Next generation solar cells: Trapping sunlight with microbeads

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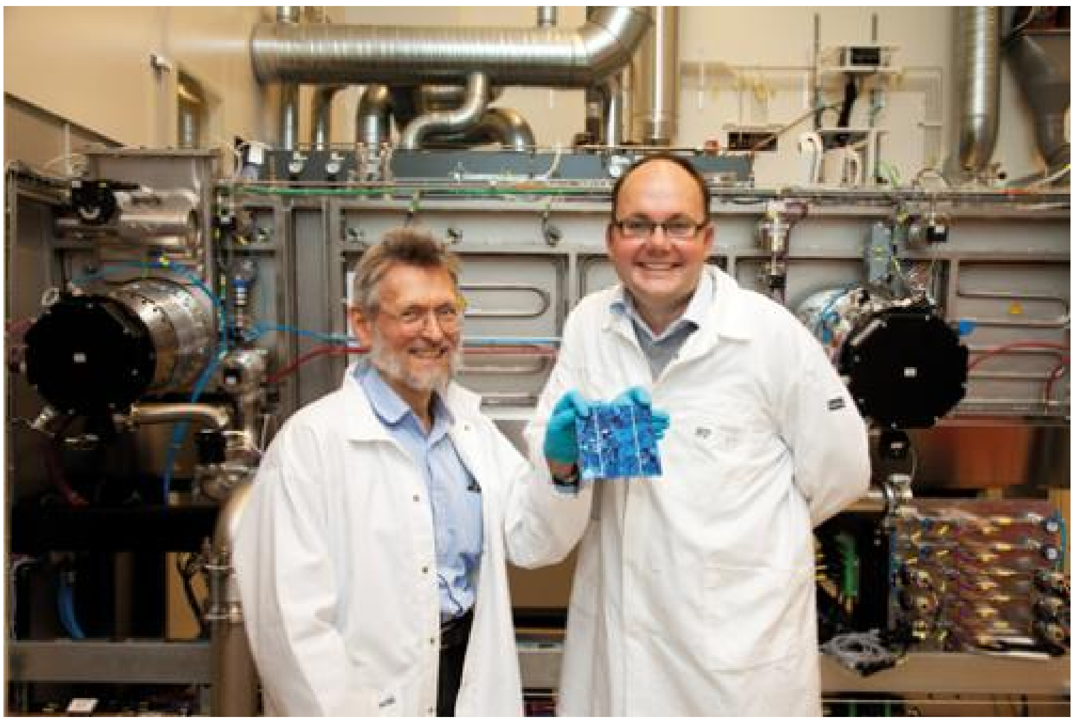

Professor Aasmund Sudbø and Head of Research Erik Marstein have used all kinds of wonderful tricks with light to reduce the thickness of solar cells by 95 per cent. Credit: Yngve Vogt

In five to seven years, solar cells will have become much cheaper and only one-twentieth as thick as current solar cells. The trick is to deceive the sunlight with microbeads.

Nanoscientists are currently developing the next generation of solar cells, which will be twenty times thinner than current solar cells.

Over 90 per cent of the current electricity generated by solar panels is made by silicon plates that are 200 micrometres thick. Several billion of these are produced every year. The problem is the large consumption of silicon: five grams per watt.

This year, between five and ten billion solar panel units will be produced worldwide. This is the equivalent of 30 GW, or the capacity of 200 Alta power stations.

Though silicon is one of the most common elements on earth, pure silicon does not exist in nature. Silicon binds readily to other elements. In order for solar cells to function, the silicon plate must consist of at minimum 99,9999 per cent silicon. You read that right: if the solar cell consists of more than one millionth other materials, it does not work.

Today, pure silicon is created in smelters at 2,000 degrees Celsius. This requires a lot of energy. Factories supply silicon in bricks the size of a piece of firewood. They are then cut into slices thin enough for solar panels. Only half become solar cells. The rest turns into sawdust.

