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Lattice- and Bandgap-Engineered Core/Shell InP Quantum Dots for High-Efficiency Narrow-Bandwidth Pure Blue Emission

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INTRODUCTIO

Environmentally benign indium phosphide (InP) quantum dots (QDs) have emerged as promising candidates for next-generation full-color displays. Red- and green-emitting InP QDs and their quantum dot light-emitting diodes (QLED) have demonstrated exceptional performance, narrowing the gap with CdSe-based counterparts. In contrast, blue-emitting InP QDs and their QLED lag behind, and the challenges of their synthesis and fabrication are widely recognized in the field. Herein, based on $(DMA)_3P$, we propose a novel Mg-doped core/shell architecture ($InP/ZnMgS/Zn_{1-x}Mg_xS/ZnS$ QDs) to achieve efficient narrow-bandwidth pure blue emission. Sustained gradient growth of Mg-doped shell layers on an initial ZnMgS monolayer achieves a dual function : (1) stepwise matching of lattice constants between core and shell, and (2) robust exciton confinement in small-size InP cores. This strategy facilitates tunable emission from 474 nm (sky-blue) to 465 nm (pure blue), with a reduced full-width-at-half-maximum from 47 nm to 36 nm, alongside significantly enhanced photoluminescence quantum yield (>90%) and fluorescence lifetime (179 ns). Meanwhile, to achieve much stronger storage stability, we have developed a thin ZnS shell layer in the outermost layer. This work provides a feasible and effective strategy for obtaining narrow-band pure blue-emitting InP QDs, aiming to advance environmentally friendly InP QDs and their QLEDs for full-color displays.

