Drying of thin film polymer solar cells – initial results

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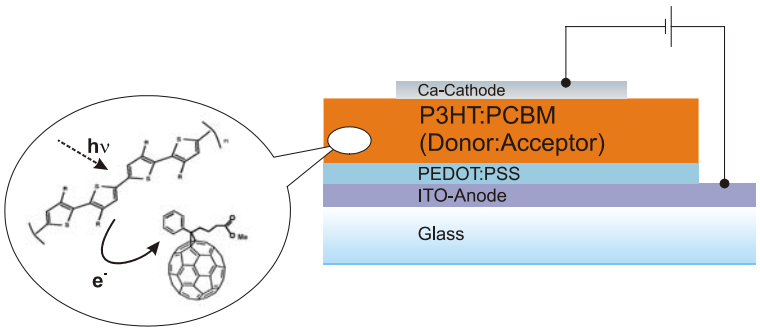
Organic polymer solar cells (PSCs) offer a promising alternative to their inorganic counterparts due to their potential for low cost photovoltaic devices. Their development is connected to the rapid advances in the field of organic light emitting diodes (OLEDs).
Semiconducting polymers exhibit electrical and optical properties similar to inorganic semiconductors while having attractive mechanical properties and processing advantages. In contrast to inorganic solar cells PSCs are considered for processing with established printing methods e.g. screen printing, doctor blading and roll-to-roll production.

In our work we focus on state of the art (bulk heterojunction) polymer solar cells based on a blend of the electron donor poly(3-hexylthiophene-2,5-diyl) (P3HT) and the electron acceptor [6,6]-phenyl-C61-butyric-acid-methyl-ester (PCBM). This blend is very well suited for generating excitons by light absorption and exciton dissociation into electrons and holes.

Commercially available ITO-coated glass substrates were structured with hydrochloric acid and cleaned. Poly-3,4-ethylene-dioxy-thiophene : polystyrenesulfonate (PEDOT:PSS) was doctor bladed from a 1:1 water diluted solution. Afterwards the active layer of a blend of P3HT:PCBM with a weight ratio of 1:0.9 and varying thicknesses were doctor-bladed from dichlorobenzene solution. Both films shrink in separated steps at about a hundredth of the wet film thickness during the drying process and the bulk structure is formed. Depending on the drying kinetics and conditions the nanomorphology of the donor and acceptor polymers forms in distinct manners, resulting in different efficiencies and characteristics of the photovoltaic devices. After drying the samples were transferred to a high vacuum chamber in order to deposit the calcium cathode.
The electronic characteristics were measured under a calibrated ORIEL solar simulator.

Several publications describe optoelectronic properties of this and other types of organic solar cells, but almost no investigations referring to drying conditions and matter transport phenomena in organic semiconducting materials are available. Therefore our focus of investigations is on the dependency of the bulk structure and PSC characteristics on drying conditions like temperature and kinetic effects (mobility of polymers, solvents and solvent mixtures in each other)



Stack of the solar cell layers: glass substrate, anode (ITO), hole conductor (PEDOT:PSS), absorbing layer (P3HT:PCBM) and cathode (Ca).

We optimize the doctor-blading manufacturing process and start determining the influences of coating and drying conditions towards cell properties and transfer the processing to flexible sub-strates.

The research project is conducted in cooperation with the "Light Technology Institute" which is well equipped with a clean room environment for organic solar cell manufacturing and characteri-zation, while the "Institute of Thermal Process Engineering" is able to characterize polymer-solvent-systems in their matter transport parameters during the drying process (magnet coupled sorption balance, in-situ Inverse Micro Raman Spectroscopy, …) and to realize a controlled and reproducible drying process.