"About 100,000 tonnes of silicon are consumed every year. However, there is obviously something fundamentally wrong when half of the silicon must be thrown away during the manufacturing process", says Erik Marstein. He is the Head of the Norwegian Research Centre for Solar Cell Technology, the Head of Research for the solar cell unit at the Institute for Energy Technology (IFE) at Kjeller outside of Oslo, and an Associate Professor in the Department of Physics at the University of Oslo (UiO).

The price of solar cells is falling steadily. Today, solar panels cost a half Euro for every watt. Only four years ago, the price was two Euros per watt.

"It is difficult to make money producing solar cells at current prices. To make money, solar cells must be manufactured much more cheaply."

Super-thin solar cells in 2020

Together with Professor Aasmund Sudbø in the Department of Physics, Erik Marstein is at the forefront of the development of the next generation of solar cells. They can come on the market in five to seven years.

"The most obvious way ahead is to make very thin solar cell slices, without increasing costs."

This general rule applies to all types of solar cells: the more electrons sunlight pushes out, the more electricity. And the more energy in the electrons, the higher the voltage.

"The thinner the solar cells become, the easier it is to extract the electricity. In principle, there will therefore be a higher voltage and more electricity in thinner cells. We are now developing solar cells that are at least as good as the current ones, but that can be made with just one twentieth of the silicon. This means that the consumption of silicon can be reduced by 95 per cent", Erik Marstein.

However, there is a big but!

The thinner the plates, the less sunlight is trapped. This has to do with the wavelengths of light. Blue light has a much shorter wavelength than red light. Blue light can be trapped by plates that are only a few micrometres thick. In order to trap the red light, the silicon plate must be almost one millimetre thick. For infrared light, the plate must be even thicker.

When the solar cell plate is to be as thin as 20 micrometres, too much of the light will go straight through.

The thickness of current solar cells is doubled by a mirror. By reflecting the light, the passage of the light through the plate is doubled.

A 20 micrometre think solar cell with a mirror will in theory be 40 micrometres thick. However, that is not enough. Furthermore, the current mirrors are far from perfect: they only reflect 70 to 80 per cent of the light.

The magic

"This is where the magic comes in. We are trying every possible wonderful trick with light. Our trick is to deceive the sunlight into staying longer in the solar cell"

"We are trying every possible wonderful trick with light."

This extends the duration of the sunlight's passage within the solar cell", explains Erik Marstein. This is called light harvesting.

His research group is now making a back sheet peppered with periodic structures, to be able to decide exactly where the light should go. They have managed to force the light to move sideways.

"We can increase the apparent thickness 25 times by forcing the light up and down all the time. We have calculated what this back sheet must look like and are currently studying which structures work."

One of the options is to cover the entire back sheet with Uglestad microbeads, which is one of the greatest Norwegian inventions of the previous century. Uglestad microbeads are very small plastic spheres. Each sphere is exactly the same size.

"We can force the Uglestad microbeads to lie close together on the silicon surface, in an almost perfect periodic pattern. Laboratory trials have shown that the microbeads can be used as a mask." Doctoral Research Fellow Jostein Thorstensen shows that lasers are well-suited to etch indentations around the microbeads.

"We are now investigating whether this and other methods can be scaled up for industrial production. We have great faith in this, and are currently in discussions with multiple industrial partners, but we cannot yet say who."

Asymmetrical tricks

To trap even more light in the solar cell, Jo Gjessing has completed a doctorate on how to make asymmetrical micro indentations on the back of the silicon slice.

"Cylinders, cones and hemispheres are symmetrical shapes. We have proposed a number of structures that break the symmetry. Our calculations show that asymmetrical microindentations can trap even more of the sunlight", says his supervisor, Erik Marstein.

In practice, this means that 20 micrometre solar cells with symmetrical micro indentations are as effective as 16 micrometre plates with asymmetrical indentations. This means that silicone consumption can be reduced by another 20 per cent.

"Our main goal has been to get the same amount of electricity from thinner cells. We will be very satisfied even if our new solar cells are 30 micrometres", notes Professor Aasmund Sudbø.

The new solar cells are produced in different ways, for instance by splitting the thin silicone foil or growing thin silicon films. And the extra bonus? Silicon wastage is minimal.

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