From Anti-Counterfeiting to Forest Monitoring: Application-Driven Development of Cr^{3+}-Activated NIR Persistent Phosphors

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Cr^{3+}-activated materials are some of the most versatile platforms for near-infrared (NIR) persistent luminescence (PersL), combining favorable emission characteristics with a rich landscape of defect-related energy storage. In our previous studies on Cr^{3+}-doped germanate and gallogermanate hosts, we demonstrated efficient broadband NIR emission, complex trapping behavior, and long-lasting afterglow governed by a quasi-continuous distribution of trap states [1], [2]. These properties enable advanced functions such as multi-level anti-counterfeiting and time-dependent information encryption. However, expanding the application of Cr^{3+}-activated PersL materials to large-area environmental monitoring requires fundamentally different conditions. Specifically, forest monitoring calls for eco-friendly, low-cost materials that can be activated by sunlight and produce minimal optical pollution, favoring NIR-only or spectrally suppressed visible emission. A critical review of the current state reveals that many established Cr^{3+}-based systems rely on suboptimal excitation conditions or exhibit residual visible emission, thereby limiting their usefulness in low-visibility settings. To overcome these issues, we have started developing Cr^{3+}-activated perovskite-type materials as environmentally safe platforms for NIR PersL. Early experimental results show NIR emission and thermally stimulated luminescence (TSL), confirming the feasibility of the chosen material system. Although phase purity and emission intensity are not yet optimized, these results give valuable insight into the underlying trapping and recombination processes and guide further material improvements. Overall, this work signifies a shift from well-controlled model systems to application-driven design of eco-friendly, NIR-persistent phosphors for remote forest monitoring.

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