Trapping capacity in persistent phosphors: limitations and workarounds

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Persistent luminescence, i.e. light emission lasting from seconds to hours after the excitation source is turned off, enables many different applications, from emergency and safety signage to bioimaging and outdoor road markings [1]. Such extended photon emission originates from the trapping of charge carriers in defect states and their gradual thermally driven release, followed by radiative recombination at luminescent centers.

The decay profile after ending the excitation is determined by the phosphor's temperature, the total number of traps and the trap depth distribution. Consequently, a lot of research efforts have been put into approaches to determine the trapping and detrapping mechanisms, measure the total trapping capacity and optimize the trap depth distribution [2].

In this presentation, the state-of-the-art of high-luminance persistent phosphors is discussed [1], along with the (intrinsic) factors that limit the total light output of persistent phosphors. For instance, the actual number of traps that can be filled is typically far less than the number of purposely introduced trapping defects, which is partly due to dopant aggregation in grain boundaries. Also, optical detrapping of previously trapped charges turns out to be very relevant to understanding this limitation [3]. In a second part, workarounds are discussed that can yield much higher luminance, by means of larger optical volumes and decoupling the trapping and the final emission.

[1] D. Van der Heggen, et al. (2022) Adv. Func. Mater., 22, 2208809
[2] D. Van der Heggen, et al. (2017) Materials, 10, 867
[3] D. Van der Heggen et al. (2025) Adv. Opt. Mater., 13, 2402153

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