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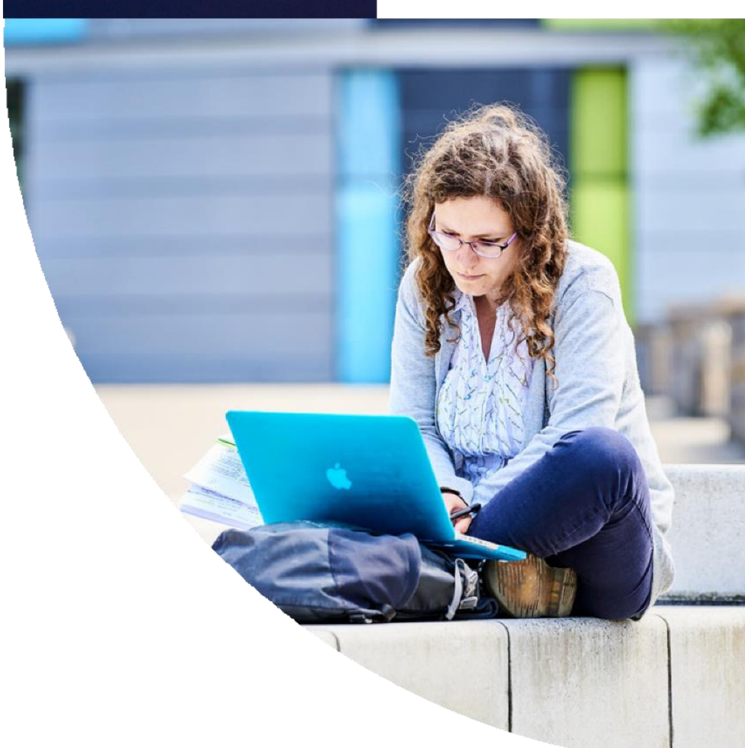
Durham Energy Institute Perspectives

Energy, Science and Society

Issue 3 | August 19



Thin-film solar cells: a quiet technological revolution

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Solar energy is on the brink of a step-change and thin-film materials are enabling the transformation.

When most people think of solar electricity they imagine south facing rooftops covered in large, rigid solar panels. They have high installation costs and due to cuts in the government's feed-in-tariff scheme to 4p per kWh (from 47p per kWh) there is no strong incentive for mass uptake of solar electricity. Critics might argue that this is inevitable: the UK after all is not the Mediterranean and even if the sun is shining the electricity generated is when demand is at its lowest.

While there is an element of truth to this it is not the whole story. Germany, which has a similar level of solar radiation to the south of the UK, has long been successful with solar electricity. Even in the UK, where solar electricity is less prominent, there have been massive strides. For example, Clayhill Solar Farm in Milton Keynes has a 10 MW capacity with 6 MW storage (thus providing electricity when needed) and furthermore total installed capacity in the UK has risen to 13 GW from less than 1 GW in 2011.

This article is not however about the merits of solar electricity over other renewable technologies such as wind or geothermal. It is instead about a less well known form of solar electricity technology called 'thin-film' solar cells.

The shortcomings of silicon

The traditional method of manufacturing solar panels is by using silicon. A solar panel works by absorbing sunlight and converting its energy into electricity. The problem with silicon is that it is a very poor absorber of sunlight. This has been known for decades, but industry has nevertheless pursued along this path because, thanks to computer technology, silicon is one of the best understood materials, along with steel in the construction industry.

However, this seemingly odd choice has adverse knock-on effects when used in solar electricity. For example, the silicon must be made thick (fraction of a millimetre) in order to absorb sufficient sunlight. This means that silicon solar panels are rigid and require a flat rooftop for mounting. The second adverse effect is that the thick piece of silicon must be purified to an extremely high quality in order to minimise electricity losses. In the electronics industry this is not a problem, since the ever shrinking size of electronic components such as the transistor means that more components can be fabricated on a single silicon wafer. But for solar electricity we need as much area as possible in order to efficiently capture sunlight. Silicon purification is also a highly energy intensive process, since it is extracted from sand, which is a very stable compound requiring large amounts of energy to break up the internal chemical bonds.

The costs of solar electricity

We can get a better feel for these effects by examining the breakdown of the levelised cost of solar electricity (levelised cost is essentially a means by which we compare different energy generating technologies on an equal footing).

21% of the levelised cost is due to the material itself, and reflects the fact that a lot of energy must be used to purify the silicon. 9% of the levelised cost is due to what is called ‘balance of module’; this is the cost of putting the solar panel together and includes the process of mounting the rigid, but fragile, silicon on a supporting substrate such as glass. As much as a third of the cost of solar electricity is therefore due to silicon being the wrong material choice. This makes it difficult to compete with fossil fuel, which is both cheap and energy dense, and is one of the reasons why solar electricity has taken so long to proliferate into the energy generation market.

The thin-film alternative

In many industrial R&D labs, as well as academia, there is a lot of interest in substituting silicon with more strongly light absorbing materials. The sub-millimetre thick silicon is replaced with a layer that is no more than a human hair in thickness. Hence the name ‘thin-film’ solar cell.

The CIGS (Copper Indium Gallium Selenide) solar panel on the active building project in the University of Swansea is an example of thin-film solar cell technology. This is the flagship of the £20 million SPECIFIC project, a collaboration between academia and industry, to design and manufacture buildings that are able to generate, store and release their own energy. The biggest commercial producer of thin-film solar cells is First Solar in the US, employing over 6,000 people and with a total annual revenue of over US$ 2 billion. In fact Global Market Insights predict that by 2024 the thin-film solar industry could be worth over US$ 30 billion.

There are many different materials being explored for thin-film solar cells, all of which are characterised by low manufacturing costs, unlike silicon. First Solar specialise in a material called cadmium telluride, but there is also a considerable R&D effort to develop other materials that are cheap, non-toxic and ‘earth abundant’; in other words materials that are readily available and easy to extract. The earth abundant materials are at a lower TRL compared to CIGS and cadmium telluride, but are essential if solar electricity is to be scaled up to the Tera Watt level required in the near future.

A further advantage of thin-film solar cells over silicon is that the technology works best at low solar illumination levels and diffuse lighting, making it ideal for the UK climate.

Building Integrated Photovoltaics

The use of thin-film technology produces a step change in the way solar electricity is deployed in buildings, also known as BIPV or Building Integrated Photovoltaics. No longer is it required to have a flat rooftop; because thin-films are so thin they can be deposited on flexible substrates, such as plastic, which can easily be incorporated onto curved surfaces. The architect therefore has complete freedom in the design of energy efficient, modern buildings. It is also possible to make glass windows energy generating. For example, the Silicon Valley based company, Ubiquitous Energy, manufacture glass coated in thin-film solar cells that generate electricity by absorbing only the solar radiation that cannot be detected by the human eye, such as UV and infrared. Because visible light is not absorbed the glass can also act as a transparent window.

The Technology Innovation Needs Assessment (TINA) for solar electricity, drafted by the Low Carbon Innovation Coordination Group, identified BIPV as an area where the UK can establish a ‘leading position internationally’. The recently launched House of Lords, Solar Commission Report highlighted the importance of government, industry and the construction sector working together to achieve this aim. Some of the recommended measures include government introducing new building regulations for zero-carbon homes, better integration of BIPV and construction standards and government using its significant purchasing power to drive demand and creating a viable market for BIPV technology.

Although silicon still currently dominates the solar electricity market, the benefits of BIPV are abundantly clear. Its success would mean a radical transformation in the built environment. **Thin-film solar cells are a key part of this technological revolution that is quietly taking place around us.**

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