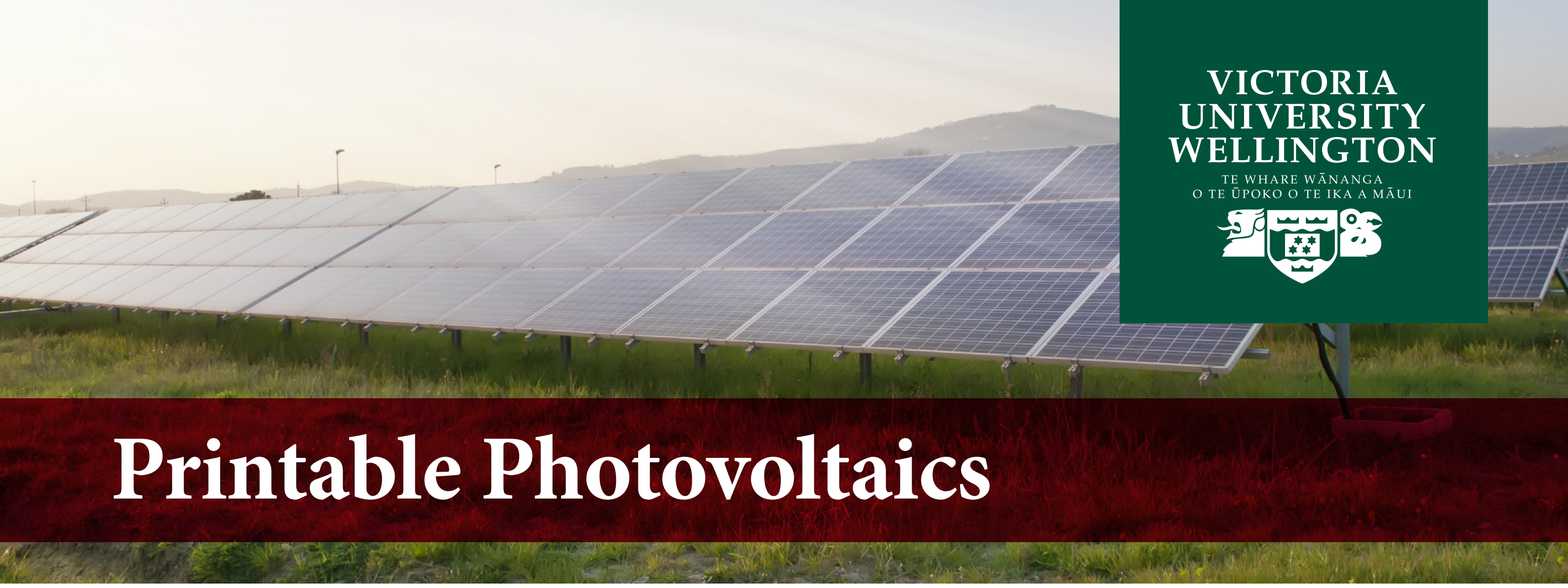


VICTORIA UNIVERSITY WELLINGTON
TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

Printable Photovoltaics

WHO?

The Ultrafast Laser Spectroscopy Research Group at Victoria University of Wellington, led by Professor Justin Hodgkiss.

WHAT ARE THEY INVESTIGATING?

Organic, printable, solar cells.

HOW DOES A TRADITIONAL SOLAR CELL WORK?

Traditional solar cells are based on crystalline silicon. Silicon has been an effective material for photovoltaic cells, because it's cheap, efficient, and lasts for a long time. However, silicon-based solar cells take a long time to make, and to be efficient they need to be relatively thick and rigid.

Silicon is a semiconductor. A semiconductor is a material that will only conduct electrons that are above a certain energy threshold. This comes about because of the way the atoms and electrons are arranged in the silicon crystal lattice.

When a small amount of another element is added through a process called 'doping', silicon can be turned from an 'intrinsic' semiconductor, into a semiconductor that has an excess of either positive or negative charges.

