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Editorial

Perovskite Semiconductor Nanocrystals

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The world is facing the grand challenges of balancing economic growth and environmental protection, urging the development of sustainable energy sources and more efficient energy consumption [1]. To tackle these challenges, new materials are in great demand. In this respect, semiconductor nanocrystals (NCs) have shown great potential in light harvesting applications such as photovoltaics, luminescent solar concentrators, and photocatalysis/photosynthesis [2–4]. They have also been intensively exploited in light-emitting devices such as light-emitting diodes (LEDs), lasers, and luminescent displays as well as other emerging fields, for example, photodetectors and radiation detectors, and in biomedicine [5–8]. In the past few years, halide perovskite and perovskite analogues have emerged as important NC materials for their unique features, such as defect tolerance, emission color purity, tunable band gap, and intriguing charge/exciton transport behavior. Significant efforts have been devoted to the synthesis and investigation of perovskite NCs with novel compositions and structures for a variety of optoelectronic applications [9].

This special issue of Energy Materials Advances, consisting of two review and six research articles, focuses on the recent developments in the synthesis and tuning of the properties of halide perovskite NCs and other emerging NCs. These articles cover a broad selection of materials, such as lead-free perovskite NCs, inorganic perovskite NCs, lead-free double perovskite NCs, type-II heterostructured NCs, ternary I-III-VI_2 NCs, and graphene quantum dots. The topics covered range from fundamental understanding of doping, synthesis, and spectroscopy to the application of NCs in solar cells and LEDs.

Specifically, Shan's group provides a comprehensive review article on the recent advances in lead-free perovskite NCs for optoelectronic devices [10] (Article ID 5198145). This review covers the design routes, morphologies, optoelectronic properties, and environmental stability issues as well as the preliminary achievements of lead-free perovskite NCs in versatile optoelectronic applications, such as light-emitting devices, solar cells, photodetectors, and photocatalysis. The review article written by Li's group focuses on the emerging topic of LEDs based on two-dimensional perovskite and CdSe-based nanoplatelets (NPLs) (Article ID 9857943). This review covers the synthesis strategy of NPLs, the recent progress on LEDs based on NPLs, and the opportunities and challenges in this field. Mohammed's group reports air-resistant lead halide perovskite NCs embedded into a polyimide matrix with intrinsic microporosity [11] (Article ID 9873846). The encapsulated $CsPbBr_3$ NCs not only have enhanced optical and photoluminescence (PL) stability but also show a much longer excited state lifetime due to the reduced density of surface trap states. This encapsulation method paves the way to the large-scale synthesis and implementation of perovskite NCs in optical devices. Bae's group presents their recent work on pushing the band gap envelop of quasi-type II heterostructured $ZnSe/ZnSe_{1-X}Te_X/ZnSe$ NCs to the blue region of the spectrum [12] (Article ID 3245731). The emission wavelength can be tuned from blue to orange by varying the composition of the emissive $ZnSe_{1-X}Te_X$ layers grown between the ZnSe seed and the shell layer. The defect-free heterostructured NCs exhibit near-unity photoluminescence quantum yield, and dichromatic white NC-based light-emitting diodes are demonstrated. Li's group reports a modification of the interfacial barrier in graphene/silicon Schottky barrier solar cells using graphene oxide quantum dots (GOQDs) [13] (Article ID 8481915). The carrier tunneling and recombination at the Schottky barrier can be controlled by the thickness and size of GOQDs, and a maximal 13.67% power conversion efficiency is achieved with an optimized barrier for GOQDs. Xia's group discusses their progress on the tunable photoluminescence enabled by lattice doping of lanthanide ions in $Cs_2AgInCl_6$ NCs through a hot-injection synthesis method [14] (Article ID 2585274). Lanthanide ions, including Dy^{3+}, Tb^{3+}, and Sm^{3+}, occupy the In^{3+} sites. The doped $Cs_2AgInCl_6:Ln^{3+}$ NCs exhibit tunable PL emission in the visible wavelength range owing to the intrinsic transitions from the lanthanide ions. This enables their application in fluorescent labeling and anticounterfeiting technology. The research paper from Brovelli's group studies intrinsic and extrinsic exciton recombination pathways in ternary I-III-VI_2 $AgInS_2$ NCs [15] (Article ID 1959321). Using temperature-dependent complementary spectroscopic, spectroelectrochemical, and magnetooptical investigations, the band structure and the excitonic recombination mechanisms in stoichiometric $AgInS_2$ NCs are revealed.

Overall, this special issue reviews the exciting progress in various fields of NCs and presents the frontier of NC-related research from many leading groups around the world.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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