Situation, Tendances, Défis et le Futur Étincelant de l'Electricité Solaire du Photovoltaïque.

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22/05/2020

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Alternative Fuels:

Because of the drawbacks of fossil fuels and nuclear power, people have been looking for alternatives. The ideal source of energy would be cheap, abundant, and clean. It would also be renewable. Several alternative energy sources are in use today. Each has strong points and weak points.

Photovoltaïque:

Photovoltaics is an empowering technology that allows us to do totally new things, as well as, do old things better. It allows us to look at whole new modes of supplying electricity to different markets around the world and out of the world (in outer space). It also allows us to do what we already do (generate electricity, which is distributed over the transmission grid) but to do it in a sustainable, pollution-free, equitable fashion. Why is photovoltaics equitable? Because nearly every one has access to sunlight!

These students are collecting solar thermal energy to cook eggs.

WHAT IS PHOTOVOLTAICS?

is the technology that generates direct current (DC) electrical power measured in Watts (W) or kiloWatts (kW) from semiconductors when they are illuminated by photons. As long as light is shining on the solar cell (the name for the individual PV element), it generates electrical power. Solar cells never need recharging like a battery. Some have been in continuous outdoor operation on earth or in space for over 30 years.

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What is the physical basis of PV operation?

Solar cells are made of materials called semiconductors, which have weakly bonded electrons occupying a band of energy called the *valence band. When energy exceeding a certain threshold, called the band gap energy, is applied to a valence electron, the bonds are broken and the electron is somewhat* “free” to move around in a new energy band called the *conduction band where it can* “conduct” electricity through the material. This energy needed to free the electron can be supplied by photons, which are particles of light.

The sun catcher has a large mirror that collects and concentrates heat, which drives a device called a stirling engine. The engine produces a turning movement, which runs a generator, producing electricity.

Solar cell:

At the heart of any solar cell is the *pn junction. Modeling and understanding is* very much simplified by using the *pn junction concept. This pn junction results from* the "doping" that produces conduction-band or valence-band selective contacts with one becoming the *n-side (lots of negative charge), the other the p-side (lots of positive charge).*

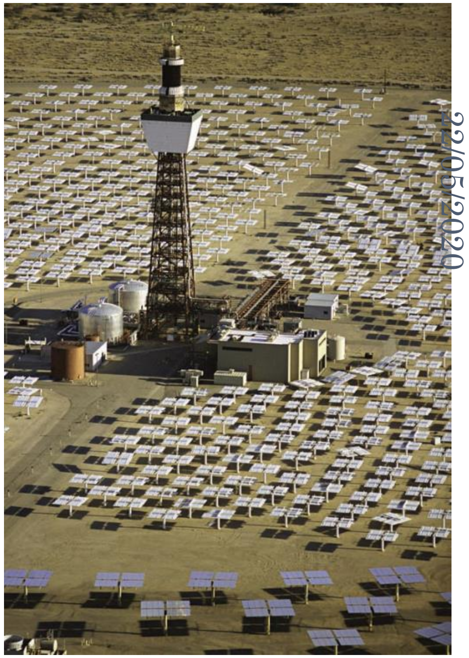
Materials used:

Silicon (Si), one of the most abundant materials in the Earth's crust, is the semiconductor used in crystalline form (c-Si) for 90% of the PV applications today. Other semiconductors are better suited to absorb the solar energy spectrum. These are amorphous silicon (a-Si), copper indium gallium diselenide (Cu(InGa)Se2 or CIGS), and cadmium telluride (CdTe). Solar cells may operate under concentrated sunlight using lenses or mirrors as concentrators allowing a small solar cell area to be illuminated with the light from larger area. This saves the expensive semiconductor but adds complexity to the system, since it requires tracking mechanisms to keep the light focused on the solar cells when the sun moves in the sky. Silicon and III-V semiconductors made from compounds such as GaAs and GaInP are the materials used in concentrator technology.

The solar furnace at Odeillo, France, has 63 mirrors to catch sunlight.

Practical applications :

A large number of solar cells are interconnected and encapsulated into units called PV modules, which is the product usually sold to the customer. They produce DC current that is typically transformed into the more useful AC current by an electronic device called *an inverter*. *The inverter, the rechargeable batteries* (when storage is needed), the mechanical structure to mount and aim (when aiming is necessary) the modules, and any other elements necessary to build a PV system are called the *balance of the system (BOS).*



A solar power tower in California produces electricity using many mirrors that direct sunlight to the top of the tower.

