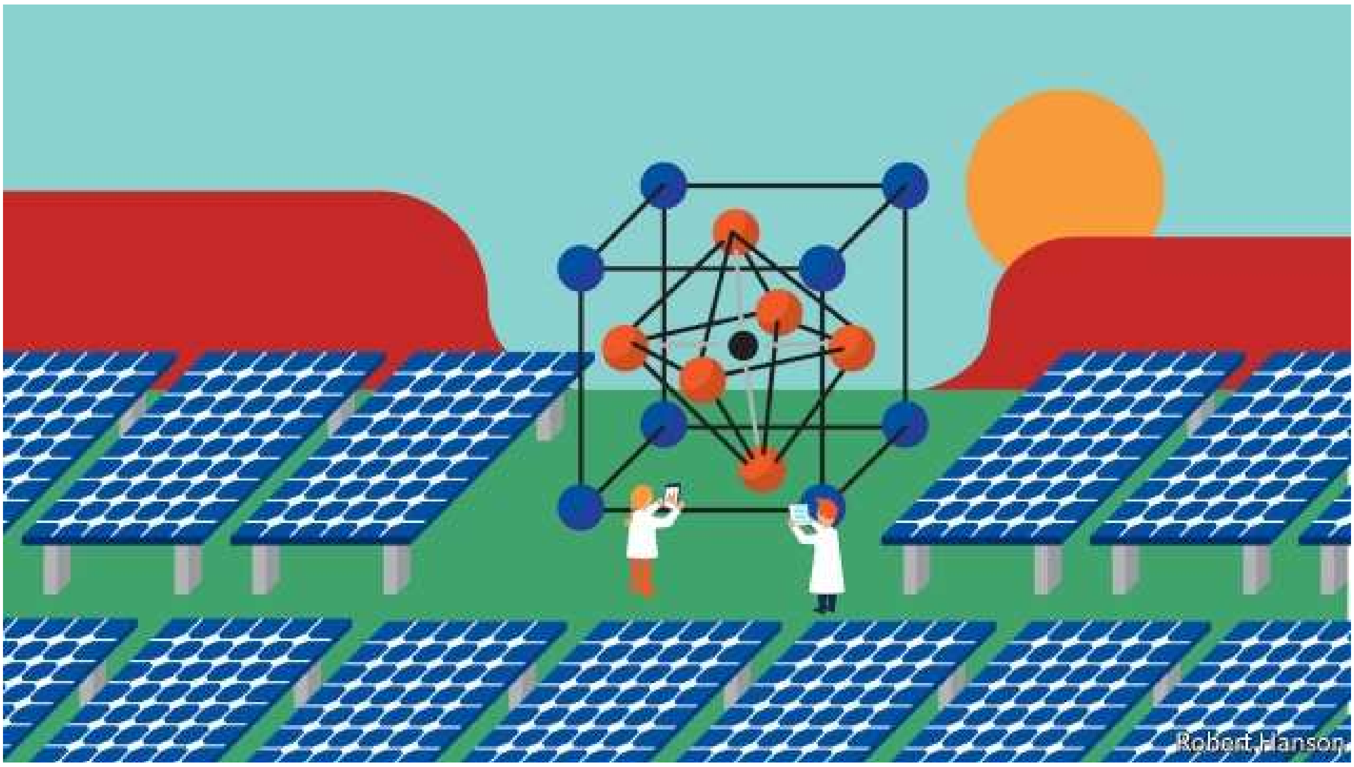
Solar energy

A new type of solar cell is coming to market

Perovskites have the potential to outshine silicon in solar panels



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SOMETIMES it takes a while for the importance of a scientific discovery to become clear. When the first perovskite, a compound of calcium, titanium and oxygen, was discovered in the Ural mountains in 1839, and named after Count Lev Perovski, a Russian mineralogist, not much happened. The name, however, has come to be used as a plural to describe a range of other compounds that share the crystal structure of the original. In 2006 interest perked up when Tsutomu Miyasaka of Toin University in Japan discovered that some perovskites are semiconductors and showed particular promise as the basis of a new type of solar cell.

In 2012 Henry Snaith of the University of Oxford, in Britain, and his colleagues found a way to make perovskite solar cells with an efficiency (measured in terms of how well a cell converts light into electric current) of just over 10%. This was such a good conversion rate that Dr Snaith immediately switched the direction of Oxford Photovoltaics, a firm he had co-founded to develop new solar materials, into making perovskites—and perovskites alone. Progress has continued, and now that firm, and also Saule Technologies, a Polish concern founded in 2014 to do similar things, are close to bringing the first commercial perovskite solar cells to market.

Today 10% is quite a modest efficiency for a perovskite cell in the coddling conditions of a laboratory. For lab cells values above 22% are now routine. That makes those cells comparable with ones made from silicon, as most of the cells in solar panels are—albeit that such silicon cells are commercial, not experimental. It did, however, take silicon cells more than 60 years to get as far as they have, and the element is probably close to its maximum practical level of efficiency. So, there may not be much more to squeeze from it, whereas perovskites could go much higher.

