Towards a better understanding of experimental High Frequency Modulated Photoluminescence Curves: Numerical Calculation and Analytical approach.

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During the last years, an efficient High-Frequency Modulated Photoluminescence setup has been developed at IPVF, covering the 500Hz-200MHz range. This is one of the two setups in the world able to probe such a wide dynamic range [1],[2]. This setup is currently used to probe several materials, including the IPVF perovskites and CIGS baseline. As previously described, V-shaped phase patterns in the MPL curves were observed at low illumination fluxes, which were assigned to the presence of traps [3] [4]. In a parallel approach, two important works have been conducted. Analytic calculations and drift diffusion simulations have been conducted at the GeePs laboratory in order to understand the influence of trap parameters on the HF-MPL phases curves. Systematic numerical simulations by parametrical study have been conducted at UMR-IPVF in the same time. Thanks to these works, appearance of V-shapes is now well understood. Multiple V-shapes and deviations from "simple" V-shapes are under study. A summary of these results will be presented.

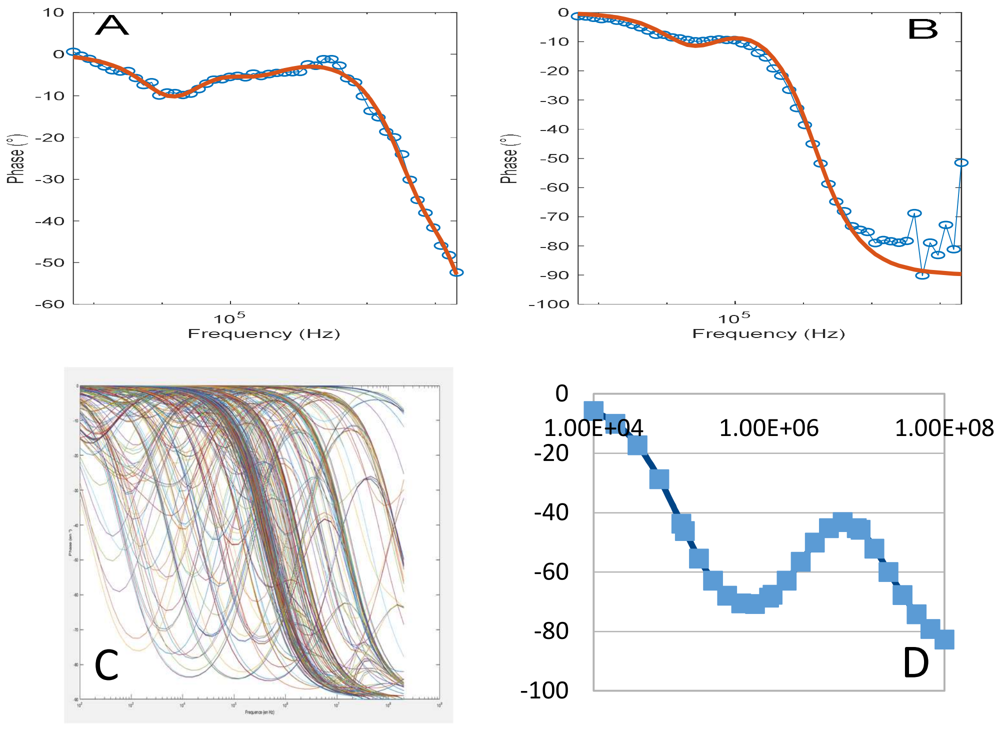

Figure. A: MPL signature of the CIGS IPVF baseline and attempt to fit the data using seven arc-tangent functions. B: MPL signature of the perovskite IPVF baseline and attempt to fit the data using three arc-tangent functions. C: parametric calculations of a one defect MPL signature. D: Silvaco simulation of a single shallow trap MPL signature for a given set of parameters

[1] I. Reklaitis *et al.*, « Photoluminescence Decay Dynamics in Blue and Green InGaN LED Structures Revealed by the Frequency-Domain Technique », *J. Electron. Mater.*, vol. 45, nº 7, p. 3290-3299, juill. 2016, doi: 10.1007/s11664-016-4557-7.

[2] 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, nº 21, p. 215305, juin 2021, doi: 10.1063/5.0033122.

[3] 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.

[4] B. Bérenguier *et al.*, « Defect Trapping in Thin Films Probed by Frequency Domain Photoluminescence», *EU-PVSEC 2021 proceedings.*