High-Throughput Manufacturing of Thin-Film CdTe Photovoltaic Modules

Solar Cells, Inc. (SCI) is participating in Phase 2B of PVMaT.

PVMaT is a 5-year, cost-shared partnership between the U.S. Department of Energy and the U.S. PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.

PVMaT Fact Sheet

Photovoltaic Manufacturing Technology

Solar Cells, Inc.

Goals

The goals of Solar Cells, Inc. (SCI) under the PVMaT Phase 2B Project are to (1) advance its PV manufacturing technologies, (2) reduce module production costs, (3) increase module performance, and (4) provide the groundwork for SCI to expand its commercial production capacities. SCI plans to meet these objectives by designing, debugging, and operating a 20-megawatt-per-year, automated, continuous PV manufacturing line that produces thin-film cadmium telluride (CdTe) PV modules that are 60 cm x 120 cm.

Technology

The SCI production-size CdTe module is fabricated on a 60-cm x 120-cm soda-lime glass superstrate that is 5-cm-thick. Typically, it comprises 116 cells connected in series, with each cell having the dimensions of 1 cm x 60 cm. This results in a high-voltage module (65 volts maximum power), intended for use in relatively large power fields having few constraints on the voltage and current of individual modules.

Cadmium sulfide (CdS) and cadmium telluride (CdTe) films are deposited on soda-lime glass at a thickness of 0.3 micrometer for the CdS and 3 micrometers for the CdTe, using close-spaced sublimation. The deposition rate of 5 micrometers per minute means lower cost because of the greater throughput of this process. Close-spaced sublimation also provides excellent electronic material properties and excellent film adhesion. The Ni/Al back electrode is deposited by sputtering.

Three laser scribes pattern the films. Thin metal ribbons are attached to the bus bars and brought out through a hole in the cover glass. The module is then encapsulated by laminating the superstrate to the cover glass using ethylene vinyl acetate. Finally, ribbons are terminated in a connector, which is molded directly to the cover glass.

Glass-washing step in SCI's module manufacturing line.

Results

The main activities during the initial activities of Phase 2B were designing, developing, and doing the initial debugging of a high-throughput deposition system. When complete, this system will be the heart of a new 10-megawatt facility. Because of improvements in raw material supply, glass conveyance, pressure control, and temperature control, the new system has 100 times the capacity of SCI's pilot system. Besides substantial increases in capacity, the system's main process benefit is that it provides steady-state conditions throughout the deposition zones by continuously conveying the substrate at close proximity. The pilot system operates in a batch mode, with the capability of running 40 substrates every other day. The high-throughput deposition system is designed to run at one substrate per minute for 5 days, three shifts each day, before requiring maintenance or component cleaning.

