Science for Environment Policy

Nanotechnology cuts costs and improves efficiency of photovoltaic cells

Researchers have summarised the most effective ways that nanostructures can improve the efficiency and lower costs of photovoltaic (PV) solar cells in a recent analysis. Sculpting ultra-thin solar cell surfaces at the nano-scale has been found to effectively boost their efficiency.

1.http://ec.europa.eu/research/e
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arch-photovoltaics-support

Making solar cells ultra-thin reduces their material costs, but often at the expense of their efficiency. These 'thin film PVs' (tfPVs) use silicon films that are between nanometres and tens of micrometres thick, whereas typical solar cells use silicon wafers around 200 micrometres thick. Silicon represents 10–20% of the cost of a solar cell, so a 100–fold reduction in silicon could significantly improve the cost-efficiency of such systems.

Most common PV systems are based on a high quality silicon crystal. When photons of light collide with electrons in the silicon, they are knocked loose, which generates an electric current. Commercial versions of such systems are currently around 22% efficient at converting sunlight into electricity.

However, tfPV systems are currently 7–13% less efficient than traditional systems. This is partly because, when PV cells become thinner, light interacts differently with their surface texture and collisions between photons and electrons are reduced (this is not an issue with thicker PVs).

The study reviews current attempts to improve 'light management' in tfPVs using nanostructures. It summarises some of the different ways that researchers are using nanostructures to boost the number of collisions between photons and electrons.

For instance, nanostructures can increase the amount of light entering a PV by reducing reflections from its surface. A polished silicon wafer reflects more than 30% of the light that it receives. Densely packed nanostructures can be used to create thin anti-reflective coatings, which work across a wide range of wavelengths and angles of light.

Varying the shape, height or width of nanostructures can alter a property called 'optical resonance'. Such structures can capture and guide light to the PV surface, or bounce light around inside the tfPV cell. This keeps light in the cell for longer, which increases the chances of colliding with an electron.

The review also explores how nanostructures can be used to 'trap light' depending on their location in a tfPV. Nanostructures on the front of the PV can guide light into the absorbing layer, or reduce reflection. Nanostructures on the back of a PV could be used as high-performance reflectors, bouncing otherwise lost light back into the PV. The light-absorbing layer itself can benefit from a sculpted nanostructure, which could change its ability to absorb light of different wavelengths, for instance. This would allow the cells to extract energy from a wider range of light wavelengths than traditional PV cells.

TfPVs also offer additional advantages, besides lower material costs. For example, they are flexible because they only use very thin silicon, whereas current non-thin-film PVs are rigid. This could make tfPVs easier to install; like paper, they could be spooled off a roll.