PVMaT Fact Sheet

Photovoltaic Manufacturing Technology

Silicon-Film™ PV Manufacturing Technology

AstroPower, Inc., participated in both Phase 1 and Phase 2A 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.

AstroPower, Inc.

Goals

The goal of AstroPower's PVMaT Phase 2A project has been to develop a new generation of module products based on large-area polycrystalline silicon solar cells. The starting material for these solar cells is a continuous sheet of polycrystalline silicon on a low-cost supporting substrate fabricated with the Silicon-Film™ process.

Technology

Producing continuous sheets of thin-film silicon on a low-cost substrate eliminates ingot sawing, which significantly reduces costs. The elapsed time from feedstock to wafer is only minutes, whereas ingot technology, including sawing time, may take 20 hours. AstroPower's focus in development has been to (1) limit the consumption of costly, high-quality silicon, (2) eliminate wafer sawing steps, (3) develop a high-yield, continuous manufacturing technology, and (4) increase solar-cell size.

This project has relied on the parallel development of two technologies: (1) a growth technique that produces high-quality, polycrystalline silicon sheets at high areal generation rates, and (2) a solar-cell fabrication technique that captures the material's potential while keeping manufacturing costs low. Grain size, growth habit, and crystal quality (diffusion length) of the silicon sheet are controlled by specific parameters of the growth process, such as areal generation rate. In developing a technology for low-cost solar-cell fabrication, AstroPower started with a baseline process that was upgraded continually by developing and integrating proven advanced processes. The advanced processes that improved solar-cell performance and allowed cells to be manufactured at a reasonable cost became part of the baseline process.

Results

The first product from this work was a 240-cm^2 solar cell known as the AP-225, which has achieved an efficiency of 12.2%. Smaller-area, lab-scale Silicon-Film™ solar cells have achieved an efficiency of 15%. A 17.1-kilowatt array, constructed for Photovoltaics for Utility-Scale Applications (PVUSA), used the AP-225 solar cell and was installed in November 1994.

A second, larger cell—the AP-675 solar cell—has an area of 700 cm^2 and an efficiency of 11.6%. Two new module products accompanied the new solar-cell products.

AP-225 developments in manufacturing and product performance between 1992 and 1994 reduced the Silicon-Film™ wafer cost by 53% and reduced the module fabrication costs by 42%. These developments included the transition to a continuous production mode, improved feedstock handling and throughput, an increased areal

Silicon-Film™ sheet growth.

generation rate, and automation of processing equipment.

During this activity, the Silicon-Film™ process progressed from an initial batch-mode version to the final continuous-mode process with a corresponding 1650% increase in areal generation rate. Development occurred in a stairstep manner: advances in areal generation rate were followed by advances in material quality, leading to increases in production capacity. In parallel, cost-reduction features and manufacturing attributes were continually being developed. Sheet production capacity for a single machine reached 7.3 megawatts per year by the end of the program.

The National Renewable Energy Laboratory (NREL) verified the performance of the Silicon-Film™ AP-225 cell at 2.93 watts, with a conversion efficiency of 12.2%. NREL also verified the performance of a 0.9-m^2 module assembled from 36 of these AP-225 cells at 93 watts.

To assess the larger-area potential of the Silicon-Film™ process, adjustments were made in the solar-cell fabrication process to accept small lots of 15.5-cm x 45-cm wafers. These solar cells have 2.8 times the area of the standard AP-225 solar cell and generated 2.7 times more power, achieving an NREL-measured efficiency of 11.6%.

During the PVMaT Project, an array of AP-225 solar cells was constructed for PVUSA. The array, installed in November 1994 at the site in Davis, California, consisted of 312 modules. Installation and safety testing were completed in only 7 days.

Company Profile

AstroPower, Inc., designs, develops, manufactures, and markets PV cells, modules, and systems that convert sunlight into electricity for power generation purposes and advanced technology applications. AstroPower is principally engaged in the solar power business through the development and manufacture of a novel thin-film polycrystalline PV solar cell. The Silicon-Film™ PV solar cell was designed and developed by AstroPower to offer a significant cost advantage compared with other silicon solar cells while retaining high performance and stability.

AstroPower PVUSA installation.

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