Perovskite cells can also be made cheaply from commonly available industrial chemicals and metals, and they can be printed onto flexible films of plastic in roll-to-roll mass-production processes. Silicon cells, by contrast, are rigid. They are made from thinly sliced wafers of extremely pure silicon in a process that requires high temperature. That makes factories designed to produce them an expensive proposition.

Racing with silicon

On the face of it, then, perovskites should already be transforming the business of solar power. But things are never that simple. First, as with many new technologies, there is a difference between what works at small scale in a laboratory and at an industrial scale in a factory. Learning how to manufacture something takes a while. Also, perovskites as materials are not without their problems—in particular, a tendency to be a bit unstable in high temperatures and susceptible to moisture, both of which can cause the cells to decompose. Such traits are unconducive to the success of a product that would be expected to last two or three decades in the open air. Researchers are beginning to solve those shortcomings by making perovskites that are more robust and waterproof.

But even if they succeed, there is a third consideration. This is that these newfangled cells will have to go up against an incumbent solar-power industry which invested $160bn in 2017 and is familiar with silicon and how to handle it.

What perovskites need, then, is a record which would provide that industry with the confidence to use them. To do this, both Oxford Photovoltaics and Saule are teaming up with large companies to ease the new materials into the market quite literally on the back of established products.

In the case of Oxford Photovoltaics those established products are existing silicon solar cells. The idea behind the resulting so-called tandem cells is that together the two materials involved can mop up more of the spectrum and turn it into electricity. This is done by tweaking the perovskite upper layer to absorb strongly at the blue end of the spectrum and leaving the lower silicon layer to capture those wavelengths falling towards the red end. That boosts the efficiency of the combined panel by 20-30% says Frank Averdung, Oxford Photovoltaics' boss. Tandem cells of this sort would allow solar-panel producers to offer a performance beyond anything silicon alone might achieve. Such panels would, of course, cost more to make—but the boost in performance will not, Mr Averdung says, increase the cost per watt and in time may reduce it.

Oxford Photovoltaics is now building a production line in Germany to start making tandem cells next year with what it describes as standard industrial processes. The factory will be used to demonstrate the technology, which will then be licensed to other manufacturers. Some of the details are still secret, because the company is working with a large but unnamed solar-energy firm.

The tandem approach lowers the barrier to perovskites entering the market, and allows the new materials to be shown to meet various industry standards. It is, though, intended only as a halfway house.

Eventually, Mr Averdung believes, perovskites will act as stand-alone cells—and not just in conventional panels. Because they are semi-transparent, perovskite films could also be used to turn windows into solar generators, by capturing part of the incoming sunlight while permitting the rest to pass through.

Saule, meanwhile, is using inkjet printing to produce its own perovskite cells on thin plastic sheets. At present it can turn these out in A4 size (210mm by 297mm), but it is scaling up the process to manufacture versions with an area of one square metre. Saule's sheets have an efficiency of 10%, so are not yet a match for the sorts of silicon panels found in solar farms. But Artur Kupczunas, a co-founder of the company, says that in combination with the cheapness, flexibility and lack of weight of perovskite sheets, an efficiency of 10% is enough to justify applying those sheets to the exteriors of buildings. The established products that Saule is hoping to ride on the back of are thus the components used to construct those exteriors.

The power of the press

To this end, Saule has granted Skanska, one of Europe's biggest construction groups, the right to incorporate perovskite printed sheets into some of its components, such as those used to make façades. This would let the walls generate electricity, thus lowering a building's carbon footprint and making it more self-sufficient. Skanska plans to test the sheets on an office block, possibly in Poland, later this year.

As the sheets would be added to their substrates off-site, there would, Mr Kupczunas points out, be no additional installation costs.

In time, he expects sheets' efficiencies to increase towards the 26% which has been achieved in laboratory conditions. The printing process also makes it easy to produce sheets of different sizes for different applications. They should function better than silicon in low light, which means they would generate more electricity on cloudy days.

Perovskites are thus now serious challengers to silicon solar cells. That does not mean they will succeed. The history of technology, in this area and in others, is littered with ideas that looked good (and, indeed, were often technically superior to existing alternatives) but nevertheless fell by the wayside. The power of incumbency should not be underestimated. And the price of silicon-based solar power has dropped markedly over the past decade, particularly as a consequence of enormous investment by the Chinese.

Nevertheless, as Sam Stranks, who leads an optical-electronics research group at the University of Cambridge, observes, the demand for renewable power is such that a huge ramp-up in production will be needed. He believes perovskites have every chance of sharing in this, both because they are cheap and because he thinks that one more turn of the technological ratchet will improve their efficiency in a way that silicon cannot match.

Because many chemical combinations result in a perovskite crystal structure, and each of them has different optical properties, choosing the chemistry of a cell also means choosing what part of the spectrum it absorbs, as Oxford Photovoltaics is doing already with its tandem silicon-perovskite cells. Dr Stranks thinks that in time silicon could be cut out of the loop by making tandem cells entirely out of layers of perovskites. This, he reckons, could push efficiency levels up to around 36%. And if that happens, it really might drive silicon solar cells into the shadows.

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