Tri-modal optical pressure sensor based on Cr^{3+} ions luminescence

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Preventing disasters resulting from uncontrolled pressure increases constitutes a crucial impetus for investigating novel pressure-sensing methods capable of swiftly and reliably detecting even minute pressure fluctuations, enabling real-time monitoring thereof. One emerging avenue of exploration in this realm involves luminescent manometers, leveraging pressure-induced changes in luminescent characteristics. Recent research in optical pressure sensing underscores the indispensable role of transition metal ions, notably Cr^{3+} ions, owing to their pronounced spectroscopic sensitivity to variations in the crystal field strength. Notably, applied pressure induces shortening of the metal-oxygen distance, affecting the strength of the crystal field which influences their spectroscopic properties [1] and thus affording opportunities for the development of highly sensitive pressure sensors.

Addressing the imperative for dependable real-time measurements with high sensitivity, we proposed a tri-modal luminescent manometer based on Cr^{3+} ions luminescence in doped $Li_3Sc_2(PO_4)_3$ [2]. The innovative approach utilizing the $^4T_2 \rightarrow {}^4A_2$ electronic transition of Cr^{3+} integrates three distinct readout modes based on luminescence intensity ratio (LIR), average lifetime of the excited state, and spectral shift of the emission band. Each of these modalities offers exceptional sensitivity of pressure readout, achieving values of 56.86% GPa^{-1}, 93.56% GPa^{-1} and 23.9 nm GPa^{-1}, respectively. Relative to previously reported high-pressure sensors, the $Li_3Sc_2(PO_4)_3:Cr^{3+}$ phosphor emerges as the most sensitive luminescent manometer up to date, operating in average lifetime and spectral shift modes, thereby exhibiting substantial potential for pressure sensing applications, even under harsh conditions.

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