Different types of solar cell

There are three main types of solar cell, which may be distinguished by the type of crystal used in them. These are monocrystalline, polycrystalline, and amorphous. To produce monocrystalline silicon cell, absolutely pure semi conducting material is necessary. Monocrystalline rods are extracted from melted silicon and then sawed into thin plates. This production process guarantees a relatively high level of efficiency.

Material	**Efficiency in lab (%)**	**Efficiency of production cell (%)**
Monocrystalline silicon	About 24	14-17
Polycrystalline silicon	About 18	13-15
Amorphous silicon	About 13	5-7

The production of polycrystalline cells is more cost-efficient. In this process, liquid silicon is poured into blocks that are subsequently sawed into plates. During solidification of the material, crystal structures of varying sizes are formed, at whose borders defects emerge. As a result of this crystal defect, the polycrystalline solar cell is less efficient.

If a thin film is deposited on glass or another substrate material, the result is a so-called amorphous or thin-layer cell. The layer thickness amounts to less than 1μm – the thickness of a human hair for comparison is 50-100μm. The production costs of this type are low because of the lower material costs. However, the efficiency of amorphous cells is much lower than that of the other two cell types. As a result, they are used mainly in low power equipment, such as watches and pocket calculators, or as façade elements.

Based on number of junction

(a) Single junction solar cell
(b) Multi junction solar cell

Based on the type of junction used

(a) Homo junction solar cell
(b) Hetero junction solar cell
© Pin/Nip solar cell
(d) Schottky barrier solar cell
(e) MIS/SIS solar cell

Hetero junction solar cell

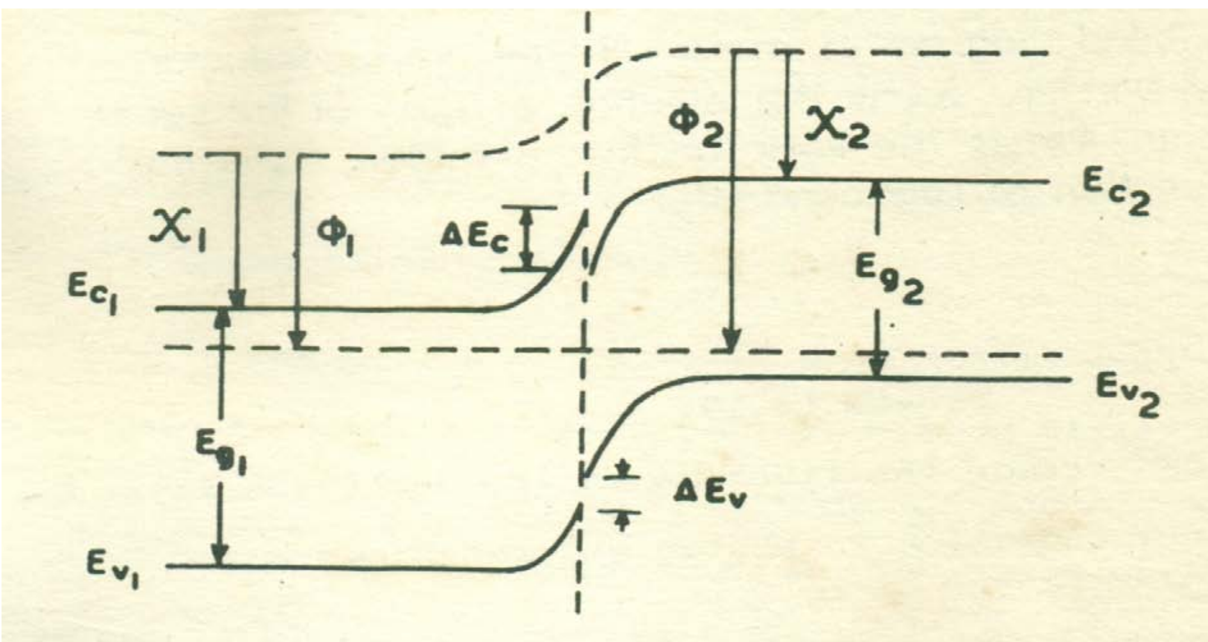
Hetero junctions are formed between two semiconductors. Conductors with different energy band gaps. This type of solar cell can make better use of the solar spectrum by having different semiconductor layers with different band gaps. Each layer is made of different material which absorbs a different portion of the spectrum.
The top layer has the larger band gap so that only the most energetic photons are absorbed in this layer. Less energetic photons pass through the top layer since they are not energetic enough to generate EHPs in the material of this layer. Lower layer has smaller band gap than the above layer. Therefore, lower layer absorbs the photons that have energies greater than the band gap of that layer and less than the band gap of the higher layer. In this way better utilization solar spectrum can be made and efficiency can be increased.

