THERMAL QUENCHING OF 5d-4f LUMINESCENCE – THE SINGLE BARRIER MODEL REVISITED

J. J. Joos[1,2,*], L.I.D.J. Martin[1,2], A. Correia[3], Y. Meuret[3], D. Poelman[1,2], P. F. Smet[1,2]

[1]*LumiLab, Dpt. of Solid State Sciences, Ghent University, Krijgslaan 281/S1, 9000 Gent, Belgium*
[2]*Center for Nano- and Biophotonics (NB Photonics), Ghent University, Belgium*
[3]*Light & Lighting Laboratory, KU Leuven, Gebroeders De Smetstraat 1, 9000 Gent, Belgium*
Departement of Chemistry

* corresponding author: *jonas.joos@ugent.be*

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White light-emitting diodes (LEDs) are currently consolidating their position in the lighting and display markets. Key components of these devices are the luminescent materials (or phosphors) that are used to convert a part of the blue excitation light into the other colors of the visual spectrum. The quality of the resulting white light, and the overall efficiency of the white LED are directly determined by the properties of the luminescent materials. In the demanding applications that are targeted, the phosphors have to resist high excitation fluxes and high temperatures up to 150°C. This implies that the luminescent properties of these materials should be maintained under these extreme conditions. Unfortunately this is often not the case, implying a constant demand for better materials [1]. This quest is mostly performed by trial-and error optimization because of an incomplete understanding of the underlying physical processes.

In the case of thermal quenching (TQ), *i.e.* the decrease of the conversion efficiency for elevated temperatures, various explanations exist. Models are often used for which the physical interpretation is unclear, hampering a thoughtful optimization. In this talk, the focus is on the widely used single-barrier model. Its physical origin and limitations are reviewed. Furthermore, two examples are shown where this model should be treated cautiously. A microscopic study on the phosphor $SrGa_2S_4:Eu^{2+}$ uncovers a complex TQ behavior that is influenced by the local Eu concentration and the presence of intrinsic defects, yielding a distribution in empirical parameters [2]. Finally, the benchmark LED phosphor $Y_3Al_5O_{12}:Ce^{3+}$ is studied in detail. It is found that multiple effects determine the shape of the TQ profile, complicating the application of the single barrier model. Energy level models are used to explain this particular behavior.

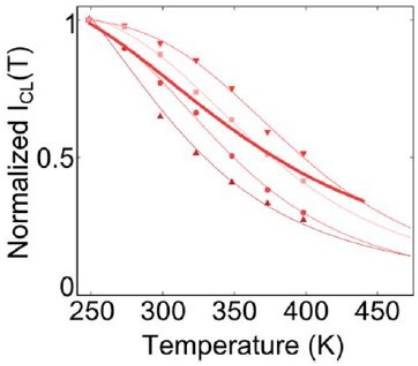

Fig. 1. Distribution of TQ behavior in $SrGa_2S_4:Eu^{2+}$, measured by SEM-CL [2].

[1] P. F. Smet, J. J. Joos, *Nat. Mater.* 16 (2017) 500.

[2] L.I.D.J. Martin, D. Poelman, P.F. Smet, J. J. Joos, *ECS J. Solid State Sci. Technol.* **7** (2018) R3052