Project

Novel interfaces in solar cells

More Than Just a Gap: Intermediate Layers in Solar Cells

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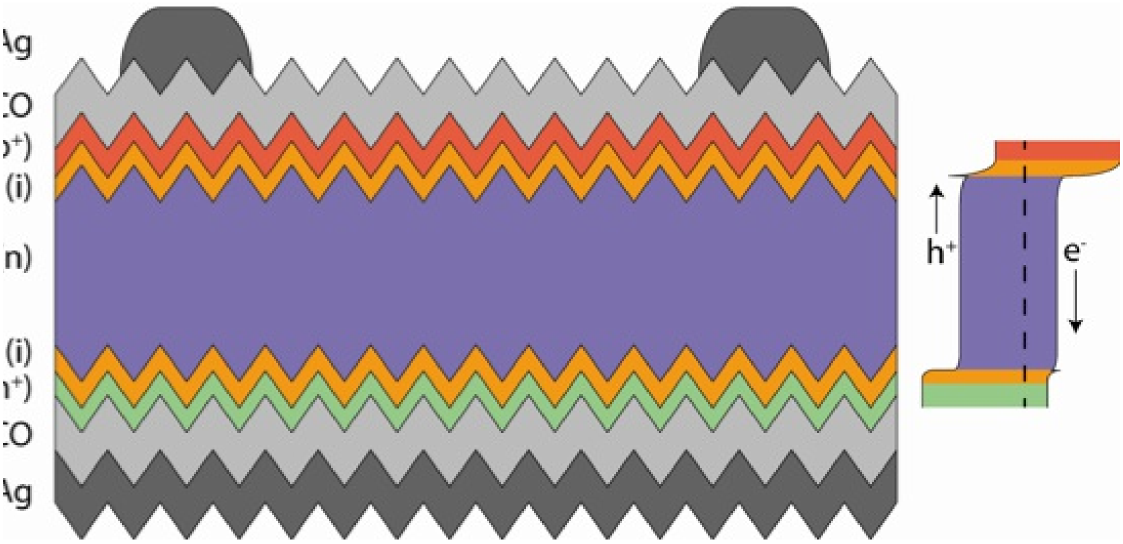
More Than Just a Gap: Intermediate Layers in Solar Cells

Behind the inconspicuous concept of intermediate layers lies the key to more efficient power generation from sunlight. Empa and EPFL researchers are using innovative materials and processes to lay the foundation for the next generation of solar cells.



Similar to membranes in biological cells, intermediate layers are crucial for the efficient functioning of solar cells. Amorphous silicon layers (in red) optimize the cell voltage in silicon solar cells. But they also absorb light, which is why researchers are seeking to develop more transparent alternatives. *Source:* EPFL - PVLab

At a glance

- Inactive, intermediate layers play a significant role in solar cells.
- Technological innovations in the field of intermediate layers make it possible to increase the efficiency of solar cells while simplifying manufacturing processes.
- Progress achieved in this field paves the way for a new generation of solar cells.

How is electricity generated from sunlight? The almost magical transformation that takes place within solar cells is made possible by high-performance, light-absorbing materials: a solar cell is not functional without so-called intermediate layers which surround the active parts of the cell and display special optical and electrical properties. Similar to membranes in biological cells, these layers perform important tasks in solar cells: without them, the energy absorbed at the heart of the solar cell cannot be converted into electrical power.

Researchers at Empa and the EPFL in Lausanne have taken on the important task of optimising the properties of these intermediate layers. By doing so, they are creating the basis for the development of more efficient and more durable solar cells, and for simpler manufacturing processes. In addition to improving available mature technologies, this will also pave the way for novel products, including solar cells that can be exposed to sunlight from both sides and two-stage tandem cells. These too place new requirements on the performance and properties of intermediate layers.

Invisible helpers

The intermediate layer's many tasks are made clear by the sensitive process of generating electricity from light, which begins with an electron being knocked out of its usual structure by the absorption of a photon. This negatively charged particle thus becomes a freely moving charge carrier, while a gap that behaves like a positively charged particle is created at its original location. This is called an electron-hole pair. When the electron falls back into this gap, its energy turns into heat or light. To prevent this so-called recombination, the negative electron and the positive "hole" must go separate ways and enter an electric circuit through electrodes. This process depends entirely on the aforementioned intermediate layers which must perform their job without obstructing the flow of light, i.e. the energy source that drives the entire operation.

In search of clever alternatives

Accordingly, many of the current developments aim to design more optically transparent intermediate layers, while of course maintaining electrical performance. Silicon solar cells are a tried technology that researchers hope to improve. Their crystalline core is usually surrounded by intermediate amorphous (i.e. non-crystalline) silicon layers which are ideal for a loss-free discharge of electrical charges, but are unfortunately also responsible for an absorption of light that produces no power. By replacing these layers with transparent metal oxides, the researchers were able to reduce losses while simplifying the manufacturing process.

