Dual role of oxygen-related defects in luminescence kinetics of AlN:Mn^{2+}

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This study presents the impact of temperature and pressure on AlN:Mn^{2+} luminescence kinetics. Unusual behaviour of Mn^{2+} optical properties during UV excitation is observed, where a strong afterglow luminescence of Mn^{2+} occurs even at low temperatures. When the temperature increases, the contribution of afterglow luminescence is further enhanced, causing a significant increase in the luminescence intensity. The observed phenomena may be explained by an energy diagram in which O_N -V_{Al} complex in AlN:Mn^{2+} plays a key role. Hence the O_N -V_{Al} complex defect in AlN:Mn^{2+} plays a double function. When the O_N -V_{Al} defect is located close to Mn^{2+} ion, it is responsible for transferring excitation energy directly to Mn^{2+} ions. However, when the O_N -V_{Al} defect complex is located far from Mn^{2+} ions, its excited state level acts as an electron trap responsible for afterglow luminescence. Additionally, three models have been tested to explain the structure of the emission spectrum and the strong asymmetry between excitation and emission spectra. From the most straightforward configuration coordinate diagram through the configuration coordinate diagram model assuming different elastic constants in the excited and ground-state ending by a model based on Jahn –Teller effect. We proved that only the Jahn–Teller effect in the excited $^4T_1$ electronic state with spin-orbit coupling could fully explain the observed phenomena. Finally, high-pressure spectroscopic results complemented by the calculation of Racah parameters and the Tanabe-Sugano diagram are presented.

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