

SYOP 2: Organic Photovoltaics: from Single Molecules to Devices

Time: Thursday 9:30–12:30

Location: BAR SCHÖ

Invited Talk SYOP 2.1 Thu 9:30 BAR SCHÖ
Material Design for Organic and Hybrid Solar Cells – structural to functional control on all length scales — ●MUKUNDAN THELAKKAT, MICHAEL SOMMER, RUTH LOHWASSER, and SEBASTIEN MARIA — Applied Functional Polymers, Department of Macromolecular Chemistry I, University of Bayreuth, 95440 Bayreuth, Germany

One of the challenging aspects in designing and developing novel functional materials is to incorporate the desired optical and /or electrical properties maintaining their film-forming and thermal characteristics which make them suitable for thin film device applications. An important criterion for photovoltaic applications is that these materials should have well-defined nanostructured morphology in thin films in order to be capable of fulfilling the complex functions of charge transfer and transport simultaneously. This morphological control on a nanoscopic level controls the interface between the functional domains as well as the long term stability of such devices. We have demonstrated the chain of control on all length scales using the self-assembly principle of a fully functionalised block polymer for photovoltaic applications.

This contribution covers the design, synthesis and properties of some novel low molecular weight semiconductors as well as poly(3-hexylthiophene)-block-Poly(perylenebisimide acrylate). Block copolymers those allow the incorporation of semiconductor quantum dots or nanocrystals to get hybrid systems with morphology control will also be discussed. The characterization of these materials in thin films and their application in devices will be presented.

Invited Talk SYOP 2.2 Thu 10:00 BAR SCHÖ
Triplet exciton formation in organic photovoltaics — XUDONG YANG, SEBASTIAN WESTENHOFF, IAN HOWARD, THOMAS FORD, RICHARD FRIEND, JUSTIN HODGKISS, and ●NEIL GREENHAM — Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, United Kingdom

We have recently found that the formation of triplet excitons can be an important loss mechanism in organic photovoltaics, particularly in donor-acceptor blends designed to have high open-circuit voltages. This can occur when the intrachain triplet state lies lower in energy than the charge-transfer state formed at the heterojunction. We find that in a blend based on the polyfluorene derivatives F8BT and PFB, triplet excitons are formed after photoexcitation with much higher efficiency than in the component polymers. We use transient absorption spectroscopy to study the dynamics of charges and triplet excitons on timescales from picoseconds to microseconds. This allows us to determine a characteristic time of ~ 40 ns for intersystem crossing in the charge-separated state, and to estimate that as many as 75% of photoexcitations lead to the formation of triplet states. To avoid losses to triplet excitons in photovoltaic devices, it is necessary to separate charge pairs before intersystem crossing can occur. We also present photophysical measurements of saturation and relaxation of the triplet excited state absorption used to quantify triplet populations.

Invited Talk SYOP 2.3 Thu 10:30 BAR SCHÖ
Charge Carrier Dissociation and Recombination in Polymer Solar Cells — ●VLADIMIR DYAKONOV^{1,2} and CARSTEN DEIBEL¹ — ¹Julius-Maximilians University Würzburg, Institute of Physics, Experimental Physics VI, 97074 Würzburg, Germany — ²Bavarian Center for Applied Energy Research e.V. (ZAE Bayern), 97074 Würzburg, Germany

We determined the dominant polaron recombination loss mechanisms in pristine and annealed polythiophene:fullerene blend solar cells by applying the photo-induced charge extraction by linearly increasing voltage (photo-CELIV). In pristine samples, we find a strongly temperature dependent bimolecular polaron recombination rate, which is strongly reduced as compared to the Langevin theory. For the annealed sample, we observe a polaron decay rate which follows a third order of carrier concentration almost temperature independently. We will discuss the impact of a reduced bimolecular recombination rate on

the main characteristics of the polymer solar cells.

Invited Talk SYOP 2.4 Thu 11:00 BAR SCHÖ
Modeling exciton diffusion and dissociation at organic-organic interfaces — ●DAVID BELJONNE — Chemistry of Novel Materials, University of Mons-Hainaut, Place du Parc 20, B 7000 Mons, Belgium

Increasing the performances of organic photovoltaic (OPV) cells requires the simultaneous optimization of various processes involved in their working principle. We will first briefly overview these processes, comment on the theoretical limits for quantum efficiencies and identify possible directions for improvement. Among other factors, the excitation diffusion length and the fraction of excitons undergoing charge generation at the interface are key to the overall OPV quantum yield. We will assess both thermodynamic and kinetic aspects of these phenomena in the case of oligoacenes:C60 bilayer devices. In particular, on the basis of quantum-chemical calculations and phenomenological models, we will discuss the reasons for the unexpected quasi-quantitative external quantum yield for charge generation that has been measured for such devices.

Invited Talk SYOP 2.5 Thu 11:30 BAR SCHÖ
Correlation of Interfacial Composition and Bulk Morphology to Device Performance in Organic Bulk Heterojunction Solar Cells — DAVID GERMACK¹, ●JOSEPH KLINE¹, DANIEL FISCHER¹, LEE RICHTER¹, CALVIN CHAN¹, DAVID GUNDLACH¹, MICHAEL TONEY², and DEAN DELONGCHAMP¹ — ¹National Institute of Standards and Technology, Gaithersburg, USA — ²Stanford Synchrotron Radiation Lightsource, Menlo Park, USA

Organic and hybrid inorganic/organic photovoltaic cells promise to drop solar energy costs low enough to compete with conventional technologies such as coal. Direct measurements of the morphology of bulk heterojunction blends are critical to future efficiency improvements. We have developed strategies to measure the orientation, distribution and dimension of morphological features in materials for organic thin film transistors and photovoltaic devices that have led to rational guidelines for the design of new polymeric materials and processing techniques. By using Near Edge X-Ray Absorption Fine Structure (NEXAFS) and ultra-violet variable angle spectroscopic ellipsometry (UV-VASE) in combination with grazing incidence X-ray diffraction (GIXD) and atomic force microscopy (AFM) we have developed models of interfacial composition and morphology and the vertical composition of a P3HT:PCBM blend. We will describe our ongoing efforts to correlate the electrical performance of P3HT/PCBM blend devices to measurements of interfacial composition and morphology and bulk morphology.

Invited Talk SYOP 2.6 Thu 12:00 BAR SCHÖ
Developments on the acceptor side in plastic PV — ●JAN C. HUMMELEN — Molecular Electronics, Zernike Institute for Advanced Materials & Stratingh Institute for Chemistry, University of Groningen, Nijenborgh 4, 9747AG Groningen, The Netherlands

The intensity of R&D on solar cells based on the bulk heterojunction principle is rapidly increasing during the last 5 years. Much progress has been reported lately on especially bulk heterojunction cells based on the combination of conjugated polymers and fullerene derivatives. One of the present issues in materials design of donor-acceptor combinations is that of the relative energies of the frontier orbitals. Recently, there is increasing discussion concerning the optimum offset between the two LUMO energies, and, related to that, whether molecular (donor-acceptor) based PV would have lower theoretical maximum efficiency than standard inorganic PV. We will address these issues and give an overview of some recent developments. Since most of the energy tuning has been performed on the acceptor components, we will report on the developments with respect to the palette of available acceptor LUMO energies, as well as some latest device results, obtained with new acceptor materials