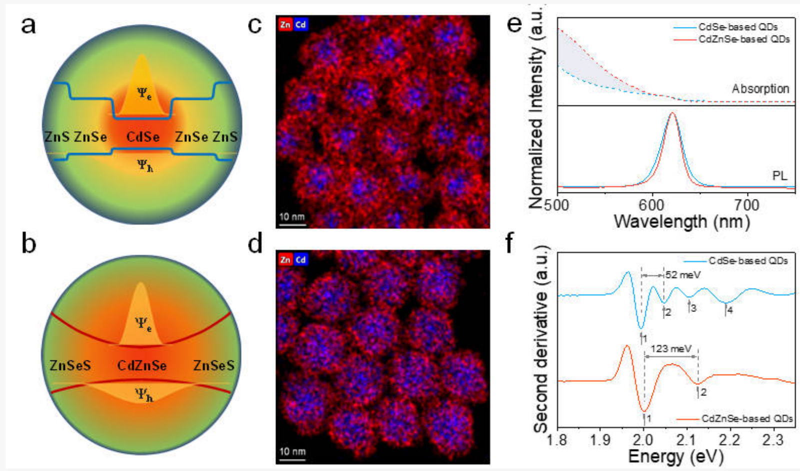
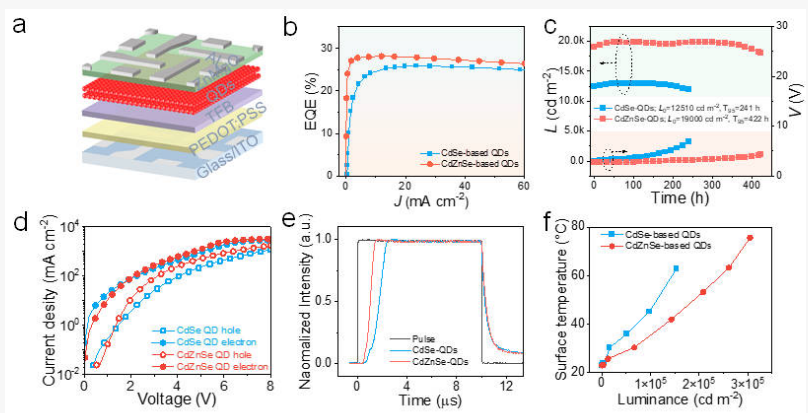
Realizing low voltage-driven bright and stable quantum dot light-emitting diodes through energy landscape flattening



Structural, morphological, and Spectroscopic properties of QDs.



Device structure, performance, and carrier dynamics analysis.

GA, UNITED STATES, January 16, 2025 /EINPresswire.com/ -- Quantum dot light-emitting diodes (QLEDs) hold great potential as competitive candidates for display and lighting applications. Scientist in China invented bright and stable QLEDs with low operating voltage and minimized heat generation. This is attributed to "giant" CdZnSe/ZnSeS quantum dots, which effectively smooth out the energy disorder at the quantum dot/hole transport layer interface. The technique will provide an efficient path to minimize heat generation and improve operational stability for photoelectronic devices.

Solution-processed quantum dots (QDs) light emitting diodes (QLEDs) have attracted enormous interests as an excellent candidate for display and lighting applications owing to their outstanding advantages, such as size-tunable emission wavelengths, near-unity quantum yield (QY), and high color purity. QLEDs produce significantly less heat compared to thermal radiation light sources. However, the suboptimal energy landscape of QLEDs and low thermal-conductivity of the functional layer materials can still lead to unavoidable heat accumulation, especially in high brightness areas, which can result in a roll-off in device efficiency and deterioration in operational lifetime.

In a new paper published in Light Science & Applications, a team of scientists, led by Professor

Huaibin Shen from Key Laboratory for Special Functional Materials of Ministry of Education, National & Local Joint Engineering Research Center for High-efficiency Display and Lighting Technology, Henan University, 475004 Kaifeng, China and co-workers have developed the novel giant full-alloy CdZnSe/ZnSeS QDs to suppress the valence-band degeneracy. The CdZnSe-based QDs reveal a suppressed ground-state band splitting and high electron concentration. The CdZnSe-based QLEDs exhibit a dramatically reduced driving voltage with EQE larger than 25%, correspondingly, a wide luminance range of 200-30,000 cd m-2. In addition to effectively inhibiting the efficiency roll-off, the CdZnSe-based devices show an excellent T95 operation lifetime exceeding 70,000 hours at 1,000 cd m-2 due to the effectively suppressed joule heat generation. Our strategy provides an efficient path to minimize heat generation and improve device stability.

The ground-state band splitting strategy effectively flattens the energy landscape of the interface between QDs and hole transport layer, which significantly facilitates the hole injection and accelerates the radiative recombination of excitons, which signifies the enhancement of carrier injection balance. In addition, CdZnSe-based QLEDs reveal a high electron concentration and a reduced and broad driving voltage, which decreases joule heat generation.

This significantly inhibits efficiency roll-off and achieves the record-high brightness at low drive voltage for CdZnSe-based devices. These results represent the best values of conventional QLEDs to date, without any light out-coupling structure and engineering of the emitter dipole. The scientists forecast that our strategy is also expected to achieve breakthrough progress for blue and green QLEDs, and other photoelectric devices.

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