Know your PV cells

It pays to know the strengths and weaknesses of mainstream photovoltaic technologies in commercial use.

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In 1839, French scientist Alexandre-Edmond Becquerel noticed that certain metals produced electric current when illuminated with sunlight. When a photon of sufficient energy (greater than the band gap energy) strikes an electron, the electron is elevated from the valence band to the conduction band, and when connected in a circuit, the electron/hole pair flows, creating an electrical current. PV (photovoltaic) cells, of course, use this effect to produce energy.

There are four PV technologies widely available. And many emerging PV technologies currently are under development. But the most common PV cell technology is known as crystalline silicon. According to the analyst firm iSuppli, crystalline silicon comprised 86% of worldwide PV cells sold in 2008.

For monocrystalline PV cells, a pure silicon crystal boule is used; multi or polycrystalline PV cells are formed from cast ingots created from molten silicon which is carefully cooled. The boule or ingot is sawed into thin wafers, into which impurities are injected to create p-n junctions.

In contrast to the crystalline process, amorphous silicon PV cells are created by depositing a thin layer of silicon onto a base material using plasma-enhanced chemical vapor deposition. The base material can be glass or even plastic —- creating the possibility of flexible cells. The resulting PV cell is dramatically thinner and lighter than crystalline PV and uses significantly less raw material. PV cells created using this and similar processes are known as thin-film PV.

Not all thin-film PV cells are based on silicon. One such device is the CIGS (cadmium indium gallium selenide) cell. CIGS PV cells can be deposited on thin flexible rolls of aluminum or plastic — as well as on glass, similar to traditional PV cells.

Cadmium telluride (CdTe) is another technology used to create thin-film PV cells. High temperatures are required to make CdTe thin films, so glass is the most commonly used substrate.

Each PV technology has a number of special physical and performance qualities. Crystalline PV cells have the highest efficiencies, leading to the smallest panel sizes. Note that while amorphous silicon generates usable energy at light levels lower than those needed by other technologies, amorphous panels also have much lower efficiency, so they are deployed in larger panels. In addition, amorphous silicon exhibits what is known as the Staebler-Wronski effect. In a feature somewhat ironic for a PV cell, amorphous silicon suffers a permanent drop in conversion efficiency when exposed to intense light (like sunlight).

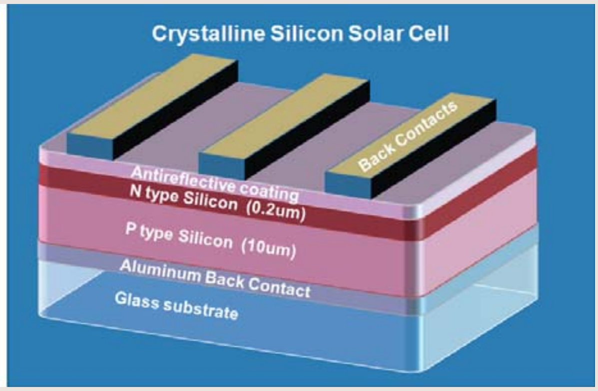
A notable quality of PV cells is that their efficiencies change with temperature. In general, all cells have negative temperature coefficients — they produce less power as temperature rises. Because of a relatively large temperature coefficient, crystalline silicon cells put out less energy when they're hot.

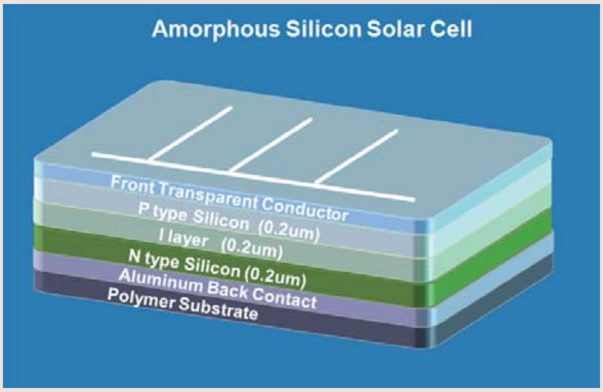
Each PV technology has a region of peak sensitivity within the light spectrum. This sensitivity has implications when choosing PV cells. Is the application likely to be in the sun most of the time? Or, does the application need to generate power when cloudy or in low light? Amorphous silicon has the highest sensitivity to the ultraviolet end of the spectrum (< 400 nm), which predominates on cloudy days.

