Time-resolved imaging of lateral charge carrier transport in photovoltaic absorbers

Adrien Bercegol[1,2], Daniel Ory[1,2], Joseph J. Berry[4], Joseph M. Luther[4], Philip Schulz[1,3], Amelle Rebai[1], Jean Rousset[1,2], Laurent Lombez[1,3]

[1] IPVF, Institut Photovoltaïque d'Ile-de-France, 30 RD 128, 91120 PALAISEAU, France
[2] EDF R&D, 30 RD 128, 91120 PALAISEAU, France
[3] CNRS, Ile-de-France Photovoltaic Institute UMR 9006, 30 RD 128, 91120 PALAISEAU, France
[4] Chemical and Materials Science, National Renewable Energy Laboratory (NREL), Golden, USA

Time-resolved fluorescence imaging (TR-FLIM) allows to obtain time-resolved photoluminescence (PL) maps with a micrometric resolution. We previously showed that wide-field illumination with TR-FLIM allows to quantify lateral transport to a more defective zone[1]. This study will be focused on point illumination, extending the breadth of this characterization technique to bare absorbers and homogeneous devices. We explore this new possibility to various photovoltaic absorbers. At first, a p-GaAs thin film is analyzed. Results constituting a proof of concept for this technique will be shown. Then, thin films of perovskite $CsPbI_3$ quantum dot[2], treated or not with methyl acetate (MeOAc) are analyzed, as well as triple cation perovskite $(MA,FA,Cs)Pb(I,Br)_3$ absorbers. The attached figure displays images extracted from the PL film just after the excitation (Figure A) and 30 ns after it (Figure B), when photo-generated charge carriers have diffused and recombined. Using algorithms solving 2D/3D drift-diffusion equations, we simulate the PL profiles at every time step and fit the experimental surface on Figure C. Noteworthy, the model remains valid at any injection level.

We therefore demonstrate that this new method allows quantifying the optoelectronic properties representative for lateral diffusion (mobility, diffusion length…) and local recombination properties (carrier lifetime, defects density…). Moreover, the diffusion length and lifetime at 1 sun excitation are then calculated to assess the performance of the investigated PV devices.

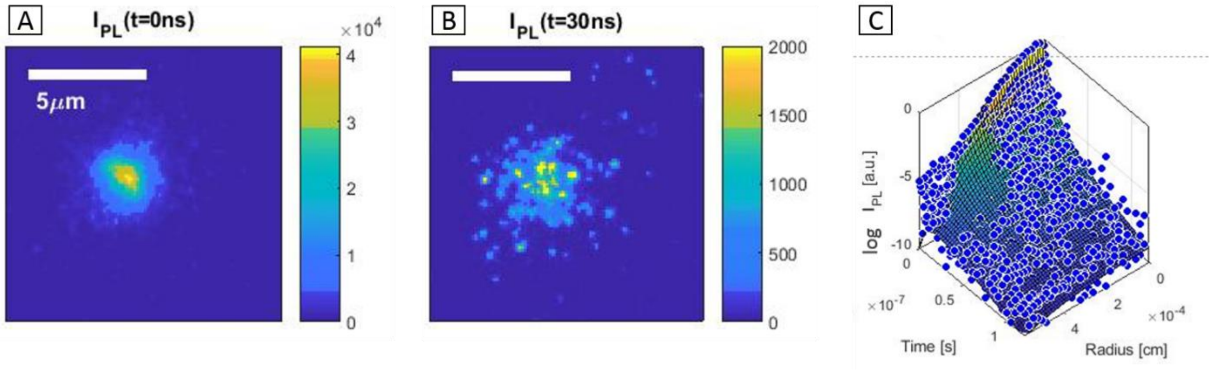

Figure (A) PL emitted by a $CsPbI_3$ quantum dot thin film 0ns after being photo-excited (λ=532 nm, 5 10^6 photons/pulse). (B) PL emitted by the same sample 30 ns after the excitation. (C) time-resolved PL profiles in radial coordinates (blue circles) and fitted surface by the fitting algorithm.

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(2) Swarnkar, A.; Marshall, A. R.; Sanehira, E. M.; Chernomordik, B. D.; Moore, D. T.; Christians, J. A.; Chakrabarti, T.; Luther, J. M. Quantum Dot–induced Phase Stabilization of a-CsPbI3 Perovskite for High-Efficiency Photovoltaics Abhishek. *Science (80-.).* **2016**, *354* (6308), 92–95.