CIGS-Based Solar Cells Prepared from Electrodeposited Precursor Films

Researchers develop electrodeposition process to deposit coatings on substrates, eliminate the expensive physical vapor deposition step, and improve device quality.

$CuIn_{1-x}Ga_xSe_2$ (CIGS) solar cells have great potential because of their large optical absorption coefficient, which results from a direct energy gap and allows use of thin layers (1–2 μm) of active material. CIGS solar cells are also known for their long-term stability. An effort is underway to develop low-cost technologies for fabricating CIGS thin films.

Scientists are currently investigating the CIGS absorbers using several techniques, including vacuum and non-vacuum technologies. Thin-film solar cell devices based on PVD CIGS have demonstrated an efficiency of 20.1%.[1] The PVD techniques are expensive and challenging to scale up because of film non-uniformity and low material utilization. Sputtering techniques are suitable for large-area deposition; however, they require expensive vacuum equipment and sputtering targets. A non-vacuum electrodeposition technique has the potential to prepare large-area uniform precursor films using low-cost source materials and low-cost capital equipment.

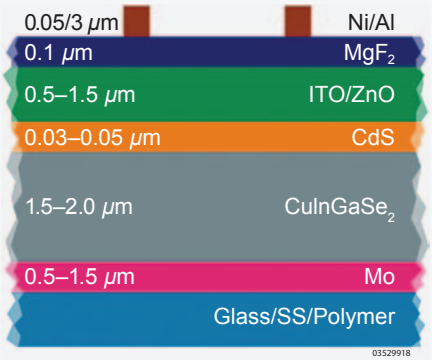
Previously, scientists at the National Renewable Energy Laboratory (NREL) reported 15.4%-efficient[2] Cu-In-Ga-Se-based photovoltaic devices from electrodeposited precursor films where final film composition was adjusted by physical vapor deposition method. At present, we are fabricating CIGS-based solar cells directly from electrodeposited precursor films, eliminating the expensive PVD step. Electrodeposited CIGS absorber layers are fabricated by a three-stage electrodeposition process where: (a) Cu-Ga-Se is electrodeposited in the first stage, (b) Cu is electrodeposited in the second stage, and (c) In-layer is deposited in the final, third stage.

This research was conducted with a Cooperative Research and Development Agreement (CRADA) between NREL and DASS TECH Co., Ltd. of South Korea.

Technical Contact: Raghu N. Bhattacharya, *raghu.bhattacharya@nrel.gov*

References: [1] Zentrum für Sonnenenergie-und Wasserstoff (ZSW) Produces a Thin-Film Solar Cell with 20.1% Efficiency, European Material Society Conference, Press Release (2010).

[2] R. N. Bhattacharya, W. Batchelor, J. F. Hiltner, and J. R. Sites, *Appl. Phys. Lett.*, **75**, 1431 (1999).



Key Research Results

Achievement

NREL electrodeposited thin films from an aqueous-based solution at room temperature in a two-electrode cell configuration where the counter electrode was platinum gauze and the working electrode was the substrate.

Key Result

NREL scientists achieved 10.4%-efficient CIGS-based solar cells fabricated directly from electrodeposited precursor films, eliminating the expensive physical vapor deposition (PVD) step.

Potential Impact

Electrodeposition could provide high-quality film with low capital investment; a low-cost, high-rate process; low-cost starting materials; a large-area, continuous, multi-component, low-temperature deposition method; controlled deposition rates and effective material use; and minimal waste generation (the solution can be recycled).

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

1617 Cole Boulevard | Golden, Colorado 80401-3305 | 303-275-3000 | www.nrel.gov

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.

NREL/FS-5900-51752 • June 2011