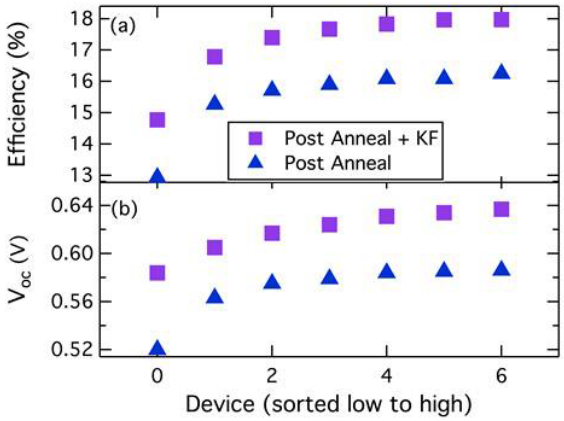
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Post-Deposition Treatment Boosts CIGS Solar Cell Performance

Highlights in Research & Development

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

$Cu(In,Ga)Se_2$ (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.



These two plots show the (a) efficiency and (b) open-circuit voltage of devices made from films with a KF post-deposition treatment (purple squares) and without (blue triangles).

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 post-deposition treatment led to an 18.6%-efficient CIGS device with a favorable V_{oc} of 0.709 volt.

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.

Technical Contact: Lorelle Mansfield, *lorelle.mansfield@nrel.gov*

Reference: Mansfield, L.M.; Noufi, R.; Muzzillo, C.P.; Dehart, C.; Powers, K.; To, B.; Pankow, J.W.; Reedy, R.C.; Ramanathan, K. (2014). "Enhanced Performance in $Cu(In,Ga)Se_2$ Solar Cells Fabricated by the Two-Step Selenizaton Process with a Potassium Fluoride Post-Deposition Treatment." *IEEE J. Photovoltaics*, forthcoming.

Key Research Results

Achievement

NREL applied a KF post-deposition treatment to solar cells made from a Cu/Ga/In stacked metal precursor.

Key Result

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.

Potential Impact

NREL's approach precludes the need to use a more complex three-stage co-evaporation process to improve CIGS solar cell performance.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

15013 Denver West Parkway
Golden, CO 80401
303-275-3000 | www.nrel.gov

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