Synthesis and surface modification of Quantum Dots for solid-state lighting applications

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In the past decades, thanks to their low toxicity, InP QDs have been extensively studied as replacements for Cd-based QDs materials in display and lighting applications. However, InP QDs have low stability under photonic/thermal stresses and their synthesis remains a challenge. I will describe a new method to tune the size of InP QDs using a novel precursor reactivity approach. Using several amino phosphine precursors with ethylenediamine substituents, the reactivity could be adjusted and the size of tetrahedral QDs controlled (edge lengths from ~ 3 to 6 nm). The underlying mechanisms were clarified by combining ^{31}P liquid NMR and UV/Visible spectroscopies. [1]

The passivation of InP QDs using anhydrous n-alkylammonium fluoride was used to improves the PLQY and luminescence linewidth. n-Alkylammonium fluoride etches the QD liberating PH3 and phosphorus oxides from the surface. The product surfaces are stabilized by metal fluorides and ammonium fluorides, which narrows the absorption and luminescence linewidth (FWHM as low as 42 nm) and increases the PLQY. The small size and the electron withdrawing properties of fluorine leads to a high surface coverage, which supports excellent surface passivation.

In order to protect the QDs in using conditions, a layered double hydroxide (LDH) matrix was designed to host red-emitting InP/ZnS core-shell QDs, yielding original high-performance functional QD-bola-LDH hybrids. The easy incorporation into silicone-based resins makes these hybrid phosphors attractive for high-tech applications. A proof-of-concept LED prototype has proven to be very promising, displaying a high color rendering index, suitable for implementation in high CRI white LEDs. [2]

References

[1] R. Valleix, F. Cisnetti, H. Okuno, P. Boutinaud, G. Chadeyron, D. Boyer, ACS Applied Nano Materials, 4 (2021), 11105-11114.

[2] R. Valleix, Q. Zhang, D. Boyer, P. Boutinaud, G. Chadeyron, Y. Feng, H. Okuno, F. Réveret, H. Hintze-Bruening, and F. Leroux, Adv. Mater., (2021) 2103411.