Nano-technology an Innovations for Non Conventional Energy Sources

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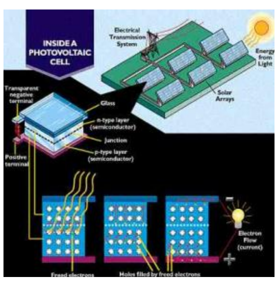
Abstact :
Today there are thousands of individuals and companies across the globes who are working hard to develop alternative energy solutions for future generations. As they hold the key towards the future, without them, our planet will eventually head into a blackout. The major sources of alternative energy such as solar, wind, geothermal and other energies.

Solar power is produced by collecting sunlight and converting it into electricity. This is done by using solar panels, which are large flat panels made up of many individual solar cells. It is most often used in remote locations, although it is becoming more popular in urban areas as well.

Introduction of Nanotechnology in PV solar cells claims to be able to produce electricity at 5-6 cents/kilowatt hour almost as cheap as power from coal and at about one-third the cost of other solar power. Conventional silicon-made solar panels have a stiff competitor from CIGS semiconductor printed solar panels - composed of copper, gallium, indium and selenium - which perform as good as conventional solar panels in lab conditions. An inexpensive printing process makes it ideal for mass production by an automated facility with robots and other hi-fi equipment.

Introduction

The "photovoltaic effect" is the basic physical process through which a PV cell converts sunlight into electricity. Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a PV cell, they may be reflected or absorbed, or they may pass right through. Only the absorbed photons generate electricity. When this happens, the energy of the photon is transferred to an electron in an atom of the cell (which is actually a semiconductor). With its newfound energy, the electron is able to escape from its normal position associated with that atom to become part of the current in an electrical circuit. By leaving this position, the electron causes a "hole" to form. Special electrical properties of the PV cell—a built-in electric field—provide the voltage needed to drive the current through an external load (such as a light bulb).



Photovoltaics (PVs) are arrays of cells containing a solar photovoltaic material that converts solar radiation into direct current electricity. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Due to the growing demand for renewable energy sources, the manufacture of solar cells and photovoltaic arrays has advanced dramatically in recent years.

Photovoltaic production has been increasing by an average of more than 20 percent each year since 2002, making it the world's fastest-growing energy technology.

At the end of 2009, the cumulative global PV installations surpassed 21,000 megawatts. Installations may be ground-mounted (and sometimes integrated with farming and grazing) or built into the roof or walls of a building, known as Building Integrated Photovoltaics or BIPV . Solar PV power stations today have capacities ranging from 10-60 MW although proposed solar PV power stations will have a capacity of 150 MW or more.

Driven by advances in technology and increases in manufacturing scale and sophistication, the cost of photovoltaics has declined steadily since the first solar cells were manufactured. Net metering and financial incentives, such as preferential feed-in tariffs for solar-generated electricity, have supported solar PV installations in many countries.

But still there are some disadvantages you will want to consider.

1. Cost: Initial start-up cost of solar power is considerable but when consideration is given to the years of maintenance-free solar power expected, the cost is rapidly defrayed. Government rebates, tax credits, and other incentives can cut initial costs. Sell excess energy to the power grid to further recoup initial solar power outlay.
2. Climate: Many are of the opinion that solar power is only realistic for those who live in the world's sunniest, hottest climates. While it is true that these climates have a great advantage in solar power usage, climates with cloudier, cooler skies can also use solar power. India is proving this true.
3. Cloudy Days: Are clouds a disadvantage of solar power? They can be. Solar power reaches a PV system as sunlight strikes the panels. Cloudy days are, therefore, not the best for generating electricity. Even when the sky

is mostly cloudy, any sunlight breaking through will bounce off the bottoms of the clouds. This can actually give more solar power than a cloudless sky.

4. Storage: For some, the task of storing solar power is a disadvantage, as that will provide power during dark hours. Such batteries are readily available, however, and do not consume a huge amount of space.

5. Space: PV solar power panels require space. Home systems can require the entire roof. This disadvantage is being addressed with new products such as PV panels designed to blend into the roof. Modern PV panels supply more solar power with fewer panels, too, since efficiency has been increased.

