NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Development of ZnTe:Cu Contacts for CdTe Solar Cells

Cooperative Research and Development Final Report

CRADA Number: CRD-08-320

NREL Technical Contact: Ramesh Dhere

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Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI.A(3) of the CRADA document, 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.

CRADA number: CRD-08-320

CRADA Title: Development of ZnTe:Cu Contacts for CdTe Solar Cells

Parties to the Agreement: Solexant

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	**NREL** Shared Resources
Year 1	$ 100,000.00
Year 2	$ 00.00
Year 3	$ 00.00
TOTALS	$ 100,000.00

Abstract of CRADA work:

The main focus of the work at NREL was on the development of Cu-doped ZnTe contacts to CdTe solar cells in the substrate configuration. The work performed under the CRADA utilized the substrate device structure used at NREL previously. All fabrication was performed at NREL. We worked on the development of Cu-doped ZnTe as well as variety of other contacts such as Sb-doped ZnTe, Cu_xTe, and $MoSe_2$. We were able to optimize the contacts to improve device parameters. The improvement was obtained primarily through increasing the open-circuit voltage, to values as high as 760 mV, leading to device efficiencies of 7%.

Summary of Research Results:

Our initial work for this CRADA began by re-establishing the baseline for a Cu-free substrate CdTe device. A Mo thin film was deposited onto a glass substrate to act as the back contact. This type of back contact had been used at NREL in the past as well as elsewhere, as seen in the literature. Several types of glass substrates were investigated, including Corning 7059, 1737, and Eagle 2000 glasses, as well as soda-lime glass. Corning 7059 glass was found to enable superior adhesion, thus it was used for subsequent experiments. CdTe films were deposited primarily by close-spaced sublimation (CSS), enabling high temperature depositions. The ambient used for the CSS CdTe deposition initially

contained O_2, as this is common in fabrication of superstrate CdTe devices. Later, an O_2-free ambient revealed benefits, so the O_2 was removed in the following experiments. Devices utilizing evaporated CdTe deposited at lower temperatures were also examined briefly. Determining the CdS and $CdCl_2$ heat treatment parameters to use was also of importance. Chemical bath deposited (CBD) CdS was used initially, but adhesion was later found to be superior for sputtered CdS films, so sputtered films were used subsequently. Based on initial results, a single $CdCl_2$ treatment and a single CdS layer were used in device fabrication in latter parts of the study. Initial Cu-free substrate CdTe devices had efficiencies of about 5%, but their open-circuit voltage (V_{oc}) values were poor (~500 mV).

The primary focus of the CRADA was to implement a ZnTe:Cu back contact interface layer in the substrate CdTe device in the interest of improving the device performance. ZnTe:Cu layers of many thicknesses (10-500 nm) and Cu levels (0.3, 1, 2, 4, and 5 wt.% Cu in ZnTe) were investigated during this study. In addition, other investigations related to the formation of the back contact were performed. A H_2 anneal after the ZnTe:Cu deposition and before the CdTe deposition was investigated, but it was found to be detrimental. Etching the Mo film surface with an Ar ion beam was investigated as a means of removing any surface oxide that might be present, but this etch was also found to be detrimental. Use of a Ti thin film at the back of the device was investigated both as a substitution for the Mo film and in addition to it. The use of Ti was not found to offer any clear benefit, and caused adhesion issues in some cases. Other back contact interface layers were also investigated. A brief study of $MoSe_2$ in substrate CdTe devices indicated that this material did not offer significant promise due to the low short-circuit currents that resulted. ZnTe:Sb was used both alone and together in a bilayer with ZnTe:Cu, but it also showed no significant promise. The use of a Cu_xTe film did show some promise, so Cu_xTe was used in comparison to ZnTe:Cu in subsequent device studies.

The best-performing substrate CdTe device with a ZnTe:Cu back contact utilized 10 nm of ZnTe:Cu containing 0.3 wt.% Cu, a CdTe film deposited by CSS at 450°C, sputtered CdS, and a resultant V_{oc} of 751 mV and efficiency of 6.87%. The best device containing a Cu_xTe thin film (10 nm thick) had a V_{oc} of 760 mV and an efficiency of 5.36%.

Subject Inventions listing: n/a

Report Date: 1/4/12 Responsible Technical Contact at Alliance/NREL: Ramesh Dhere

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