What's The Difference Between Thin-Film And Crystalline-Silicon Solar Panels

Electronic Design
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Solar cells have been around a long time, although most of that "time" was and still is devoted to research and development. When light hits a solar cell, it generates electricity, producing the photovoltaic effect. The amount of electricity depends on a number of factors: cell material (silicon, thin-film, other), cell size (larger means more individual cells translating into either more voltage or current), and the intensity and quality of the light source. The most effective and desirable light source is the sun, which is the most available and costs nothing.

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A Brief Solar Bio

If sources bode accurate, French physicist Alexandre-Edmond Becquerel inadvertently observed the photovoltaic effect around 1839 while manipulating an electrode inside a conductive fluid exposed to light. American inventor Charles Fritts is credited with fabricating the first photovoltaic (solar) cell around 1883. His approach involved coating selenium with a thin layer of gold, creating a cell that was less than 1% efficient at best, but it worked. Of course the high cost of the materials¾selenium and gold¾put a bit of tarnish on his accomplishment.

As the story progresses, 1888 found Russian physicist Aleksandr Stoletov assembling a photoelectric cell based on a photoelectric effect discovered by Heinrich Hertz in 1887. In 1905, Albert Einstein explained the photoelectric effect. American engineer Russell Shoemaker Ohl patented the junction semiconductor solar cell in 1946 while performing research that would lead to the invention of the transistor.

Bell Laboratories gets credit for developing the first efficient photovoltaic cell in 1954. Using a diffused silicon P-N junction gave the device an efficiency boost, but not enough to get it into a cost-effective price range. Four years later, the Vanguard I satellite launched into space with its outer body covered with solar cells. The goal was to extend mission time, which was usually limited by the amount of battery run time available. Proving to be effective, solar cells were integrated into emerging satellite designs such as Bell Labs' Telstar.

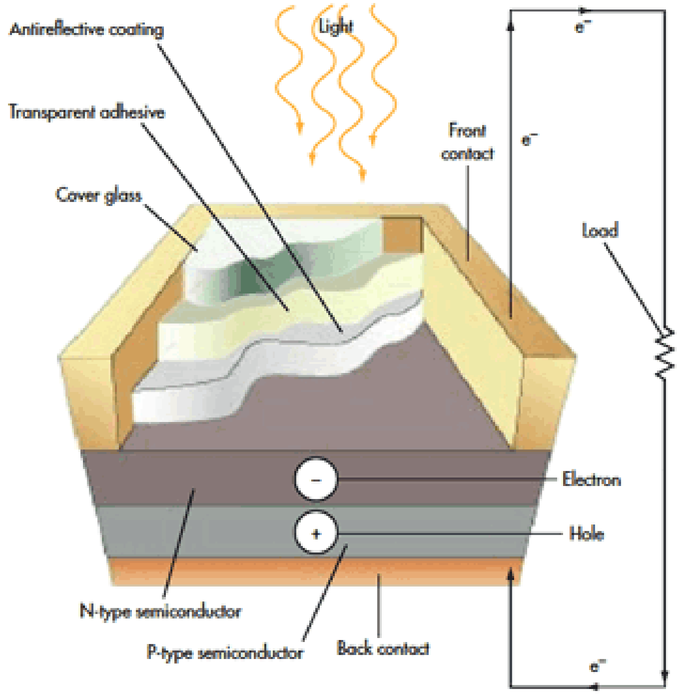
Solar-cell progress, however, was quite slow for about 20 years until Exxon's Eliot Berman made some price and efficiency breakthroughs. Around 1969, Berman first noted that solar cells were fabricated using a semiconductor manufacturing process. Rather than cut and polish silicon devices from scratch and apply antireflective coatings, he noted that the industry's scrap silicon wafers already had anti-reflective front surfaces. They only needed to be cut to size with the printed circuits applied to the anti-reflective surface.

Berman's approach eliminated two costly processes while enabling a vast recycling of scrap silicon. He realized that the silicon need not be perfect for solar apps and that the minor imperfections of discarded stock had no significant effect on its performance as a solar cell. Long story shorter, 1973 saw Berman and crew cranking out silicon solar panels at a cost of around $10/W and selling them for more than $20/W.

Crystalline-Silicon Solar Panels

Crystalline silicon (c-Si) solar cells are currently the most common solar cells in use mainly because c-Si is stable, it delivers efficiencies in the range of 15% to 25%, it relies on established process technologies with an enormous database, and, in general, it has proven to be reliable. Ironically, c-Si is a poor absorber of light and, what might be a sin in this micro-miniature age, it needs to be fairly thick and rigid.

A basic c-Si cell consists of essentially seven layers *(Fig. 1)*. A transparent adhesive holds a protective glass cover over the antirefelective coating that ensures all of the light filters through to the silicon crystalline layers. Similar to semiconductor technology, an N layer sandwiches against a P layer and the entire package is held together with two electrical contacts: positive topside and negative below.



1. One example of a crystalline silicon cell consists of seven material layers, two of which - the outer electrical contact - hold the entire package together.

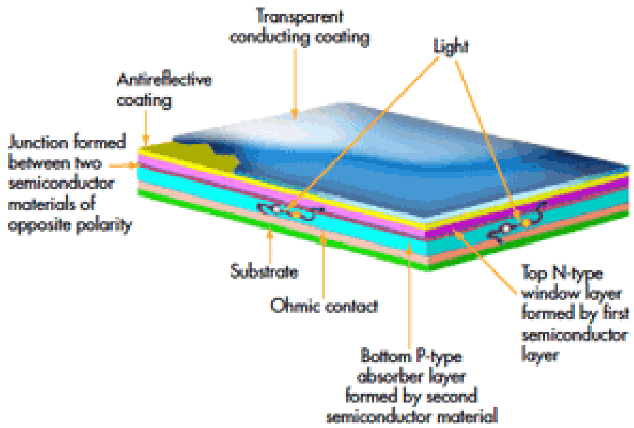
Two types of c-Si are in common use: monocrystalline and multicrystalline silicon. Cut from a high-purity single crystal, monocrystalline silicon consists of 150-mm diameter wafers measuring 200 mm thick. Despite gaining more favor, multicrystalline silicon seems more involved to make, i.e., sawing silicon blocks into bars and then wafers. In either case, one c-Si cell generates approximately 0.5 V, and multiple cells are connected in series to boost output voltage.

