# Solar cell types and efficiency

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The most recent world record for each technology is highlighted along the right edge in a flag that contains the efficiency and the symbol of the technology. The company or group that fabricated the device for each most-recent record is bolded on the plot.

Unlike batteries, solar systems do not use chemical reactions, nor do they require fuel. In addition, solar cells don’t have moving parts like electric generators. Domestic solar systems convert around 20% of the sunlight the receive into electricity, while more expensive commercial systems can convert up to 40%. However, with technological advances the solar efficiency of these panels is expected to rise.

The largest formation of solar cells are called arrays, which are made up of thousands of individual cells and can be put together into solar farms to convert sunlight into power for large scale commercial, industrial and residential use.

On the smallest level, solar cells are used in many consumer products, including toys, calculators and radios. These solar cells can also use artificial light as well as sunlight for power.

TWI is part of this collaborative, EC-funded project to develop innovative manufacturing processes and in-line monitoring techniques for solar panels and optoelectronic devices. The aim of the project is to improve the quality and yield of fabricated devices as well as improving processing efficiency and sustainability. Automated processing software controls roll-to-roll and sheet-to-sheet manufacture, as new recycling strategies reduce product waste costs. Sensors monitor the process to provide quality control, inspection and functional testing.

All solar cells have the same basic structure. Light enters the system via an optical coating or antireflection layer that minimises the amount of light lost by reflection. This traps the light and promotes its transmission to the energy conversion layers below. This top antireflection layer is typically an oxide of silicon, tantalum or titanium and is formed by spin-coating or vacuum deposition.

Below the top antireflection layer are three energy conversion layers. These are the top junction layer, the absorber layer and the back junction layer. There are also two additional electrical contact layers to carry the electric current to an external load and then back to the cell to complete the electric circuit.

The top electrical contact layer on the surface of the cell uses a grid pattern composed of a good conductor material such as metal. However, since metal blocks light, the grid lines are thin and widely spaced to allow light through while also allowing the collection of the electrical current. The back electrical contact layer has no such restrictions and is usually made solely of metal.

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To maintain high efficiency, a solar cell absorber needs to be able to absorb electromagnetic radiation at the wavelengths of visible light. Materials able to absorb this visible radiation are called semiconductors and can manage this at thicknesses of just one-hundredth of a centimetre or less. The junction forming and contact layers are even thinner, meaning that the thickness of a solar cell is basically that of the absorber. Semiconductor materials used in solar cells include copper indium selenide, gallium arsenide, indium phosphide and silicon.

Since solar cells cannot produce power in darkness, they store some of the energy so it can be used when light is not available. This can be by charging electrochemical storage batteries and is similar to the process of photosynthesis in plants.

Solar cells can be divided into three broad types, crystalline silicon-based, thin-film solar cells, and a newer development that is a mixture of the other two.

Around 90% of solar cells are made from crystalline silicon (c-Si) wafers which are sliced from large ingots grown in laboratories. These ingots take up to a month to grow and can take the form of single or multiple crystals. Single crystals are used to create monocrystalline solar panels and cells (mono-Si), while multiple crystals are used for polycrystalline panels and cells (multi-Si or poly c-Si).

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