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Event Report

Solar Power 2006, San José, CA

Abstract

The Solar Power 2006 conference in San José was the largest solar conference event in United States history. This meeting marks a new awakening of the United States to Solar Power, since the peak in interest in it during the 1970s. This editorial reviews the highlights of the meeting, with an emphasis on the companies that participated, and the areas where further research is crucially needed. Primarily, the meeting was focused on a review of the industries currently involved in solar conversion-related manufacturing and development, and the factors that limit market introduction of products. Some of the key outcomes of the meeting include the realization that large-scale concentrating solar thermal installations, rather than photovoltaic (PV) systems, will likely dominate utility-scale energy production (i.e. system outputs of over 100 MWe). It was noted that there has been a steady cost reduction in silicon PV modules, and the goal of a PV module cost near US$1.44/W (in 2002 dollars) is expected around 2013, at which time there will have been a cumulative module production of over 10,000 MW. However, the current shortage of silicon feedstock (polysilicon) will drive PV research directions for many years to come. Many venture-capital funded start-up companies have arisen to develop commercial approaches to thin film solar cells and modules that use less silicon.

1. Introduction

Inventors, investors, policymakers, energy users and manufacturers, were all drawn to the heart of Silicon Valley in San José in October for an unprecedented event which demonstrated that solar energy technologies are ready to take their place as viable and profitable businesses. There were over 6500 registered participants to Solar Power 2006, hosted by the Solar Electric Power Association and the Solar Energy Industries Association, making it the largest solar event in the history of the United States [1]. There were more than 165 exhibitors, in the concurrent exhibition, and over 100 speakers. Keynote speakers included well known names in the field of Solar Energy Materials Science such as Richard Swanson of SunPower and Martin Green of the University of New South Wales. California Governor Arnold Schwarzenegger [2] even addressed the crowd. This editorial will review the highlights of the meeting, with an emphasis on the companies that participated, and the areas where further research is crucially needed (Figs. 1 and 2).

2. Investor focus

The conference took place from October 16 to 19, 2006 and began with pre-conference workshops given by companies such as Sharp, Fronius, Conergy, and others. A welcome from Julia Judd, Executive Director, Solar Electric Power Association, and Rhone Resch, President, Solar Energy Industries Association, kicked off the formal sessions. Vinod Khosla, President of Khosla Ventures, gave the first keynote address and set the tone for the conference by highlighting the keen interest funding companies and institutions currently have in solar energy. Major solar companies such as Q-Cells, Ersol, SunPower, REC and SunTech Power have caught the attention of a number of investors. Other sessions during the week included Solar Energy Education Initiatives, Investing Opportunities in Solar, PV Markets, Costs and Trends, and Public Company Valuation, with Panelists from Piper Jaffray, Deutsche Bank AG, and Sustainable Energy Associates/New Energy Fund. Most of the talks given during the conference were not very technical in nature, but rather gave an overview of a variety of different topics so that attendees could learn the key issues facing the industries involved in the field of solar conversion.

3. Key materials issues in solar conversion

During one of the keynote lectures, Richard Swanson described how photovoltaics (PV) have gone from occupying a niche market to being a mainstream supplier of clean energy. The talk focused on the growth of the photovoltaic industry, and issues surrounding the primary material being used, silicon (Si). Two of his graphs presented convincing evidence that there has been a steady and predictable cost reduction in silicon modules over time, and the goal of PV module costs near US$1.44/W (in 2002 dollars) will likely be reached around 2013 when there will be a cumulative module production of over 10,000 Megawatts (MW). At that point, PV generated electricity will have costs similar to conventional sources of energy.

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Fig. 1. A large tracking PV array produced by Solon, and a Cruise Car Inc. golf cart welcomed visitors to the San José Convention center on October 16–19, 2006.

Fig. 2. Schott Solar's parabolic trough concentrator and receiver tube converts solar energy to super-heated water and steam, and ultimately to electricity.

SunPower recently released a monocrystalline (c-Si) solar module based on its back contact architecture [3] that produces 315 W, with a cell efficiency of 22% and a module efficiency of 19.3% at AM1.5. This means that about 50% less modules are required for a given power level compared to most conventional Si solar panels. This has favorable implications for the Balance of Systems (BOS) costs of a PV system using such modules. Martin Green then outlined the future of thin-film solar cells and described the need for these technologies due to the current polysilicon (poly-crystalline Si feedstock) shortage. He also outlined the theoretical basis for understanding how solar conversion efficiencies might be raised in the future to beyond the 33% level predicted by thermodynamics for a single bandgap PV device [4]. Special materials properties are required to implement these new schemes, and practical devices have yet to be demonstrated.

