

CPP 42: Perovskite and Photovoltaics 5 (joint session HL/CPP/KFM)

Time: Thursday 15:00–16:30

Location: H31

CPP 42.1 Thu 15:00 H31

Atomically Thin Sheets of Lead-Free 1D Hybrid Perovskites Feature Tunable White-Light Emission from Self-Trapped Excitons— ●PHILIP KLEMENT¹, NATALIE DEHNHARDT², CHUAN-DING DONG³, FLORIAN DOBENER¹, JULIUS WINKLER², SAMUEL BAYLIFF⁴, DETLEV M. HOFMANN¹, PETER J. KLAR¹, STEFAN SCHUMACHER^{3,5}, SANGAM CHATTERJEE¹, and JOHANNA HEINE² —¹Institute of Experimental Physics I and Center for Materials Research (ZfM), Justus Liebig University Giessen, Giessen, Germany — ²Department of Chemistry and Material Sciences Center, Philipps-Universität Marburg, Marburg, Germany — ³Department of Physics and Center for Optoelectronics and Photonics Paderborn (CeOPP), Paderborn University, Paderborn, Germany — ⁴Department of Chemistry and Biochemistry, University of Oklahoma, Norman, OK, USA — ⁵College of Optical Sciences, The University of Arizona, Tucson, AZ, USA

One of the major current challenges in 2D materials' synthesis is the intentional design of building blocks to introducing superior chemical and physical properties. The limiting factor in this approach is the commonly-believed paradigm that in-plane covalent interactions are strictly necessary to form 2D materials, limiting the number of candidates. Here, we go beyond the paradigm that atomically thin materials require in-plane covalent bonding and report single layers of the one-dimensional organic-inorganic perovskite [C₇H₁₀N]₃[BiCl₅]Cl. Its unique 1D-2D structure enables single layers and the formation of self-trapped excitons which show white-light emission.

CPP 42.2 Thu 15:15 H31

Multiple spin-flip Raman scattering in bulk lead halide perovskites— ●MAREK KARZEL¹, DENNIS KUDLACIK¹, NATALIA E. KOPTOVA¹, INA KALITUKHA², MAKSYM V. KOVALENKO³, DMITRI R. YAKOVLEV¹, and MANFRED BAYER¹ — ¹Experimentelle Physik 2, Technische Universität Dortmund, 44227 Dortmund, Germany — ²St. Petersburg, Russia — ³Laboratory of Inorganic Chemistry, ETH Zürich, 8093 Zürich, Switzerland

Lead halide perovskites like FACs are promising competitors for conventional semiconductors in spintronics due to their highly efficient light absorption and emission properties. We study spin-flip Raman scattering (SFRS) of resident carriers and investigate possible carrier exchange interactions. The measurements are performed at low temperatures around 1.6 K and external magnetic fields up to 10 T in Faraday and tilted geometries. This method allows us to observe Raman shifts in high magnetic fields which according to [1] are attributed to the g-factors of resident electrons and holes. The SFRS efficiency significantly increases for resonant probing of the free exciton resonances. We conduct from our measurements, that the creation of the free exciton is the essential requirement for observation of multiple spin-flip Raman scattering.

[1] E. Kirstein et al., Adv. Mater. 34, 2105263 (2022).

CPP 42.3 Thu 15:30 H31

Stability Enhancement of perovskite nanoplatelets via crosslinking of ligands

— ●MAXIMILIAN GRUBER, ULRICH LEO, NINA HENKE, PATRICK GANSWINDT, MICHAEL LICHTENEGGER, CONNOR HEIMIG, and ALEXANDER URBAN — Nanospectroscopy Group and Center for Nanoscience (CeNS), Nano-Institute Munich, Department of Physics, Ludwig-Maximilians-Universität München, Königinstr. 10, 80539 Munich, Germany

In recent years lead halide perovskite nanoplatelets (NPL) have attracted a lot of attention due to low-cost production and excellent spectral tuning. Additionally, perovskite NPLs exhibit the benefit of exciton energy tunability via quantum confinement as well as large photoluminescence quantum yield. The high surface to volume ratio of the NPLs, however, makes them susceptible to degradation by water, air and ion migration.

One solution to these issues of degradation investigated here is a process called crosslinking. Hereby the exposure of a film of NPLs to a dose of electron radiation induces intermolecular bonds between the organic ligands attached to the individual nanocrystals, hence forming a protective matrix around a film of pristine perovskite NPLs.

