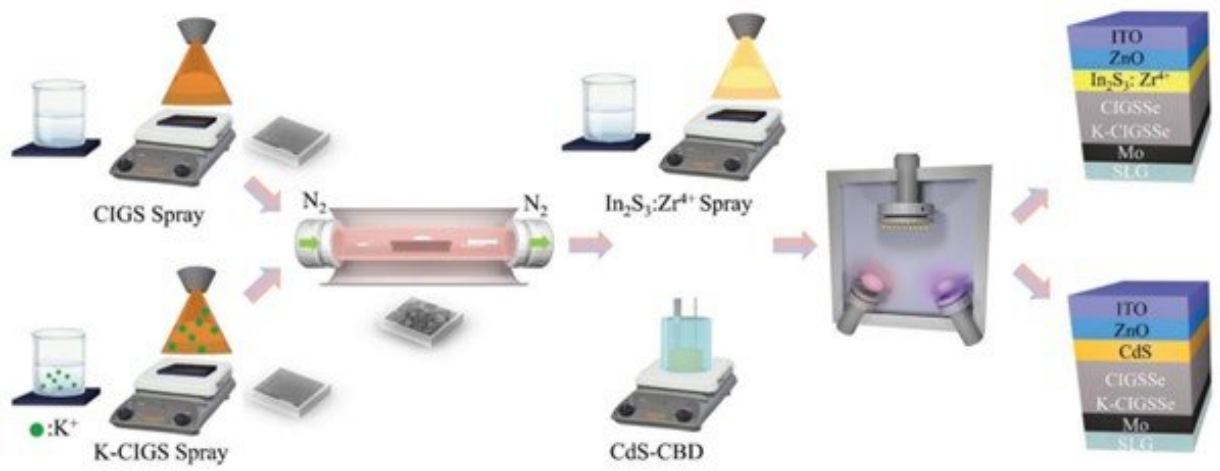
Economical eco-friendly fabrication of high efficiency chalcopyrite solar cells

December 8 2022



Incheon National University researchers report an eco-friendly, cost-effective, scalable fabrication technique for high-efficiency copper indium gallium sulfur diselenide solar cells, which uses aqueous spray deposition in air environment and avoids expensive vacuum conditions. Credit: JunHo Kim, Incheon National University

Clean, sustainable energy solutions are essential to meet the ever-increasing energy demands of the human population. High efficiency solar cells are promising candidates to reduce carbon emissions and achieve carbon neutrality. In this regard, solution-processed copper indium gallium sulfur diselenide solar cells (CIGSSe) solar cells have generated significant interest owing to their excellent photovoltaic

properties, such as high absorption of visible light, stability, and tunable bandgap.

However, large scale, practical applications are limited by a two-fold challenge. Firstly, solution-based CIGSSe fabrication yields very low power conversion efficiency and often uses solvents that are not environment-friendly. Secondly, to achieve higher power conversion efficiency, fabrication methods rely on expensive vacuum environment that leads to substantial material loss.

To this end, a team of researchers led by Professor JunHo Kim from Global Energy Research Center for Carbon Neutrality, Incheon National University, Korea have developed a low-cost and eco-friendly fabrication method of high efficiency CIGSSe solar cells.

In a study published in *Advanced Functional Materials*, the researchers used aqueous spray deposition in an air environment and developed a CIGSSe solar cell with power conversion efficiency (PCE) larger than 17 %.

"For spray solution, we used deionized water, which is eco-friendly and cheapest solvent till date," explains Prof. Kim. Moreover, conventional solution-based fabrication processes rely on environmentally hazardous, cadmium-based buffers for the optimization of thin-film solar cells. In this novel technique, the researchers used indium sulfide-based buffer that is a cadmium free, eco-friendly alternative.

The researchers further investigated the alloying effects of zirconium on indium sulfide buffers. Remarkably, the team found that zirconium alloying increases the electron concentration in the buffer. Moreover, this method "passivates" or reduces defect states in the CIGSSe absorber, optimizing the charge transfer between various interfaces, leading to enhanced PCE.

Furthermore, the researchers achieved even more defect passivation and higher PCE, of more than 17%, by alloying the CIGSSe absorber with potassium. The fabricated cell has an optimum bandgap for high efficiency applications such as a bottom cell or a tandem cell.

This novel technique is cost-effective and easily scalable as it does not require a vacuum environment. As Prof. Kim observes, "We carried out spray deposition in an air environment without using any high vacuum facility, which significantly reduces fabrication cost and thus makes the fabrication technique more practical and competitive in the industry sector."

This development simultaneously improves the performance and fabrication of CIGSSe solar cells. This will revolutionize the application of these cells in integrated photovoltaic devices and vehicle integrated photovoltaic devices, and as energy sources for internet of things devices.

More information: Md Salahuddin Mina et al, High Efficiency Aqueous Solution Sprayed CIGSSe Solar Cells: Effects of Zr^{4+}-Alloyed In_2S_3 Buffer and K-Alloyed CIGSSe Absorber, *Advanced Functional Materials* (2022). DOI: 10.1002/adfm.202206561

Provided by Incheon National University