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Exploratory Reliability and Performance R&D

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Exploratory Reliability and Performance R&D

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ABSTRACT

This paper presents a brief overview of the status and accomplishments during fiscal year (FY) 2005 of the Photovoltaic (PV) Exploratory Reliability and Performance R&D Subtask, which is part of the PV Module Reliability R&D Project (a joint NREL-Sandia project).

1. Objectives

The objectives of this project, as stated in the FY 2005 Solar Program Annual Operating Plan (AOP), are to provide "…the accelerated indoor, accelerated outdoor, and a portion (outdoor testing at NREL) of the long-term outdoor testing elements of the project. Corresponding analyses, modeling, and characterization of performance and degradation rates, along with general reliability, are performed in collaboration with SNL [Sandia National Laboratories] and the industry partners."

2. Technical Approach

Long-term testing of PV modules on an ongoing basis, both indoors and outdoors, is the most important technical approach used for determination of reliability and performance. An important adjunct to long-term testing is indoor environmental stress testing, which is used to uncover susceptibility to known failure mechanisms.

2. Results and Accomplishments

3.1 Accelerated Indoor Stress Testing

Thermal cycling was performed on a prototype copper indium gallium diselenide (CIGS) thin-film roofing shingle product for Solar Roofing Systems (SRS). SRS is a small U.S. manufacturer engaged in product development, so this provided testing they otherwise might not have been able to obtain. Results of this testing were communicated directly to the manufacturer.

We initiated a cooperative testing program on SunPower's high-efficiency crystalline-Si modules, including light soaking, thermal cycling, and damp heat exposure indoors, and real-time outdoor exposure. At this time, the program is geared toward helping SunPower improve the fabrication of their solar cells. Results of this testing are communicated directly to the manufacturer.

Indoor stress testing of SBM Solar's prototype crystalline-Si modules that feature a polymer superstrate instead of glass was performed in FY 2005. The testing included damp heat, thermal cycling, UV exposure, humidity-freeze, and the standard module surface cut test. This test program is helping SBM Solar advance their module design toward full qualification and eventually production, and the results are communicated directly to the manufacturer.

In cooperation with the other two subprojects of the Module Reliability R&D NREL/SNL joint project, a major U.S. thin-film manufacturer was assisted with diagnosing a serious degradation problem that developed suddenly in this manufacturer's product line. The cause of the degradation was determined, and recommendations were provided for elimination of the problem.

3.2 Thin-Film Module Hot & Humid Support

This task directly supports the Thin-Film PV Partnership through ongoing efforts. All data and reports received from the two hot & humid exposure subcontractors (Florida Solar Energy Center and Texas A&M University) are archived, and data are analyzed for indications of performance changes in the exposed modules. This project is also responsible for advising the subcontractors concerning the details of their experimental setups. Site visits by task personnel provided data acquisition system calibrations and advice on improvements to their array exposure designs.

A journal article was written that documents the implications of using fixed resistive loads for long-term PV module exposure testing.[1] This study showed that iden-tical degradation rates can be observed with resistive loads compared with maximum-power tracking loads, provided the resistance values are chosen correctly, and helped fulfill an FY 2005 milestone.

3.3 High Voltage Stress Testing

A novel high voltage array experiment commenced operation in the High Voltage Stress Testbed (HVST) of the Outdoor Test Facility (OTF).[2] The array consists of both positive and negative strings of Shell Solar Inc. CIGS ST-40 modules, featuring a maximum voltage for each string of ±300 volts DC. Such high-voltage applications are envisioned as necessary for future scale-up for utility-scale electric power generation.

3.4 Long-Term Si Cell Degradation

The controlled light soaking experiment designed to determine the cause of the slow degradation of short-circuit current previously observed in crystalline-Si modules that was initiated in FY 2003 continues. At

the time of this writing, a total UV dose of about 3,600 MJ/m^2 has been accumulated, and the goal of this testing is to accumulate at least 5,000 MJ/m^2 (about 18 years equivalent exposure). Preliminary results were presented at the 31st IEEE PV Specialists Conference in January 2005.[3]

3.5 Ref. Meteorological and Irradiance System (RMIS)

Work continued during FY 2005 toward development of an in-situ calibration procedure for pyranometers at latitude tilt. This calibration procedure, which will utilize a new tilted diffuse radiation measurement installed in the RMIS, will allow pyranometers used with the grid-tied PV systems in the OTF array field to be calibrated in place.

3.6 Outdoor Accelerated Solar Weathering

A solar weathering experiment that includes crystalline-Si, CdTe, and Cu-In-Ga-S-Se modules installed in the Outdoor Accelerated-weathering Test System continued during FY 2005 (Fig. 1). In December 2004 the last four old mirrors in this two-axis concentrator system were replaced.

3.7 Performance and Energy Ratings Testbed (PERT)

All available historical data generated by the PERT dating back to 1994 have been transferred from magneto-optical discs to the Engineering & Technology Validation Team file server. It is anticipated that the new central location of these data will allow determination of individual module degradation rates in FY 2006,and that these results can be published in the open literature.

An internal National Center for Photovoltaics module test report on CIGS module stability was generated and communicated to the module manufacturers. Analysis of 7.5 and 2.5 years of real-time outdoor performance data formed the basis of this report, which concluded that performance degradation rates on two CIGS modules are less than 2% per year.[4]

4. Conclusions

Long-term module testing has been performed at the OTF for more than 15 years, and during FY 2005 this testing has continued and has been expanded and enhanced. All milestones that were identified in the AOP have been achieved.

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Fig. 1. The Outdoor Accelerated-weathering Test System at the NREL Outdoor Test Facility.

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