Particularly noteworthy, was the next keynote talk by Michael Geyer of IEA SolarPACES. His talk was titled, "From Research to Concentrating Solar Power Market Introduction: Progress and Advances of Concentrating Solar Power Technologies". During the talk, it was made clear that large-scale concentrating thermal systems are already cost competitive in many areas of the world, and a number of projects in the 10–100 MW range are either on-line, or will be built soon (primarily in Nevada in the US, or in Spain). These projects highlight the advancements made in spectrally selective high temperature coatings for use in thermal conversion, an area of interest to contributors to Solar Energy Materials and Solar Cells. At the exhibition that took place during the conference, Schott Solar displayed a commercial solar trough concentrator, complete with an evacuated tube design coated with advanced solar thermal absorber materials. Such troughs are used in some of the utility-scale projects described by Geyer.

In a packed session on Solar Electric Generating Systems (SEGS), or thermal electric production, it was shown that large parabolic trough steam power plants have been operating non-stop since the 1980s, supplying utility grade solar power in California. According to Rainer Aringhoff (Solar Millenium LLC, Berkeley, CA), the Kramer Junction SEGS Plants near Barstow, CA have produced 15 Terawatt-hours electric (TWhe), with 12 TWhe from solar energy itself. This represents two billion (US) dollars of electricity sold over the last 20 years [5]. Combined, the group of plants totals 354 MWe. The Kramer Junction plants use Solel Receivers (formerly Luz) and FlagSol reflectors. Solargenix is building a new plant using Schott solar receivers near Boulder City, NV. The Nevada plant is rated at 64 MWe and will be completed in June 2007. Other new plants are being discussed for the South-western United States. A dual plant is also being built in Granada, Spain. The Spanish AndaSol plant is rated at 2×50 MWe, and designed to produce 360 Megawatt-hours electrical energy annually (MWhe/a). Other SEGS projects include those in Mexico, Algeria, Egypt, Israel, and South Africa.

The future looks very bright for these plants with their advanced turn-key designs, and improved high performance materials. The cost to construct the plants will drop from US$170 to 200/MWhe to an expected US$100/Mhe over the next few years. Notable is that about 7.7 mi^2 (square miles) of area is needed to produce 1 Gigawatt electrical energy (GWe) from these types of plants. It is estimated that in four southwestern states of the US, unused and underdeveloped land could produce 4132 Gigawatt-hours electrical energy annually (GWhe/a). The SEGS plants have been a success story for large-scale, utility-grade solar energy, and are expected to play an increasing role in energy production. Materials challenges include the design of advanced selective surfaces to operate at temperatures above 400 °C, and higher performance heat transfer and storage materials. These are among the areas in which the journal Solar Energy Materials and Solar Cells welcomes continued submissions.

In the field of concentrator-based PV, Roland Winston moderated a session describing how several companies are refocusing interest in residential concentrating PV due to innovations from SpectroLab on high efficiency III–V multijunction solar cells. The presenters described how such a cell might enable lower electricity costs, because the solar cell becomes a small part of the overall solar concentrator conversion system. Several of the systems being explored for commercial development feature non-imaging optics that Winston pioneered over two decades ago. Companies that presented at the session included: SolFocus, SpectroLab, Energy Innovations and Sharp Electronics.

4. Silicon feedstock manufacturing developments

With 95% of PV industry modules based on silicon, the on-going silicon feedstock (polycrystalline Si, or polysilicon) shortage threatens to stall the growth of this promising industry. According to the consultants at Solarbuzz LLC, the World Solar PV Market annual growth rate was 34% in 2005, and reached a record high of 1460 MW installed in 2005, with 837 MW installed in Germany alone [6]. According to Richard Winegarner of Sage Concepts Inc., a total of 31,400 metric tons of polysilicon was refined in 2005, with an expectation that 77,600 metric tons will be produced in 2010. A typical Si refining plant currently produces anywhere from 5000 to 8000 metric tons annually. By 2008, it is expected that increased Si production capacity will meet the demands of the PV module industry, and the polysilicon shortage will be over. Currently, silicon is used by the PV industry at a rate (about 17,600 metric tons in 2005) about equal to that by the semiconductor electronics sector. Worldwide, large investments, $400–500 million per company, are being made into production capacities for polysilicon. Most companies that produce polysilicon feedstock will more than double their production capacity by 2010.

