

1 Flexible ITO-free organic solar cell module fabricated at Fraunhofer ISE.

ORGANIC SOLAR CELLS FOR NEW APPLICATIONS

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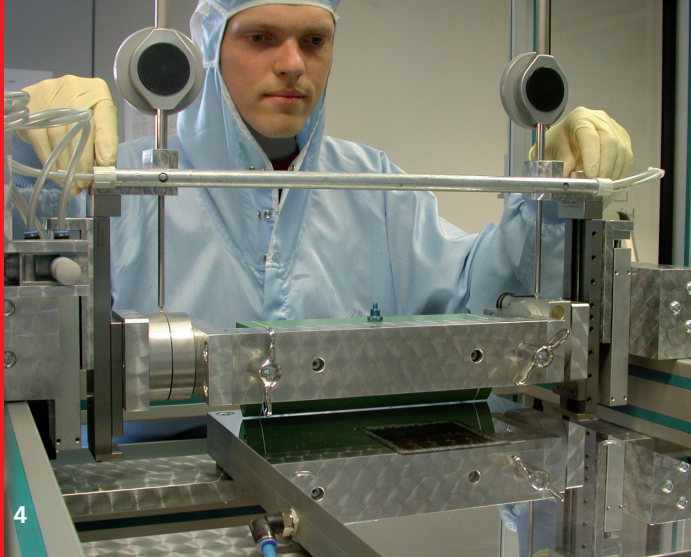
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Advantages and Challenges

Organic solar cells are based on a composite of organic semiconductors and represent a new type of solar cell. They show great promise due to their potentially low production costs, light weight and mechanical flexibility – characteristics which open up a new range of solar cell applications. Currently, small-area organic solar cells have power conversion efficiencies of up to c. 8 %. First results point to potential applications as a power supply for small mobile devices. Further possible applications are power sources for stand-alone sensor networks and simple electronic circuits based on organic electronic components. At Fraunhofer ISE, our long-term goal is the contribution of organic solar cells to a sustainable global energy supply.

With a staff of over 1000 employees Fraunhofer ISE is the biggest solar energy research institute in Europe and provides a wide range of services. Our R&D portfolio for organic photovoltaics aims at the commercialization of this technology. This includes the following aspects:

- development of novel solar cell architectures and module concepts which meet the requirements of low material costs and cost-efficient production
- investigation and evaluation of novel solar cell components
- investigation of the long-term stability of encapsulated devices
- development of procedures for upscaling organic solar cells in a continuous roll-to-roll process
- optical and electrical simulations



2 Automated measurement setup allowing efficient characterization of organic solar cells.

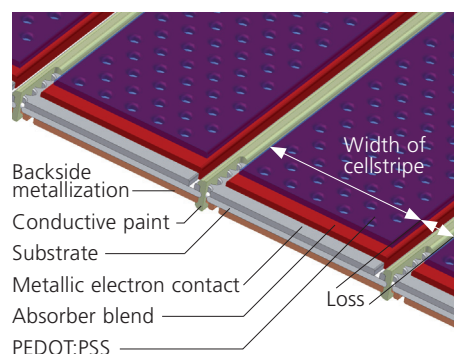
Characterization

The chemical tailoring of organic semiconductors offers a large potential for increasing the solar cell efficiency and stability. Therefore, the efficient screening of novel organic semiconductors and semiconductor combinations as well as the process optimization for novel solar cell architectures is an important issue for the improvement of organic solar cells. We have established a highly efficient characterization setup for organic solar cells, incorporating the basic measurement techniques (Fig. 2). The high characterization throughput in combination with an electronic lab book and a statistical evaluation of the process and device parameters enables efficient optimization of the solar cells. To complete the characterization of selected solar cells, we have a large number of more advanced measurement techniques available in our labs. The physical characterization is complemented by optical and electrical simulations to gain deeper understanding of the working principles as well as the efficiency limiting factors of organic solar cells.

Solar Cell Architectures

One of the essential requirements to be met for the production of cheap solar cells is the use of cost-effective materials. To fulfill this requirement, we develop novel solar cell architectures in which the expensive transparent indium tin oxide (ITO) electrode is replaced.

One of the so-called ITO-free solar cell architectures developed by Fraunhofer ISE is based on the substitution of the ITO-electrode by a transparent polymer hole contact which is supported by metal structures. In order to enable efficient production technologies, the deposition sequence of the electrodes was inverted in comparison to the standard organic solar cell. Based on this setup, Fraunhofer ISE holds a patent for a solar cell and module concept where the current is collected through small via-holes in the substrate and transported on the backside of the module, a so called wrap-through contact (Fig. 3). First promising results with this concept have already been achieved at Fraunhofer ISE.



3 Schematic of an ITO-free organic solar cell module based on the wrap-through concept.

Another approach is to replace the ITO-layer by a very thin silver film (< 10 nm) embedded between semiconducting

4 Coating the polymer anode and the photoactive layer of organic solar cells. We are investigating the suitability of different coating methods for future roll-to-roll production.

oxides. This type of transparent contact can be adapted to function either as hole or electron contact. Organic solar cells built with these electrodes reach the same efficiency values compared to ITO-based devices.

Manufacturing

Together with industrial partners, we develop procedures for manufacturing organic solar cells in a continuous roll-to-roll process. Aspects of the process include the development of wet-chemical coating technology for the contacts and the photoactive layer as well as techniques to structure the thin films for monolithic interconnection of the cell stripes to a module. Furthermore, we use sputtering techniques for the deposition of the transparent electrode systems. We have built flexible modules using a batch coating process to investigate the influence of these techniques and processes on functional modules. In the near future we will upscale these processes with an industrially compatible roll-to-roll coating machine installed at our laboratory. Fraunhofer ISE has performed several investigations of coating processes on roll-to-roll machines together with industry partners. Depending on the sheet conductivity of the transparent electrode and the lighting conditions in the intended application (indoor or outdoor), we dimension the connection circuit of the modules based on electrical simulations.