describe the illuminated curve – is not valid if the active layer conductivity is rather low [1].



The resulting changes can be described by the figure of merit for transport resistance α [2], determined around open circuit conditions, or by a "photoshunt" [3] that appears around short circuit conditions and increases with higher illumination intensity. This is shown in Figure (a), with the current density *relative* to the short circuit current density. A higher "photoshunt" corresponds to a lower active layer conductivity, which leads to a reduced fill factor; this is illustrated in Figure (b) [4].



I want to discuss the different viewpoints and show that the "photoshunt" and the transport resistance are closely related. It is important to understand the connection to be able to describe the transport resistance limiting the fill factor in a unified manner.

[1] S. J. Robinson, A. G. Aberle, and M. A. Green, Departures from the principle of superposition in silicon solar cells, J. Appl. Phys. 76, 7920 (1994).
[2] M. Saladina and C. Deibel, Transport resistance strikes back: unveiling its impact on fill factor losses in organic solar cells. arXiv:2404.06190 (2024).
[3] E. Kim, L. Christen, and T. Kirchartz, Correlating the Photoshunt with Charge-Collection Losses in Organic Solar Cells, Adv. Energy Mater. 2403129 (2024).
[4] C. Wang, R. C. I. MacKenzie, U. Würfel, D. Neher, T. Kirchartz, C. Deibel, and M. Saladina, Transport resistance dominates the fill factor losses in record organic solar cells. arxiv:2412.13694 (2024).