Cross correlated defect spectroscopy techniques as a support to extract defect states properties in solar cell absorbers.

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Admittance Spectroscopy and ultralow temperature photoluminescence are well established techniques to detect the presence of defects in solar cell absorbers. Time Resolved Photoluminescence (TRPL) is also a reference method for lifetime measurement.

During the last years, we also developed an efficient High-Frequency Modulated Photoluminescence (MPL) setup at IPVF, covering a frequency range of 10Hz-200MHz [1]. As previously described, several different phase patterns in the MPL curves were observed at low illumination fluxes, from which were extracted traps parameters [1-2] , in accordance with analytical calculations developed by N. Moron [3].

In this presentation, we will use several of the above techniques in the same set of samples to cross-reference the results obtained on defect state properties (Round Robin). We measured MPL, TRPL (see figure below graphs a) and b)) and calibrated PL at room temperature and also temperature resolved MPL on p-type and n-type **$Al_{0.25}Ga_{0.75}As$**. Also, we are currently performing comparison with ultra-low temperature dependent PL and with Admittance Spectroscopy on full cells made with the same absorbers. MPL data treatment by global fitting of the bode diagrams and its dependence to the laser power (phase, amplitude and relative intensity of the signal) reveals a majority carrier trap close from valence band (graph c)) and will be compared to other results.

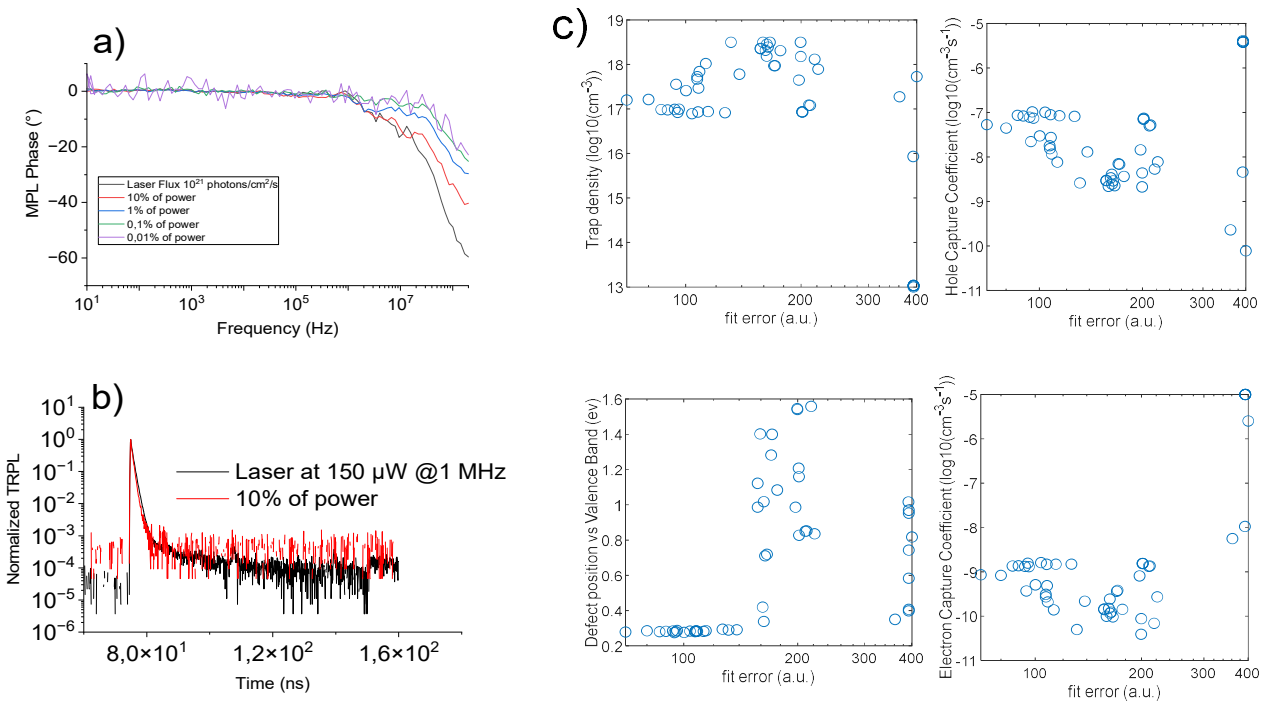

Figure. a: MPL signature versus laser power of the $Al_{0.25}Ga_{0.75}As$ n -type sample material fabricated at IPVF. b: TRPL transients at the same point of the sample. c: Results of 50 fits with different starting points showing that low fitting error correspond to a specific set of trap parameters.

[1] W. Zhao *et al.*, « Coupled time resolved and high frequency modulated photoluminescence probing surface passivation of highly doped n-type InP samples », *J. Appl. Phys.*, vol. 129, n° 21, p. 215305, juin 2021, doi: 10.1063/5.0033122.
[2] B. Bérenguier *et al.*, « Defects characterization in thin films photovoltaics materials by correlated high-frequency modulated and time resolved photoluminescence: An application to Cu(In,Ga)Se2 », *Thin Solid Films*, vol. 669, p. 520-524, janv. 2019, doi: 10.1016/j.tsf.2018.11.030.
[3] N. Moron, B. Bérenguier, J. Alvarez, et J.-P. Kleider, « Analytical model of the modulated photoluminescence in semiconductor materials », *to be published*.