Nanotechnology in Solar Power

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Introduction

Solar panels are one of the most popular forms of renewable energy. They are increasingly being used by individual households and businesses to produce some of their own electricity, particularly in warm countries, and more eco-conscious countries like Germany (see inset).

At the core of commercial solar panels are photovoltaic (PV) cells - devices which convert solar energy into an electrical voltage. These are constructed from several layers of materials, each with a specific set of properties suited to its job. Advances in the materials used in PV cells will push the efficiency and cost of solar panels down, and ultimately help the application of solar panels to become more widespread, across domestic, industrial, and grid-level applications.

Germany has broken multiple records for solar power generation in 2012, for installed capacity, and for total solar power generated over one day and over six months.

Waldpolenz Solar Park in Germany. Image credit: Juwi Group via Wikimedia Commons.

The main aims of R&D for PV technologies are:

- increase the light absorption rate
- increase the efficiency of the photovoltaic effect
- decrease the cost of manufacturing
- make PV cells adaptable to different scales and localities

Three Generations of Solar Panels

Photovoltaic technology has been categorized into three distinct generations, which mark step shifts in the materials and manufacturing techniques used to make the cells.

The first generation of solar cells uses very high quality crystalline silicon. These are expensive to manufacture, and have a fairly low theoretical efficiency limit of around 33%.

Second generation PV cells use thin film technologies with other semiconducting materials such as cadmium telluride (CdTe) and copper indium gallium selenide (CIGS). These materials can significantly reduce processing costs, and promise much higher theoretical efficiencies than silicon-based PV materials.

Third generation PV is a much broader group of technologies, all of which are emerging or in the development phases. Technologies often considered part of this third generation include quantum dots, nanostructured semiconductors, and amorphous silicon.

The Role of Nanotechnology

Nanotechnology can help with design and manufacture second generation, thin film PV cells. However, nanomaterials will truly come into their own in the third generation of solar cell technologies, where novel technologies like nanowires, quantum dots and radial junctions will begin to push the upper limits of PV efficiency.

Nanostructures can also allow efficient solar cells to be made from cheaper, more conventional materials, like silicon and titanium dioxide. Although there will be cost barriers involved in developing mass production techniques for nano-enhanced PV cells, the use of cheaper raw materials will allow the cost of commercial solar cells to continue to decrease.

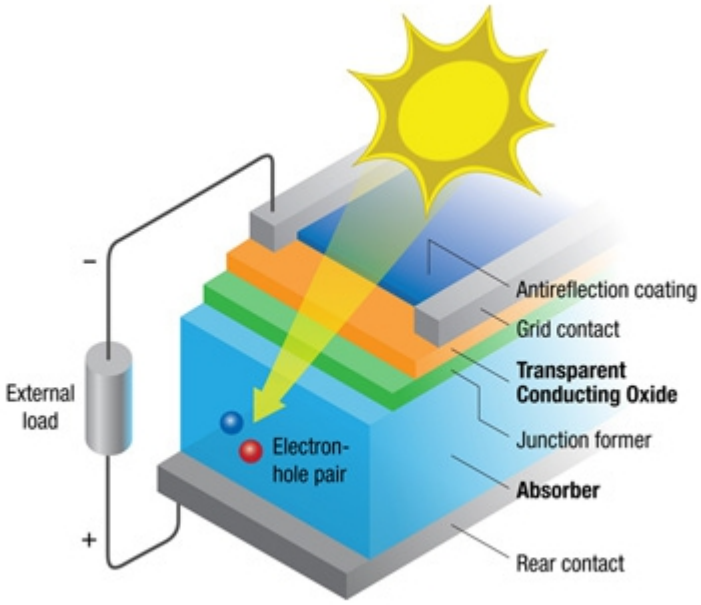

Figure 2. Schematic of a photovoltaic cell. Nanomaterials have the potential to enhance the performance of each layer in the cell - from more transparent coatings and more conductive electrodes to more efficient absorbers. Image credit: NREL

Recent Advances in Solar Panel Nanotechnology

Self-Cleaning Solar Panels

In July 2012, ecoSolargy launched a range of solar panels which use self-cleaning glass - this keeps the panels free of dirt and debris, to ensure that the PV cells receive as much of the incident solar energy as possible. This technique is very effective in helping the conventional cells to perform at peak efficiency.

We will probably see much more of this sort of indirect application of nanotechnology to solar panels in the coming years, before nanotechnology is able to gain a significant market share in the actual PV materials used.

Dye-Enhanced Solar Cells - Mimicking Photosynthesis

In May 2012, Northwestern University researchers developed a new sort of "dye-sensitized" solar cell (part of the second generation of photovoltaic technologies), which uses an organic dye monolayer to help absorb sunlight, much as plants do for photosynthesis.

Dye-sensitized PV cells have been explored before - however, the organic dye used is usually a liquid, which can leak out, drastically shortening the lifetime of the cell. The advance made by the team at Northeastern University is to use a dye which is just as effective at capturing solar energy, but solidifies, preventing it from leaking and giving the cell a viable lifetime.

Their novel solar cell also uses a number of other nanomaterials, like titanium dioxide nanoparticles and caesium tin iodide thin films, as high-performance p-type and n-type semiconductors.

The "SolarWindow" fabrication technology announced by New Energy Technologies in 2011 allows flexible solar cells to be created using a variety of simple techniques such as screen-printing and spraying. This is done using organic semiconductors which can be easily dissolved to create thin film photovoltaic cells just a 100nm thick.

You can read more about this innovative process in this Thought Leader article.

Conclusions

Solar power is looking more and more attractive, as other power generation methods such as fossil fuels and nuclear power come under increasing scrutiny. The power which could potentially be harvested from sunlight is far beyond our requirements . However, the high cost of manufacture associated with solar panels, coupled with relatively low efficiency, means that it still takes a long time to recover the investment, whether installing solar panels on the roof of a house or building a megawatt-scale solar farm.

There are still barriers to manufacturing the nanomaterials which could lift the current limits on PV efficiency. It is encouraging, however, to see the wealth of research going into the area, and to see some small companies beginning to commercialize nano-enhanced solar panels. With the current rate of development, solar power is likely to break out of its current relatively niche markets and gain a substantial share of the world energy market.

Click here for the latest news on solar nanotechnology from AZoNano.

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