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The Effect of Cu-Zn Disorder on Charge Carrier Mobility and Lifetime in $Cu_2ZnSnSe_4$

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Abstract

Cu-Zn disorder is one possible origin for the limited efficiencies of kesterite solar cells and its impact on the band gap and band tails have been intensively studied. However, the effect on charge transport and recombination, which are key properties for solar cells, has not been investigated so far. Therefore, we probe the impact of the Cu-Zn order on charge carrier mobility and lifetime. To this end, we change the Cu-Zn order of a co-evaporated $Cu_2ZnSnSe_4$ thin film by sequential annealing and probe the impact by time-resolved terahertz spectroscopy. Aside from of the well-known band gap shift, we find no significant change in mobility and lifetime with Cu-Zn order. This finding indicates that Cu-Zn disorder is not limiting efficiencies of kesterite solar cells at their current status by means of charge carrier recombination and transport.

Keywords kesterite; disorder; mobility, lifetime; terahertz spectroscopy; solar cell

1 Introduction

$Cu_2ZnSn(Se_x,S_{x-1})_4$ semiconductors in kesterite structure are promising candidates for thin film solar cells due to their beneficial properties such as: a high absorption coefficient, the abundance of the constituting elements, the stable solar cell performance and the cheap ink based deposition techniques [1]. However, their record cell efficiency of 10.0 %, has not reached the level of competing thin film technologies such as 22.9 % for $Cu(In,Ga)(Se,S)_2$ or