Current transport efficiency mapping in solar cells by luminescence

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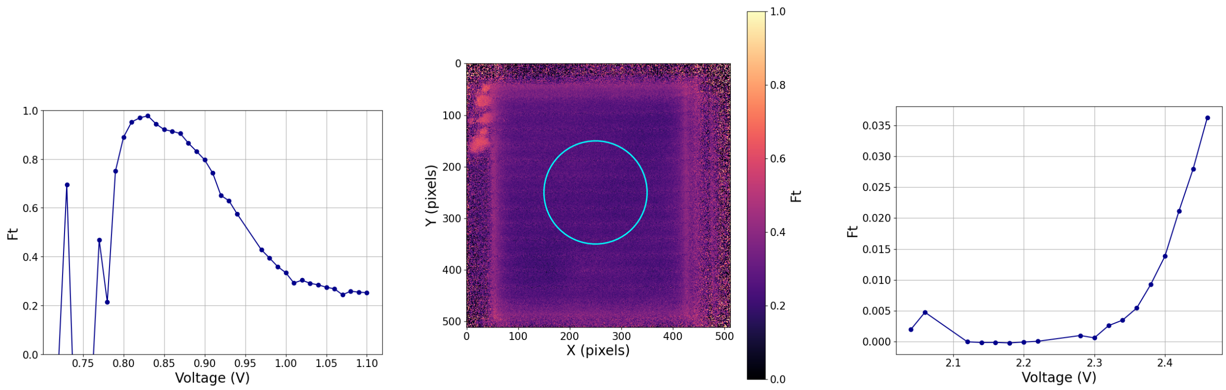
Abstract

Context. The fabrication of the tandem cells permit to go beyond the Shockley-Queisser limit for single junction cells (SJ). These new devices work in a different way from SJ because of new interfaces and the addition of a second junction. Scientists therefore need to find new characterization methods to study and understand new mechanisms and phenomena, which is essential for making better tandem cells and having a non-destructive method for assessing device durability. In this work, we search to develop a new characterization methods to determine the *current transport efficiency* (f_t) defined at working point as : $f_t(x,y) = dI_T/dI_L(x,y)$ [1], with I_T the terminal current measured and $I_L(x,y)$ the current photogenerated. In this way, the current transport efficiency indicates the quantity of local charge carriers flowing from the junction at (x,y) to the terminal. And with its reciprocity relation we can measure (f_t) via the cell luminescence [1]. To confirm this method, we are going to focus on GaAs SJ and the InGaP/GaAs tandem (in 2T) because the III-V materials are homogeneous and stables so they will serve as a model for the future.

Results. The figures show the current transport efficiency variation (averaged on an area of the sample) in relation to the voltage and under illumination with LED 565nm. For the GaAs SJ (fig.a) a long-pass filter 650nm has been added. From this method we obtain a map (fig.b) and from this map we determine a f_t spatially averaged on the sample. On fig.a, at low voltage ft takes random values then ft = 1 and decreases. We expect ft = 1 at low voltage, as carrier charges are easier to extract since the device is close to the short-circuit condition[2]. Thereafter, ft should decrease as we have observed, because of resistance series which prevail when the voltage enhances. In fact, at low voltage, the luminescence signal is quite weak so the most important signal is the camera noise. This result show that the measurements at low voltage is a limit of our method. In the futur, we use this method in the 2T tandem for investigating the behavior of each subcell. For the InGaP/GaAs tandem (fig.c), we also used LED 565, so only the top cell is excited, and a short-pass filter 750nm has been added to observe only the top cell. We see that ft increases with the voltage. This result is in agreement with expectations, given that the bottom cell is limiting and therefore behaves like a low voltage resistor. But at high voltage, the limiting cell is no longer blocking so ft starts to rise.
Then, with this method, we will investigate CIGS tandems (for inhomogeneity), perovskite tandems (for inhomogeneity and instability) and aged tandems.

Key words : Characterisation, tandem cells, current transport efficiency



(a) (b) (c)

Figure 1: Current transport efficiency variation, averaged on the area of the sample, in relation to the voltage and under illumination with a LED 565nm. Results for GaAs SJ (a) and its ft map at 1.10V(b) where the blue circle is the area over which ft is averaged. Results for InGaP/GaAs tandem, with illumination and observation of the upper cell (c).

References

[1] J. Wong, M. A. Green (2012). *From junction to terminal: Extended reciprocity relations in solar cell operation*. Phys. Rev. B, 85(23), 235205.

[2] A. Delamarre and al. (2016). *Experimental Demonstration of Optically Determined Solar Cell Current Transport Efficiency Map*. IEEE J. Photovoltaics, 6(2), 528-531.