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Main manuscript

Surface modification through air annealing $\text{Cu}_2\text{ZnSn}(\text{S},\text{Se})_4$ absorbers

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Abstract

Recent studies demonstrate that air annealing can have a positive effect on the device performance of $\text{Cu}_2\text{ZnSn}(\text{S}_x\text{Se}_{1-x})_4$ [CZTSSe] solar cells. In this work air annealing of the selenium containing CZTSSe is compared to the pure sulfide CZTS. It is discovered that the selenium containing absorbers benefit from air annealing at higher temperatures than selenium free absorbers. The highest efficiency obtained utilizing the air annealing treatment on selenium containing absorbers is 9.7 %. We find that the band gap is narrowed when air annealing, which is partially explained by increased Cu-Zn disorder. Furthermore Zn enrichment of the surface after etching is identified as a possible cause of enhanced device performance. It is additionally observed that elemental selenium present on the CZTSSe surface is reduced in the air annealing treatment. Selenium removal is another possible explanation for the enhanced performance caused by the air annealing treatment.

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