Highly Luminescent Nanocrystals of Cesium and Formamidinium Lead Halide Perovskites: From Discovery to Applications

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We discuss the discovery and recent developments of colloidal lead halide perovskite nanocrystals (LHP NCs, NCs, A=Cs^+, FA^+, FA=formamidinium; X=Cl, Br, I) [1,2,3] and some lead-free analogues. We survey the synthesis methods, optical properties and prospects of these NCs for optoelectronic applications, foremost as classical and quantum light sources [4,5].

LHP NCs exhibit spectrally narrow (<100 meV, 12-45 nm from blue-to-near-infrared) sponaneous and stimulated emission, originating form bright triplet excitons [6], and tunable over the entire visible spectral region of 400-800 nm [1-4]. 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 [7]. Cs- and FA-based perovskite NCs are highly promising for backlighting of LCD displays, for light-emitting diodes and as precursors/inks for perovskite solar cells. Towards these applications, a unique feature is that perovskite NCs appear to be trap-free without any electronic surface passivaiton [8], in spite of having structural defects.

The processing and optoelectronic applications of perovskite NCs are, however, hampered by the loss of colloidal stability and structural integrity due to the facile desorption of surface capping molecules during isolation and purification. To address this issue, we have develop new ligand capping strategy utilizing common and inexpensive long-chain zwitterionic molecules, resulting in much improved chemical durability [9].

Perovskite NCs also readily form long-range ordered asssemblies known as superlattices. These assemblies exhibit accelerated coherent emission (superfluorescence) [10], not observed before in semiconductor nanocrystal superlattices.

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