High-Efficiency Solar Cells for Concentrating Photovoltaics

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Solar energy production has grown tremendously over the last decade. The current explosion in installed capacity has been lead primarily by an excess supply of silicon solar panels priced at or below cost. In order for the solar industry to grow and become a healthy and profitable industry, the levelized cost of solar power must continue to drop by decreasing manufacturing costs and increasing module efficiencies.

Materials innovations have been the primary drivers towards cost reduction. Non-silicon thin film materials such as CdTe and CuInGaSe held much promise on the hopes it would have production efficiencies equal to silicon, but with lower cost. However, with the exception of companies such as First Solar and Solar Frontier, this technology has not reached the wide-spread acceptance that silicon panels have obtained.

Another technology called concentration photovoltaics (CPV) is based on replacing a large portion of the sun collecting area with inexpensive metal and plastic focusing optics and minimizing the amount of semiconductor materials. By using mass-produced materials like aluminum, acrylic, and glass, the cost of the system can be reduced. Since the amount of semiconductor is now a small fraction, roughly 10-20%, of the total system cost, more advanced solar cell technologies and materials can be used without increasing the overall cost due to the increased power conversion efficiency.

CPV systems use multi-junction solar cell architectures made of compound-semiconductor materials. These cells are two to three times more efficient than that of silicon cells and are made of the same class of III-V materials as mass produced LEDs and RF power devices. Current multi-junction solar cell products have 40-44% conversion efficiencies which create CPV modules with 30-34% conversion efficiencies. One of the primary advantages of CPV is the ability to continue to increase cell efficiencies due with a well-accepted roadmap. Over the next 5 years, it is expected that multi-junction solar cells will reach 48-50% efficiency and enable CPV modules to be 40% efficient, double that of the top-tier silicon products. This increase in efficiency will dramatically reduce the cost of solar electricity provided by CPV.

Aside from pure efficiency gains, multi-junction solar cells in CPV systems also have less power degradation under real operating conditions compared to silicon and thin film technologies. With performance much closer to the rated power and the ability to use solar tracking systems, the total energy power harvest of CPV exceeds that of any other solar technology.

While silicon flat panels are the dominant source of solar power today, many countries around the world are seeing the advantages and potential of CPV. Countries which have population centers in or near areas with high solar resource are installing their first CPV farms to generate electricity. In China, companies such as Suncore and Suntrix are installing CPV in the northern and western areas of China, capitalizing on the excellent solar resource to generate clean electricity.