Solar Cells and Nanotechnology

By Mike Priaulx

Current solar power technology has little chance to compete with fossil fuels or large electric grids. Today's solar cells are simply not efficient enough and are currently too expensive to manufacture for large-scale electricity generation. However, potential advancements in nanotechnology may open the door to the production of cheaper and slightly more efficient solar cells. First, I would like to examine the current solar cell technologies available and then look at their drawbacks. Then I will explore the research field of nano solar cells, and the science behind them. Finally, I will consider the implications that these technologies would have on our society.

Before introducing new solar products which use nanotechnology, it is necessary to explain the basic process that a normal solar cell uses. Conventional solar cells are called photovoltaic cells. These cells are made out of semiconducting material, usually silicon. When light hits the cells, they absorb energy though photons. This absorbed energy knocks out electrons in the silicon, allowing them to flow. By adding different impurities to the silicon such as phosphorus or boron, an electric field can be established. This electric field acts as a diode, because it only allows electrons to flow in one direction (Ref. 1). Consequently, the end result is a current of electrons, better known to us as electricity.

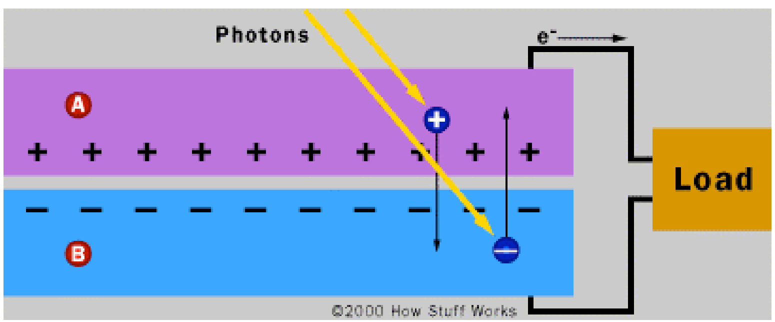

Diagram of a photovoltaic solar cell (Ref 1).

Conventional solar cells have two main drawbacks: they can only achieve efficiencies around ten percent and they are expensive to manufacture. The first drawback, inefficiency, is almost unavoidable with silicon cells. This is because the incoming photons, or light, must have the right energy, called the band gap energy, to knock out an electron. If the photon has less energy than the band gap energy then it will pass through. If it has more energy than the band gap, then that extra energy will be wasted as heat. Scott Aldous, an engineer for the North Carolina Solar Center explains that, "These two effects alone account for the loss of around 70 percent of the radiation energy incident on the cell"(Ref. 1) Consequently, according to the Lawrence Berkeley National Laboratory, the maximum efficiency achieved today is only around 25 percent (Ref 4). Mass-produced solar cells are much less efficient than this, and usually achieve only ten percent efficiency.

Picture of a solar cell, which utilizes nanorods to convert light into electricity (Ref. 5).

Nanotechnology might be able to increase the efficiency of solar cells, but the most promising application of nanotechnology is the reduction of manufacturing cost. Chemists at the University of California, Berkeley, have discovered a way to make cheap plastic solar cells that could be painted on almost any surface. These new plastic solar cells achieve efficiencies of only 1.7 percent; however, Paul Alivisatos, a professor of chemistry at UC Berkeley states, "This technology has the potential to do a lot better. There is a pretty clear path for us to take to make this perform much better"(Ref. 5).

These new plastic solar cells utilize tiny nanorods dispersed within in a polymer. The nanorods behave as wires because when they absorb light of a specific wavelength they generate electrons. These electrons flow through the nanorods until they reach the aluminum electrode where they are combined to form a current and are used as electricity (Ref. 5). This type of cell is cheaper to manufacture than conventional ones for two main reasons. First, these plastic cells are not made from silicon, which can be very expensive. Second, manufacturing of these cells does not require expensive equipment such as clean rooms or vacuum chambers like conventional silicon based solar cells. Instead, these plastic cells can be manufactured in a beaker. UC Berkeley graduate student Wendy Huynh says, "We use a much dirtier process, and that makes it cheap"(Ref. 5).

Another potential feature of these solar cells is that the nanorods could be 'tuned' to absorb various wavelengths of light. This could significantly increase the efficiency of the solar cell because more of the incident light could be utilized. According to a 2001 report, "*The Societal Implications of Nanoscience and Nanotechnology*," by the National Science Foundation, if the efficiency of photovoltaic cells was improved by a factor of two using nanotechnology, "The role of solar energy would grow substantially"(Ref. 6).