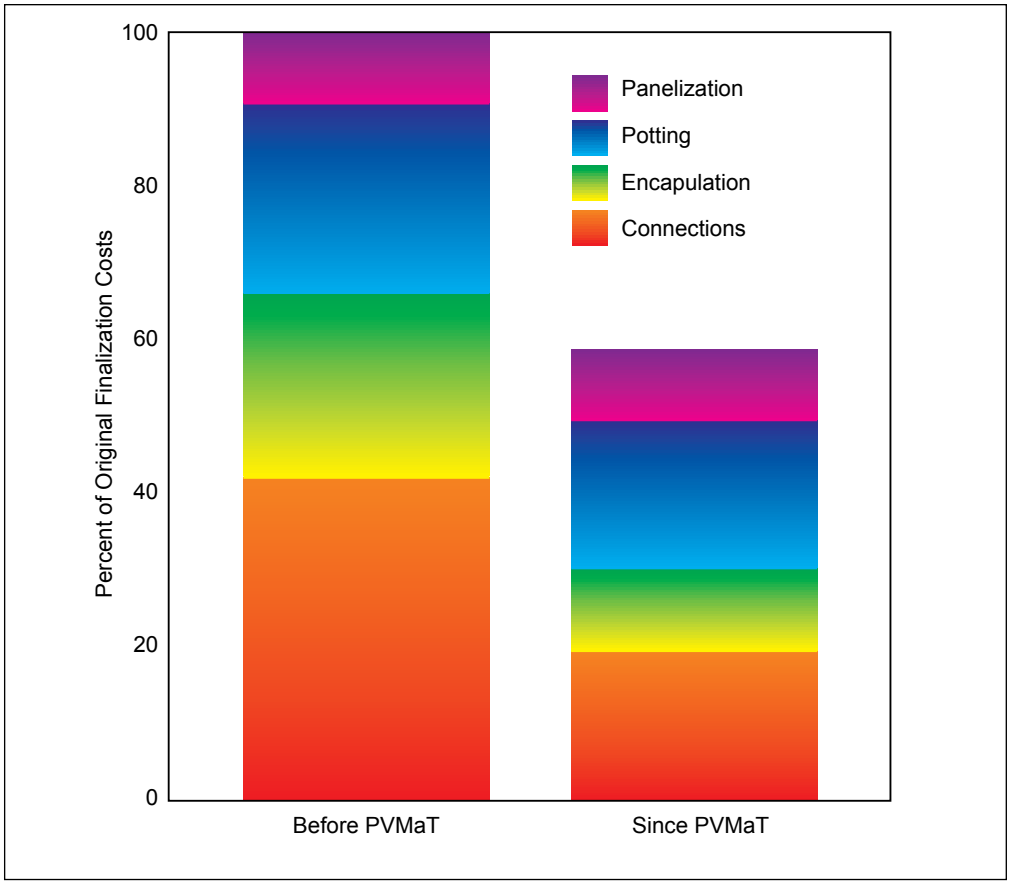
SCI has stepped up its pilot production to an annual rate of more than 100 kilowatts. These modules are being used for internal interim qualification testing (IQT), product demonstrations, and other performance experiments. As part of this effort, quality-control process charting has been incorporated to reduce process variation. Efforts supported by the PVMaT Project have resulted in average module efficiencies increasing by more than 15% (from 6.3% to 7.4%).

Another major effort under the PVMaT subcontract is to define and test the final product. SCI has used the IQT protocol to test more than 50 modules, concentrating on the humidity-freeze test, which has verified the encapsulation method, and on a new potting concept that eliminates costly junction boxes and reduces panelization costs. SCI researchers are investigating alternative encapsulation methods, to eliminate the cover glass from the product design.

Advances made as part of the PVMaT activities allowed SCI to successfully install more than 50 kilowatts of CdTe modules at an average efficiency of approximately 7% in the summer of 1995.

Company Profile

Solar Cells, Inc., was founded in 1987, with a twin commitment: first, to develop and operate a continuous, automated manufacturing system capable of producing PV modules at a competitive cost for use by electric utilities; and secondly, to install solar-electric generating fields for grid connection, as well as stand-alone installations.



PVMaT activites have accounted for over 40% reduction in panel finalization costs.

References

Nolan, J.F. (1993). "Development of 60-cm x 120-cm Thin-Film PV Modules," *Conference Record of the Twenty-Third IEEE Photovoltaic Specialists Conference - 1993, 10-14 May 1993, Louisville, Kentucky;* pp. 34–41.

Meyers, P.V.; Zhou, T.; Powell, R.C.; and Reiter, N. (1993). "Elemental Vapor-Deposited Polycrystalline CdTe Thin-Film Photovoltaic Modules," *Conference Record of the Twenty-Third IEEE Photovoltaic Specialists Conference - 1993, 10-14 May 1993, Louisville, Kentucky;* p. 400.

Foote et al., (1993). *Process for Making Photovoltaic Devices and Resultant Product,* United States Patent Number 5,248,349, September 28, 1993.

Sandwisch, D.W. (1994). "Development of CdTe Module Manufacturing," 1994 IEEE First World Conference on Photovoltaic Energy Conversion: *Conference Record of the Twenty-Fourth IEEE Photovoltaic Specialists Conference, 5-9 December 1994, Waikoloa, Hawaii;* pp. 836–839.

Sandwisch, D.W. (November 1995). *High Throughput Manufacturing of Thin-Film CdTe Photovoltaic Modules; Annual Subcontract Report, 16 November 1993-15 November 1994.* NREL/TP-411-20278.

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