

HL 28: Organic Semiconductors 1

Time: Thursday 9:30–11:45

Location: H34

HL 28.1 Thu 9:30 H34

Dual-color organic LEDs for on demand activation and inhibition of cellular activity — ●GIUSEPPE CICCONE¹, ILENIA MELONI², RODRIGO GASTON FERNANDEZ LAHORE³, HANS KLEEMAN¹, PETER HEGEMANN³, KARL LEO¹, and CAROLINE MURAWSKI² — ¹Dresden Integrated Center for Applied Physics and Photonic Materials (IAPP) and Institute for Applied Physics, Technische Universität Dresden, Dresden, Germany. — ²Kurt-Schwabe-Institut für Mess- und Sensortechnik Meinsberg e.V., Waldheim, Germany — ³Institute for Biology, Experimental Biophysics, Humboldt-Universität zu Berlin, Berlin, Germany

Optical stimulation of light sensitive proteins in neurons allows optogenetics to stimulate and probe cellular activity with high spatial and temporal resolution. Multiple light sources with different wavelengths are usually required to stimulate light-sensitive proteins that combine a cation-conducting and an anion-conducting channel. Here, we present two stacked OLED architectures that can emit light with two different emission colors from the same pixel, addressing the single domains of bidirectional ion channels expressed in *Drosophila melanogaster* larvae and ND7/23 cells with one single, organic device. Tuning of microcavities allowed us to well match the OLED emission spectra to the activation spectra of the combined photo-sensitive proteins BiPOLES and BiPOLES-ChRmine. Our work shows that OLEDs can provide narrowband light emission with minimal crosstalk between sub-pixels, enabling us to switch between optogenetic activation and inhibition of living systems with a single device.

HL 28.2 Thu 9:45 H34

Revealing the origin of short channel effects in organic electrochemical transistors — ●ANTON WEISSBACH¹, HSIN TSENG¹, LAURIE E. CALVET², HANS KLEEMANN¹, and KARL LEO¹ — ¹Technische Universität Dresden, Germany — ²Université Paris-Saclay-CNRS, Palaiseau, France

Organic electrochemical transistors (OECTs) emerged as promising building blocks for brain-inspired hardware. Several studies demonstrated the synaptic-like properties of OECTs. However, the fabrication of integrated hardware with OECTs is hampered by the nature of the electrolyte. In particular, liquid electrolytes are prone to evaporation and cover multiple devices. Here, we present an OECT with photopatternable solid electrolyte that we structure down to 10 micrometer resolution. The patternability of the electrolyte allows us to integrate OECTs in circuitry without crosstalk between devices. On the single-device-level, it exhibits an on-off ratio of 10^6 , and a sub-threshold swing of 61 mV/dec, close to the thermodynamic minimum.

Moreover, we show that these devices exhibit short channel effects, even at large channel lengths up to 100 micrometers. We reveal that the origin lies in the capacitive coupling of the drain electrode with the electrolyte. We then quantify and systematically study the strength of the coupling and show that it can be altered by the overlap of the semiconductor with the drain electrode. Our results reveal that the capacitive drain coupling can be more than 50% compared to the gate coupling. Based on that, we provide a design principle for diminishing the detrimental short channel effect in OECTs.

HL 28.3 Thu 10:00 H34

Laser induced fluorescence spectroscopy of TIPS pentacene attached to rare gas cluster — ●MICHELBACH MORITZ, DEMIANENKO ALEXANDER, HARTWEG SEBASTIAN, and STIENKEMEIER FRANK — Institute of Physics, University of Freiburg, Germany

In the recent years bis(triisopropylsilyl)ethynyl (TIPS) pentacene has gained interest in the field of singlet fission. Originally developed for field-effect transistors, the TIPS side groups of the pentacene lead to favourable intermolecular orientation, high hole mobility in thin films and better solubility in organic solvents [1]. We present a comparison study of the pentacene and its derivate, in which we cover the energetic structure of the excited states, the influence of the surrounding medium and the effect of neighbouring molecules. Especially the collective effects are investigated with a lifetime analysis and give a direct hint for lifetime reducing effects like superradiance and singlet fission [2], [3].

[1] Giri et. al., Nature 480, 504-508 (2011)

[2] Bohlen, M. et al., J. Chem. Phys. 156, 034305 (2022)

[3] Izadnia, S. et al.. J. Phys. Chem. Lett. 8, 2068*2073 (2017)

HL 28.4 Thu 10:15 H34

Heterostructure photodiodes of PbS nanocrystals with different types of ligands — ●SHAIMAA ABDALBAQI¹, FLORIAN GRASSL¹, ALEXANDER HOFMANN¹, AHMED MANSOUR², ALADIN ULLRICH¹, NORBERT KOCH², ANDREAS OPITZ², MARCUS SCHEELE³, and WOLFGANG BRÜTTING¹ — ¹Institut für Physik, Universität Augsburg, Germany — ²Institut für Physik & IRIS Adlershof, Humboldt-Universität zu Berlin, Berlin, Germany — ³Institut für Physikalische und Theoretische Chemie, Universität Tübingen, Tübingen, Germany

The influence of the ligands in coupled organic-inorganic nanostructures (COINs) on the performance of optoelectronic devices is investigated. We fabricate photodiodes based on pentacene and PbS nanocrystals coupled to organic ligands like 1,2-ethanedithiol (EDT) and tetrabutylammonium iodide (TBAI) and a combination of both as a heterostructure. These ligands were first separately used to fabricate a single ligand-type of organic-inorganic device and later compared with a heterostructure of PbS-EDT and PbS-TBAI. To tune the optical energy gap of COINs to align with the triplet level of pentacene, it was necessary to choose the suitable particle size. For this purpose, ultraviolet photo-emission spectroscopy (UPS) was used to determine the energy of the highest occupied molecular orbital (HOMO) and the work function of COINs. Devices with heterostructure COINs achieve a higher short circuit current than COINs with a single type of ligands. Incident photon to current efficiency (IPCE) shows different excitonic absorption peaks in the visible range for different stacks.

