NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Scale-Up of CdTe Photovoltaic Device Processes for Commercial Application

Cooperative Research and Development Final Report

CRADA Number: CRD-06-196

NREL Technical Contact: David Albin

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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-06-196

CRADA Title: Scale-up of CdTe Photovoltaic Device Processes for Commercial Application

Parties to the Agreement: PrimeStar Solar

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 20,000.00
Year 2	$ 00.00
Year 3	$ 00.00
TOTALS	$ 20,000.00

Abstract of CRADA work:

Through this Cooperative Research and Development Agreement, NREL and PrimeStar Solar will work together to scale up the NREL CdTe photovoltaic process from the laboratory to produce photovoltaic devices in a size that is commercially viable. The work in this phase will focus on the transference of NREL CdTe device fabrication techniques to PrimeStar Solar. NREL and PrimeStar Solar will engage in a series of technical exchange meetings and laboratory training sessions to transfer the knowledge of CdTe PV film growth from NREL to PrimeStar Solar. PrimeStar Solar will grow thin films on PrimeStar Solar equipment and interleave them with NREL-grown films in an effort to develop a commercial scale process on PrimeStar Solar equipment. Select NREL film growth equipment will be upgraded either by PrimeStar Solar or at PrimeStar Solar's expense to increase equipment reliability and throughput.

Summary of Research Results:

During year 1, this CRADA consisted largely of providing necessary measurement and characterization support to the company. This was done primarily through onsite meetings to discuss past work and mutual development of experiments and characterization needs involving the interleaving of samples between NREL and PrimeStar facilities. Interleaving was a process by which films deposited at NREL on glass substrates were subsequently taken to PrimeStar for further film layer depositions as well as vice versa, films deposited by PrimeStar were subsequently taken to NREL for further film layer depositions.

With such a process, differences associated with different equipment systems and the process conditions inherent to them were determined and better understood.

Year 2 saw the upgrading of an NREL system, including the purchase of computer automation equipment for our cadmium chloride system as well as sputter targets for cadmium and zinc stannate deposition. The automation equipment, as well as any unused targets, were returned to PrimeStar upon the termination of the CRADA. Discussions, experiments, and characterization efforts focused on numerous aspects of the CdTe processes developed at NREL. Some of the work related to cadmium and zinc stannate deposition and zinc-telluride back contact sputtering. Additional efforts were also expended toward better understanding and optimization of processes, some of which had been previously described in literature, such as the vapor $CdCl_2$ process and contact processing using graphite pastes. Year 2 also saw the start of research focused on ascertaining the reliability of CdTe devices made by PrimeStar, as well as the involvement of General Electric (GE) as a part-owner of PrimeStar Solar.

The latter years of the CRADA involved heavy collaboration with both PrimeStar Solar located in Colorado and GE's Global Research Center (GRC) located in Niskayuna, NY. An additional technical services agreement (TSA) was developed with the GRC to allow the NREL PI to visit the Niskayuna facility for approximately 3 weeks. The purpose of this work was to help establish a cell-fabrication line at the GRC to support the future development of the CdTe technology at PrimeStar Solar. Prior to these visits, numerous members of the technical staff had visited NREL to interact with NREL scientists involved in film characterization and growth. These scientists also helped plan and discuss research being performed as part of the CRADA involving PrimeStar and NREL. Strategically, it was the general consensus that PrimeStar required more characterization and growth support than what NREL could provide in a timely basis. The resulting cell-fabrication line was designed to support multiple shifts of operation in addition to considerably more "scientist and technician" support time.

By the time the Niskayuna facility was completed, GE had taken full ownership of PrimeStar Solar and was providing most of the necessary support for developing their CdTe technology. NREL has maintained several smaller TSAs to help them acquire further knowledge in areas where there was a need including admittance spectroscopy, cathodluminescence imaging, and time-resolved photoluminescence. In addition, a small TSA was established to finalize an understanding of cell transient behavior and its relationship to CdTe cell durability.

The involvement of NREL with PrimeStar Solar was viewed favorably in its ability to jump-start the CdTe technology with a significant U.S. industrial company. The prognosis for CdTe remains good.

Subject Inventions Listing:

1. U.S. Application No. 13/192,545 entitled, "Method for Making Photovoltaic Devices," filed July 28, 2011.

2. U.S. Provisional Application No. 61/705,546 entitled, "Varying CdTe Growth Temperature During Deposition to Increase Solar Cell Reliability," filed September 25, 2012.

Report Date: 10/29/2012 **Responsible Technical Contact at Alliance/NREL**: David Albin

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