University of Oldenburg,
Energy- and Semiconductor Research Laboratory (EHF)

The Energy and Semiconductor Research Laboratory (EHF) assembles three research groups in material sciences (photovoltaics, nanochemistry and physics of complex systems). Our photovoltaics group has a current team strength of 20 highly motivated people (physicists, chemists, engineers and students) and carries out research projects in different fields of commercialized and emerging thin film PV-technologies:

- CIS/CIGS solar cells, modules & technology
- Organic photovoltaic devices, modules & technology
- Organic-inorganic semiconductor heterostructures & devices.

In these fields we perform fundamental and application-oriented research with interdisciplinary approach. There are different cooperations with industrial partners, SMEs as well as research institutions in framework of bilateral arrangements and public research grants.

Team Profile & Research Activities

Our team is specialized in fundamental investigations of organic semiconductor systems and provides strong expertise in development, fabrication and characterization of photovoltaic devices based on solution processed semiconductor composites (*conjugated polymers, small molecules and semiconducting nanocrystals*). For studies of OPV-relevant fundamental processes we can offer different techniques for electrical and photophysical investigation:

- Studies of charge transport in organic field effect transistors (OFET) based on pristine and blended semiconductors; measurements of space charge limited currents (SCLC) in semiconducting diodes.
- Capacitance spectroscopy (C-V, AS, DLTS) for studies of the dielectric behavior of organic semiconductors and detection of defect states.
- Excited states spectroscopy (PIA, PL) and magnetic resonance techniques (ESR, LESR, ODMR) for investigation of charge carrier generation and recombination dynamics in donor-acceptor heterojunctions.

Our organic PV-devices are typically based on solution processed semiconductor heterojunctions. Basically we concentrate on conventional polymer-fullerene blends as well as composites employing inorganic nanocrystals, which are synthesized in our labs. The latter (Cd(S,Se), InP, CZTS, and core-shell systems with ZnS) are expected to establish a novel class of acceptor material for BHJ-systems with outstanding optical and dielectric properties compensating inherent loss mechanisms coming along with fullerene acceptors.

Our strategies in device development concentrate on advanced device architectures with functional intermediate layers for single and multijunction BHJ solar cells as well as OPV-modules with monolithic circuitry. Our R&D activities also include prototyping of sealing techniques and their evaluation in accelerated lifetime tests in a climate chamber capable of 'in-situ' monitoring under illumination. Elementary and advanced characterization of laboratory solar cells is done in our PV-laboratory where the following techniques are installed:

- Current-voltage (I-V) measurements under simulated AM 1.5G illumination (thermostatic)
- I-V-characterization under variable temperature (20…450 K) and illumination intensity (0…2 suns) in a He-closed cycle cryostat
- External and 'internal' photon conversion efficiency (300…1200nm, thermostatic) under optional electrical and optical bias. Measurements under constant photon flux can be performed. External PCE can be also measured at variable temperature

Equipment

Sample preparation:	2-chamber glove-box (integrated evaporator & spin coater), HV-PVD (thermal/e-beam), linear film applicator, clean room with mask aligner for UV-lithography, wire bonder, wet chemical processing and nanocrystals synthesis, Langmuir-Blodgett, device encapsulation
Structure analysis:	AFM, KPFM & MFM (ambient/UHV), STM, FIB/E-SEM, profilometry, dynamic light scattering (DLS), XRD with texture analysis
Optical analysis:	UV-Vis-NIR-spectrometer, fluorescence spectrometer, spectral ellipsometry (VASE)Electrical characterization: I-V-profiling* (variable illumination), int./ext.[1] quantum efficiency (electrical & optical bias), climate chamber for accelerated lifetime tests with in-situ-monitoring, capacitance-voltage (C-V*), admittance spectroscopy (AS*), deep-level-transient spectroscopy (DLTS*).
Photophysics:	Photoluminescence* & excited states spectroscopy (PIA*), magnetic resonance (ESR*, LESR*, ODMR*), variable excitation

* temperature-dependent (20K…400K; HV, contact atmosphere)

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