Distinguishing surface and bulk recombination on triple cation perovskite layers with time resolved photoluminescence imaging and the δ_1-technique

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Perovskite-based solar cells are the subject of intense study today because of their promise in terms of high efficiency, easy and low-cost fabrication. To gain insight on the behavior of carriers inside the perovskite layer, time resolved photo luminescence (TR-PL) and time resolved fluorescence imaging (TR-FLIM) are used[1]. However, owing to their long lifetimes (~1µs) and slow diffusion ($D \sim 10^{-2} cm^2 s^{-1}$) the acquired signals require specific care for interpretation. In the literature, a general question arises regarding the position of defects in the films: are they located more at the surface or in the bulk of the material?[2]

In this work, we propose to adapt a method found in the literature[3] to distinguish bulk from surface recombination of triple cation perovskite layers at the local level on images. The technique was introduced for doped semiconductors, and we extend the model to intrinsic ones. We obtain a method that we name δ_1-technique that is applicable to *images,* in that it is very fast to compute. We will describe the method in a first part of the presentation. We will show how it relates to other existing techniques such as drift-diffusion fitting and wavelength-dependent TR-FLIM[4].

In a second part, we tackle study of X-Ray damaged triple cation perovskite half cells. Then we use the δ_1-technique to evidence that electrically active defects caused by X-Rays are bulk defects and not surface defects. Although X-Rays, due to their penetration depth should initially create defects essentially in the bulk, there could be either migration or phase segregation induced effects leading to changes in surface recombination. We discuss the obtained results via comparison with other techniques and discuss the opportunities offered by the method presented, especially in terms of imaging.

Finally, we conclude by discussing the range of materials that are suited for this technique.

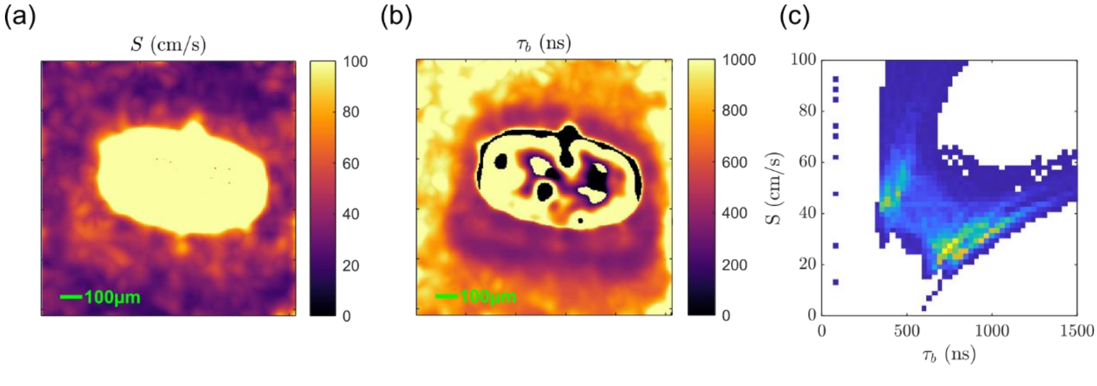

Figure 1: Maps obtained with the δ_1-technique (a) top surface recombination velocity (b) bulk decay time (c) cross-correlation for the pixels.

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