# High Frequency Modulated Photoluminescence for thin film solar cell absorbers: a comparison between simulation and experiments.

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Modulated optoelectrical characterization techniques such as modulated photocurrent or admittance spectroscopy are well known in the semiconductor field and suitable for thin film solar cells characterization [1,2]. However, the extension of modulated photoluminescence from silicon [3] to thin films absorbers was difficult, because the effective lifetime in such films is several order of magnitude lower than silicon, in the ns range. This implies to measure low light level and at the same time to increase the modulation frequency until a delay becomes observable between excitation and photoluminescence.

Last year we developed a new setup using Time Correlated Single Photon Counters (TCSPC) for the measurement of fast temporal photoluminescence signals, performing High Frequency Modulated Photoluminescence (HF-MPL). The excitation laser intensity is temporally modulated instead of pulsed as in Time Resolved Photoluminescence. The measured modulated photoluminescence is collected and sent to a Single Photon Avalanche Photodiode connected to a TCSPC, allowing the reconstruction of one sinusoidal period.

First experiments conducted on CIGS revealed that HF-MPL is suitable for defect tracking and characterization [4-5] and provide complementary information to TRPL. We developed at the same time a one dimensional drift diffusion simulation program including carrier trapping equations and were able to simulate both MPL and TRPL signals. This year, we will perform simulations in order to study the influence of traps parameters on both HF-MPL and TRPL signals. The results will be compared with experimental data measured on CIGS, perovskites or InP.

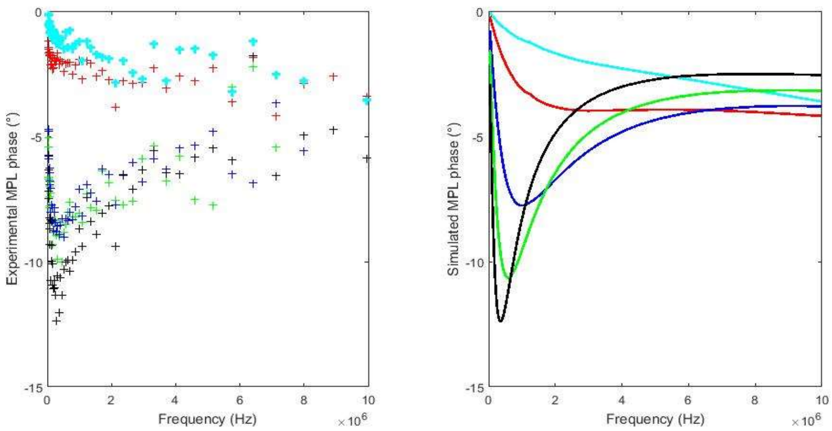


Fig.1. A comparison between experimental (left) and simulated (right) HF_MPL phase versus frequency data carried at several excitation powers. Laser power increases from black (1.3 $10^{19}$ photons/cm$^2$/s) to green, blue, red, cyan with a factor $\sqrt{10}$ at each step . Measurement were made on a CIGS as grown absorber.

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[5] Baptiste Bérenguier , Nicolas Barreau, Alexandre Jaffre, Daniel Ory, Jean François Guillemoles, Jean-Paul Kleider, Laurent Lombez, Defects characterization in thin films photovoltaics absorbers by correlated high-frequency modulated and time resolved photoluminescence: an application to Cu(In,Ga)Se2, This Solid Films, submitted.

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