Thin-Film Solar Panels

Even in the form of scrap, crystalline silicon wafers are not exactly inexpensive based on the efficiency levels they achieve. Enter thin-film solar cells, which are potentially cheaper than traditional panels but less efficient, in the realm of 20% to 30% of light-to-voltage conversion.

Typical thin-film solar cells are one of four types depending on the material used: amorphous silicon (a-Si) and thin-film silicon (TF-Si); cadmium telluride (CdTe); copper indium gallium deselenide (CIS or CIGS); and dye-sensitized solar cell (DSC) plus other organic materials.

Not too different than c-Si components, thin-film solar cells consist of about six layers (*Fig. 2*). In this case, a transparent coating covers the antireflective layer. These are followed by the P- and N-type materials, followed by the contact plate and substrate. And, obviously, the operating principle (photovoltaic) is the same as c-Si cells.



2. Consisting of six layers in this case, a thin-film solar cell is not much different in construction than its c-Si counterpart and operates on the same photovoltaic principle.

One would think, and rightfully so, that with a name like thin-film cell, the component in question would be thinner and lighter than other cell technologies. Otherwise identical in function and structure, the singular difference between thin-film and c-Si solar cells is the thin and flexible pairing of layers and the photovoltaic material: either cadmium telluride (CdTe) or copper indium gallium deselenide (CIGS) instead of silicon.

Silicon Versus Thin Film

So, c-Si technology has been around a while and proven its worth and mettle, while thin film is still pretty much in its infancy but has the potential to be significantly less expensive and at least comparable in efficiency and reliability. With that said, which does one choose?

Advantages of c-Si cells include a high efficiency rate of about 12% to 24.2%, high stability, ease of fabrication, and high reliability. Longevity is another plus: c-Si modules deployed in the 1970s are still in operation, and single crystal panels can withstand the harsh conditions associated with space travel. Other benefits include high resistance to heat and lower installation costs. And, silicon is more environmentally friendly come disposal/recycling time.

On the downside, c-Si cells are the most expensive solar components in terms of initial cost. Also, they have a low absorption coefficient and are rigid and fairly fragile.

On the other side of the fence, thin-film soar cells are less expensive than older c-Si wafer cells. Available in thin wafer sheets, they are more flexible and easier to handle. They're also less susceptible to damage than their silicon rivals.

The main disadvantage of thin-film solar components is their lower efficiency, which in some applications can offset the price advantage. They also have a more complex structure. Flexible versions require unique installation skills. And, not yet at least, they aren't viable for aerospace applications.

Apps

Both c-Si and thin-film solar panels suit a wide range of similar power applications. Based on their pros and cons, you'll see more c-Si in apps requiring higher efficiency, and thin-film panels will take on more cost-effective and flexible situations.

Crystalline silicon solar panels are a common fixture in power harvesting systems as well as general utility designs *(Fig. 3)*. They also figure into unique scenarios such as the solar-powered Nuna 6 racing car built by the Dutch Nuon Solar team (*Fig. 4*).

3. Crystalline silicon solar panels primarily are used in power generating and harvesting applications, particularly where higher efficiency is necessary.

4. Extending the Nuna series of solar-powered cars, the Nuna 6 spreads 1690 monocrystalline silicon solar cells over its body. The cells work with a 21-kg Li-ion battery and deliver an efficiency of 22%.

Unveiled in July 2011, Nuna 6 is the latest in the Nuna series. Its 1690 monocrystalline silicon solar cells cover an area of 6 m2. The cells work in conjunction with a 21-kg lithium-ion (Li-ion) battery. Solar-cell efficiency in this app is specified at 22%. Overall, the car weighs 145 kg, which is significantly lighter than previous vehicles in the series.

Thin-film solar panels are also viable for outdoor, energy-garnering applications.

SoloPower of San Jose, Calif., offers a line of flexible panels for commercial rooftops using thin-film solar cells made from a combination of copper, indium, gallium, and selenium integrated on a flexible foil (*Fig. 5*). These panels are lighter than glass-encased c-Si panels and install quickly.

5. Lighter than c-Si panels, SoloPower's flexible thin-film solar panels install easily on commercial rooftops.

Semi Conclusion

There seems to be a feeling in the market that thin film will not only catch up with c-Si components, but also will surpass them on all levels, which truthfully are just cost and efficiency. One way to cut cost in thin-film solar cells is to use an environmentally unfriendly material like cadmium. The makers claim it's safe as long as it's encased and in use. As of now, however, there are no recycling plans for these components.

References

1. "Polycrystalline Silicon"
2. "Thin film solar cell"
3. "How Thin-film Solar Cells Work", by William Harris
4. "Crystalline-Silicon Solar Cells for the 21st Century", Y.S. Tsuo, T.H. Wang, and T.F. Ciszek
5. "Crystalline Silicon Solar Cells", Martin A. Green
6. "Advances in crystalline silicon solar cell technology for industrial mass production," Tatsuo Saga
7. "Thin Film Solar vs. Crystalline Solar Panels - home applications", Betsy Ferris Wyman, et al.
8. "GE places solar bets on thin-film cells", Martin LaMonica