Towards the Future of Kesterite Photovoltaics: Flexible Inkjet-Printed CZTSSe Solar Cells with >10% Efficiency

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Kesterite $Cu_2ZnSn(S,Se)_4$ (CZTSSe) is one of the most promising materials among the emerging inorganic thin-film photovoltaic technologies, thanks to its earth-abundant constituents, p-type semiconductor properties, a high absorption coefficient and a direct tunable bandgap. It can be easily deposited as a thin film, both on rigid and flexible substrates, through different chemical and physical processes. Solution-based methods have achieved the best results, with spin coating leading to the current record efficiencies. However, the small-area limitations and the waste of a non-negligible amount of precursor solution of the latter hinder its scalability. Inkjet printing is a promising, fully automated solution-based technique, appealing from an industrial point of view due to almost-zero materials waste and suitability with large areas and roll-to-roll processes. In this work, this methodology has been applied to fabricate flexible CZTSSe thin-film solar cells for the first time. A 2-methoxyethanol-based precursor solution has been optimized to allow inkjet printing of the CZTSSe thin-film absorber. The results show the first example of an inkjet-printed flexible CZTSSe solar cell with efficiency of 10.4%, surpassing its spin-coated counterpart, relying on a higher quality material. Inkjet printing stands out as a reliable path for a sustainable scale-up of flexible CZTSSe solar cells suitable for emerging integrated PV applications.