Varying dosages of irradiation of three monolayer CsPbBr₃ NPLs

were investigated followed by an exposure to other halides, NPLs with a different halide composition as well as different solvents, showing a drastic increase in stability of the crosslinked compared to untreated NPLs. This enables the possibility of a future application of lead halide perovskite NPLs under ambient conditions.

CPP 42.4 Thu 15:45 H31

Enhancing the optical performance of perovskite nanoplatelets— ●STEFAN MARTIN¹, CAROLA LAMPE¹, NINA HENKE¹, IOANNIS KOUROUDIS², MILAN HARTH², ALESSIO GAGLIARDI², and ALEXANDER URBAN¹ — ¹LMU Munich, Nanospectroscopy Group — ²TU Munich

Lead halide perovskites have been drawing a lot of interest during the last few years due to their unique properties. Their excellent optical performance combined with easy and cost-efficient production are interesting for both light-emitting devices and solar cells. Perovskite nanoplatelets are furthermore convincing with high photoluminescence quantum yields and narrow emission linewidths tunable from 430 to 505 nm. The thickness of these nanoplatelets can be tuned with a monolayer precision and determines the absorption and emission profile of the sample.

By using different machine learning approaches the synthesis parameters were investigated and optimized based on the emission spectrum. With this method, the emission properties of nanoplatelets with thicknesses reaching from 2 to 8 monolayers were enhanced. Additionally, the emission wavelengths can be finetuned using a post-synthetic enhancement treatment comprising a lead halide ligand solution. Depending on the time interval between synthesis and enhancement, a redshift of controllable extent can be introduced while further reducing the emission linewidth. With these strategies, a narrow and symmetric emission peak can be achieved at any desired wavelength. This is particularly interesting for the implementation in optoelectronic devices.

CPP 42.5 Thu 16:00 H31

Extensive study on sequential physical vapor deposition of mixed-cation perovskite (Cs,FA)PbI₃— ●KARL HEINZE¹, TOBIAS SCHULZ¹, ROLAND SCHEER¹, and PAUL PISTOR² — ¹Institute of Physics, Martin-Luther-University Halle-Wittenberg, von-Danckelmann-Platz 3, 06120 Halle (Saale), Germany — ²Universidad de Pablo Olivade, Carretera de Utrera 1, 41013, Sevilla, Spain

Sequential deposition via physical vapor deposition (PVD) is underexplored, even though it offers precise adjustment of components and composition and a variety of routes to investigate the optimization of perovskite growth. We combine in situ XRD and in situ laser light scattering to monitor phase evolution of (Cs,FA)PbI₃ during PVD. We study the influence of deposition sequence of the components PbI₂, FAI and CsI on CsFAPbI₃ growth. Noticeably, the sequence strongly influences the orientation of deposited components. Similarly, diffusion before and during annealing as well as resulting alpha phase share depend on the evaporation sequence. When depositing PbI₂ first, conversion to the perovskite phase was not achieved, unless an over stoichiometric share of FAI was deposited. Depositing FAI first and PbI₂ later resulted in a high probability of layer conversion to the perovskite phase without secondary phases being detected. A striking feature during our investigation was the absence of the delta phase during deposition and annealing, seemingly caused solely by the preparation method. We deliver important insight into this poorly investigated preparation path and provide a foundation for further research based on our detailed study of sequence-dependent crystalline growth.

CPP 42.6 Thu 16:15 H31

Ultrafast transient spectroscopy of Cu(In,Ga)Se₂ coupled to different buffer layers.

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The dynamic parameters of photo-induced electron-hole pairs, such as recombination time and charge conductivity, play a major role in the efficiency of photovoltaic devices. Among thin film materials for photovoltaics, one of the most interesting is the p-type Cu(In,Ga)Se₂ alloy (CIGS) on which an n-type buffer layer is deposited, forming the

initial part of the device p-n junction. The inter-material transport dynamics strongly depend on how the band structure is affected by the buffer layer, and also on the quality of the CIGS \ buffer layer interface which may contain defects. In our experiments we have compared the ultrafast transient reflectivity on CIGS epitaxially grown on a GaAs substrate. New Cd free buffer layers In_2S_3 and band offset tunable $\text{Zn}(\text{O,S})$, are compared to the most commonly used buffer layer, CdS.

The transient reflection measurements allows for the extraction of the electronic transport dynamics at the interface with the buffer. This study allows us to draw conclusions about the pair formation capacity mediated by the transport properties between the CIGS and the buffer layer. The results can guide the development of Cd free buffer layers thus reducing the environmental impact caused by CdS in traditional CIGS solar cells.