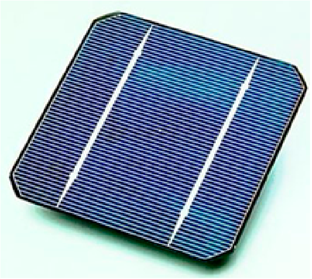
Crystalline Silicon (~200 µm)

A double layer antireflection coating is used to reduce reflection losses on the front surface of crystalline silicon wafers. The wafers are typically about 400 µm thick to ensure near complete absorption of all photons having energy greater than the band gap. At the bottom of the wafer, a SiO_2 layer is inserted between the wafer and the aluminum backing to achieve reflectance back toward the cell.

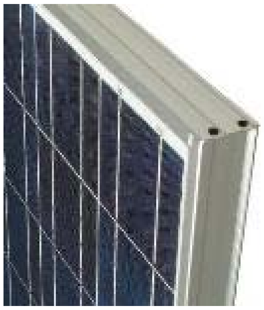
Single- or Mono-Crystalline Si

The semiconductors of many photovoltaic (PV) solar cells are made from single-crystalline Si. Manufacturing of mono- crystalline silicon requires that highly purified silicon be crystallized into ingots. These ingots are then sliced into thin wafers which are used to make an individual PV cells that are strung together in a single PV module. Solar modules commonly contain 48, 60 or even 72 individual cells, generating ~28 to 43 volts DC output. Where available real estate is limited, energy production needs to be maximized, and cost is a less critical factor, modules made of mono-crystalline Si cells often are the best choice



Polycrystalline Si

Polycrystalline Si cells are produced utilizing a method very similar to that used to create mono- crystalline cells. The primary difference is that the process uses silicon of a lower level of purity when making polycrystalline cells. The result is an increase in production efficiency and reduced unit cost, but at the cost of a small loss in cell efficiency. Modules composed of poly-silicon cells are very popular due to their low cost relative to their energy production capacity. Where cost needs to be balanced as a parameter along with energy production capability, Poly-Si based modules are often the best candidate.



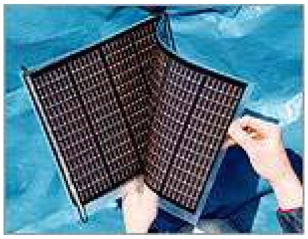
Ribbon Si

Ribbon type PV cells are produced in a similar fashion to single- and polycrystalline silicon cells. The primary difference is that a ribbon is grown from molten silicon instead of an ingot. These cells often have a prismatic rainbow-like visual appearance due to their anti-reflective coating. These cells have lower efficiencies than poly-Si, but often can be produced at lower cost due to a great reduction in silicon waste, as the manufacturing approach does not require sawing the Si wafers from ingots. Currently few ribbon-Si-based modules are available on the market at competitive cost per production capability.

Thin film (~5 µm)

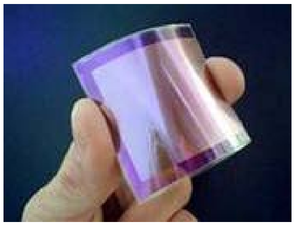
Thin film semiconductor technology isn't as efficient as traditional (crystalline-silicon) semiconductor technology, but its light weight and lower cost make it an ideal solution for certain applications, such as *building-integrated* solar, of particular interest in commercial construction. Due to the lower efficiency of thin-film devices relative to crystalline-silicon, they typically don't make economical sense for installation where system real estate is limited and production optimization from that space is desired. One advantage of most thin-film technologies is their ability to absorb both direct and incident solar radiation, versus crystalline-silicon cells, which can only convert direct radiation into electrical energy. Thus, thin film cells can produce even on cloudy days when traditional-technology-based modules receive little direct insolation (solar radiation). Thin-firm application is more logical where very large areas are available for installation and/or where minimizing system weight is a critical objective. As this technology matures, we may see its application in more scenarios. Here are details of several types of thin film technologies that are in production and/or in development for use in PV solar applications:

Amorphous Si



Unlike crystalline semiconductors, which have a band gap of 1.1 eV, by manipulating the alloy of amorphous silicon semiconductors the band gap energy can be tuned to between 1.1 eV and 1.75 eV. Additionally, because they have a much greater absorptance than crystalline silicon, amorphous silicon semiconductors can be sliced much thinner (less than 1 µm) and still be effective. Although amorphous Si cells can be manufactured at low temperatures (200-500 C) and at low costs, a major drawback in their use is their light induced degradation.

Cadmium Telluride (TeCd)



Cadmium Telluride is a thin film technology that's been available longer and has undergone more research than any other thin film technology. Although there are diverse manufacturing techniques that can be used to produce these films, many of which are promising for large scale production, currently the cost and potential health concerns remain as drawbacks for broad-scale utilization this technology.

Copper Indium Gallium Diselenide Solar Cells (CIS Cu In Se2) (CIGS Cu(In Ga) Se2)

Due to its relatively high efficiency and low material cost, CIGS technology has emerged as one of the most promising thin films. By adjusting the ratio of In to Ga in CIGS cells, the band gap can be tuned between 1.02 eV and 1.68 eV. The absorption elements of CIGS cells are incredibly high, allowing more than 99% of incoming radiation to be absorbed within the first µm of material. Although this technology has a relatively low material cost, the complicated and capital intensive manufacturing methods remain as significant drawbacks to wide-scale commercialization.

Micro Si

Micro silicon cells are expected to surpass the efficiency and performance of amorphous silicon cells and become an effective competitor with other thin film technologies. The high efficiency and negligible degradation of Micro Si cells has been widely reported. This technology will be one to watch.

Titanium dioxide (TiD)

Instead of the traditional range of semiconducting materials used in most cells, TiD cells use a dye-impregnated layer of titanium dioxide to generate voltage when struck by solar radiation. Because of its relatively low cost, TiD/TiO technology has the potential to significantly reduce the cost of solar cells. This is another technology to watch over time.