In a similar manner multi-junction solar cells can be prepared to utilize the full solar spectrum and increased efficiency.

A typical n-on-p hetero junction band diagram in thermal equilibrium is shown in the figure below.

E_g1	$h\upsilon_1$
E_g2	$h\upsilon_2$

$E_{g1} > E_{g2}$



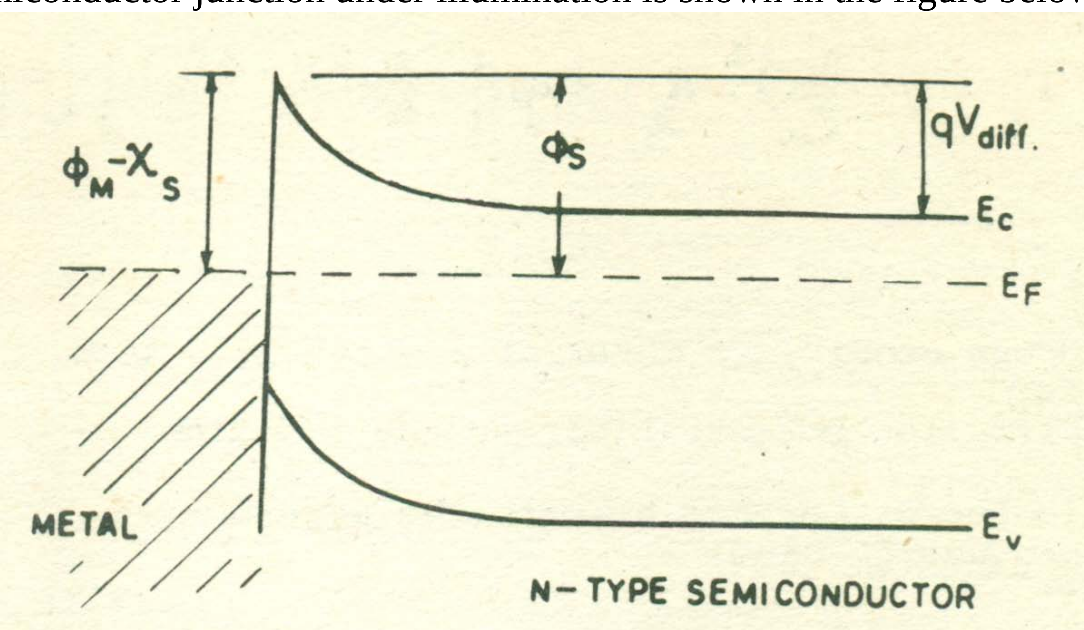
Light with energy less than E_{g1} but greater than E_{g2} will pass through the first layer of the junction. This layer acts as a window, and will be absorbed by the second layer. Carriers created in the depletion region and within a diffusion length of the junction will be collected similar to an n-p homo junction solar cell. Light with energy greater than E_{g1} will be absorbed by the first semiconductor and carriers generated within a diffusion length from the junction or in depletion region will also be collected.

