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Luminescence from Nanoscale Perovskite Semiconductor Materials

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Semiconductors exhibit distinctive electronic behavior governed by transitions across narrow bandgaps, typically 0 to a few electron volts. Upon optical or electrical excitation, electrons are promoted to the conduction band, leaving holes in the valence band. Luminescence is produced when these electron–hole pairs recombine radiatively, emitting photons. Because emission efficiency depends strongly on radiative pathways, defect states, and electron–phonon interactions, semiconductors remain central to luminescence technologies, including light-emitting diodes (LEDs), which are valued for their high energy efficiency, long operating lifetimes, and strong brightness. In this work, we investigate Mn-doped vacancy-ordered hexagonal perovskites as promising phosphor candidates for solid-state lighting. The materials were synthesized using a facile solution-based method and characterized by X-ray diffraction and electron microscopy to confirm phase formation and assess crystal structure and morphology. Mn incorporation was systematically optimized using photoluminescence measurements to tune emission features and improve quantum efficiency. Additional spectroscopic studies were carried out to probe energy-transfer pathways, defect-related relaxation processes, and thermal stability, properties that ultimately determine performance under practical device conditions. Finally, the synthesized phosphors were incorporated into phosphor-converted LED prototypes, demonstrating their potential as efficient and stable emitters for next-generation solid-state lighting.

Academic or Professional Status

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