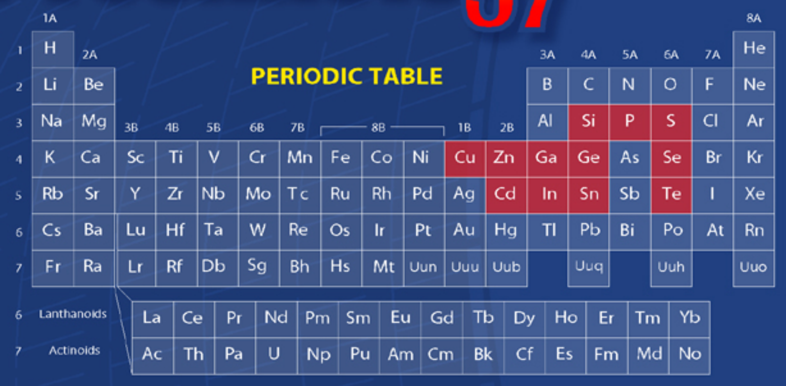
#7

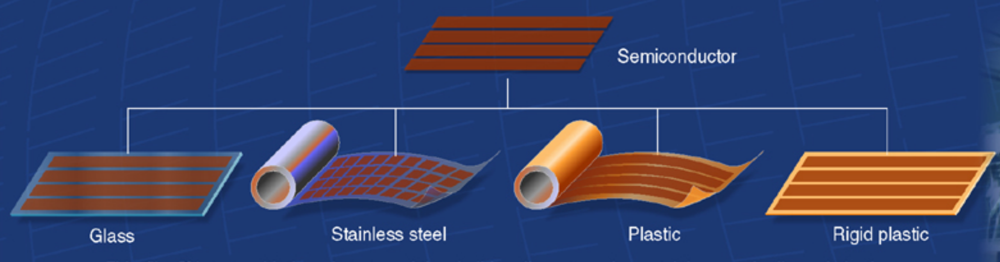
Thin-Film Technology

Thin-film modules differ from conventional silicon modules because they may use a variety of semiconductor materials deposited in thin layers on a substrate. While silicon modules start with silicon and build modules around it, thin-film PV modules start with a substrate—stainless steel, glass, plastic—and deposit the semiconductor onto it.

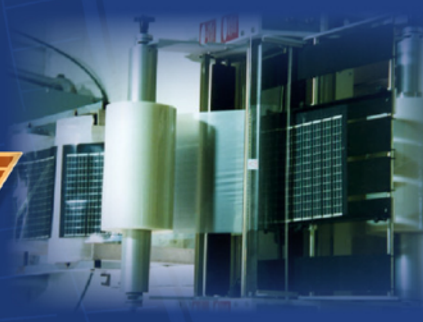


Below is a basic outline of some of the options in thin-film manufacture. The displays to the right detail some of the unique approaches that different companies use.

SUBSTRATE



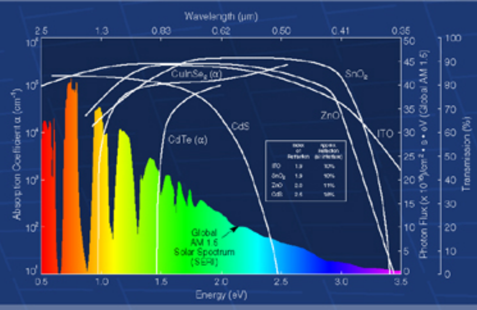
Thin-film PV starts with the substrate and then builds cells on top; glass, stainless-steel rolls, and plastic are all potential substrates, depending on the target application and the semiconductor that will be used.



Thin-film PV may be produced through conventional batch processing, in which one module is processed at a time, or through continuous sheet or roll-to-roll processing, in which module components are manufactured continuously.

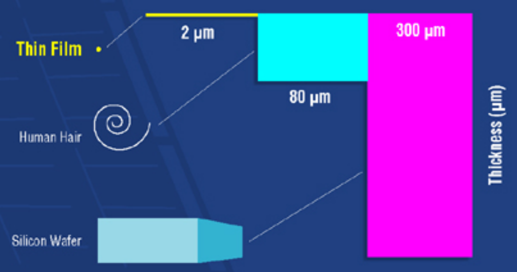
SEMICONDUCTOR MATERIALS

Thin-film technologies may use a variety of semiconductors. Different semiconductors have different bandgaps, meaning they capture different parts of the solar spectrum.



Comparison of Proportional Thickness

Thin-film PV is a good solution because it requires less material—a fraction of the width of a human hair—to capture the same amount of light as silicon.