<u>Advantages of hetero- junction solar cell.</u>

1. Enhances short-wavelength spectral response
2. Lower series resistance, if first semiconductor is heavily doped without affecting its light transmitting characteristics.
3. High radiation tolerance, if first semiconductor is thick in addition to being high in band gap.

A Schottky Barrier Solar Cell

A Schottky type metal semiconductor junction has been utilized to separate the photo generated carriers. The schematic energy band diagram of a metal-n-semiconductor junction under illumination is shown in the figure below.



The metal is deposited as semitransparent film through which most of the light can pass. There are three photocurrent components.

(a) Light with energy $h\upsilon \geq q\varphi_b$ is absorbed in the metal and excite

electrons over the metal into the semiconductor.
(b) Light transmitted through the metal into the semiconductor is mainly absorbed in the depletion region creating electron hole pairs.
(c) Longer wavelength light is absorbed in the neutral region and the holes diffuse to the depletion edge to be collected.

The first component of photocurrent is negligibly small. The current voltage characteristics of the Schottky barrier is similar the p-n junction and is given by

$$I = I_s \,[\exp(qV/ k_BT) - 1] - I_{ph}$$

Where

$$I_s = AT^2 \exp(- q\varphi_b/ k_BT)$$

The main advantage of Schottky barrier cell over a junction diode cell are:

(a) Possibility of low temperature processing.
(b) Use of polycrystalline materials.
© The presence of the depletion region very near the surface reduces the effect of high surface recombination velocity and improve the spectralresponse characteristics.

A thin oxide layer is usually present between the metal and semiconductor. This thin oxide layer controls the junction performance. The device is also known as metal insulator semiconductor (MIS) solar cell.

Thin Film Solar Cell

A **thin-film solar cell** (TFSC), also called a **thin-film photovoltaic cell** (TFPV), is a solar cell that is made by depositing one or more thin layers (thin film) of photovoltaic material on a substrate. The thickness range of such a layer is wide and varies from a few nanometers to tens of micrometers.

Many different photovoltaic materials are deposited with various deposition methods on a variety of substrates. Thin-film solar cells are usually categorized according to the photovoltaic material used:

- Amorphous silicon (a-Si) and other thin-film silicon (TF-Si)
- Cadmium Telluride (CdTe)
- Copper indium gallium selenide(CIS or CIGS)
- Dye- sensitized solar cell (DSC) and other organic solar cells

Thin-film deposition

Several different deposition techniques can be used, and all of them are potentially less expensive than the ingot-growth techniques required for crystalline silicon. They can be broadly classified as:

- Physical vapor deposition,
- Chemical vapor deposition,
- Electrochemical deposition or a combination.

Like amorphous silicon, the layers can be deposited on various low-cost substrates (or''Superstrates") such as glass, stainless steel, or plastic in virtually any shape.

In addition, these deposition processes can be scaled up easily, which means that the same technique used to make a 2-foot x 5-foot PV module- in a sense, its just one huge PV cell. Thin films are unlike single- crystal silicon cells, which must be individually interconnected into a module. In contrast, thin-film devices can be made as a single unit- that is, monolithically-with layer upon layer being deposited sequentially on some substrate, including deposition of an antireflection coating and transparent conducting oxide.

Thin-film cell structure

Unlike most single-crystal cells, a typical thin-film device doesn't have a metal grid for the top electrical contact. Instead, it uses a thin layer of a transparent conducting oxide, such as tin oxide. These oxides are highly transparent and conduct electricity very well. A separate antireflection coating might top off the device, unless the transparent conducting oxide serves that function.