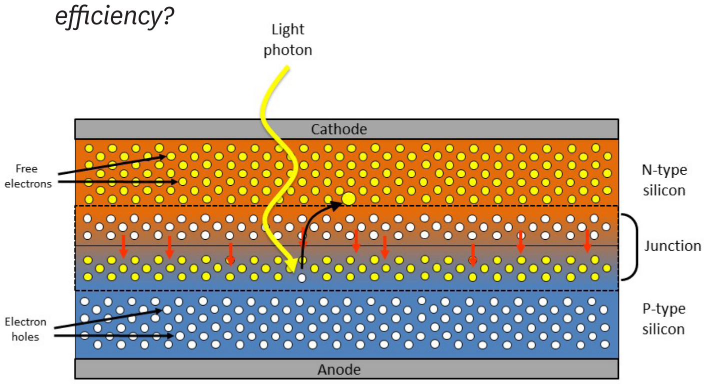
- *Which elements do you think they would dope the silicon with, and which elements would lead to p-type or n-type behaviour in the silicon?*

When silicon is doped with elements that have a greater number of electrons than silicon in their outer shell, such as phosphorus or arsenic, it creates a crystalline structure where one electron is free. Because there is an excess of electrons, this is called n-type (negative) silicon.

When silicon is doped with elements that have less electrons in their outer shell, such as boron or gallium, it creates a structure with 'holes' where one silicon electron is unpaired. As there is a deficiency of electrons, this is called p-type (positive) silicon.

When n and p type silicon are layered together, an electric field is formed at the interface of the two layers. This happens because the free electrons in the n-type silicon move between the layers to fill the holes of the p-type silicon. This makes the n-type silicon positively charged, so when electrons are energised by a photon of light, and thus free to move about the silicon, they move into the n-type silicon and create an excess of electrons. At the same time, the hole left over by the electron will move into the p-type silicon. By connecting the n-type to the p-type silicon with a conductor, a circuit can be created and a current will flow between the two layers of silicon. This is how most solar energy is generated.

- *What are the current limitations on solar cell efficiency?*



CAPITAL THINKING. GLOBALLY MINDED.
MAI I TE IHO KI TE PAE

ORGANIC SOLAR CELLS

- *What would make a solar cell organic?*

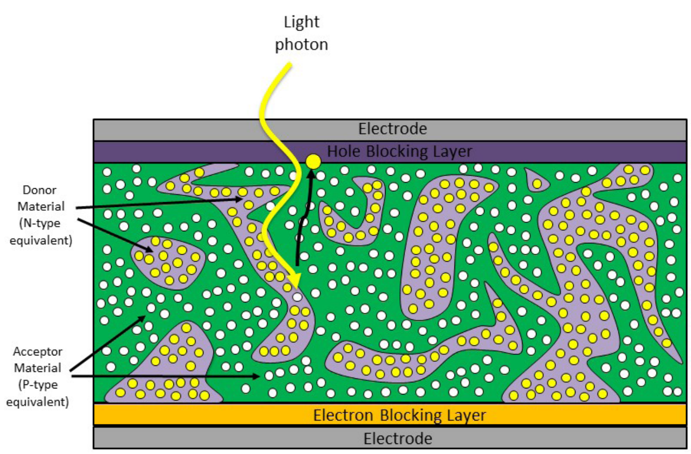
HOW DO ORGANIC SOLAR CELLS WORK?

Organic solar cells are one answer to the limitations of traditional solar panels. They use organic molecules and polymers to perform the same function as doped silicon. Because they can be made in solution in large quantities, they have low production costs and can be quickly and easily printed onto surfaces. Unfortunately, they tend to be less efficient than silicon-based solar cells, and degrade faster. However, Professor Hodgkiss' team is working on overcoming these obstacles.

Most organic solar cells use two types of organic molecules – electron donors and electron acceptors. Exactly which organic molecules are used as donors or acceptors varies a great deal, and is the subject of ongoing research.

Rather than the donors and acceptors being layered on top of each other like they are in silicon solar cells, the most common arrangement is called the 'bulk heterojunction' where the donor and acceptor materials are blended into a single layer. This is sandwiched between the electrodes, which are coated with hole-blocking and electron blocking layers.

When the molecules in an organic solar cell gain energy by absorbing light, this triggers electron transfer from the donor molecule to the acceptor. The free electrons are then channelled to the anode, and become electrical current. Whenever an electron is transferred it also creates a hole, which will be filled by an electron moving from the opposite electrode.