A session on silicon feedstock coved manufacturing issues, including advances in the so-called Siemens process, and the potential of the fluidized bed processes. Leading companies in the field include Renewable Energy Corporation (REC), Deutsche Solar, Sage Concepts, GT Solar, Hemlock, Wacker, Tokuyama, MEMC, and Mitsubishi.

Most polysilicon is currently produced via a chemical purification/reaction method using trichlorosilane or silane decomposition.

Because of a shortage of solar grade silicon, there are a number of techniques that are being explored to meet PV demand [7]. These include the use of solar concentrators described previously, as well as techniques that allow for less usage of silicon per peak watt of the produced module (a parameter called the "silicon intensity"). This is accomplished, for example, using thinner Si wafers and cells (e.g. a reduction from 270 to 180 μm). This seems to be the trend, with further reductions possible due to enhancements in light trapping, surface texturization and advanced coatings. Currently, most cells are manufactured by sawing thin wafers from the cylindrical boules produced by the Czochralski growth process. During his presentation, Chandra Khattak of GT Solar Inc. highlighted the need to make further reductions to kerf losses incurred during the sawing of wafers, and he stressed the need for recycling of the Si dust and Si waste produced during the process.

Other methods to reduce the silicon intensity of a solar panel include techniques that allow cells to be produced without sawing them from the cylindrical Czochralski boules. These include: edge defined film-fed growth, string ribbon, and silicon sheet from powder. Another technique to alleviate the silicon shortage is to mix metallurgical grade silicon with feedstock that is more highly purified. For example, a mixture of metallurgical and semiconductor industry grade Si could result in impurity levels of 10–100 parts per billion (ppb), thus qualifying it for photovoltaic applications. Such PV grade silicon is in excess of 99.999999% pure. Efforts are being made to learn how to use Si of lesser purity without degrading module solar conversion efficiencies.

5. Thin film solar cell technologies

Another method to alleviate the need for large amounts of Si is to use thin film solar PV technologies, namely amorphous and microcystalline silicon (a-Si, and μc-Si), cadmium telluride (CdTe) and copper indium gallium diselenide (CIGS). During two sessions dedicated to this topic, panelists discussed solar cell efficiencies, module efficiencies, research and development issues, technology pathways, companies involved in development and production, as well as various applications. Companies that gave talks in these sessions included: Global Solar, United Solar Systems, Applied Materials and Miasole. In a major development and shift for the PV industry, Applied Materials Inc., maker of equipment that supports the semiconductor (e.g. computer chip) industry, has recently announced that it will enter the PV industry. It has acquired German PV equipment producer Applied Films. In addition, Applied Ventures, LLC, the venture capital fund of Applied Materials, announced that it has invested several million US dollars in Solaicx, a manufacturer of single-crystal silicon (c-Si) wafers for the solar PV industry. This is an example of how companies and investors are betting on both thin film and standard c-Si technologies. Companies such as Miasole and Nanosolar are stressing that CIGS solar cells can be manufactured using a high speed, high throughput roll-to-roll process. United Solar Systems is already using such techniques to commercially produce a-Si modules, so this approach is reasonable as long as there is sufficient materials availability (e.g. Indium, Gallium or Tellurium). The journal is keenly interested in publications on these topics.

6. Conclusions

As noted by Photon International Magazine, an exhibitor at the conference, profit margins in the photovoltaic industry have doubled from 15 to 30% during the past two years, and production costs have significantly decreased. Near the end of the Solar Power 2006 conference, California Governor Arnold Schwarzenegger addressed a plenary session, and described policies such as the recently signed landmark legislation called the Global Warming Solutions Act (AB 32) and the Million Solar Roofs initiative. AB 32 requires the California Air Resources Board to develop regulations and market mechanisms that will ultimately reduce California's greenhouse gas emissions by 25% by 2020. This joins a growing list of similar policy measures in countries such as Germany and Japan. Economic and policy indicators, and the significant attendance at the conference, leads one to conclude that readers of, and contributors to, Solar Energy Materials and Solar Cells will likely have ample incentives to conduct research that can be an important part of this growing field. The next Solar Power Conference will be held at the Long Beach Convention Center in California, September 24–27, 2007. It is expected that over 7000 people will attend [8].

Acknowledgments

This article will hopefully be the first in a series of event reports submitted by our readers. To submit your text and figures, visit the Solar Energy Materials and Solar Cells portion of the Elsevier Editorial System web site: http://ees.elsevier.com/solmat/. The journal also welcomes brief descriptions of recently issued patents in the field, and notices for our events calendar. For details on the format for calendar entries, as well as a Guide for Authors for other submissions, please see the January 2007 issue of the journal.

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