ORAL ICANS26: New insights into the modulated photocurrent technique using 2D full numerical simulations (Poster preferred for JNPV 2015)

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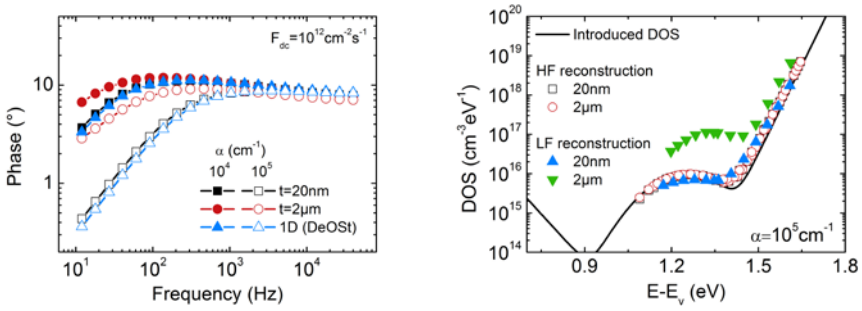
The modulated photocurrent (MPC) technique has proved to be a powerful tool to investigate the density of localized states (DOS) in the bandgap of disordered semiconductor thin films. In previous works two regimes were identified: the high frequency (HF) regime where the MPC is determined by the trapping and release of carriers producing a significant phase shift of the MPC relative to the excitation, and the low frequency regime (LF) where the MPC is determined by the recombination of carriers with a very low phase shift [1]. Each regime was analysed in order to describe the phase shift and amplitude of the MPC and to reconstruct the DOS from the frequency and temperature dependence of these quantities [2]. However, these analyses relied on a simplified analytical treatment of the transport equations. In particular, it was assumed that all physical quantities under light (like the generation rate, the free carrier concentrations, etc.) were homogeneous within an effective depth related to the light absorption. This means that the true profiles of generation rate, carrier densities were not considered.

We here present for the first time the full calculation of the MPC without any simplifying assumption using 2D numerical simulations. This calculation is compared to the previous analyses of the MPC. Particular emphasis is put on the transition between the HF and LF regimes and on the DOS reconstruction in both regimes.

It is demonstrated that the reconstruction in the HF regime works very well. However very strong errors can occur in the transition between the HF and BF regimes and in the reconstruction of the DOS from the LF regime. Our simulation results also nicely explain the previously observation that the dependence of the reconstructed DOS upon the dc light flux was weaker than predicted by the simplified analytical approach. We show that the approximate analytical approach underestimates the phase shift values in the LF regime (Figure 1). This discrepancy increases with αd (α being the absorption coefficient and d the sample thickness) and can yield to errors of more than a factor of 10 in the DOS reconstructed from the LF formulas (Figure 2). This is interpreted by the contribution to the MPC originating from regions in the sample that are deeper than $1/\alpha$ from the illuminated surface and that are not working in the recombination regime, thus adding a non negligible contribution to the phase shift.

In conclusion, this work is an original extension of the MPC analysis. It brings new insights into the physics of the modulated photocurrent allowing one to avoid misinterpretations of experimental data such as overestimated reconstructed DOS values.

FIGURE 1 / FIGURE 2:



[1] C. Longeaud and J.-P. Kleider, Phys. Rev. B 45 (1992) 11672.

[2] M.-E. Gueunier, C. Longeaud and J.-P. Kleider, Eur. Phys. J. Appl. Phys. 26 (2004) 75.