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Editorial

Editorial for the Special Issue on Quantum Dots Frontiers

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Thanks to state-of-the-art chemical and device engineering in past decades, we have witnessed more and more novel applications based on semiconductor nanocrystals: quantum dots (QDs). Besides the applications on bio-labeling [1], QDs have already exhibited great commercial value in lighting applications due to their unique properties compared to traditional technologies. For instance, the emission of QDs is bright, tunable in a visible range, and narrow in bandwidth, enabling high-quality and low-cost lighting including high-color-rendering lights and wide-color-gamut display backlights (known as photoluminescence (PL)-type QD applications) [2–4]. On this basis, with ligand engineering and refined encapsulation, PL-type QD applications have successfully inspired lighting and display commercialization. Moreover, based on efforts of device engineering, electroluminescence (EL)-type QDs applications, known as QD-light-emitting diode (or QLED), are also very close to commercialization, particularly for green and red QLED. The main challenge remaining is achieving efficient and stable QLED with blue emission. Notably, the QDs for lighting and display applications are mainly referred to CdSe QDs, InP QDs (mostly merged as core-shell structured QDs, and the alloyed QDs) [3,5–7], and perovskite nanocrystals [8–10].

Another branch of QD applications is based on the unique properties of QDs: the solution processibility and the broad wavelength spectral response. In this branch, the most representative QDs are lead chalcogenides QDs, PbS, and PbSe, which bring new opportunities for fabricating low-cost and high-resolution short-wave infrared (SWIR) imagers. The processibility of these QDs enables direct integration with the present CMOS technique and thus significantly reduces the price of SWIR imagers [11–13]. The key component of the SWIR imager is known as a diode-type photodetector (PD) array in which a single pixel exhibits a similar device architecture to a photovoltaic device [14,15]. In such a charge extraction application, the QDs are atomically surface passivated in the film, working as both a light absorber for charge generation and a charge carrier transport medium. Therefore, the surface passivation and the inter-dot distance-dominated stacking configuration of the QDs are both important to stable and efficient solid films in such applications [16].

Overall, QDs, as novel materials with a large surface-to-volume ratio, are sensitive to ambient conditions. Thus, to address different application requests, the type of QDs and the treatments can be fundamentally different. In this Special Issue on "Quantum Dot Frontiers", we included nine papers on different QDs with different application backgrounds. Specifically, for QDs in material science, Hu et al. investigated the properties of doped perovskite QDs with mixed-A-cations [10]. Moreover, Yoo et al. improved the efficiency of cadmium-free QDs via advanced surface passivation [6]. Halim et al. investigated the electron–phonon coupling mechanism of PbS QDs and PbS/MnTe QDs by tracking their temperature-dependent PL spectra [17]. For the bio-labeling application, Le et al. employed core-shell structured QDs in detecting doxycycline in nature water and in food [1]. For

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PL-type QD applications, Xiao et al. presented a method to optimize the light quality of white-light LED, in which the QD-based white-light LED is also involved [2]. Zhao et al. reported high-resolution QD arrays in micro-LED applications [3]. Towards EL-type QD applications, Ye et al. reported an efficient QLED device with the perovskite QD active layer deposited via an ink-jet method [8]. To improve the QLED performance, Wang et al. introduced a novel organic hole transport layer material in the QLED fabrication process [9]. A flexible QLED device exhibiting an exemplary performance compared with the rigid device was demonstrated by Kim et al. by employing novel device components [5]. We believe that based on further developments in chemistry engineering and device engineering, the era of QD applications is approaching.

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