POSTER pour session Caractérisation Avancée

The modulated photoluminescence technique versus temperature: opportunities for better determination of trap parameters.

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During the last years, we developed both an efficient High-Frequency Modulated Photoluminescence (MPL) setup, covering a frequency range of 10Hz-200MHz [1] and a corresponding analytical theory [2] allowing us to explain the appearance of V-shaped phase patterns in the MPL bode diagrams of probed semiconductor layers by the presence of Shockley Read Hall (SRH) recombination. An example of V-shape in phase behavior can be seen in the bode diagram in figure 1a. We precedingly investigated a fitting strategy based on curves obtained at several illumination levels. However, experiments at several temperatures are also a promising way to explore recombination paths. This year, we performed theoretical calculations and analytical simulations in order to show that the variations of the V-shape corner frequencies ω_1, ω_3, and especially ω_2 with respect to the temperature allow for recovering some trap parameters such as the energy position in the bandgap (activation energy) and the minority carrier capture cross section. In particular ω_2 is linked to one of the trap emission coefficients (see Figures 1b), either to the minority carrier emission or to the majority carrier emission coefficient. The validity domain of this theory will be discussed for low and high injection as well as doped and intrinsic materials. We also extended the previous theory [2] by finding supplementary rules for the appearance and disappearance of V-shapes. We proved that the MPL amplitude curve also contains information about the injection level during the experiment. Finally, we are currently performing MPL versus temperature experiments in order to validate our theory. We will present all these results during the conference.

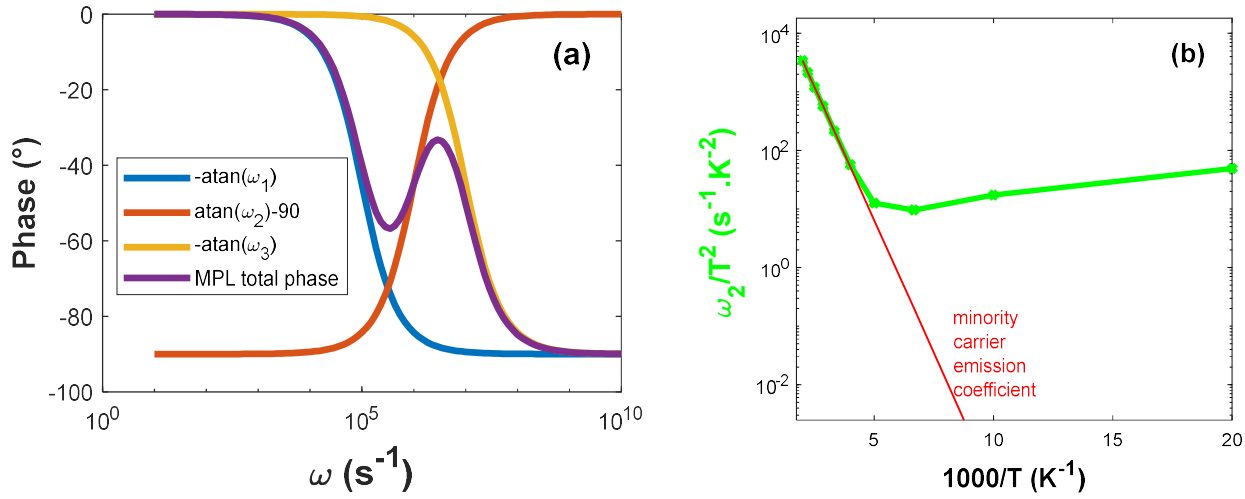

Figure 1: (a) Schematic of a V-shape phase pattern due to an SRH defect as the sum of three contributions; (b) Arrhenius diagram of the second corner frequency in the case of a shallow minority carrier trap showing a negative logarithmic slope at high temperatures due to the minority carrier emission coefficient

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

[2] N. Moron, B. Bérenguier, J. Alvarez, et J.-P. Kleider, « Analytical model of the modulated photoluminescence in semiconductor materials », *J. Phys. Appl. Phys.*, vol. 55, nº 10, p. 105103, mars 2022, doi: 10.1088/1361-6463/ac39c4.