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OPV

Organic photovoltaic devices convert sunlight directly into electricity via a complex sequence of events, starting with the absorption of light, followed by creation, separation, transport, and collection of charges. The expectation that lightweight, flexible, and large area polymer solar cells can be fabricated at low cost, in combination with high energy efficiencies spurs a worldwide fast growing interest in this area. An attractive application arises in the field of all-organic electronics smart labels. Smart labels with circuitry, light emissive and detective devices need power that can be supplied by organic solar cells. Such high volume, printable, low-complexity short-lived applications may provide an attractive entry point for the commercialization of organic solar cells.

Interdisciplinary research

So far, the development of organic solar cells was to a large extent a semi-empirical trial-and-error process, in which organic semiconducting materials were selected on the basis of their known or partially known separate properties. It has recently become clear that this provides an insufficiently sound basis for a further development. For further progress, an interdisciplinary approach with new materials, device concepts, models and characterization methods is critical. Therefore CSEM is an active partner within the Photovoltaic European Research Area Network.

In the APOLLO project the research focuses on single cells and tandem cells with record efficiency that feature ease of production and proof-of-principle for the interdisciplinary research approach. In this approach the expertise of the individual partners within the project are combined. Data from microscopic and spectroscopic analysis of the cells, I-V characterization, and impedance spectroscopy serve as an input for realizing a comprehensive device model for the operation mechanism of the cells. The detailed understanding of device operation allows for steady improvements in efficiency.

Combinatorial device fabrication

To speed up the generation of experimental data, CSEM has built a High Troughput Apparatus (HTA-7). Originally designed for material screening and systematic performance optimization of solution processed OLEDs, this tool not only enables automated solar cell characterization, but also a well defined device fabrication process. By sweeping over parameters like material blend ratio, blend concentration, layer thickness, and annealing temperature, the parameters for optimal device performance can quickly be identified.

Printing technology

Fabrication tools for larger area highly efficient polymer bulk heterojunction solar cells are slowly emerging. It is generally accepted that printing can be a suitable technology for large scale production of organic solar cells. In this respect, inkjet printing is promising because it is compatible with various substrates and allows easy patterning.

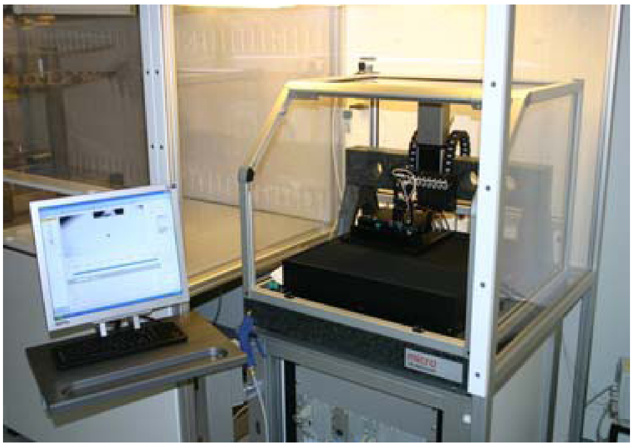

Figure 1 CSEM's Ink-Jet Printer "Autodrop"

In addition to inkjet printing, CSEM has established organic layer deposition by spinning, screen printing as well as hot-embossing of 3D structures as part of an EU-project ("ROLLED") on roll-to-roll gravure printed OLED fabrication. This knowledge is used as a basis for developing printable polymer solar cells. In general, challenges in printing of polymer thin films for optoelectronic devices arise with viscosity constraints, interface roughness, thickness non-uniformity, etc.

One of the crucial issues that receive considerable attention is the search for new solvents or solvent mixtures and temperature conditions that enable the creation of the optimal bulk heterojunction morphology. The morphological and interfacial properties of the inkjet-printed layers can be favorably influenced by a suitable solvent formulation. During the drying process and prospective thermal annealing, the optimized solvent mixture should provide an optimum phase separation network of the polymer donor and fullerene acceptor to bring the device performance close to record efficiencies obtained with spin-coated devices.