Novel Approaches to Photovoltaic Technology

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In testimony before the U.S. Senate Commerce Committee in 1974, Thomas Carr explained that "The word 'energy' incidentally equates with the Greek word for 'challenge'" (qtd. in Fields). The **challenge today is to employ renewable sources of energy, making them inexpensive and practical**. The number one source of renewable energy is the sun. With the current fears about the rapid consumption of fossil fuels, today's focus is on solar power. Our scientific and engineering knowledge needs to be poured into **novel approaches to photovoltaic technology.** Some of those approaches include tandem cells, electricity-conducting plastics, and parabolic dishes to concentrate the sun's rays.

Because of the low efficiency of photovoltaic technology, research and experimentation are being done to try to improve the efficiency of solar cells. One example of current research is the attempt to use high-energy electrons that are loosened when photons of a higher energy than the bandgap hit the photovoltaic cell before those electrons settle down to a lower energy state and become waste heat (Nozik, 2003, p. 1). One approach to capture electrons more effectively is using multiple-junction solar cells, also known as tandem cells, with each junction having a different bandgap. This allows for a wider range of bandgap energies by use of layers of different elements. (See Figure 1 below.) The 2007 record efficiency of this type of photovoltaic cell is 40.7% (Derbyshire, 2007).

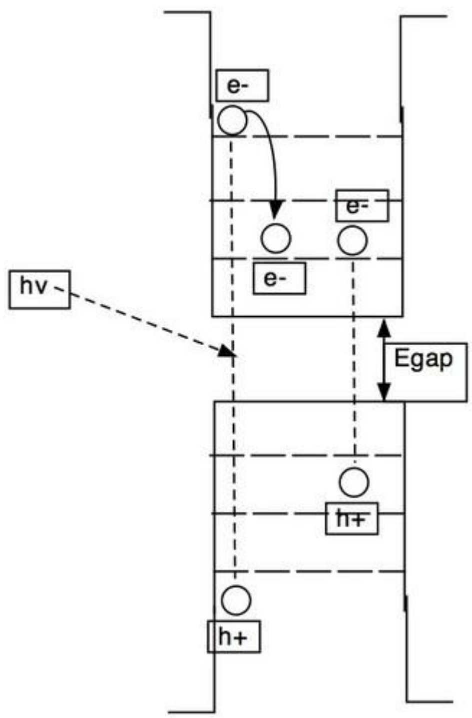

Figure 1: Diagram of a multiple-junction solar cell: e- are electrons; h+ are holes; hv is a photon (http://images.pennnet.com/articles/sst/thm/th_263688.jpg).

A second method, called multiple energy level solar cells, creates additional energy levels for photons of different energies to be absorbed, essentially making more bandgaps ("Solar Photovoltaics," 2007, p. 11). This is done by creating quantum wells, which are regions that confine electrons to two dimensions. They "are built with multiple nanoscale semiconductors layered on top of one another with a lateral conduction layer" ("Quantum Well Solar Cells," 2009). This one-to-ten nanometer thickness is what confines the electrons to moving in two dimensions and therefore helps direct the electricity so that it is more efficient.

Tandem cell technology originally used crystalline silicon but now has been incorporated in cells made of other materials, including glass and even plastic. Some of the thin-film photovoltaic technology today "including amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium-gallium diselenide (CIGS)….are expected to improve markedly as manufacturers gain production experience and the technology matures" ("Solar Photovoltaics," 2007, p. 8).

One of the newest solar cell technologies is in the development of electricity-conducting polymers, named "Power Plastic," which Alan J. Heeger shared the 2000 Nobel Prize in chemistry for discovering. Like tandem cell technology, "Power Plastic" is based on layers, but this time the layers are sensitive to different wavelengths of light as seen in Figure 2 below. Basically this allows the solar cells to absorb photons from a wider range of wavelengths ("Plastic Power").

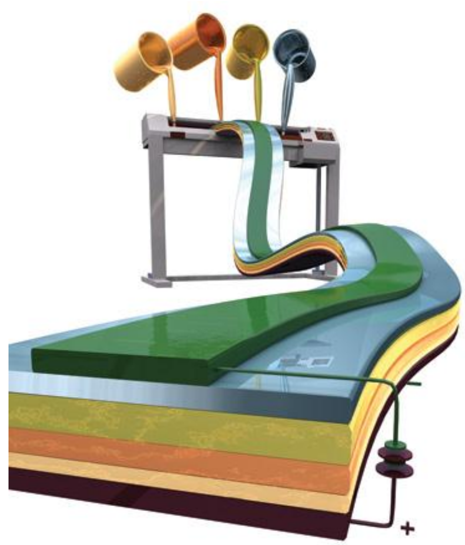

Figure 2: Different-colored layers allow a solar cell to absorb photons from a wider range of wavelengths (http://convergence.ucsb.edu/files/articles/plastic-power/heeger_press.jpg).