To over come these disadvantage Nano-technology on thin film is a new innovation in field of solar power technology

What is Nanotechnology?

Nanotechnology is the engineering of functional systems at the molecular scale. Dr Eric Drexler popularized the word 'nanotechnology' in the 1980's,This technology deals with particles that are of the size of one billionth of a meter called “Nanometer”(10-9). A centimeter is one-hundredth of a meter, a millimeter is one-thousandth of a meter, and a micrometer is one-millionth of a meter, but all of these are still huge compared to the nanoscale. A nanometer (nm) is one-billionth of a meter, smaller than the wavelength of visible light and a hundred-thousandth the width of a human hair. Why do we need to go to such a minute level of matter?. The reason is at the nano scale the physical, chemical and biological properties of material differ in fundamental and valuable ways from the properties of individual atom and molecules at bulk. Nanosolar Technology focus is to safeguard the environment by using innovative technology that harnesses the most widespread and universal source of energy provided by the Sun.

Photovoltaic solar panels are likely to become national landmarks for innovation and green technology. Research in the field is basic to assure progressive development of the actual state of technology.

Snap View on Nanosolar Production Process : Solar panel-cells go through five major stages before becoming the final product. Each stage is specifically planned to assure that the process remain cost effective and reliable.

Stage 1 – Semiconductor Nano-particles: Solar panel technology uses nano-technology. The film used is micro-thin and this means that the nano-particles are miniature. To be precise nano-particles are 20nm which is tantamount to 200 atoms in respect to its diameter. The technique that is used is to assure that the nano-particles capture the energy from the sun with minimum lost.

Stage 2 – Nano-particle ink. : Specific chemical properties are used to assure high-quality coating. The composition of chemicals produces a non-agglomerating coating and thereby effectively generating energy from the sun.

Stage 3 – Printed Foil: A specific metal foil is used which can effectively be coated with nano-particle ink. The technique used allows production to be performed in contemporary temperature and atmosphere. There are no general atmospheric or hygienic factors required for the production process.

Stage 4 – Cell Formation: The cell formation has cables that efficiently assure transmission of current at minimum cost. Each solar-electric foil becomes cells of various sizes. The cells are tested individually to assure that integrity in term of current transmission remains standardized and up to highest potential.

Stage 5 – Panel Assembly

All the solar panels are manufactured by using only the approved cells. The performance and reliability of the assembly line is opting for lowest possible rate of deficiency with a capacity of automatically producing a solar panel in sequence of 10 seconds per assembly line.

How Thin-film Solar Cells Work : The solar panel is an enduring icon of the quest for renewable energy. You'll see the black-paned rectangles on the rooftops of houses or assembled into arrays across fields and prairies. But the panel as we have come to know it -- 5.5 feet by 2.75 feet by 2 inches (1.7 m by 0.8 m by 5 cm) -- may be history. That's because a new type of technology stands ready to take its rightful place next to traditional silicon wafer-based panels as an efficient, cost-effective way to convert sunlight into electricity. The technology is the thin-film photovoltaic (PV) cell, which, by 2010, will be producing 3,700 megawatts of electricity worldwide [source: National Renewable Energy Laboratory].

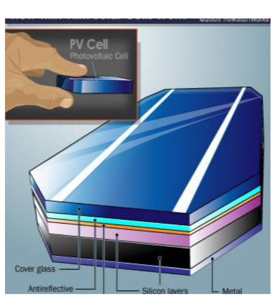


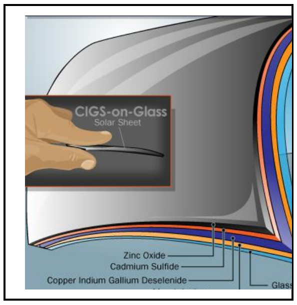
***Fig.* The layers of a photovoltaic (PV) solar cell**

Beyond 2010, production capacity will increase even more as thin-film PV cells find their way into solar-powered commercial buildings and homes, from California to India to China.

