Small molecule organic solar cells: Status and perspectives

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Organic semiconductors with conjugated electron system are currently intensively investigated for optoelectronic applications. This interest is spurred by novel devices such as organic light-emitting diodes (OLED), and organic solar cells. While OLEDs are commercially available, organic solar cells still suffer from low efficiency and short lifetimes. The fields of all solid-state organic devices has currently two more or less defined subfields: Although the physics of organic semiconductors are general, communities of wet processing (polymers) and vacuum processing (small molecules) are coexisting.

In this talk, I will first address the status of small-molecule organic solar cells. In the last few years, efficiencies have steadily grown, but are still way too small for a broad application and below current polymer best values. The materials basis is still very small and still dominated by the phthalocyanine/C_{60} system. Lifetime data are scarce and not sufficient for more challenging applications. Differences to polymer solar cells in improving these points, like the differences in achieving the suitable bulk heterojunction absorber morphology, will be addressed.

Then, I will address where future challenges are. Key points are the broadening of the materials basis, the improvement of all solar cell parameters, and future paths towards low-cost manufacturing. From our own work, I will address novel absorber materials, use of electrically doped transport layers, and vacuum roll-to-roll processing.

Finally, I will compare the organic solar cells with its elder brother, the OLED. What can we learn about materials, systems, and manufacturing from these devices already successful in the market?

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Institut für Angewandte Photophysik

The Technische Universität Dresden dates back to the Technische Bildungsanstalt Dresden, founded in 1828 and, thus, ranks among the oldest technical-academic educational establishments in Germany. The TU Dresden has about 35.000 students and almost 4.200 permanent employees (excepting the Faculty of Medicine), 419 professors among them, and, thus, is the largest university in Saxony, today. Having been committed to sciences and engineering before the reunification of Germany, TU Dresden now is a multi-discipline university, also offering humanities and social sciences as well as medicine. There are only few universities in Germany which are able to match this broad scientific spectrum.

The IAPP (Institut für Angewandte Photophysik, http://www.iapp.de) is an institute within the Technische Universität Dresden with broad experience in the investigation of physical properties of organic molecules, and their application in organic optoelectronic devices, as organic light-emitting diodes and organic solar cells. The topics span from the investigation of the molecular properties (using ultra-fast spectroscopy, scanning probe methods, optical characterisation in vacuum, etc.), over the study of molecular epitaxy (in vacuum and from solution), to the preparation and electro-optical investigation of the above-mentioned optoelectronic devices. Special focus is on electrical doping for efficient organic devices, using novel molecular dopants. In addition to the experimental work, each of the topics is supported by theoretical calculations. The institute has in total approx. 70 employees, mostly funded by third-party research contracts (German BMBF, DFG, EU etc.). The IAPP is part of the Organic Cluster Saxony (http://www.organic-valley.org/), Europe's largest organic cluster.

The Organic Solar Cell group within the IAPP currently consists of approx. 15 scientists at different level (PhD or Post-Doc)[1]. Two large cluster systems are available for the preparation and characterisation of organic devices on 25x25mm². Each system is equipped with several vacuum deposition chambers that are connected to a glove box for further processing. A third single chamber deposition system is available for up to 15x15cm² samples, allowing the processing of up to 64 different test solar cells on the same substrate. This system is ideal for the systematic investigation of variations in parameters like layer thickness. A second such system is currently being planned. For characterisation all standard solar cell setups are available (current-voltage, external quantum efficiency with light bias, etc.) as well as a home-made photoinduced absorption setup, UPS/XPS spectroscopy, impedance spectroscopy, AFM/STM, a measurement station for Seebeck and standard spectrometers.

Intense cooperation takes place within the Organic Cluster Dresden with IAPP-spin-offs (Heliatek GmbH, Novaled AG, CreaPhys GmbG, sim4tec GmbH) and the Fraunhofer IPMS. Further cooperations include e.g. the University Ulm regarding the synthesis of new materials.

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