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Solar energy

Powering up

Sep 14th 2006

From *The Economist* print edition

Improved devices may make better use of sunlight

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MOST of the power generated by mankind originates from the sun. It was sunlight that nurtured the early life that became today's oil, gas and coal. It is the solar heating of the Earth's atmosphere and oceans that fuels wave power, wind farms and hydroelectric schemes. But using the sun's energy directly to generate power is rare. Solar cells account for less than 1% of the world's electricity production.

Recent technological improvements, however, may boost this figure. The root of the problem is that most commercial solar cells are made from silicon, and silicon is expensive. Cells can be made from other, cheaper materials, but these are not as efficient as those made from silicon.



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The disparity is stark. Commercial silicon cells have efficiencies of 15% to 20%. In the laboratory, some have been made with an efficiency of 30%. The figure for non-traditional cells is far lower. A typical cell based on electrically conductive plastic has an efficiency of just 3% or 4%. What is needed is a way to boost the efficiency of cells made from cheap materials, and three new ways of doing so were unveiled this week in San Francisco, at the annual meeting of the American Chemical Society.

Solar cells work by the action of light on electrons. An electron held in a chemical bond in the cell absorbs a photon (a particle of light) and, thus energised, breaks free. Such electrons can move about and, if they all move in the same direction, create an electric current. But they will not all travel in the same direction without a little persuasion. With silicon, this is achieved using a secondary electrical field across the cell. Non-silicon cells usually have a built-in “electrochemical potential” that encourages the electrons to move away from areas where they are concentrated and towards places where they have more breathing space.

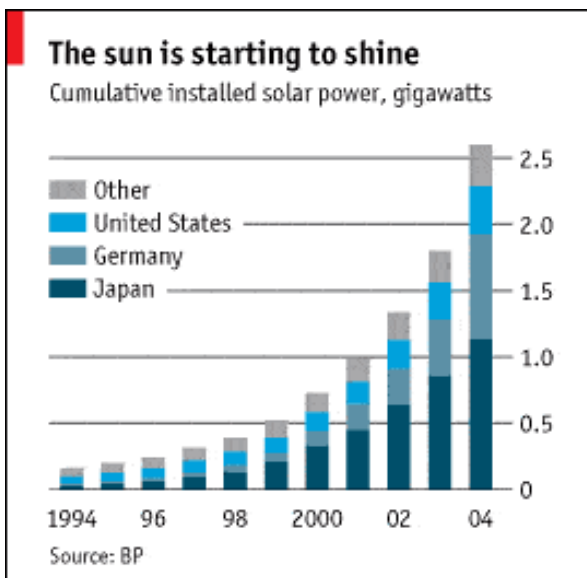
Cooking the chips

Kwanghee Lee of Pusan National University, in South Korea, and Alan Heeger of the University of California, Santa Barbara, work on solar cells made of electrically conductive plastics. (Indeed, Dr Heeger won a Nobel prize for discovering that some plastics can be made to conduct electricity.) They found that by adding titanium oxide to such a cell and then baking it in an oven, they could increase the efficiency with which it converted solar energy into electricity.

The trick is to put the titanium oxide in as a layer between the part of the cell where the electrons are liberated and the part where they are collected for dispatch into the wider world. This makes the electrically conductive plastic more sensitive to light at wavelengths where sunlight is more intense. Pop the resulting sandwich in the oven for a few minutes at 150°C and the plastic layer becomes crystalline. This improves the efficiency of the process, because the electrons find it easier to move through crystalline structures.

The technique used by Dr Lee and Dr Heeger boosts the efficiency of plastic cells to 5.6%. That is still poor compared with silicon, but it is a big improvement on what was previously possible. Dr Lee concedes that there is still a long way to go, but says that even an efficiency of 7% would bring plastic cells into competition with their silicon cousins, given how cheap they are to manufacture.

A second approach, taken by Michael Grätzel of the Swiss Federal Institute of Technology, is to copy nature. Plants absorb solar energy during photosynthesis. They use it to split water into hydrogen ions, electrons and oxygen. The electrons released by this reaction are taken up by carrier molecules and then passed along a chain of such molecules before being used to power the chemical reactions that ultimately make sugar.



Dye-sensitised solar cells seek to mimic this assembly line. The dye acts like chlorophyll, the pigment that makes plants green and that is responsible for absorbing sunlight and liberating electrons. The electrons are passed via a semiconductor to an electrode, through which they leave the cell. By using a dye called phthalocyanine, which absorbs not only visible light but also infra-red wavelengths, Dr Grätzel has been able to raise the efficiency of the process to 11%. That, he says, should be enough to make dye-sensitised cells competitive with silicon.

The third technique, being developed by Prashant Kamat of the University of Notre Dame, Indiana, and his colleagues, uses that fashionable scientific tool, the carbon nanotube. This is a cylinder composed solely of carbon atoms, and one of its properties is good electrical conductivity. In effect, nanotubes act as wires a few billionths of a metre in diameter.

Dr Kamat and his team covered the surface of an experimental cell made of cadmium sulphide, zinc oxide and titanium dioxide with nanotubes, so that the tubes stuck up from the surface like hairs. The tubes then eased the passage of the liberated electrons from the cell to the electrode that collected them. Using this technique doubled the efficiency of Dr Kamat's cell from 5% to 10% at ultraviolet wavelengths and he reckons it would create similar increases in efficiency in both plastic and dye-based cells.

Such a boost would take novel solar cells closer to becoming a commercial reality. And that would be a very good thing. Production of solar cells has increased by 32% a year, on average, for the past decade and jumped by 45% in 2005. That sounds impressive, but it has been achieved largely by subsidies from the governments of Germany, Japan and California. Only in places unconnected to an electricity grid, such as much of rural Africa and rural Asia, are solar cells truly commercially viable. But if the price were to come down because efficient cells could be made from cheap materials, that could change quickly. The rest of the world would then be able to join the poor of Africa and the rich of California, and generate solar power for itself.

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