Because these plastic solar cells are very thin and flexible, "Heeger says they can be applied like paint and literally printed like ink" ("Plastic Power"). This may prove to be a cost-efficient technology. On the other hand, it still has some inherent problems, such as getting the electrons to travel to the electrodes because, on the atomic level, the polymers are not smooth; they are bulky. This bulkiness prevents electrons and holes from flowing smoothly through the plastic solar cells. Basically, "it's difficult to keep the electrons from breaking ranks and popping into the nearest holes" ("Plastic Power," 2007).

Instead of experimenting with different materials and layers, another approach to increasing solar cell efficiency is to concentrate the sun's energy. This can be done by mirrors or creating a parabolic dish. Figure 3 on the next page shows how a parabolic dish is laid out. The sunlight reflects off the dish itself and is focused to a central point where the receiver/absorber is located ("Active Solar Systems," n.d.).

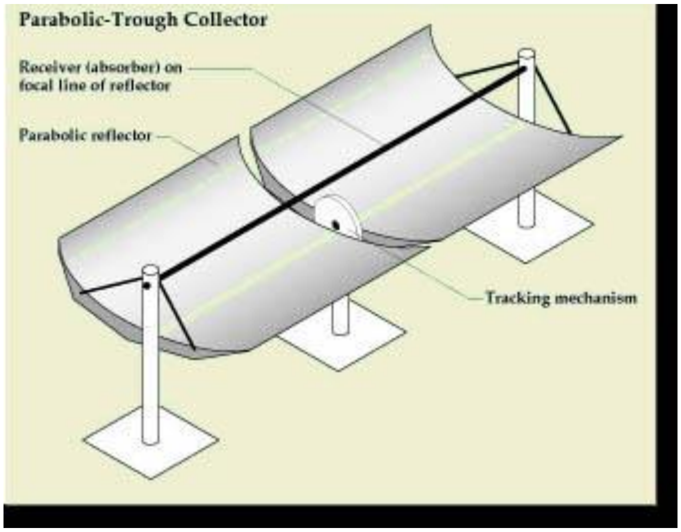

Figure 3: Basic diagram of a parabolic dish with reflector and receiver (http://www.usc.edu/dept/architecture/mbs/tools/thermal/finals/solcol_parab.jpg).

One example of this technology is parabolic dishes produced by Zenith Solar in Israel. (See photo in Figure 4 below.) The working prototype consists of "a 10-sq.-meter (107.6-sq.-ft.) dish lined with curved mirrors made from composite materials. The mirrors focus the sun's radiation onto a 100-sq.-centimeter (15.5-sq.-in.) 'generator' that converts light to electricity" (Sandler, 2008). The company claims that this prototype is five times more efficient and concentrates more than a thousand times more solar energy than traditional flat-panel technology. This technology is going into commercial production in 2009 and may prove to live up to its claim (Sandler, 2008).

Figure 4: The Zenith Solar parabolic solar panels (http://images.businessweek.com/story/08/600/0326_zenith_solar.jpg).

Along with the electricity produced, the Zenith system also captures thermal energy from the excess heat to heat up water (Sandler, 2008). However, this is not done through electricity, but rather through thermal energy from solar radiation. The circulating pump itself, however, may indeed be regulated by a photovoltaic panel (Block and Harrison, 1997, p. 1).

Most of the research into solar energy has been aimed towards improving the efficiency of photovoltaic conversions by manipulating the materials in the solar cells themselves. Some of these have been done by changing it chemically, by layering, and even by changing the thickness of the layers. Silicon was used for the original solar cells, but now a variety of materials is being used, including plastic polymers. New technologies have also been developed using the concentration techniques, such as parabolic dishes. Other systems combine photovoltaic power with thermal energy to more efficiently use the excess heat. The emphasis has been on the "development of new technologies with higher conversion efficiencies and low production costs" ("Assessment of Solar Energy," 2006). **While all of these approaches are showing some improvements in the technology, much more research needs to be done to make solar energy efficient and inexpensive.**

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Images Used

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Figure 2— http://convergence.ucsb.edu/files/articles/plastic-power/heeger_press.jpg

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Figure 4— http://images.businessweek.com/story/08/600/0326_zenith_solar.jpg