15 min. break

HL 28.5 Thu 10:45 H34

Development of an OLED as excitation light source for photocatalytic active materials — ●DOMINIK WEBER¹, DANIEL SCHONDELMAIER¹, DIETRICH R.T. ZAHN², TERESA ISABEL PICOTO PENA MADEIRA², SALVAN GEORGETA², and ANNIKA MORGENSTERN² — ¹Westfälische Hochschule Zwickau, Faculty of Physical Engineering and Computer Sciences/ Nanotechnology, Zwickau, Deutschland — ²Technische Universität Chemnitz, Physics Department / Semiconductor Physics, Chemnitz, Deutschland

Since its first publication in 1987 by Tang and VanSlyke, organic light-emitting diodes (OLEDs) have been in the focus of science for more than 3 decades and have been continuously improved. Especially in the field of RGB OLEDs, substantial progress has been achieved in terms of lifetime and efficiency, which is why they are used today in particular in the display and solid-state lighting technology.

The work presented focuses on the optimization of UV-to-blue OLEDs for use as an illumination source and a source of excitation for photocatalytic active layers. Therefore, an OLED with a suitable characteristic (wavelength, lifetime, efficiency) is developed, by studying the influences of different materials, layer systems, and the integration of nanostructures. Additionally, the photocatalytic active layer titanium dioxide is generated and optimized (absorption behavior, effectiveness), which can be realized by thermally excited phase conversion. The relationship between photocatalytic activity and the phase composition will be investigated here.

HL 28.6 Thu 11:00 H34

Photoexcited charge carrier and spin dynamics in methylammonium lead bromide doped by magnetic transition metals — ●STANISLAV BODNAR¹, JONATHAN ZERHOCH^{1,2}, ANDRII SHCHERBAKOV^{1,2}, SHANGPU LIU^{1,2}, LISSA EYRE¹, and FELIX DESCHLER^{1,2} — ¹Walter Schottky Institut, Physik Department, Technische Universität München, Garching, Germany — ²Heidelberg University, Heidelberg, Germany

One of the most challenging tasks for LED applications is emitting 100% polarized light from the device. Typically, this is achieved by introducing an additional layer of polarization filter which leads to losing half of the light intensity. To overcome this issue, one has to find a system with a high degree of photoluminescence (PL) polarization. A promising approach here is using magnetic metal doping in combination with a highly efficient semiconductor. We have chosen to use transient absorption (TA) spectroscopy at cryogenic temperatures to

investigate changes in the optical properties induced by magnetic metal doping in $\text{CH}_3\text{NH}_3\text{PbBr}_3$ since it gives spectral information about the energies of electronic states and dynamic properties of the photoexcited carriers. We find a change in the main ground state bleach (GSB) peak position in doped $\text{CH}_3\text{NH}_3\text{PbBr}_3$, which depends on the transition metal used. The main GSB peak of pure $\text{CH}_3\text{NH}_3\text{PbBr}_3$ at 4 K is at 2.32 eV. Doping $\text{CH}_3\text{NH}_3\text{PbBr}_3$ with Mn leads to a shift of the main peak to lower energies by 0.04 eV and 0.08 eV, respectively. The modifications of the TA spectra are associated with changes in the bandgap energy, which is the result of doping-induced lattice expansion.

HL 28.7 Thu 11:15 H34

Ultrastrong light-matter interaction of J-aggregated squaraine in an open cavity for polariton lattices —

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Organic molecule exciton-polaritons in artificial lattices are an emerging platform to emulate complex electronic Hamiltonians at ambient conditions. We present J-aggregated squaraine dye (SQ) thin films [1] as a promising candidate for exciton-polaritons in optical cavities due to its high oscillator strength and tunable resonance. Using white light reflection spectroscopy, we demonstrate tunable ultrastrong coupling of light to the SQ thin film in an open cavity at room temperature [2], which we support by transfer matrix calculations. In ongoing exper-

iments, we introduce structured photonic lattices to the open cavity to investigate the coupling of the polaritons to tailored potential landscapes.

- [1] M. Schulz, et al., Nat Commun 9, 2413 (2018).
- [2] L. Lackner, et al., Nat Commun 12, 4933 (2021).

HL 28.8 Thu 11:30 H34

Exploring the Device Physics of Photomultiplication in Organic Photodetectors — •LOUIS CONRAD WINKLER, JONAS KUBLITSKI, JOHANNES BENDUHN, and KARL LEO — TU Dresden, Germany

Recently, photomultiplication (PM) in organic photodetectors has been achieved, but working mechanism and physics are not fully understood. Contrary to inorganic photodiodes, impact ionization and avalanche breakdown cannot be achieved in organic semiconductors. Instead, the accumulation of one charge carrier type close to an electrode leads to a strong energy level bending, which increases the tunnelling probability of the opposite charge carrier type under reverse bias from the metal contact into the device. In this contribution, we investigate the well-known donor-acceptor system $\text{ZnPc}:\text{C}_{60}$, using the acceptor as an electron trapping state to inject holes into the donor phase. Since the effective electron mobility is strongly decreased, we investigate whether shifting the generation location influences the device operation, e.g. the response speed and external quantum efficiency. Furthermore, a gradient donor-acceptor mixing ratio is introduced to increase both response speed and free charge carrier generation efficiency via an enlarged donor-acceptor interface. We also investigate the effect of trapping time being larger than the carrier transit time, leading to reduced cut-off frequencies.