Six myths of photovoltaics

1. *Photovoltaics will require too much land area to ever meet significant fraction of world needs.*
2. *Photovoltaics can meet all of the world's needs today if we would just pass laws requiring photovoltaics and halting all fossil and nuclear plants.*
3. *Photovoltaics cannot meet any significant fraction of world needs. It will remain a small-scale "cottage" industry that will only meet the needs of specialty markets like remote homes in developing countries or space satellites.*
4. *No more R/D is needed since PV technology has demonstrated the technical capability to perform, so we should stop all public funding and let the economic markets decide if it is worthwhile.*
5. *Photovoltaics is polluting just like all high-technology or high-energy industries only with different toxic emissions.*
6. *PV modules never recover all of the energy required in making them, thus they represent a net energy loss.*

PV COSTS, MARKETS AND FORECASTS

Impressive gains in cell and module efficiency were made. Costs also fell dramatically as solar cells moved from pilot scale to semiautomated production.

WHAT ARE THE GOALS OF TODAY'S PV RESEARCH AND MANUFACTURING?

Since the overall goal is to produce a low cost PV *system, we need more than* low-cost-efficient solar cells, we need a low cost efficient system including mounting hardware, power conditioning electronics, fuses, cables, storage, tracking, and so on. Less research and development has gone into these areas than into PV solar cells and modules.

- Use less semiconductor material by making thinner cells or
- Use less expensive semiconductor materials. These tend to be less pure and less perfect.
- Improve solar cell performance with less expensive, less perfect semiconductors
- Even with this poorer material keep a high production yield, that is, reduce the number of cells or modules rejected by the quality control.
- Increase material utilization by reducing waste in semiconductor and cell fabrication

- Increase solar cell flux on the solar cells by using concentrators without increasing cost or optical losses too much. In this way, less semiconductor material is used.
- Increase solar radiation utilization by absorbing more of the spectrum efficiently

• Increase speed and throughput of manufacturing processes
• Simplify processing steps (this reduces fabrication costs and increases the yield) and reduce equipment costs
• Reduce costs and improve reliability of BOS (auxiliary elements).

Helping Other Technologies

Solar energy may help us use other promising new energy sources. Take, for example, the device known as a hydrogen fuel cell. A hydrogen fuel cell is a very clean energy source that makes electricity by combining hydrogen with oxygen from the air. The chief waste product is water. The electricity from these cells could be used to power a car.

Hydrogen is extremely common in nature. It is, for instance, found in water. There is a big problem, however, in getting the hydrogen: A great deal of energy has to be used to do so. The energy can be gotten by burning fossil fuels, but they release new ways of using cells. In 2008, for example, scientists at the MIT came up with a way to turn windows into collectors of light for solar cells. They put special dyes on the glass of a window that has PV cells at its edges. The dyes let through much of the light that hits the glass, so the window still works like a window. The dyes also send some of the light energy to the solar cells. The result is that the entire surface of the window can be used to make electricity.

A solar energy powered car

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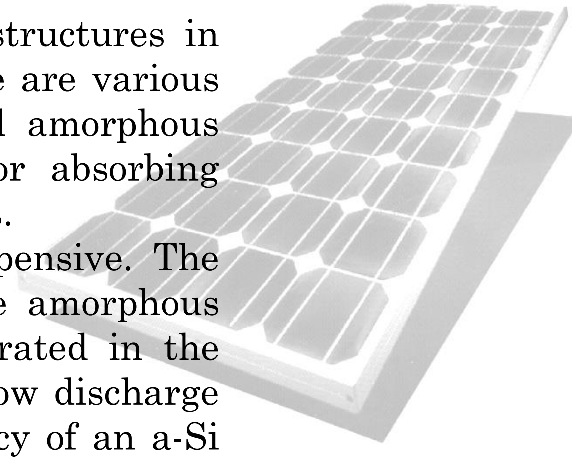
Photovoltaic Materials



