

Research and development activities on organic photovoltaics at the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg, Germany

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The Fraunhofer Institute for Solar Energy Systems ISE conducts research on the technology needed to supply energy efficiently and on an environmentally sound basis in industrialised, threshold and developing countries. To this purpose, the Institute develops systems, components, materials and processes in the areas of the thermal use of solar energy, solar building, solar cells, electrical power supplies, chemical energy conversion, energy storage and the rational use of energy. The Institute's work ranges from fundamental scientific research relating to solar energy applications, through the development of production technology and prototypes, to the construction of demonstration systems. The Institute plans, advises and provides know-how and technical facilities as services. The research and development on organic photovoltaics was initiated in 2000. Here, we give an overview on our current research activities on this topic.

Investigation of novel organic semiconductors in organic photovoltaic cells

In collaboration with industry and universities, we investigate novel organic semiconductors for organic photovoltaic cells. The investigations are carried out with an automated measurement setup that allows an efficient characterisation and thus evaluation of the materials. These methods include current-voltage characteristics, absorption, external quantum efficiency, light intensity dependent photocurrent and field effect mobility. Additional methods are impedance spectroscopy and CELIV-charge carrier mobility measurement. For the elucidation of the nano morphology of the composite we employ scanning probe microscopy methods and scanning electron microscopy (SEM).

Longterm stability

We investigate the degradation of organic photovoltaic cell by accelerated ageing under defined atmosphere. Longterm stability investigations are carried out on sealed organic solar cells under ambient atmosphere. The measurements can be carried out under continuous illumination without UV-exposure, under enhanced UV exposure or under elevated temperatures in the dark.

Light trapping structures

Light trapping structures can be beneficial if the organic solar cell efficiency is primarily limited by the charge carrier mobility. Increasing of the thickness of the photoactive layer with the goal of enhancing the light absorption will result in a decrease of the device efficiency, as charge carrier recombination will reduce the fill factor. Light trapping structures contribute to an increased light absorption without increasing the thickness of the photoactive layer. Micro prism solar cells are one type of the light trapping structures, we have developed. The contribution of an enhanced light absorption is due to an inclined incident angle and multiple absorption processes. Fraunhofer ISE has a profound background on the generation of nano- and microstructured surface relief profiles. These structures can be generated on large areas up to 1m². Subsequent micro replication allows a cost efficient production. The development of these structures and solar cell architectures is accompanied by optical and electrical modelling.

ITO free organic solar cells

For the production of cost-effective solar cells, two necessary conditions must be fulfilled: Low material costs and application of cost-effective production technology. To fulfil these conditions, we are developing new solar cell configurations, in which the expensive transparent electrode of indium tin oxide (ITO) is replaced. Efficient roll-to-roll coating technology and structuring methods can be used to manufacture these solar cells. **An "ITO-free" solar cell, which we are developing at Fraunhofer ISE, is based on replacing the ITO electrode by a transparent polymer electrode.**

Upscaling of the production technology

We regard Roll-to-Roll production as the most promising production technology for organic photovoltaic cells. In a first step towards mass production of these devices, we develop solar cell architectures and production technologies on the lab scale that can be transferred to industrial processes in a second step. This second step will be done in close collaboration with partners from industry.