Periodic Graphics

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

More online

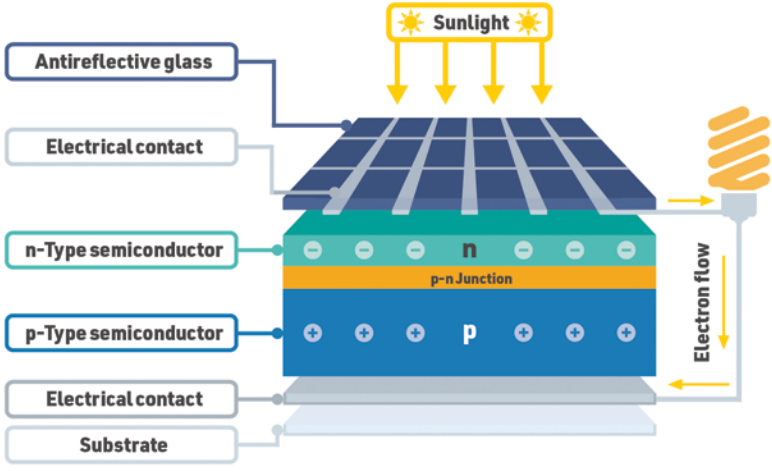
To see more of Brunning's work, go to **compoundchem.com.** To see all of C&EN's Periodic Graphics, visit **cenm.ag/periodicgraphics.**

HOW DO SOLAR PANELS WORK?

The climate crisis has the world looking to renewable energy sources as one option to take the place of fossil fuels. This graphic explains how solar panels work and the materials used to make them.

INSIDE A SOLAR PANEL

A typical solar panel consists of two silicon semiconductor layers. Boron is added to one layer (p type) to produce positively charged holes, which are vacancies in the structure where an electron could sit. Phosphorus is added to the other layer (n type) to create an excess of electrons. When the sun shines on the solar panel, the light releases electrons and creates additional holes in these layers. Where the two layers touch, the p-n junction, an electric field stops electrons and holes from moving between the layers. But when the layers are connected in a circuit, the electric field pushes electrons through the circuit, creating a current.



CURRENT SOLAR PANEL MATERIALS

Silicon is the most commonly used material for solar panels and is also currently the most efficient.

Si	CdTe	CIGS
95% of market	4% of market	1% of market

Source: Fraunhofer Institute for Solar Energy Systems ISE.
Note: Figures are for 2020.

Cadmium telluride (CdTe) and copper indium gallium selenide (CIGS) are both thin-film technologies. Neither material is as efficient as silicon, though CdTe cells are cheaper to manufacture. Both CdTe and CIGS contain scarce elements, tellurium and indium.

THE FUTURE OF SOLAR PANELS?

Perovskite solar cells

ABX_3

Methylammonium lead trihalides
Formamidinium lead trihalides

Perovskite solar cells are cheap to make and have shown increasing efficiencies in recent years. But they tend to be unstable, limiting commercial uses. The presence of lead in the cells could also create disposal problems.

Organic solar cells

Polymer solar cells

Polymer electron donor | **Small-molecule electron acceptor**

The most-studied organic cells pair polymer electron donors with acceptor molecules. They are lightweight and low cost but not as efficient as current commercial cells. Like perovskites, their long-term stability remains an issue.

PERIODIC GRAPHICS