We use a solar-powered calculator, which has a solar cell based on thin-film technology. Clearly, the small cell in a calculator is not big and bulky. Most are about an inch (2.5 cm) long, a quarter-inch (0.6 cm) wide and wafer-thin. The thinness of the cell is the defining characteristic of the technology. Unlike silicon-wafer cells, which have light-absorbing layers that are traditionally 350 microns thick, thin-film solar cells have light-absorbing layers that are just one micron thick. A micron, for reference, is one-millionth of a meter (1/1,000,000 m or 1 µm). Thin-film solar cell manufacturers begin building their solar cells by depositing several layers of a light-absorbing material, a semiconductor onto a substrate -- coated glass, metal or plastic. The materials used as semiconductors don't have to be thick because they absorb energy from the sun very efficiently. As a result, thin-film solar cells are lightweight, durable and easy to use.

There are three main types of thin-film solar cells, depending on the type of semiconductor used: **amorphous silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium deselenide (CIGS)**. Amorphous silicon is basically a trimmed-down version of the traditional silicon-wafer cell. As such, a-Si is well understood and is commonly used in solar-powered electronics. It does, however, have some drawbacks.

Fig. **A copper indium gallium deselenide solar cell using glass**

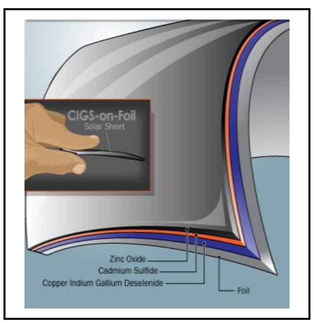


One of the biggest problems with a-Si solar cells is the material used for its semiconductor. Silicon is not always easy to find on the market, where demand often exceeds supply. But the a-Si cells themselves are not particularly efficient. They suffer significant degradation in power output when they're exposed to the sun. Thinner a-Si cells overcome this problem, but thinner layers also absorb sunlight less efficiently. Taken together, these qualities make a-Si cells great for smaller-scale applications, such as calculators, but less than ideal for larger-scale applications, such as solar-powered buildings.

Promising advances in non-silicon thin-film PV technologies are beginning to overcome the issues associated with amorphous silicon.

Structure of Thin-film Solar Cells

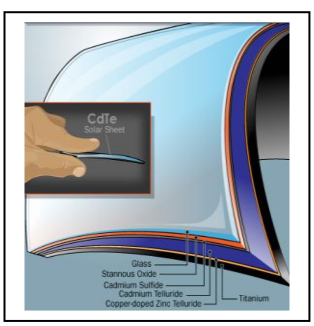
Traditional solar cells use silicon in the n-type and p-type layers. The newest generation of thin-film solar cells uses thin layers of either cadmium telluride (CdTe) or copper indium gallium deselenide (CIGS) instead. Development has been made to make the CIGS material as an ink containing nanoparticles. A nanoparticle is a particle with at least one dimension less than 100 nanometers (one-billionth of a meter, or 1/1,000,000,000 m). Existing as nanoparticles, the four elements self-assemble in a uniform distribution, ensuring that the atomic ratio of the elements is always correct.



The layers that make up the two non-silicon thin film solar cells are shown below. Notice that there are two basic configurations of the CIGS solar cell. The CIGS-on-glass cell requires a layer of molybdenum to create an effective electrode. This extra layer isn't necessary in the CIGS-on-foil cell because the metal foil acts as the electrode. A layer of zinc oxide (ZnO) plays the role of the other electrode in the CIGS cell. Sandwiched in between are two more layers -- the semiconductor material and cadmium sulfide (CdS). These two layers act as the n-type and p-type materials, which are necessary to create a current of electrons.

Fig. **A copper indium gallium deselenide (CIGS) solar cell using foil**

The CdTe solar cell has a similar structure. One electrode is made from a layer of carbon paste infused with copper, the other from tin oxide (SnO2) or cadmium stannate (Cd2SnO4). The semiconductor in this case is cadmium telluride (CdTe), which, along with cadmium sulfide (CdS), creates the n-type and p-type layers required for the PV cell to function.