A similar problem arose with another type of solar cell, the thin-film cell based on copper indium gallium selenide (CIGS). In this case, a cadmium sulfide intermediate layer absorbed too much light. The scientists managed to reduce the thickness of the separating intermediate layer by replacing an adjacent layer of zinc oxide with a zinc-titanium compound.

On a technical level, so-called tandem cells are even more challenging. These solar cells consist of two layers that make use of light of different wavelengths. To achieve this, the upper cell must be completely transparent in a certain range of the light spectrum. This, among other things, calls for transparent alternatives for electrodes that are normally made of gold. With their newly developed coatings, the researchers have achieved an 80.4 % permeability of the upper cell in the near infrared range, and even higher values for certain layers.

The key to progress

The upper layer of a tandem cell consists of the temperature-sensitive material perovskite. Accordingly, the process engineering requirements for such new developments are considerable, particularly if the tandem cells are to be manufactured in one piece: such designs call for the reconciliation of the manufacturing processes associated with two different technologies.

However, tandem cells are not yet ready for the market: the service life of the upper-layer perovskite cell is still insufficient. Here, too, intermediate layers are part of the problem as well as part of the solution. This is demonstrated by the headway that researchers have already made using innovative materials.

Intermediate layers in solar cells offer an important field of activity for further research. New materials and processes are bringing forth revolutionary results, thus paving the way for a new generation of solar cells such as tandem solar cells displaying record-high efficiencies, as described here.

Produkte aus diesem Projekt

- Effcient silicon solar cells with dopant-free asymmetric heterocontacts
  Date of publication: 25.09.19
- 22.5 % efficient silicon heterojunction solar cell with molybdenum oxide hole collector
  Date of publication: 25.09.19
- Controlled growth of PbI2 nanoplates for rapid preparation of CH3NH3PbI3 in planar perovskite solar cells
  Date of publication: 25.09.19
- Highefficiency polycrystalline thin film tandem solar cells
  Date of publication: 25.09.19
- Evolution of carbon impurities in solution-grown and sputtered Al:ZnO thin films exposed to UV light and damp heat degradation
  Date of publication: 25.09.19
- High Efficiency Perovskite Solar Cells Employing a S,N - Heteropentacene-based D-A Hole-Transport material
  Date of publication: 25.09.19
- On a better estimate of the charge collection function in CdTe solar cells: Al 2O3 enhanced electron beam induced current measurements
  Date of publication: 25.09.19
- ALD-ZnxTiyO as Window Layer in Cu(In,Ga)Se 2 Solar Cells
  Date of publication: 25.09.19
- Low-temperature-processed efficient semi-transparent planar perovskite solar cells for bifacial and tandem applications
  Date of publication: 25.09.19
- Impact of interlayer application on band bending for improved electron extraction for efficient flexible perovskite mini-modules
  Date of publication: 25.09.19
- A transparent, solvent-free laminated top electrode for perovskite solar cells, in Science and Technology of Advanced Materials
  Date of publication: 25.09.19
- A Novel Dopant- Free Triphenylamine Based Molecular “Butterfly” Hole-Transport Material for Highly Efficient and Stable Perovskite Solar Cells, in Advanced Energy Materials
  Date of publication: 25.09.19
- Over 20 % PCE perovskite solar cells with superior stability achieved by novel and low-cost hole-transporting materials
  Date of publication: 25.09.19
- One-Dimensional Organic–Inorganic Hybrid Perovskite Incorporating Near-Infrared-Absorbing Cyanine Cations
  Date of publication: 25.09.19
- TiO2 as intermediate buffer layer in Cu(In,Ga)Se2 solar cells
  Date of publication: 25.09.19
- Flexible NIR-transparent perovskite solar cells for all-thin-film tandem photovoltaic devices
  Date of publication: 25.09.19
- Dopant-free star-shaped hole-transport materials for efficient and stable perovskite solar cells, in Dyes and Pigments
  Date of publication: 25.09.19

- High-efficiency inverted semi-transparent planar perovskite solar cells in substrate configuration
  Date of publication: 25.09.19
- Fully textured monolithic perovskite/silicon tandem solar cells with 25.2 % power conversion efficiency
  Date of publication: 25.09.19
- Ternary semitransparent organic solar cells with a laminated top electrode
  Date of publication: 25.09.19
- Evolution of carbon impurities in solution-grown and sputtered Al:ZnO thin films exposed to UV light and damp heat degradation
  Date of publication: 25.09.19

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