Cast Polycrystalline Silicon Manufacturing

Solarex (Crystalline Silicon) has participated 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

Solarex

Goals

The goals of Solarex under the PVMaT Project Phase 2B are to (1) advance its polycrystalline silicon PV manufacturing technologies, (2) reduce PV module production costs, (3) increase average module performance, and (4) expand commercial module production capacity. Two specific objectives of this program are to reduce the manufacturing cost for polycrystalline silicon PV modules to one half of the pre-PVMaT cost and to increase manufacturing capacity by a factor of 3.

Technology

The present Solarex crystalline silicon technology is based on cast polycrystalline silicon wafers. Solarex developed and patented a directional solidification casting process specifically designed for PV. In this process, silicon feedstock is melted in a ceramic crucible and solidified into a large-grained semicrystalline silicon ingot, which is then cut into wafers using internal diameter (ID) saws. The wafers are processed into solar cells using a thick-film paste metallization process sequence. A commercially available screen-printed silver paste is applied as the current-carrying grid on the front of the solar cell. The high-temperature process steps—including diffusion, firing of the front print paste, and chemical vapor deposition of the antireflective coating—are all performed in belt furnaces with automatic loading and unloading. Modules are assembled using an automated system, upgraded as part of the PVMaT Project. The automated assembly system tabs cells, lays them up and solders them together into a 36- or 72-cell matrix, which is then laminated into a package with low-iron, tempered-glass superstrate, ethylene vinyl acetate (EVA) encapsulant, and a Tedlar

Solarex standard cast ingot versus larger size PVMaT-developed ingot.

back sheet, developed and qualified under the PVMaT Project. The modules are then finished with frames and junction boxes as required by the customer.

Results

During the first year and a half of the Phase 2B subcontract, Solarex has accomplished the following:

- Developed a process to cast larger ingots in the same casting stations. This increases production capacity by 100%, while reducing the labor content of the product.
- Demonstrated (in the laboratory) wire-saw cutting of large wafers on 400-micrometer centers, yielding a 50% increase in solar cell and module output from the same silicon feedstock.
- Operated the wire saw, producing wafers on 500-micrometer centers, with higher yields and lower cost than the ID saws.
- Verified a 5% gain in cell efficiency by using a cost-effective aluminum paste back-surface field.
- Identified a cost-effective integrated cell process sequence that could increase the production-line cell efficiency to 15%. Achieved 14.5% cell efficiency in a laboratory trial of the integrated sequence.
- Increased the degree of automation and the capacity in the module assembly area. With the help of the Automation and Robotics Research Institute (ARRI) at the University of Texas at Arlington, Solarex upgraded its module assembly area to double the throughput capacity without adding additional labor. Solarex and ARRI developed a plan to further increase the assembly capacity over the next 2 years.
- Selected, developed, demonstrated, and qualified a frameless module mounting system using 3M VHB tape as the adhesive. Solarex built several large PV systems using this frameless mounting system.
- Selected, developed, and qualified a module electrical termination system that costs less than $1 per module.
- Qualified two lower-cost back-sheet materials. Transferred Tedlar back sheet into production to save 50% of the back-sheet cost. Identified a new material that could further reduce back-sheet cost by an order of magnitude.
- ARRI completed a study of the fracture properties of cast polycrystalline silicon wafers, providing information necessary to design handling equipment for large, thin wafers and cells.

Company Profile

Solarex was founded in 1973 as one of the first commercial companies specializing in terrestrial PV. Solarex was purchased by Amoco Corporation in 1983 and, in 1995, Solarex became part of Amoco/Enron Solar. With the support of Amoco/Enron, Solarex has remained an active participant in polycrystalline silicon, amorphous silicon, and copper indium diselenide PV technologies. Solarex is involved in all commercial aspects of PV, including manufacture, sales, market development, application development, systems development, reliability testing, process and equipment development (particularly automation), and research and development of new processes, materials, and products.

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