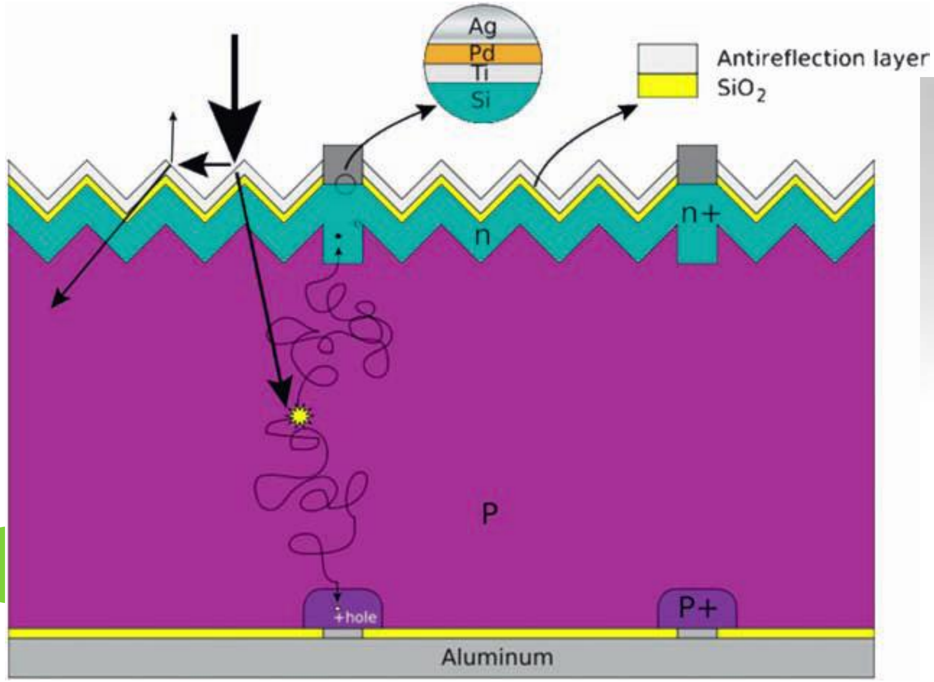
Solar cells are made of various materials and with different structures in order to reduce the cost and achieve maximum efficiency. There are various types of solar cell material, single crystal, polycrystalline and amorphous silicon, compound thin-film material and other semi-conductor absorbing layers, which give highly efficient cells for specialized applications.

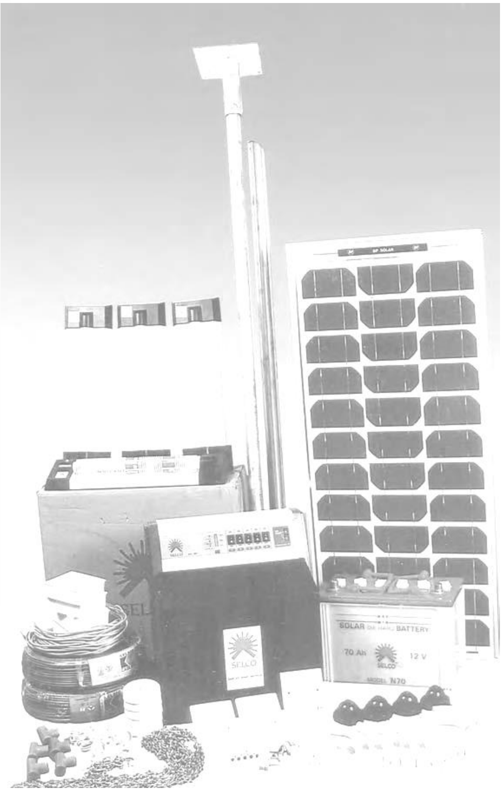
Crystalline silicon cells are most popular, though they are expensive. The amorphous silicon thin-film solar cells are less expensive. The amorphous silicon layer is used with both hydrogen and fluorine incorporated in the structure. These a-Si: F: H alloys have been produced by the glow discharge decomposition of SiF4 in the presence of hydrogen. The efficiency of an a-Si module is about 6–8%.

A variety of compound semi-conductors can also be used to manufacture thin-film solar cells. These compound materials are $CuInSe_2$, CdS, CdTe, Cu_2S and InP. The $CuInSe_2$ solar cell stability appears to be excellent. The combinations of different band gap materials in tandem configurations lead to photovoltaic generators of much higher efficiencies.

GaAs multijunction devices are the most efficient solar cells to date, reaching a record high of 40.7% efficiency under solar concentration and laboratory conditions. These devices use 20 to 30 different semi-conductors layered in series.