RESULTS

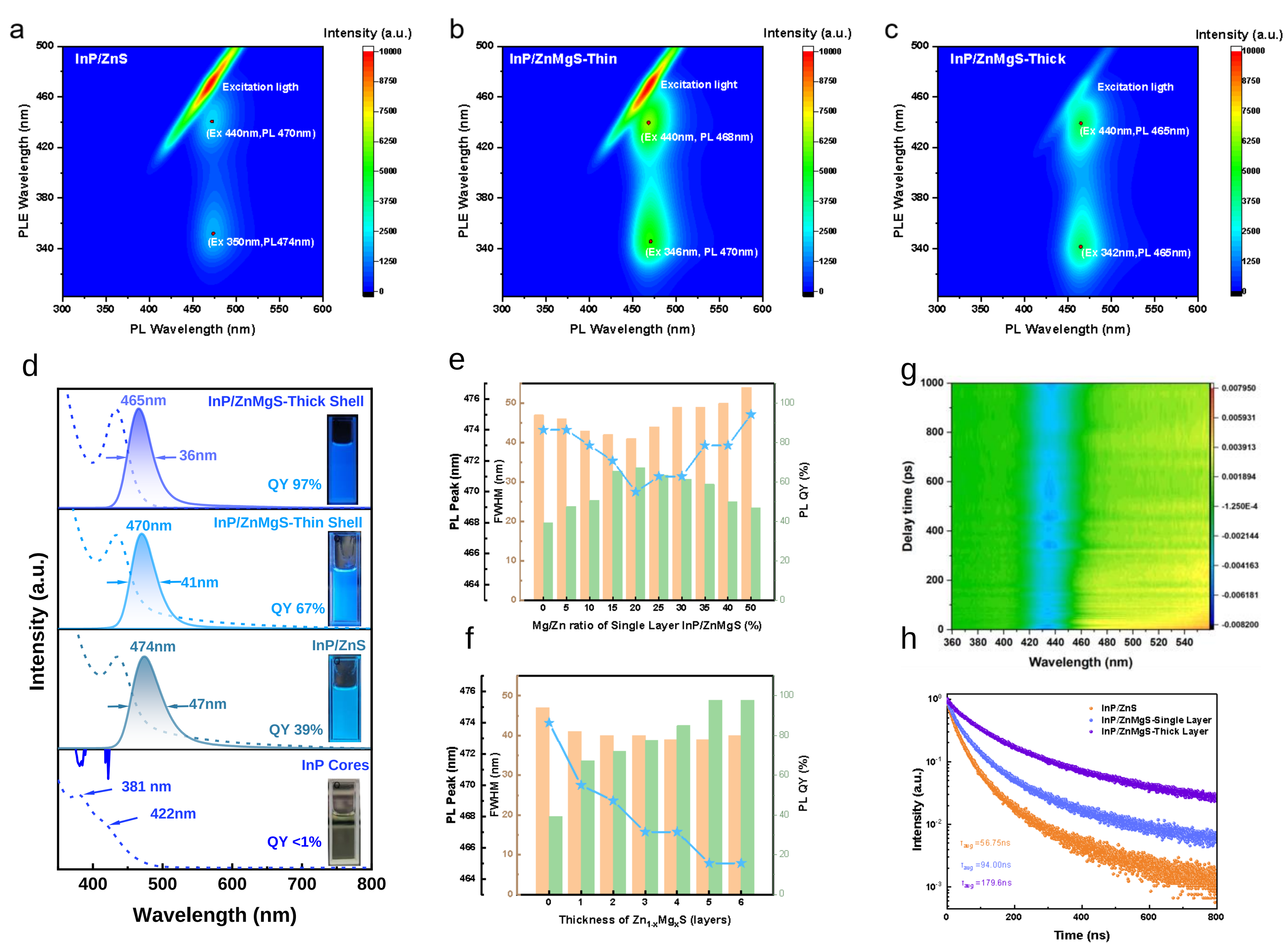

Figure 2. Characterization of optical properties

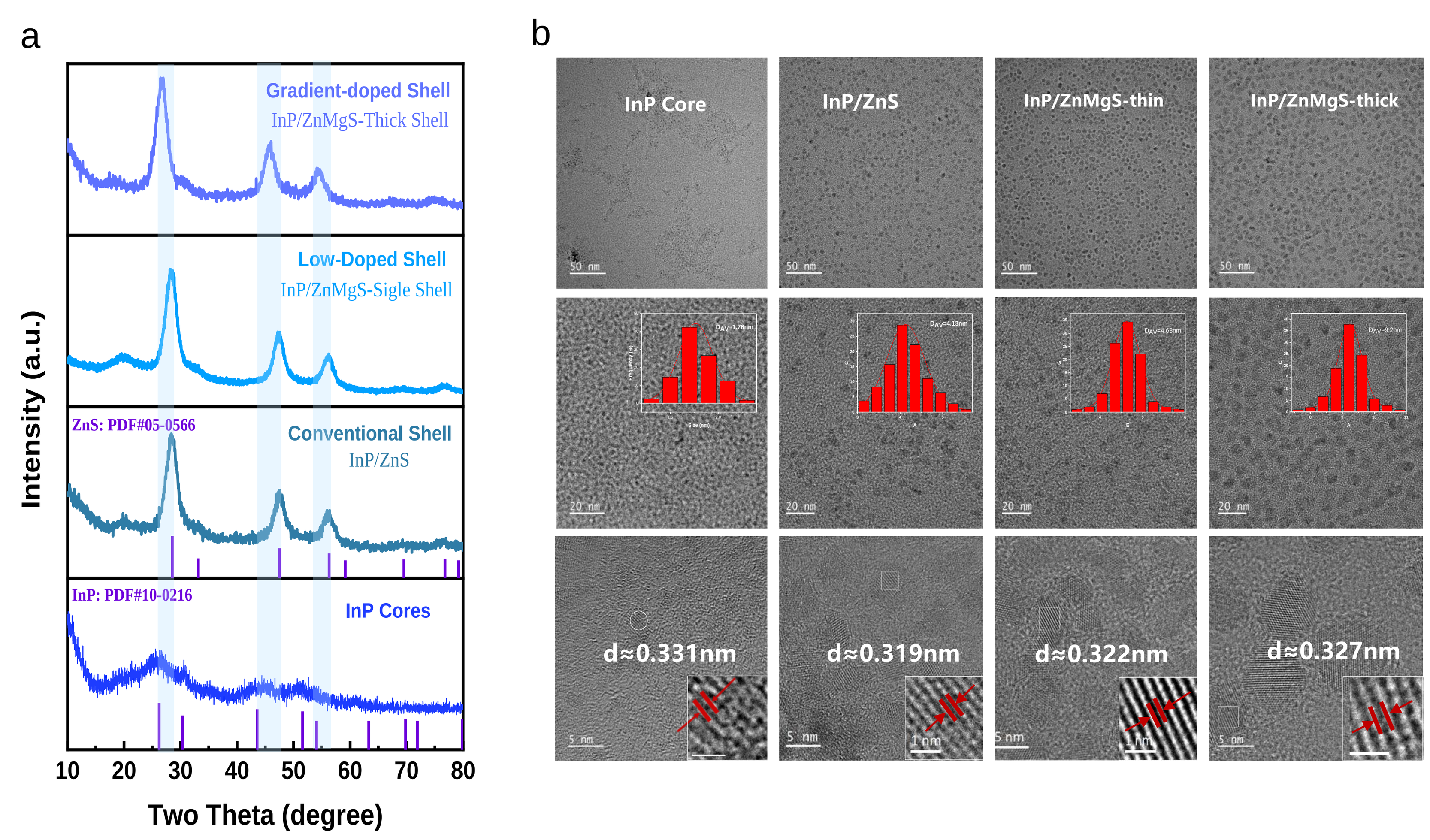

Figure 3. Structural characterization of materials

$InP/Zn_{1-x}Mg_xS$ QDS DEVELOPMENT STRATEGY

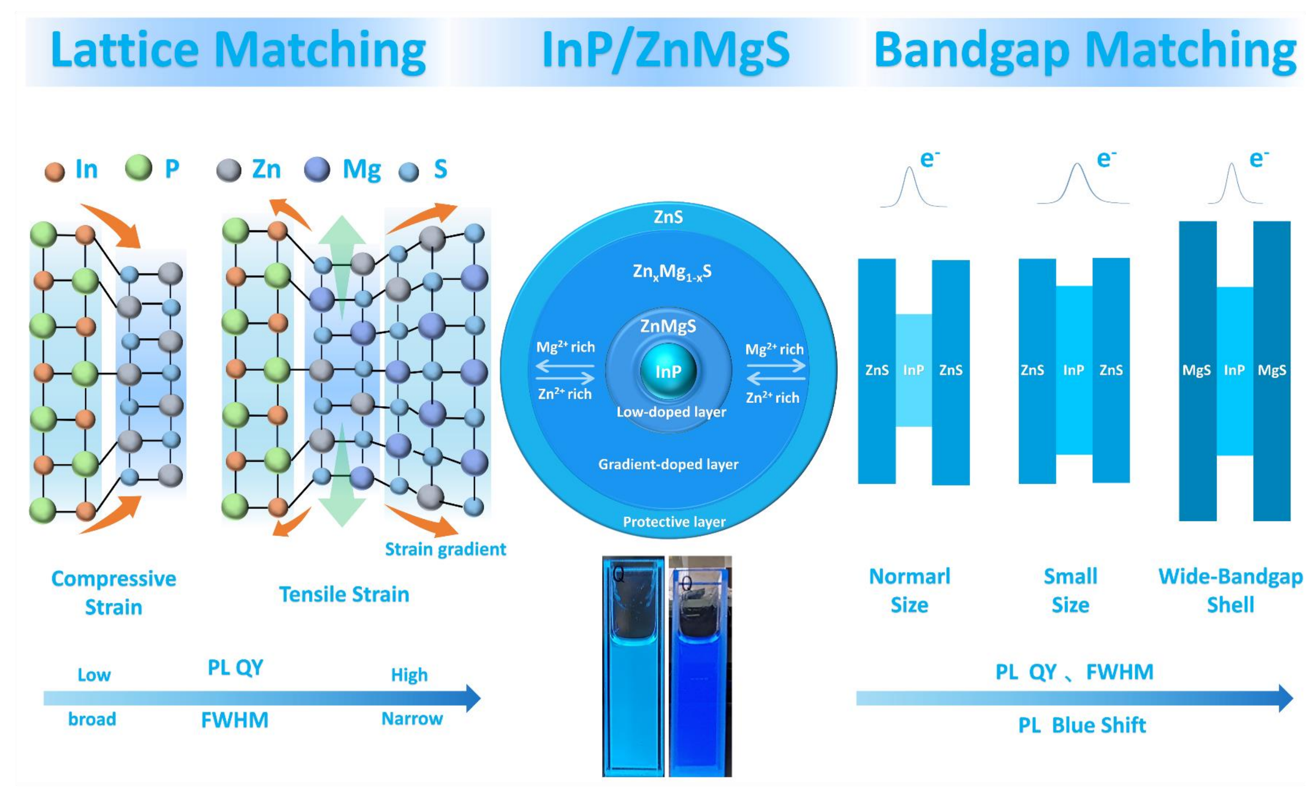

Figure 1. Development strategy of $InP/Zn_{1-x}Mg_xS$ QDs

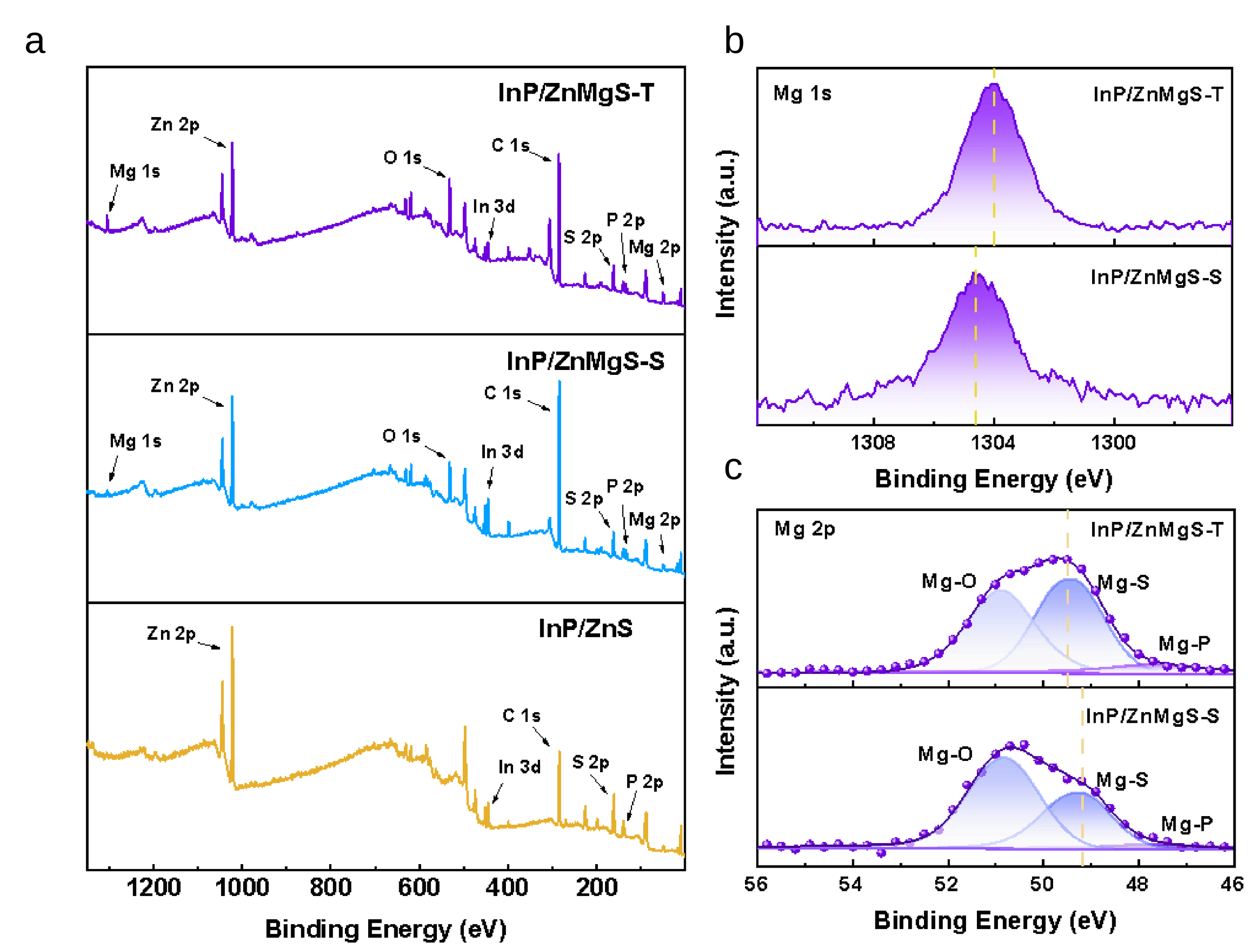

Figure 4. Characterization of interfacial chemical states

CONCLUSION

Key Findings:

- InP/ZnMgS-Thick QDs achieve a high PLQY (> 90%) with narrow FWHM (36 nm), surpassing conventional InP/ZnS.
- Mg alloying enables simultaneous band gap adjustment, lattice matching and surface passivation.

Impact:

This work provides a toxic-free alternative to Cd-based QDs for high-color-purity displays.

Future Directions:

Further stability tests under conditions of constant light, high heat and humidity are in progress.

FUTURE WORK / REFERENCES

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[1] J Zhao, R Jiang, M Huang, Y Qiao, S Wang, W Zhang, P Tian, J Wang, R Guo, S Mei, Advancing Ecofriendly Indium Phosphide Quantum Dots: Comprehensive Strategies toward Color-Pure Luminescence for Wide Color Gamut Displays, ACS Energy Letters, 2025, 10 (5), 2096-2132.