Persistent photoconductivity vs sodium content in $Cu(In,Ga)Se_2$ thin films

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Quarternary compound $Cu(In,Ga)Se_2$ (CIGS) is an exceptionally good absorber for thin film solar cells. CIGS based solar cells efficiency presently exceeds 23% and addition of alkali elements such like sodium and potassium is in part responsible for this achievement. Sodium might diffuse from the soda lime glass substrate during fabrication or might be provided after sample preparation during the so called post deposition treatment (PDT). The ongoing discussion is whether sodium improves material quality through grains passivation or through changes in the defect spectrum. Another phenomenon which is not completely understood is persistent photoconductivity (PPC), a metastable increase of conductivity after illumination, which persists below 200 K. It is a phenomenon observed in Cu(In,Ga)Se2 (CIGS) since early nineties, however its origin is still not well understood.

In this work we explore the relation between the relative and absolute magnitude of the persistent photoconductivity and sodium content. The samples we investigate have a controlled sodium content provided via PDT thus the influence of sodium on the material structure and morphology is avoided. The aim of this contribution is to estimate whether sodium affects the concentration of metastable defects straightforwardly (metastable defects are sodium-related) or through promotion of conversion probability in terms of a model of relaxing defects. In such model PPC value depends not only on the concentration of these metastable defects but also on the position of the Fermi level in the thermal equilibrium state [1]. The main difficulty in the analysis is here hard to estimate impact of grain boundaries which affects the transport in planar samples. Literature data indicate that sodium increases the mobility in thin films by almost one order of magnitude via passivation of grain boundaries [2] and the analysis should take this into account.

We make an attempt to calculate the metastable defect concentrations taking all this factors into account and also the results of calculations of Maciaszek and Zabierowski [3]. Main conclusion is that amount of sodium in the sample increases the absolute but decreases the relative value of PPC. The latter is a positive result from the point of view of photovoltaic device in which stable performance and as low as possible metastable behavior is an asset.

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