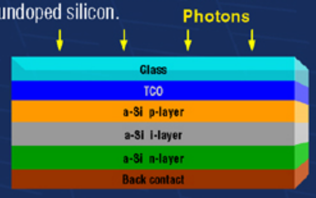
STRUCTURE

Thin-film PV has a variety of structures, depending on the type of semi-conductor chosen and the end product being made.

The common element of all of these structures is that they have junctions between one or more n-type and p-type layers. (See "PV Basics" poster at far left for more information.)

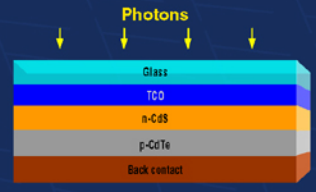
1 Amorphous Silicon (a-Si)

Uses layers of doped and undoped silicon to create multiple p/n junctions. This is called a p-i-n structure, in which 'i' is intrinsic, undoped silicon.



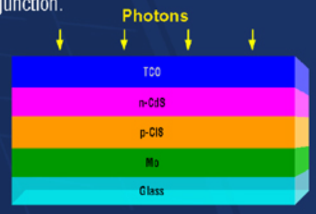
2 Cadmium Telluride (CdTe)

Uses semiconductors that are naturally p-type or n-type to create a single p/n junction.



3 Copper Indium Diselenide (CIS)

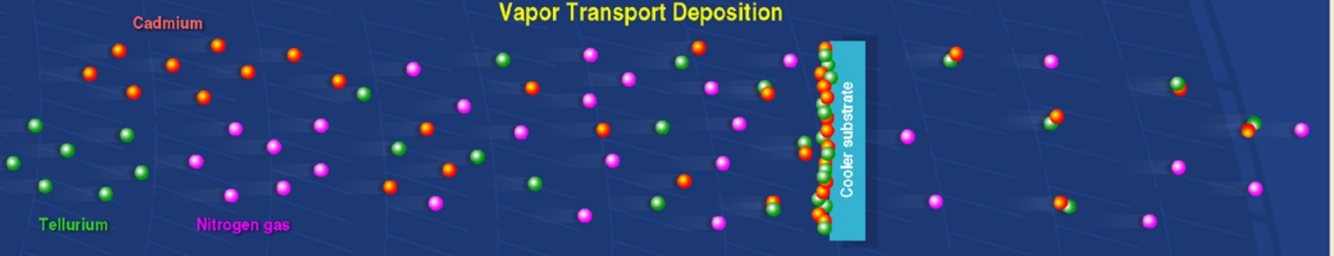
Uses semiconductors that are naturally p-type or n-type to create a single p/n junction.



DEPOSITION

The semiconductor layer can be deposited onto a low-cost substrate through evaporation, sublimation, spraying, sputtering, electrodeposition, vapor transport, or chemical vapor transport. Vapor transport, a method used to deposit cadmium telluride thin-film, is shown to the right.

Vapor Transport Deposition

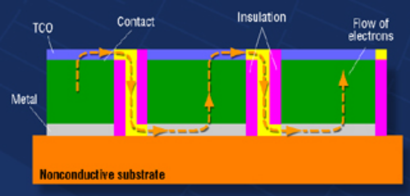


Hot nitrogen 'carrier' gas flows into chamber with cadmium and tellurium vapors | The cadmium and tellurium atoms combine with each other | The compound adheres to the cooler substrate, creating the cadmium telluride layer | Carrier gas and some wasted source material are exhausted

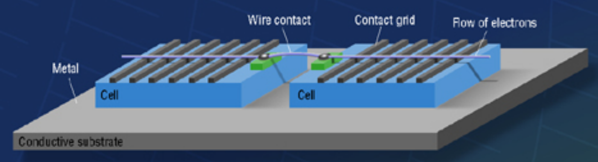
INTERCONNECTION

As with crystalline silicon technology, thin-film technologies must gather and funnel the electricity from the semiconductor material. Thin-film technologies can do this in two ways.

1 The method that is most often used to interconnect cells is to scribe the PV material into strips, and then reconnect them top to bottom.



2 The second method is to connect separate gridded cells. This is the same way that crystalline silicon wafers are connected. Companies that use this method include Global Solar Energy and Uni-Solar, which use a metal substrate.



ASSEMBLY

The conductive "bus" contacts, which connect the electrical circuit to the external wires, are applied.

Finally, the module is finished according to the requirements of the end product being created. The thin-film material may be laminated, cut, shaped, or even sewn into fabrics.

The goal for thin films is inexpensive PV electricity on a grand scale.

ADD SAMPLE MODULES