NREL’s use of potassium fluoride process improves the open-circuit voltage and conversion efficiency.

Cu(In,Ga)Se\textsubscript{2} (CIGS) solar cells that are fabricated using two-step selenization processes often exhibit low open-circuit voltage ($V_{oc}$). National Renewable Energy Laboratory (NREL) scientists have found a way to improve $V_{oc}$ without using a more complex three-stage co-evaporation process.

Previously, NREL investigated the two-step selenization process using two different evaporated precursors—stacked metal precursors and Se-containing precursors. These experiments led to a 16.2%-efficient solar cell fabricated from the Cu/Ga/In stacked metal precursor. But the goal was to increase the efficiency and decrease the time needed for selenization. To accomplish efficiency gains, the $V_{oc}$ needed to be increased.

The two-step selenization process has a few limitations. First, Ga segregation toward the back of CIGS films degrades performance due to lower $V_{oc}$. This can be alleviated by adding a sulfurization step to widen the bandgap near the CIGS surface. Second, these films lack a precisely engineered surface. A desired Cu-depleted surface region can be created using a three-stage co-evaporation process. The challenge with the two-step selenization process is to produce a similar surface without adding a third stage of Ga and In.

NREL found that the $V_{oc}$ of solar cells made from a Cu/Ga/In stacked metal precursor can be increased by using a potassium fluoride (KF) post-deposition treatment. A two-step selenization process that included this KF post-deposition treatment led to an 18.6%-efficient CIGS device with a favorable $V_{oc}$ of 0.709 V.

In addition, efficiency and fill factor values were also improved. For devices made from the same CIGS absorbers, the KF treatment improved efficiencies by 1.5%–1.9%, which resulted from $V_{oc}$ values being boosted by 48–70 millivolts. In one case, fill factor was improved by 2.9%.

The KF post-deposition treatment even improved the $V_{oc}$ and efficiency of previously grown CIGS solar cells that were treated at a later time.

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