A direct observation of ultrafast energy transfer, charge trapping and thermal quenching in luminescent materials

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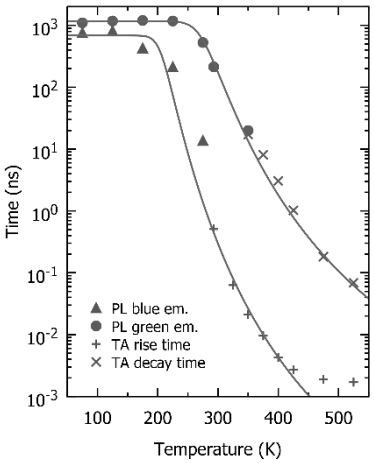
Persistent phosphors, materials that glow for hours after excitation has ended, are often seen as a typical example of slow-emitting materials. Yet, their performance hinges on ultrafast processes like energy and charge transfer.[1] Here we will present new insights into the excited-state dynamics of the benchmark persistent phosphor $SrAl_2O_4$:Eu,Dy (SAO:Eu,Dy).[2] Using a novel combination of transient absorption and time-resolved luminescence spectroscopy, we've captured the full dynamic range of these processes, spanning from picosecond to microsecond timescales.

Our findings reveal that nonradiative energy transfer between distinct Eu^{2+} centers occurs within nanoseconds, accelerating with increasing temperature to reach a remarkable 5-picosecond limit at high temperatures. Charge transfer from Eu^{2+} to trapping defects is ten times faster than radiative decay, while reverse transfer - triggered by optical stimulation - happens in just 2–3 picoseconds. This work demonstrates that pump–probe techniques can resolve the ultrafast events governing seemingly slow phosphors, bridging the gap between fast and slow timescales.



[1] Romero M. et al. (2025) Adv. Opt. Mater., 13, e01847
[2] Van der Heggen D. et al. (2022) Adv. Fun. Mater., 32, 2208809

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