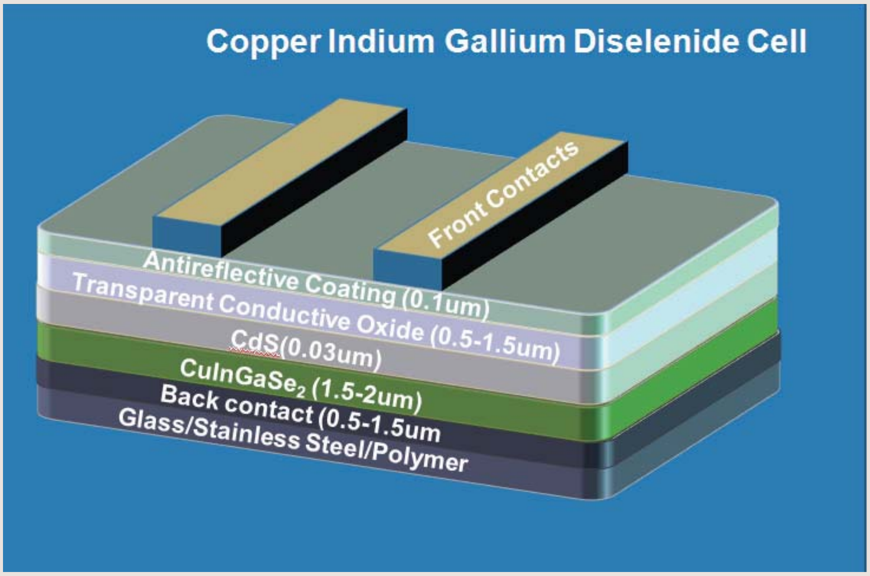
What does all this mean for solar

PV TECHNOLOGY COMPARISONS

	Module Conversion Efficiency	Temperature Coefficient	Diffused/Low Light	Degradation due to light	Flexible	Cost
Crystalline Silicon	14-18%	Highest				Higher
Amorphous Silicon	8%	Lowest	Good	Degrades in intense light	Yes	Low
CIGS	11%	High	Good		Yes	Low
CdTe	10%	Low				Lowest







(Above) Construction differences for crystalline and amorphous silicon cells and for CIGS and CdTe cells become evident from their cross sections.

Different PV technologies have different spectral sensitivities. However, some cell technologies still in the research phase may demonstrate sensitivities unlike those shown here.

power applications? Historically, crystalline silicon has been the dominant player in PV applications. It will continue to be strong because of availability, performance and efficiency, not only in utility and residential grid-tied power applications, but in off-grid applications as well. Similarly, crystalline silicon will likely be best for space-limited applications because of its high efficiency.

CdTe is interesting because of its low manufacturing cost and moderate efficiency. However, it likely will remain centered in utility scale installations in the near term. The perception of environmental issues related to the inclusion of cadmium (a toxic metal) may limit its use in residential settings. CdTe PV panel companies have instituted aggressive recycling programs to manage the environmental impact of using cadmium. And they will continue to expand recycling programs as production panels are decommissioned.

Amorphous silicon or CIGS cells are likely to be best for applications that must be light or which must take an unusual shape. Because CIGS PV cells can be deposited on flexible substrates such as thin sheets of metal, they are increasingly adopted in building integrated photovoltaics (BIPV), and can be found in new roofing materials.

Examples of thin and lightweight amorphous silicon PV cells are those from Powerfilm Solar. In Powerfilm's manufacturing process, amorphous silicon cells are deposited on a plastic substrate in an inexpensive, roll-to-roll process similar to printing processes. This makes possible a flexible cell array which can attach to any number of materials, including cloth. Pre-cut modules are available for a variety of applications. ■

More info

More information on research and development in the PV field can be found on the NREL (National Renewable Energy Lab) website at http://www.nrel.gov/pv/research_development.html. For additional information and data sheets on Powerfilm Solar PV cells and other solar-related products, visit http://www.em.avnet.com/solar.

Our regular columnist Cary Eskow is on vacation this issue. Look for Cary in the January/February issue of EE&T.