Synergy of Optical Traps and Vibronic-Level Thermalization in Mn^{2+}-Doped Materials for Visual Thermal Imaging and Thermal Threshold Detection

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The development of next-generation luminescent thermometers requires new mechanisms enabling pronounced, temperature-dependent spectral responses suitable for both sensing and imaging applications. In this lecture, we present a novel thermometric concept based on the synergistic interplay between thermalization of vibronic components of the Mn^{2+} excited state and thermally assisted energy transfer from optical trap states in phosphate-based phosphors. Using two examples: $Ca_{19}Zn_2(PO_4)_{14}:Mn^{2+}$, Ce^{3+} and $Ca_{19}Ce(PO_4)_{14}:Mn^{2+}$ as model materials, we demonstrate that this cooperative effect induces simultaneous thermal enhancement and a blueshift of the Mn^{2+} emission band associated with the $^4T_1 \rightarrow {}^6A_1$ transition[1].

This unique thermal behavior enables multiple temperature readout modes. First, distinct thermal responses of Ce^{3+} and Mn^{2+} emissions allow the construction of ratiometric thermometers with sensitivities up to 4.5% K^{-1}. Second, selective analysis of different spectral regions within the Mn^{2+} emission band provides an additional ratiometric approach. Most importantly, the thermally activated increase of emission in the green spectral region enables filter-free thermal imaging using standard RGB cameras. This effect also allows the design of luminescent threshold indicators, where the appearance of a signal in the green channel marks the treshold of a critical temperature.

Furthermore, the activation temperature of this signal can be precisely tuned by adjusting the Mn^{2+} concentration, providing a versatile platform for application-specific sensor design. Overall, this approach introduces a simple, robust, and cost-effective strategy for multidimensional temperature sensing and visualization, opening new perspectives in luminescent thermometry and thermal imaging technologies.

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