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Unifying Concepts in Catalysis

Special Lecture

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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-synthestic 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 $CsPb(Cl/Br)_3$ or $CsPb(Br/I)_3$ 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±1 μJ cm^{-2} and high values of modal net gain of at least 450±30 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} cm^2 V^{-1}, low dark carrier density 10^9 - $10^{11}cm^{-3}$ and low density of charge traps 3×10^{10} cm^{-3}, and high absorptivity of hard radiation by lead and iodine atoms.

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

Building C, Lecture Hall **C 230**

Prof. Dr. Driess (TUB)
Organizer

Guests are cordially invited to attend!
Prof. Dr. Matthias Driess - Chair of the Cluster of Excellence UniCat - www.unicat.tu-berlin.de