Influence of secondary barriers on DLTS measurements in Cu(In,Ga)Se_2 - based solar cells

Wiśniewski Konrad[1]**, Zabierowski Paweł**[1]

[1] *Warsaw University of Technology, Faculty of Physics, Koszykowa 75, 00-662, Warszawa, Poland*

Cu(InGa)Se2 (CIGS) solar cells are the most efficient (23.4%) among all thin film solar cells. Thanks to high absorption coefficient the thickness of these devices is one hundred times smaller than that of standard c-Si devices. CIGS solar panels are already available on the market. However, some of its properties are still the subject of lively debates. One of the ongoing disputes in that field pertains to the interpretation of Deep Level Transient Spectroscopy (DLTS) measurements. This very powerful technique is used extensively for detection and characterization of deep defects in semiconductor junctions. The common assumption for all DLTS modes is that a voltage pulse changes the occupation of defects which results in a capacitance transient reflecting the relaxation of the system to the initial stationary state after the perturbation. This transient is further analysed which provides rich information on defect parameters. However, if applied to more complicated structures, e.g. thin film CIGS solar cells, the interpretation of DLTS signals faces serious difficulties.

The fact that DLTS signal can be induced by secondary barriers instead of defects was demonstrated previously in ref. [1], [2]. We developed further this idea with reference to CIGS solar cells in ref. [3]. In this work we analyse whether the parameters used for modelling of DLTS peaks are physically reasonable. Firstly, we show that assuming the emission mechanism over the secondary barrier leads to unphysical values of corresponding equivalent circuit elements. Therefore, in the second step, we explore the possibility that the transport mechanism over the secondary barriers is dominated by diffusion. The results show very good agreement with experiment. However, to obtain best fits the mobility of holes must be strongly reduced. We discuss possible mechanisms leading to a very low mobility and show that parameters extracted from the fitting procedure allow to properly simulate DLTS signal for different modes of the experiment (e.g. for different height of voltage pulses). We also show how this analysis helps to interpret the results obtained by Impedance Spectroscopy (IS) on the same samples.

[1] J. Lauwaert, S. Khelifi, K. Decock, M. Burgelman, and H. Vrielinck, *J. Appl. Phys.*, vol. 109, no. 6, p. 063721, Mar. 2011.

[2] J. Lauwaert, J. Lauwaert, L. Van Puyvelde, J. W. Thybaut, and H. Vrielinck, *Appl. Phys. Lett.*, vol. 104, no. 5, p. 053502, Feb. 2014.

[3] K. Wiśniewski, A. Urbaniak, and P. Zabierowski, *Thin Solid Films*, vol. 674, pp. 76–81, Mar. 2019.