PVMaT Fact Sheet

Photovoltaic Manufacturing Technology

Amorphous Silicon PV Manufacturing

Advanced Photovoltaic Systems participated in Phase 2A of PVMaT as a lower-tier subcontractor to Utility Power Group.

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

Advanced Photovoltaics Systems

Goals

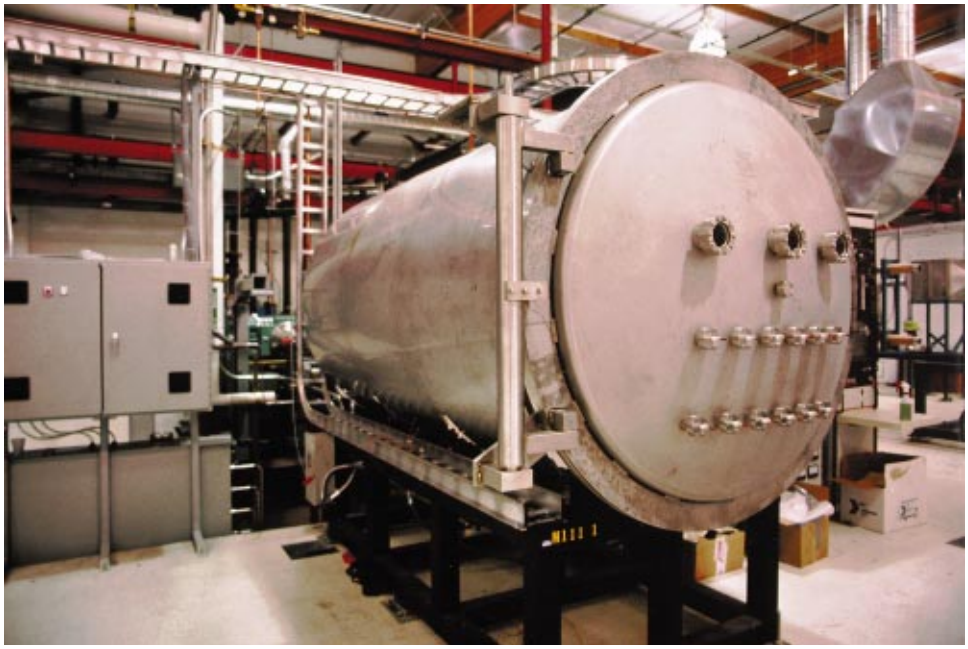
The goal of Advanced Photovoltaic Systems (APS) under the PVMaT Phase 2A Project has been to greatly improve its PV manufacturing technology, primarily by improving process control, increasing automation of the manufacturing line, and improving the quality of its product.

Technology

APS produces large-area amorphous silicon (a-Si) PV modules, made in a 12-megawatt manufacturing facility in Fairfield, California. The process consists of depositing three very thin layers of material on inexpensive soda-lime glass. The first layer is tin oxide; APS currently purchases glass with this layer already deposited. The second layer consists of several compositions of a-Si deposited by glow discharge at low pressures. The final layer—the back contact—is made of very thin zinc oxide and a somewhat thicker layer of aluminum, both applied by sputtering. Each layer is about 3000 angstroms thick.

These thin films are protected from the environment by encapsulating the glass with a second piece of glass, using ethylene vinyl acetate (EVA) as the bonding agent. This process includes attaching wires and brackets and processing the PV plate perimeter to prevent moisture from reaching the thin film.

The stabilized power output of the 0.76-m x 1.52-m modules is typically between 50 and 60 watts (W). Because a-Si efficiencies fall off during the first few months of exposure to light, the output of the modules must be derated from their initial production rating to account for this light-induced degradation. Typical initial wattages are in the range of 70 to 85 W. This manufacturing process, done in a 6500-m^2 facility with mostly automated equipment, reduces production costs and provides better process control than is possible with manual operation.



APS's deposition chamber for making 48 modules, each having a 13-ft^2 area.

Results

In the first year of Phase 2, the Utility Power Group/APS team completed module qualification tests for candidate encapsulation materials, reduced module termination and encapsulation manufacturing costs by 50%, introduced three new module products, automated 60% of the production encapsulation line, and completed a design for full-scale enhanced modules.

A major part of this work was automating the equipment installed in the new factory. Automation and process improvements allow APS to predict total manufacturing costs to be near $1 per peak watt in 4 years.

Two improvements in the encapsulation process reduced manufacturing costs and made possible the planned throughput. At the beginning of this contract, one step required at least 3 days to complete. In this step, the wire connection from the PV films to an outside connector is protected from the environment with a silicone sealant—a step that requires storing 2000 modules for curing, which is a very difficult requirement. During this contract, a newly developed procedure reduced this time to less than 3 hours.

In a second step, APS significantly increased its manufacturing capacity in curing the EVA that binds the two pieces of glass. Because this curing is done in line, throughput is improved. By curing the EVA in two stages, the in-line cure time was reduced from 11 minutes to 4 minutes, which reduced planned equipment. Associated process steps were then combined, greatly simplifying the overall encapsulation process.

APS significantly improved the uniformity of the silicon deposition over the module area of more than 1.2 m^2. When the program began, silicon thickness varied by more than a factor of three between the thinnest and thickest regions. Through successive improvements, this variation was reduced to less than ±10%. A major improvement was a redesigned discharge system—specifically, the container that holds the glass during the silicon deposition. Processing conditions were also changed. Improved uniformity made other changes possible, helping to increase the modules' power output by 10% to 15%.

Company Profile

Advanced Photovoltaic Systems, Inc., with its headquarters and engineering offices in Princeton, New Jersey, was established in December 1990. As a leading manufacturer of low-cost, thin-film PV modules and systems, it serves utility, architectural, and remote power applications around the world. APS's newest facility is its manufacturing plant in Fairfield, California, which has an annual production capacity of 12 megawatts.

Aerial view of APS PVUSA field.

References

Duran, G.; Mackamul, K.; Metcalf, D.; Koniares, A.; Skinner, D.; and Volltrauer, H. (February 1994). *Amorphous Silicon Photovoltaic Manufacturing Technology - Phase 2A: Annual Subcontract Report, 1 May 1992 - 30 April 1993;* NREL/TP-411-6263; 66 pp.

Volltrauer, H. (1994). "APS Module Stability and Reliability," NREL Photovoltaic Performance and Reliability Workshop, September 21–23, 1994; Lakewood, Colorado.

PVMaT Photovoltaic Manufacturing Technology

For More Information

Ed Witt, NREL 303-384-6402

Richard King, DOE 202-586-1693

Doug Ruby, SNL 505-844-0317

Clay Aldrich, SEIA 202-383-2628

Ralph Romero,
APS 609-275-5000

Printed with a renewable source ink on paper containing at least 50 percent wastepaper, including 20 percent postconsumer waste

Color printing costs were paid for by several U.S. PV companies.

SP21587
DOE/GO-10096-298
DE96013080