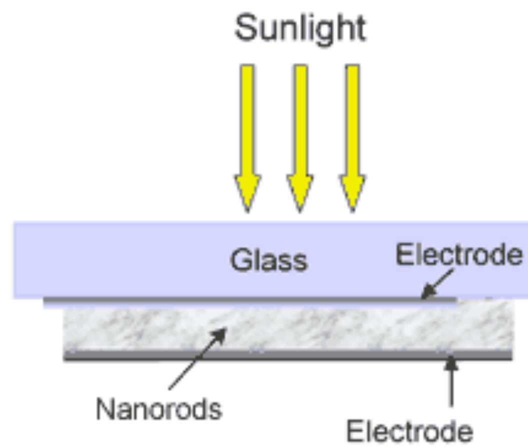

Diagram of a nano solar cell (Ref. 5).

In addition to the University of California Berkeley, a well-known company named Konarka Technologies is also pursuing the use of nanotechnology to improve solar energy. In fact, they are already manufacturing a product called, "Power Plastic" which absorbs both sunlight and indoor light and converts it into electricity. For patent reasons, their technology is kept secret, but the basic concept is that Power Plastic is made using nanoscale titanium dioxide particles coated in photovoltaic dyes, which generate electricity when they absorb light. According to Engineer Magazine, Konarka has already, "built fully functional solar cells that have achieved efficiencies of around 8%"(Ref. 3). Future designs are already underway which includes tuning the nanorods to absorb certain wavelengths of light in order to exploit a greater range of the color spectrum.

Improvements such as this could make it possible to manufacture inexpensive solar cells with the same efficiency as current technology. Since the manufacturing cost of conventional solar cells is one of the biggest drawbacks, this new technology could have some impressive effects on our daily lives. Although this new technology is only capable of supplying low power devices with sufficient energy, its implications on society would still be tremendous. It would help preserve the environment, decrease soldiers carrying loads, provide electricity for rural areas, and have a wide array of commercial applications due to its wireless capabilities. Now I will examine each of these implications in further detail.

Inexpensive solar cells, which would utilize nanotechnology, would help preserve the environment. According to Engineer Magazine, Konarka Technologies is already proposing, "coating existing roofing materials with its plastic photovoltaic cells" (Ref. 3). If it were inexpensive enough to cover a home's entire roof with solar cells, then enough energy could be captured to power almost the entire house. If many houses did this then our dependence on the electric grid (fossil fuels) would decrease and help reduce pollution. Some people have even proposed covering cars with solar cells or making solar cell windows. Even though their efficiency is not very great, if solar cells were inexpensive, then enough of them could be used to generate sufficient electricity.

New technology in solar cells would also have military implications. The U.S. Army has already hired Konarka Technologies to help design a better way to power their soldiers' electrical devices. According to Daniel McGahn, Konarka's executive vice president, "A regular field soldier carries 1.5 pounds of batteries now. A special operations soldier has a longer time out, has to carry 140 pounds of equipment, 60 to 70 pounds of which are batteries (Ref. 2)." If nanotechnology could be used to create inexpensive and reasonably efficient solar cells, it would greatly improve soldiers' mobility.

Inexpensive solar cells would also help provide electricity for rural areas or third world countries. Since the electricity demand in these areas is not high, and the areas are so distantly spaced out, it is not practical to connect them to an electrical grid. However, this is an ideal situation for solar energy. If it were inexpensive enough, it could be used for lighting, hot water, medical devices, and even cooking (Ref. 2). It would greatly improve the standard of living for millions, possibly even billions of people!

Finally, inexpensive solar cells could also revolutionize the electronics industry. Solar cells could be imbedded into clothing and be 'programmed' to work for both indoor light and sunlight. In fact, Konarka Technologies has already begun developing a 'photovoltaic fabric' that could be woven into clothing (Ref. 3). For the first time, our electronics would be truly wireless, and we wouldn't have to plug them into an outlet at night to recharge them.

Consequently, even though conventional solar cells are expensive and cannot yet achieve high efficiency, it may be possible to lower the manufacturing costs using nanotechnology. Institutions such as the University of California Berkeley and Konarka Technologies are actively pursuing ways to make this happen. Although solar cells are not efficient enough to replace large-scale electric grids, there are many opportunities for them to be used for low power devices. The effects that a low cost, reasonably efficient (low power) solar cell would have on society are tremendous. It would help preserve the environment, protect soldiers, provide rural areas with electricity, and transform the electronics industry. These dramatic effects, which would all be a result of nanotechnology, would greatly change and even improve society.

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