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Tailoring Surface and Optical Properties of Trivalent Metal-Doped ZnO Thin Films for Environmental Sensing and Remediation

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Abstract

The development of advanced oxide materials with tunable surface and optical characteristics is critical for next-generation environmental sensing and photocatalytic remediation technologies. This presentation highlights a systematic investigation of ZnO thin films doped with trivalent metal ions (Cr^{3+}, Fe^{3+}, Sm^{3+}, La^{3+}, and Al^{3+}) at low concentrations (0.1–1 at.%), synthesized via spray pyrolysis. The study focuses on tailoring crystallite size, surface morphology, and strain to modulate functional performance. Detailed XRD and Raman spectroscopy analyses reveal dopant-specific effects on lattice distortion and defect-related vibrational modes, particularly LO phonon behavior. Optical characterization goes beyond conventional bandgap estimation, employing absorption maxima as a sensitive tool to detect sub-band transitions and energy level perturbations. These tailored properties directly impact light–matter interaction and surface reactivity, essential for photocatalytic pollutant degradation and gas detection under real-world conditions. The results demonstrate that precise doping strategies can engineer the physicochemical landscape of ZnO, offering a platform for sustainable applications in environmental monitoring and clean-up. This work contributes to the broader vision of using innovative materials chemistry to address global environmental challenges.

Keywords: ZnO thin films, trivalent metal dopants, surface tailoring, environmental sensors, photocatalysis.

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