Development of Electrodeposited CIGS Solar Cells

Cooperative Research and Development Final Report

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In accordance with Requirements set forth in Article XI. Reports and Abstracts A.(3), of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Dasstech Co., Ltd.

CRADA Number: CRD-09-357

CRADA Title: Development of Electrodeposited CIGS Solar Cells

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
TOTAL	$00.00

Abstract of CRADA Work:

Solar cells are a very attractive source of clean energy. $CuIn_{1-x}Ga_xSe_2$ (CIGS) has the potential to become a major candidate in this field. Its large optical absorption coefficient, which results from a direct energy gap, permits the use of thin layers (1–2 µm) of active material. Currently, a great deal of effort is being expended to develop low-cost technologies for fabricating CIGS thin films. Physical vapor deposition (PVD) is an excellent tool for understanding film growth and for developing models, but it is challenging to scale up for commercial production. Sputtering techniques are suitable for large-area deposition, but they require expensive vacuum equipment and sputtering targets. Electroplating is a potentially suitable preparation method to obtain low-cost precursor films. The electrodeposition process could provide: (a) high-quality film with very low capital investment; (b) a low-cost, high-rate process; (c) use of very low-cost starting materials (e.g., low-purity salts, solvents), based on automatic purification of the deposited materials during plating; (d) a large-area, continuous, multi-component, low-temperature deposition method; (e) deposition of films on a variety of shapes and forms (wires, tapes, coils, and cylinders); (f) controlled deposition rates and effective material use (as high as 98%); and (g) minimum waste generation (i.e., solution can be recycled).

In this CRADA work we will investigate jointly electrodeposited CIGS-based materials. The precursor films will be processed at high temperature in Se atmosphere to obtain high efficiency photovoltaic devices. Photovoltaic devices will be completed by chemical-bath deposition of about 50 nm ZnS, followed by RF sputtering of 50 nm of intrinsic ZnO and 350 nm of Al_2O_3-doped conducting ZnO. Bilayer Ni/Al top contacts will be deposited in an e-beam system. The final step in the fabrication sequence is the deposition of an antireflection coating (100 nm of MgF_2).

Summary of Research Results:

Previously, we reported 15.4%-efficient copper indium gallium diselenide (CIGS)-based photovoltaic devices from electrodeposited precursor films in which the final film composition was adjusted using the physical vapor deposition (PVD) method. Under this CRADA, CIS and CIGS-based solar cells were fabricated directly from electrodeposited precursor films, eliminating the expensive PVD step.

Electrodeposited CIS and CIGS absorber layers were fabricated from stacked Cu/In and Cu/In/Ga layers, respectively. All films are electrodeposited from aqueous-based solutions at room temperature in a two-electrode cell configuration, with platinum gauze as the counter electrode and a glass substrate as the working electrode. The substrate is DC-sputtered with about 1 µm of Mo. The electrodeposited films are selenized at high temperature (~550ºC) to obtain 10.9%-efficient CIS device and 11.7%-efficient CIGS device.

This work was communicated in a peer-reviewed paper: "Electrodeposited CIS and CIGS-based Solar Cells," DOI: 10.1149/05040.0023ecst

Subject Inventions Listing:

ROI-12-00002: Title: "Preparation Method for **IBIIIBVIB** compound solar cell precursor via successive applications of one-bath and multi-bath electrodepositions"

Report Date:

July 22, 2016

Responsible Technical Contact at Alliance/NREL:

Nathan Neale for Raghu Bhattacharya (former NREL employee)

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