THIN-FILM SOLAR CELLS 75

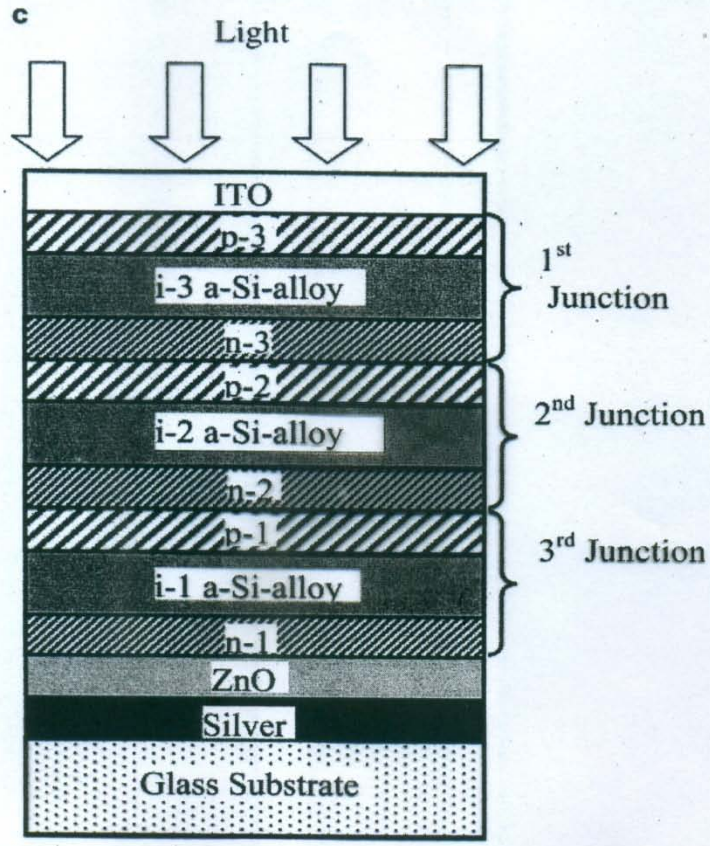


Figure 3. Continued

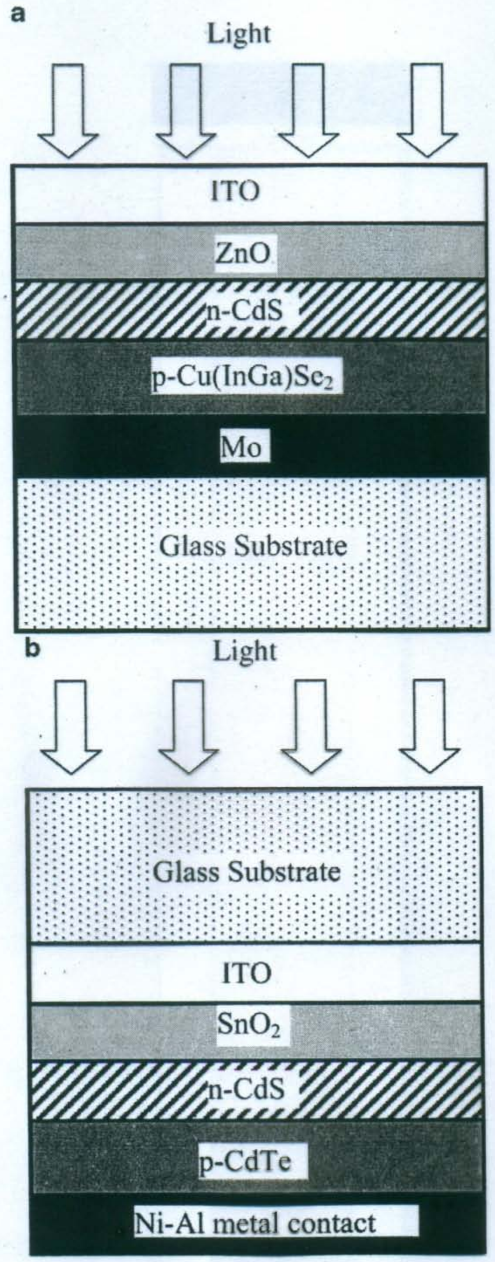


Figure 3. Typical TFSC structures for single-junction: (a) substrate $Cu(InGa)Se_2$; (b) superstrate CdTe; and (c) tandem a-Si triple-junction devices