The structure of a silicon solar cell and working mechanism.





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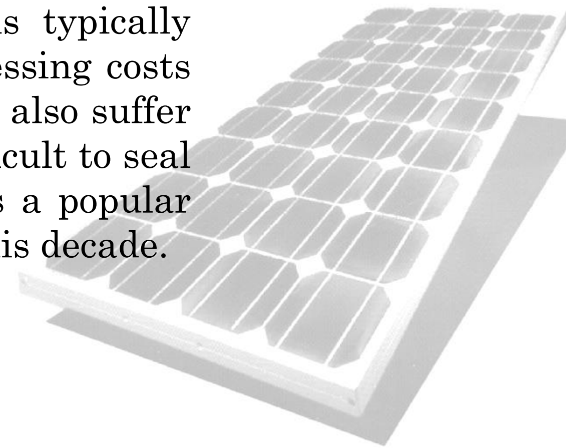
Light-absorbing Dyes

Typically a ruthenium metal organic dye (Ru-centred) is used as a monolayer of light-absorbing material. The dye-sensitized solar cell (DSSC) depends on a mesoporous layer of nanoparticulate titanium dioxide to greatly amplify the surface area. The photogenerated electrons from the light-absorbing dye are passed on to the n-type TiO2, and the holes are passed to an electrolyte on the other side of the dye. The circuit is completed by a redox couple in the electrolyte, which can be liquid or solid.

This type of cell allows a more flexible use of materials, and is typically manufactured by screen printing, with the potential for lower processing costs than those used for bulk solar cells. However, the dyes in these cells also suffer from degradation under heat and UV light, and the cell casing is difficult to seal due to the solvents used in assembly. In spite of the above, this is a popular emerging technology with some commercial impact forecast within this decade.



Organic/Polymer Solar Cells

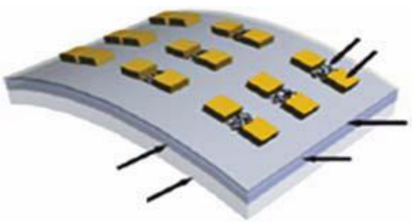
Organic solar cells and polymer solar cells are built from thin films (typically 100 nm) of organic semi-conductors such as polymers and small-molecule compounds like polyphenylene vinylene, copper phthalocyanine (a blue or green organic pigment) and carbon fullerenes. Energy conversion efficiencies achieved to date using conductive polymers are low compared to inorganic materials, with the highest reported efficiency of 6.5%7 for a tandem cell architecture. However, these cells could be beneficial for some applications where mechanical flexibility and disposability are important.

Low-cost Solar Cells

Dye-sensitized solar cells (DSSC) are considered the lowest-cost solar cells. These cells are extremely promising because they are made of low-cost materials and do not need elaborate apparatus to manufacture, so they can be made in a DIY way allowing more players to produce them than any other type of solar cell. In bulk they should be significantly less expensive than older solid-state cell designs. They can be engineered into flexible sheets. Although their conversion efficiency is less than the best thin-film cells, their price/performance ratio should be high enough to allow them to compete with fossil fuel electrical generation.

Polymer Processing

The invention of conductive polymers may lead to the development of much cheaper cells that are based on inexpensive plastics. However, all organic solar cells made to date suffer from degradation upon exposure to UV light, and hence have lifetimes which are far too short to be viable. The conjugated double-bond systems in the polymers, which carry the charge, are always susceptible to breaking up when radiated with shorter wavelengths. Additionally, most conductive polymers, being highly unsaturated and reactive, are highly sensitive to atmospheric moisture and oxidation, making commercial applications difficult.



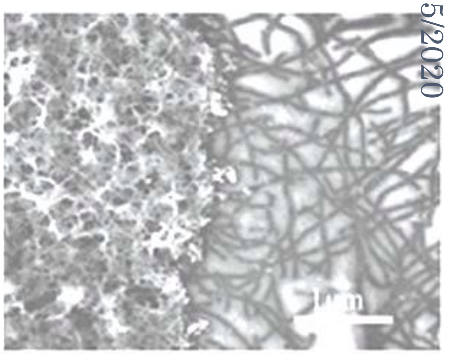
Nanoparticle Processing

Experimental non-silicon solar panels can be made of quantum heterostructures, e.g. carbon nanotubes or quantum dots, embedded in conductive polymers or mesoporous metal oxides. In addition, thin films of many of these materials on conventional silicon solar cells can increase the optical coupling efficiency into the silicon cell, thus boosting the overall efficiency. By varying the size of the quantum dots, the cells can be tuned to absorb different wavelengths.

