

Special Lecture

PROF. DR. MAKSYM KOVALENKO

ETH Zürich, Department of Chemistry and Applied Biosciences

Nano- and single-crystals of lead halide perovskites: from bright light emission to hard radiation detection

Chemically synthesized inorganic nanocrystals (NCs) are considered to be promising building blocks for a broad spectrum of applications including electronic, thermoelectric, and photovoltaic devices. We have synthesized monodisperse colloidal nanocubes (4-15 nm edge lengths) of fully inorganic cesium lead halide perovskites (CsPbX_3 , X=Cl, Br, and I or mixed halide systems Cl/Br and Br/I) using inexpensive commercial precursors. Their bandgap energies and emission spectra are readily tunable over the entire visible spectral region of 410-700 nm. The photoluminescence of CsPbX_3 NCs is characterized by narrow emission line-widths of 12-42 nm, wide color gamut covering up to 140% of the NTSC color standard, high quantum yields of up to 90% and radiative lifetimes in the range of 4-29 ns. Post-synthetic chemical transformations of colloidal NCs, such as ion-exchange reactions, provide an avenue to compositional fine tuning or to otherwise inaccessible materials and morphologies. While cation-exchange is facile and commonplace, anion-exchange reactions have not received substantial deployment. Here we present fast, low-temperature, deliberately partial or complete anion-exchange in CsPbX_3 NCs. By adjusting the halide ratios in the colloidal NC solution, the bright photoluminescence can be tuned over the entire visible spectral region (410-700 nm). Furthermore, fast inter-NC anion-exchange is demonstrated as well, leading to uniform $\text{CsPb}(\text{Cl}/\text{Br})_3$ or $\text{CsPb}(\text{Br}/\text{I})_3$ compositions simply by mixing CsPbCl_3 , CsPbBr_3 and CsPbI_3 NCs in appropriate ratios. We also present low-threshold amplified spontaneous emission and lasing from CsPbX_3 NCs. We find that room-temperature optical amplification can be obtained in the entire visible spectral range (440-700 nm) with low pump thresholds down to $5 \pm 1 \mu\text{J cm}^{-2}$ and high values of modal net gain of at least $450 \pm 30 \text{ cm}^{-1}$. Two kinds of lasing modes are successfully realized: whispering gallery mode lasing using silica microspheres as high-finesse resonators, conformally coated with CsPbX_3 NCs, and random lasing in films of CsPbX_3 NCs.

Here we also demonstrate that 0.5-1 centimeter large, solution-grown single crystals of MAPbI_3 can serve as inexpensive, operating at ambient temperatures solid-state gamma detectors (e.g. for direct sensing of photons with energies as high as mega-electron-volts, MeV). Such possibility arises from extremely high room-temperature mobility(μ)-lifetime(τ) product of $10^{-2} \text{ cm}^2 \text{ V}^{-1}$, low dark carrier density $10^9 - 10^{11} \text{ cm}^{-3}$ and low density of charge traps $3 \times 10^{10} \text{ cm}^{-3}$, and high absorptivity of hard radiation by lead and iodine atoms.

Friday, October 14, 2016 at 5:15 PM

TU Berlin, Institute of Chemistry
Straße des 17. Juni 115, 10623 Berlin

Building C, Lecture Hall C 230

Prof. Dr. Driess (TUB)

Organizer

Coffee and cake will be served 30 minutes before the lecture. Guests are cordially invited to attend!
Prof. Dr. Matthias Driess - Chair of the Cluster of Excellence UniCat - www.unicat.tu-berlin.de

