Cr^{3+}-activated phosphors: Yesterday, today and tomorrow

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A significant boost in the development and investigation of Cr^{3+}- doped crystals was triggered by the discovery of the ruby laser by Maiman in 1960 [1]. Renewed interest arose from the crucial role of chromium in persistent luminescent materials, where it works as an electron trap and/or luminescent center [2], and from the peculiar near-infrared (NIR) emissions resulting from the $3d^3$ electronic configuration, which have potential for bioimaging [3]. Moreover, in addition to the search for pressure sensors with higher sensitivity than the standard ruby [4,5], the possibility to tune and control the position and the relative intensity of the sharp spin-forbidden $^2E \rightarrow {}^4A_2$ and the broadband spin-allowed $^4T_2 \rightarrow {}^4A_2$ transitions by designing host properties, has generated great interest in the scientific community for the development of temperature sensors [6]. More recently, Cr^{3+}- doped crystals characterized by the $^4T_2 \rightarrow {}^4A_2$ broadband emission have been extensively investigated for phosphor-converted NIR LEDs [7].

In this tutorial lecture, spectroscopic features and the most important parameters describing the effect of the environment on the $3d^3$ electrons of Cr^{3+} ions will be described considering the most popular theories. The models used to calculate important parameters and their limitations will be discussed, highlighting the parameters that should be considered for evaluating the performance of the phosphors. Trends and prediction models for the selection of suitable hosts for specific applications will be critically reviewed. Finally, open questions, current challenges and future perspectives will be presented.

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