Transparent Conductors

Many new solar cells use transparent thin films that are also conductors of electrical charge. The dominant conductive thin films used in research now are transparent conductive oxides (TCO), and include fluorine-doped tin oxide ($SnO2:F$, or FTO), doped zinc oxide (e.g. ZnO:Al) and indium tin oxide (ITO).

Maximum Power Point Tracker (MPPT)

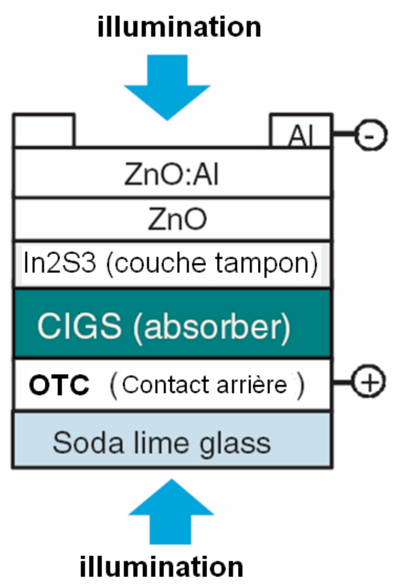


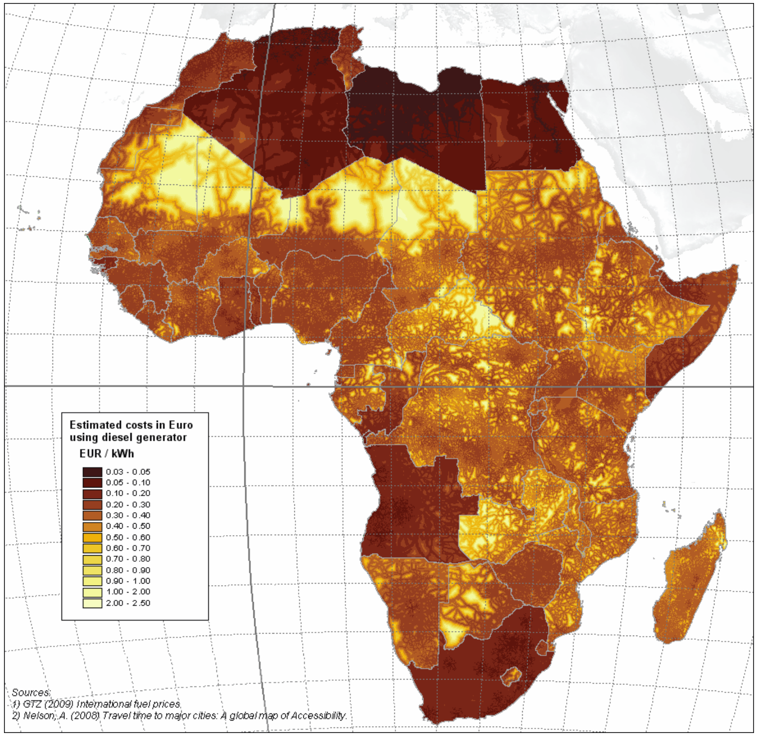
A maximum power point tracker (or MPPT) is a high-efficiency DC-to-DC converter, which functions as an optimal electrical load for a photovoltaic (PV) cell, most commonly for a solar panel or array, and converts the power to a voltage or current level which is more suitable to whatever load the system is designed to drive. PV cells have a single operating point where the values of the current (I) and Voltage (V) of the cell result in a maximum power output. These values correspond to a particular resistance, which is equal to V/I as specified by Ohm's Law. A PV cell has an exponential relationship between current and voltage, and the maximum power point (MPP) occurs at the knee of the curve, where the resistance is equal to the negative of the differential resistance. Maximum power point trackers utilize some type of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available from a cell.

MPPT is not a mechanical tracking system that 'physically moves' the modules to make them point more directly at the Sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different.

La cellule solaire de type CIGS/In_2S_3/i-ZnO/ZnO:Al a été Réalisée au sein du laboratoire.

On espère élargir ce travail à développer des cellules bifaciales pour atteindre des rendements plus importants.





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