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“Sintering of Non-Vacuum Deposited Cu-Zn-Sn-S Precursor Layers”

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Abstract

Within the last few years, the material $Cu_2ZnSn(S,Se)_4$ (CZTSSe, called kesterite according to its crystal structure) has gained attention as an absorber layer in thin film photovoltaics because it contains only readily available, low-toxic elements. In this work, the conversion (sintering) of Cu-Zn-Sn-S containing precursor layers to crystalline thin films is investigated. Most precursor layers are based on nanoparticles, which has the advantage of being a non-vacuum technique and enabling printing and high-throughput deposition.

Two types of precursors are employed: One is deposited by doctor blading a dispersion of quaternary CZTS nanoparticles, the other by spin coating a metal salt solution. The sintering under different atmospheres (S, Se, SnS) in an open reactor as well as under Se atmosphere in an approximately closed reactor is studied. Besides achieving sintered layers which are crystalline, homogeneous, phase pure and have the right composition, a particular challenge is to prevent the decomposition of CZTSSe.

In the open reactor, i.e. in non-equlibrium, S, Se and SnS losses are possible, which promote the decomposition of CZTS. This can only be reduced significantly under S or Se atmosphere. Sintering under SnS atmosphere fails partially due to the low vapour pressure of SnS, partially due to the reactor design. Furthermore, sintering under Se atmosphere leads to a complete substitution of S by Se atoms (selenisation). Sintering in the approximately closed reactor is nearer to an equilibrium situation: The overpressure of Se can be maintained, so that there are no metal losses and no decomposition. The closed reactor also proves beneficial for the film morphology; however, the selenisation is not complete. Processing absorber layers to solar cells results in rectifying behaviour; with the nanoparticle precursor an efficiency of 0.37% is reached. The enhancement of the photovoltaic parameters is feasible by improving the morphology and increasing the film thickness.