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NATIONAL RENEWABLE ENERGY LABORATORY

Optimization of Solar Cell Design for Use with GreenVolts CPV System

Cooperative Research and Development Final Report

CRADA Number: CRD-08-00281

NREL Technical Contact: Scott Ward

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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: 08-00281

CRADA Title: Optimization of Solar Cell Design for Use with GreenVolts CPV System

Parties to the Agreement: GreenVolts

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	**NREL** Shared Resources
Year 1	$500,000.00
Year 2	$00.00
Year 3	$00.00
TOTALS	$500,000.00

Abstract of CRADA work:

GreenVolts, a Bay area start-up, was developing a CPV system that was based on a unique reflective optical design. They were interested in adapting the inverted GaInP/GaAs/GaInAs cell structure designed at NREL for use in their system. The purpose of this project was to optimize the inverted GaInP/GaAs/GaInAs cell for operation in the GreenVolts optical system.

Summary of Research Results:

Standard reporting conditions for indoor testing of concentrator solar cells are generally not representative of conditions afforded by real-world optical systems. Most indoor testing is done with a flash simulator. Solar cell efficiencies are routinely specified by manufacturers at 25° C under uniform illumination. An analysis of the GreenVolts optical system quickly determined that one of the primary challenges to maintaining high efficiency performance was the fact that the flux distribution was likely to be non-uniform. The mechanical nature of the system and the difficulty of obtaining parts within the required tolerances meant that achieving a uniform flux distribution would be very difficult if not impossible.

During the first year of the project, the focus was on developing tools and techniques for simulating non-uniform flux distributions in the laboratory. The goal was to have the means to simulate the unique

types of flux patterns generated by the GreenVolts optical system, and use this capability to engage in an optimization process for the inverted IMM device structure.

Two techniques were arrived at for generating non-uniform flux distributions. The first involved the deposition of patterned neutral density filters directly onto the surface of test cells. The neutral density filters were formed with thin layers of titanium deposited directly on top of the cell's dielectric anti-reflection coating.

The second technique involved the use of external filters suspended above the cell during testing in the flash simulator. It was found that the toner from common laser printers has a remarkably flat absorption spectrum in the range of interest and a gray scale map of the flux distribution can be generated on a high quality laser printer. Once characterized, a map of the flux distribution could be 'printed out' onto an acetate. Test jigs were fabricated that allow the flux map to be suspended over the cells under test while they are characterized.

The IMM device structure is complicated, comprised of many layers all of which can potentially be modified to some degree to optimize its performance under certain conditions. Having developed the tools to simulate non-uniform flux conditions in the laboratory, we decided to begin the optimization process by looking at the interplay between the grid design and the emitter layer of the top cell under these conditions.

Four different grid designs were tested. The standard parallel finger, double bus design that is quite commonly employed. The four quadrant design. A circular radial design. And a hexagonal design. All four designs had 10% shadowing losses and similar spacing. Modeling was performed using the standard 1-D grid design equations. Work on more advanced distributed resistance modeling of at lest two of these designs had begun.

The project was terminated when GreenVolts decided to scrap their optical system as unworkable. They have since moved to a more conventional freznel lens system with much greater flux uniformity. They have an uncertain economic future and are now focused on survival rather than next generation product. As such they are interested in trying to bring a product to market with off-the-shelf components.

The lessons learned from this activity are that it was a good idea to focus up front on developing the new capability to characterize non-uniform flux in the laboratory and then focus on the particulars of this one optical system. Having the capability to explore the effects of non-uniform flux distributions for CPV devices in the laboratory will prove to be useful for the community as a whole going forward.

Subject Inventions listing: None

Report Date: 2/3/11 Responsible Technical Contact at Alliance/NREL: Scott Ward

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