Series Resistance Imaging for Tandem Application

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For technologies vulnerable to detrimental inhomogeneities like perovskite-based multijunction devices, advanced defect imaging is crucial for a better understanding of upscaling, stability and ageing related issues. This study introduces and validates a new series resistance imaging technique for the determination of transport losses within solar cells. The method, based on differential luminescence imaging, has been used in different case studies for resistive defect identification of single junction perovskite cell and different perovskite based multijunction devices. This practical and powerful characterization method is relatively simple to implement, fast and non-destructive.

The series resistance (R_s) map of a device is being determined from two photoluminescence (PL) images under constant illumination ($\Delta J_L = 0$) with two different bias voltages. The R_s can be calculated following the equation established by Wong et al. [1]:

$$R_S(x,y) = \left.\frac{\Delta V_T - \Delta V(x,y)}{\Delta J(x,y)}\right|_{\Delta J_L=0}, (1)$$

with $\Delta V_T = V_{T,1} - V_{T,2}$, the difference of terminal voltages, $\Delta V(x,y) = V_1(x,y) - V_2(x,y)$, the difference of local voltages, $\Delta J(x,y) = J_1(x,y) - J_2(x,y)$, the difference of local current densities between the two images. To probe the perovskite top subcell, (i) we use green LEDs so that the illumination is only absorbed by the perovskite material; (ii) we use a specific filters stack in front of our silicon CCD camera to ensure that only the light emitted by the perovskite subcell is detected; (iii) we measure a third PL image and the J_{sc} of the perovskite subcell for a novel and promising method of voltage and current calibration of the two PL images and; (iv) we measure/estimate beforehand the R_s of the silicon subcell for a newly developed calculation method of ΔV_T applied on the perovskite subcell.

One of the case studies is presented on Figure 1. The sample architecture and materials are presented on Figure 1a, while the corresponding R_s map is plotted on Figure 1b. With this image, we can easily identify four finger interruptions merging into two main regions of high resistivity. The method, applied to other samples, also allowed the detection of ITO scratches, perovskite scratches, PbI_2 residuals and possibly missing transport layer areas. Further investigations are planned, studying specifically designed defects or comparing this method with a contactless approach [2].

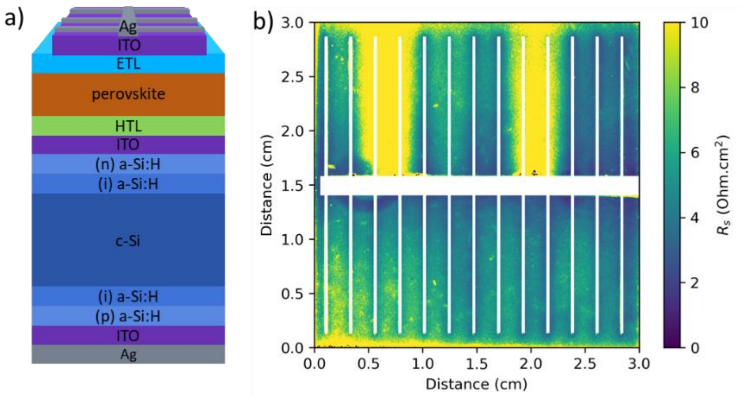

Fig. 1 – a) Representation of one of the investigated perovskite/silicon samples and b) the corresponding R_s image.

[1] J. Wong and M. A. Green, *Phys. Rev. B*, 85, 235205, **2012**, 0.1103/PhysRevB.85.235205.
[2] J. M. Greulich et al. *Sol. Energy Mater.*, 248, 111931, **2022**, 10.1016/j.solmat.2022.111931.