Lifetime-based luminescence manometry on the transition metal ions doped phosphors

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The employment of luminescence for development of sensors capable of detecting physical quantities, such as temperature and pressure, offers rapid, electrically passive, precise, and remote measurement capabilities. While spectral pressure sensors have been recognized for several decades and are extensively utilized, lessons from luminescence thermometry experiments indicate that the emission spectrum's shape, and consequently the pressure readout, may be influenced by the absorption and scattering of emitted light by the medium hosting the phosphor or present in the optical pathway between the detector and the phosphor [1]. Given these considerations, in certain scenarios, luminescence kinetics, which are not subject to such interferences, emerge as a more dependable metrological figure of merit.

Materials doped with transition metal ions, particularly those with a $3d^3$ electronic configuration, are deemed highly suitable for these applications. For such ions, an enhancement in the crystal field strength interacting with the dopant ion due to applied pressure modifies the overlap of the wave functions of the ^2E and $^4T_2$ states. This alteration influences the probability of radiative processes, leading to a elongation of luminescence decay profile—an effect distinctly different from that observed in for example lanthanide ions and of significant application relevance. Moreover, the careful selection of the host material's chemical composition, ensuring minimal thermal shorthening of the emitting level's luminescence lifetime across a specific temperature range, facilitates the development of a thermally independent, highly sensitive luminescence lifetime-based pressure sensor. During the lecture the implementation of described approach will be presented based on phosphors doped with Mn^{4+} ions (e.g., $K_2Ge_4O_9$[2], $Sr_4Al_{14}O_{25}$[3], $SrGdAlO_4$[4]) and Cr^{3+} (e.g., $Li_3Sc_2(PO_4)_3$[5]).

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