Collecting the sun's energy: Novel electrode for flexible thin-film solar cells

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Conventional silicon-based rigid solar cells generally found on the market are not suitable for manufacturing moldable thin-film solar cells, in which a transparent, flexible and electrically conductive electrode collects the light and carries away the current. A woven polymer electrode developed by Empa has now produced first results which are very promising, indicating that the new material may be a substitute for indium tin oxide coatings.

The scarcity of raw materials and increasing usage of rare metals is making electronic components and devices more and more costly. Such rare metals are used, for example, to make the transparent electrodes found in mobile phone touchscreen displays, liquid-crystal displays, organic LEDs and thin-film solar cells. The material of choice in these cases is indium tin oxide (ITO), a largely transparent mixed oxide. Because ITO is relatively expensive, however, it is uneconomic to use in large area applications such as solar cells.

The search for alternatives

Indium-free transparent oxides do exist, but with demand for them increasing they too are tending to become scarce. In addition, the principal disadvantages such as brittleness remain. The search for alternative coatings which are both transparent and electrically conductive is therefore intense, with materials such as conductive polymers, carbon nanotubes or graphenes coming under scrutiny. Carbon-based electrodes, however, generally show excessive surface resistance values which make them poor electrical conductors. If a metallic grid is integrated into the organic layer, it reduces not just its resistance but also its mechanical stability. If a solar cell made out of this material is bent, the electrode layers break and are no longer conductive. The challenge thus consists of manufacturing flexible yet stable conductive substrates, ideally in a cost-effective industrial rolling process.

One solution: woven electrodes

One particularly promising possibility is the use of a transparent flexible woven polymer, which Empa has developed together with the company Sefar AG in a project financially supported by the Swiss Commission for Technology and Innovation (CTI). Sefar, which specializes in precision fabrics, is able to produce the woven polymer economically and in large quantities using a roll to roll process similar to the way newspapers are printed. Metal wires woven into the material ensure that it is electrically conductive. In a second process step the material is embedded in an inert plastic layer which does not, however, completely cover the metal filaments, thus retaining its conductivity. The electrode which results is transparent, stable and yet flexible. The Empa researchers then applied a series of coatings to this new substrate to create a novel organic solar cell whose efficiency is compatible to conventional ITO-based cells. In addition, the woven electrode is significantly more stable when deformed than commercially available flexible plastic substrates to which a thin layer of conductive ITO has been applied.

Provided by EMPA