Analysis of Photon Recycling in Perovskite Solar Cells Based on Fully Coupled Optoelectronic Simulation

Simon Zeder[1,2], Beat Ruhstaller[1,3] and Urs Aeberhard[1,4]

[1]Fluxim AG, 8400 Winterthur, Switzerland
[2]École Polytechnique Fédérale de Lausanne, PV-LAB Institute of Microengineering, 2002 Neuchâtel, Switzerland
[3]Zurich University of Applied Sciences, Institute of Computational Physics, 8401 Winterthur, Switzerland
[4]Eidgenössische Technische Hochschule Zürich, Integrated Systems Laboratory, 8092 Zürich, Switzerland

Consideration of optical emission is often restricted to light emitting devices such as Perovskite LEDs (PeLEDs), while for solar cells this process is mainly only taken into account as an electrical loss term through radiative inter-band recombination. However, such emitted photons are not necessarily lost from the system and can have an impact back on device performance, either through reabsorption of photons in the same layer as they were emitted from (photon recycling, especially in Perovskites due to the large overlap of emission and absorption spectra [1]), or through reabsorption in a different absorber for multijunction cells (radiative coupling). We present a recently established optical model based on an electromagnetic Green's function approach to consistently consider such reabsorption processes in a full wave picture, additionally ensuring detailed-balance compatibility of the resulting rates. [2]

This model can be applied to simple single-junction Perovskite cells for pure photon recycling [3], or also tandem cells like all-Perovskite or Perovskite-Silicon cells for combined photon recycling and luminescent coupling interactions, as will be shown. Furthermore, the resulting emission and reabsorption rates can be directly coupled to an electronic drift-diffusion-Poisson solver, in order to consider also various electronic processes in the solar cell such as non-radiative recombination and transport losses. Such a model will be helpful to guide the design of future device architectures which aim to maximize the beneficial impacts of photon recycling on the device performance.

References:

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