Photovoltaic Manufacturing Technology

PVMaT Fact Sheet

Texas Instruments

Spheral Solar™ PV Manufacturing

Texas Instruments 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.

Goals

The goals of Texas Instruments (TI) under the PVMaTPhase 2B Project are to (1) optimize existing processes, and (2) investigate alternative approaches for reducing material waste, material-handling (labor) costs, and cycle times of its Spheral Solar™ technology. Research and development (R&D) focus on developing manufacturing technologies that have the greatest impact on efficiency. R&D also focuses on those processes that represent the greatest risk in scaling to full product commercialization. TI places strong emphasis on optimizing yields and product performance of its PV product as it moves into full-scale production.

Technology

In 1983, TI embarked on an innovative and unique approach to producing solar cells—an approach now termed Spheral Solar™ technology. This technology used inexpensive methods of crystal growth and materials processing to create low-cost, lightweight, and flexible PV cells.

The Spheral Solar™ technology begins with an inexpensive silicon feedstock (as low-cost as metallurgical grade), which is formed into spheres through a series of furnace melts and either mechanical grinds or acid etches. Each sphere at this stage is a p-type crystal. The spheres are then processed through a standard industry diffusion method to add an n+ layer. Once completed, each sphere becomes an independently operating PV cell.

Texas Instrument's Spheral Solar™ PV technology production line.

Parallelling the manufacture of the spheres, a sheet of aluminum foil is processed to create a strip of three 100-cm^2 squares with about 18,000 perforated squares in each. The spheres are then flooded onto the surface of the foil and pulled into place with a vacuum. They are then metallurgically bonded to the foil by a thermo-mechanical process. At this point, the aluminum foil contacts the n+ layer of the sphere. The sphere backside is etched, exposing the p core, and the front side is thinned to enhance the current. A polyimide insulator is applied to prevent an aluminum-to-aluminum short later in the processing. Then a mechanical process is used to remove the insulator material from the tips of the spheres. A process called selective electro-dissolution (SED) eliminates shunted or shorted spheres from the matrix. The SED process basically anodizes the bad spheres to remove them from the circuit. The foil then has a layer of antireflective coating applied to the front using a standard industry process called backbond to connect the p material in a circuit. A second foil is then bonded to the backside of the spheres contacting to the p-core, completing the circuit. The result is a flexible solar cell, easily connected in series or parallel to configure it into a variety of industry-standard or flexible module packages.

Results

In the first year of the PVMaT Project, TI made dramatic progress toward achieving the goals of cost reduction and capacity growth for the Spheral Solar™ technology, through improving the process and simplifying the pilot production line.

The cost goal of TI's development effort is to demonstrate a process that produces PV modules with a manufacturing cost of $2 per watt, with potential to achieve less than $1 per watt cost with moderate additional improvements. Work focuses on the two key areas of efficiency and yield.

Sphere yield was initially optimized by material segregation and process differentiation based on sphere size. This required using multiple foil sizes with increased cost and logistic complexity. A new TI proprietary method now builds spheres from piles of silicon, creating a much tighter size distribution and, thus, greatly increasing yield while reducing cost and improving logistics. This, in addition to evaluating different feedstocks—including off-spec semiconductor-grade material—is expected to about double the yields throughout the sphere processes. Cell yields are being improved through the optimization of bonding pressures, temperatures, and foil configuration parameters.

TI has demonstrated cell yields as high as 90% on the pilot production line. Efficiencies have dramatically improved. Development efforts toward efficiency increases from 8.5% to well over 10% are showing promising results, and researchers expect to achieve efficiencies of greater than 11% before the end of 1994. To take advantage of Spheral Solar™ technology's physical makeup, researchers are evaluating several alternative module packages that may reduce cost, add flexibility, and boost efficiency.

Finally, TI has developed and installed equipment capable of multi-megawatt production rates for the highest-risk processes. Further, TI has identified a new proprietary furnace design that more effectively handles the initial melt operation while increasing throughput and reducing capital costs.

Company Profile

Texas Instruments Incorporated (TI), headquartered in Dallas, Texas, is a high-technology company with sales or manufacturing operations in more than 30 countries. TI products and services include semiconductors, defense electronic systems, software productivity tools, computers and peripheral products, custom engineering and manufacturing services, electrical controls, metallurgical materials, and consumer electronics products.

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