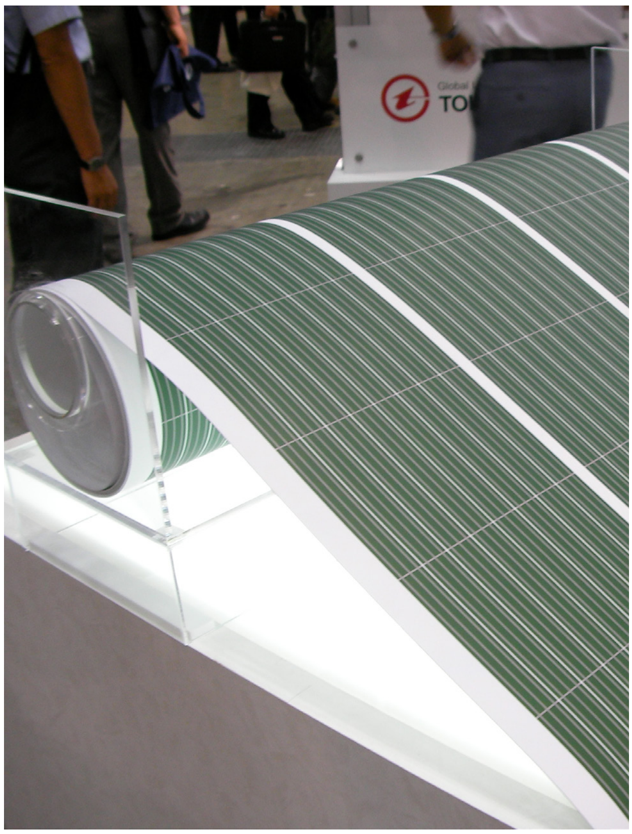


- *What do you think the purpose of the hole-blocking and electron-blocking layers is?*
- *What are some other alternative configurations for organic solar cells, and why is the bulk heterojunction design the most common?*
- *What are some common molecules used as electron donors and electron acceptors?*

A SNAPSHOT OF LIGHT

Because there are so many potential electron donors and acceptors, understanding how the different materials behave is very important to maximising the potential of organic solar cells. Professor Hodgkiss' team has developed ultrafast laser spectroscopy methods that fire light pulses as short as 30 femtoseconds. The rapid pulses give a high-resolution understanding of how the materials react to the absorption of light. This enables them to assess the effectiveness of molecules as electron donors or acceptors, and figure out the most efficient combinations for generating solar energy.

- *What would be the global implications of printable solar cells that are as efficient as the standard silicon panels?*

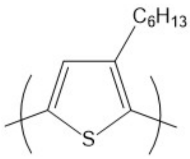


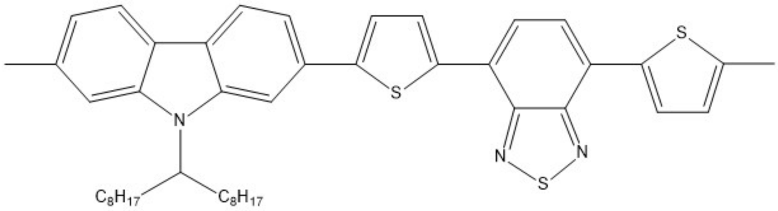
POTENTIAL ORGANIC SOLAR CELL MOLECULES

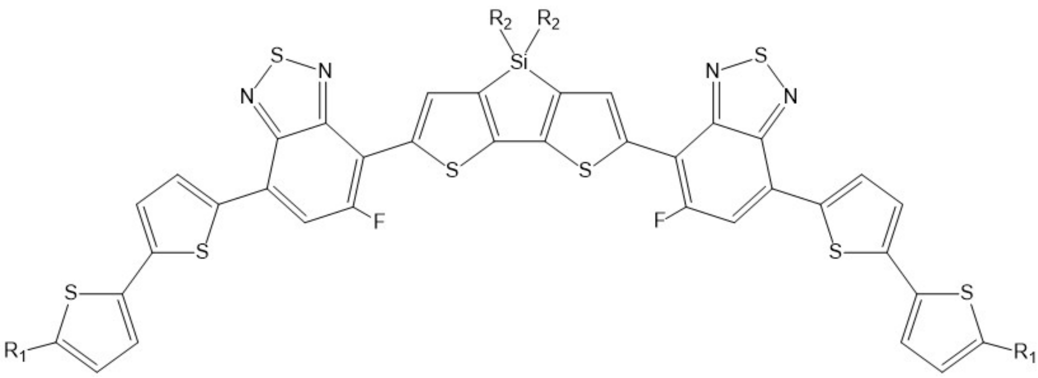
Below are a selection of common molecules used in organic solar cells.

Electron Donors

- *Are there any noticeable patterns?*
- *How many functional groups can you identify?*







Electron Acceptors

- *Are there any noticeable patterns?*
- *How many functional groups can you identify?*