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# Role of Na in Solution-Processed CuInSe<sub>2</sub> (CISE) Devices: A Different Story for Improving Efficiency

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## Abstract:

Na has been believed to improve the device parameters of open circuit voltage ( $V_{OC}$ ) and fill factor (FF) presumably by increasing the carrier concentration ( $N_A$ ) of vacuum-processed Cu(In,Ga)Se<sub>2</sub> films. In solution-processed CI(G)Se devices as well, Na reportedly increases  $V_{OC}$  and FF but this improvement is not correlated with the increase in  $N_A$ , suggesting a different physical mechanism associated with Na in solution-based routes. In this contribution, experimental results on the role of Na addition in solution-processed CISE films and devices were reported, in which Na addition had no influence on  $N_A$  nor film composition in spite of the notable increase in the device efficiency. On the contrary, Na was found to mitigate the interfacial recombination by reducing the undesirable surface defects. Along with this understanding, Na addition in our air-processable route resulted in a CISE device with 12.83 % efficiency, which is comparable to the current world record efficiency of solution-processed CISE devices.

## Graphical Abstract

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