Understanding Host-Activator Interactions for Luminescence Thermometry

Eugeniusz Zych#, Justyna Zeler, Joanna Trojan-Piegza, Dagmara Stefanowska

University of Wrocław, Faculty of Chemistry, Luminescent Materials Group
50-383 Wrocław, 14 F. Joliot-Curie Street, Poland

Over the last twenty years or so, luminescence thermometry has advanced significantly and has become an established methodology for determining temperature from luminescence spectra or decays. It continues to grow, and both the design of materials and the development of methods for analyzing experimental data contribute to this field of luminescence.

Many papers and reports on thermometric phosphors exploit the effect of the Boltzmann distribution. At low temperatures, emission arises from radiative relaxation from a lower-energy electronic level, whereas at higher temperatures the upper level is populated at the expense of the lower one, and both contribute to luminescence. As a result, two bands with temperature-dependent intensity ratios are recorded and may be used to sense temperature. This method is elegant, and the physics behind it is described with a simple mathematical equation:

$$\frac{p_i}{p_j} = \exp\left(-\frac{\Delta E}{k_B T}\right),$$

where $\frac{p_i}{p_j}$ is the Boltzmann factor with p_i and p_j representing occupancy of the higher and lower levels, respectively. ΔE is the energy gap between the two levels "i" and "j", k_B is the Boltzmann constant, and T stands for temperature in kelvins. This method has limitations, however. Among others, it works well only within a restricted temperature range. Hence, when genuinely wide-range, high-quality luminescence thermometry is needed, a more complex, multidimensional approach is required.

In this presentation, we will focus on the possibility and need to combine different spectroscopic effects to obtain a sensitive, robust, and operating over a wide temperature range thermometric phosphor.

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corresponding author: eugeniusz.zych@uwr.edu.pl