The dark saturation current density in organic solar cells

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The dark saturation current density is a critical parameter for diodes, as it not only characterises the recombination current in the absence of light at zero volts, but also provides insights into how this current changes under illumination for higher voltages [1]. The dark saturation current density can provide valuable information about the effective energy range where charge carrier losses occur. Recent studies on organic solar cells have proposed that this effective energy range corresponds to mid-gap states, which possess energies approximately half of the effective bandgap of the respective photodiode or solar cell material blends [2]. However, I will argue that this observation is inconsistent with the ideal diode equation. In addition, the determination of the effective energy gap from the temperature dependent dark saturation current density has to account for the dependence of the diode ideality factor on the open circuit voltage – which is the case in organic solar cells [3]. I will present experimental data and modelling results for various organic semiconductor blend devices to demonstrate that the dark saturation current is not dominated by mid-gap states.

References:

[1] K. Tvingstedt and C. Deibel, Temperature Dependence of Ideality Factors in Organic Solar Cells and the Relation to Radiative Efficiency, Adv. Energy Mater. 6, 1502230 (2016)
[2] O. J. Sandberg et al., Mid-gap trap state-mediated dark current in organic photodiodes, Nature Photonics 17, 368 (2023)
[3] M. Saladina et al., Power-law density of states in organic solar cells revealed by the open-circuit voltage dependence of the ideality factor, Phys. Rev. Lett. 130, 236403 (2023)