But how does the efficiency of thin-film solar cells compare to traditional cells? The theoretical maximum for silicon-wafer cells is about 50 percent efficiency, meaning that half of the energy striking the cell gets converted into electricity. In reality, silicon-wafer cells achieve, on average, 15 to 25 percent efficiency. Thin-film solar cells are finally becoming competitive. The efficiency of CdTe solar cells has reached just more than 15 percent, and CIGS solar cells have reached 20 percent efficiency.

Fig. **A cadmium telluride (CdTe) solar cell**

There are health concerns with the use of cadmium in thin-film solar cells. NREL are currently investigating cadmium-free thin-film solar cells.

Production of Thin-film Solar Cells: Cost has been the biggest barrier to widespread adoption of solar technology. Traditional silicon-wafer solar panels require a complex, time-consuming manufacturing process that drives up the per-watt cost of electricity. Non-silicon thin-film solar cells are much easier to manufacture and therefore remove these barriers.

Process that makes thin-film solar cells by depositing layers of semiconductors on aluminum foil in a process similar to printing a newspaper.

The biggest recent breakthroughs recently have come with CIGS-on-foil manufacturing. It has solar cells using a process that resembles offset printing. Here's how it works:

1. Reams of aluminum foil roll through large presses, similar to those used in newspaper printing. The rolls of foil can be meters wide and miles long. This makes the product much more adaptable for different applications.
2. A printer, operating in an open-air environment, deposits a thin layer of semiconducting ink onto the aluminum substrate. This is a huge improvement over CIGS-on-glass or CdTe cell manufacturing, which requires that the semiconductor be deposited in a vacuum chamber. Open-air printing is much faster and much less expensive.
3. Another press deposits the CdS and ZnO layers. The zinc oxide layer is non-reflective to ensure that sunlight is able to reach the semiconductor layer.
4. Finally, the foil is cut into sheets of solar cells. Sorted-cell assembly, similar to that used in conventional silicon solar technology. That means the electrical characteristics of cells can be matched to achieve the highest panel efficiency distribution and yield.

Case Study:

A "typical home" in India can use either electricity or gas to provide heat -- heat for the house, the hot water, the clothes dryer and the stove/oven. If you were to power a house with solar electricity, you would certainly use gas appliances because solar electricity is so expensive. This means that what you would be powering with solar electricity are things like the refrigerator, the lights, the compute¬r, the TV, stereo equipment, motors in things like furnace fans and the washer, etc. Let's say that all of those things average out to 600 watts on average. Over the course of 24 hours, you need 600 watts * 24 hours = 14,400 watt-hours per day. ¬From our calculations and assumptions abo¬ve, we know that a solar panel can generate 70 milliwatts per square inch * 5 hours = 350 milliwatt hours per day. Therefore you need about 41,000 square inches of solar panel for the house. That's a solar panel that measures about 285 square feet (about 26 square meters). That would cost around Rs. 8,00,000 right now. Then, because the sun only shines part of the time, you would need to purchase a battery bank, an inverter, etc., and that often doubles the cost of the installation.

Because solar electricity is so expensive, you would normally go to great lengths to reduce your electricity consumption. Instead of a desktop computer and a monitor you would use a laptop computer. You would use fluorescent lights instead of incandescent. You would use a small B&W TV instead of a large color set. You would get a small, extremely efficient refrigerator¬. By doing these things you might be able to reduce your average power consumption to 100 watts. This would cut the size of your solar panel and its cost by a factor of 6, and this might bring it into the realm of possibility.

The thing to remember, however, is that 100 watts per hour purchased from the power grid would only cost about 24 cents a day right now, or Rs. 4500 a year. That's why you don't see many solar houses unless they are in very remote locations. When it only costs about Rs. 5000 a year to purchase power from the grid, it is hard to justify spending Lakhs of rupees on a solar system.

Conclusion : Nanotechnology is developing nanoparticle-printing based CIGS technology. The world – record performance demonstrate that, with innovation in science and nano material, low cost processes can yield solar cells whose film quality is good as that obtained with far more expensive high vacuum based deposition techniques.

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