Optical properties of Ni^{2+} Short-Wave Infrared emission under extreme conditions

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Phosphor-converted infrared light-emitting diodes (pc-LEDs) mark a promising departure from conventional semiconductor LEDs based on InGaAs and GaAs, as well as traditional infrared light sources like tungsten halogen lamps and laser diodes. They offer improved versatility and temperature stability. As a result, there is a growing demand for pc-LED light sources capable of emitting broadband SWIR light within the 900–1700 nm range. These advancements would open up exciting possibilities in spectroscopy, optical coherence tomography, optical communication, and noninvasive medical imaging applications. Therefore, the quest for the most efficient phosphor is paramount.

Among the ions investigated for these applications, Ni^{2+} stands out as exceptionally promising, thanks to its wide emission range spanning from 1000 to 1700 nm. Significantly, systems combining both Cr^{3+} and Ni^{2+}, utilizing energy transfer between them, have showcased improved overall luminescence.[1,2] Achieving optimal phosphor efficiency necessitates a deeper understanding of the optical properties of Ni^{2+}.

In this study, we present an investigation focused on $MgGa_2O_4$:Cr^{3+}, Ni^{2+} with Al^{3+} and Sn^{4+} cation dopants. Our research integrates high-pressure measurements with temperature-dependent analyses and luminescence kinetic measurements. The objective is to elucidate how the crystal field strength influences optical properties and to explore the mechanisms behind thermal quenching. Moreover, we change the chemical pressure by incorporating smaller Al or larger Sn ions or into the crystal lattice and compare this process with externally applied pressure using the Diamond Anvil Cell. As both the concentration of Al^{3+} and mechanical pressure increase, a noticeable blueshift of the $^3T_2 \rightarrow ^3A_2$ transition emerges, while the incorporation of Sn^{4+} results in opposite effect i.e. the redshift of the Ni^{2+} emission. Finally, we present a comparison between the temperature-dependent total integrated intensity and calculated decay times, considering their implications for thermal quenching.

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[2] C.-Y. Chang, M.-H. Huang, K.-C. Chen, W.-T. Huang, M. Kamiński, N. Majewska, T. Klimczuk, J.-H. Chen, D.-H. Cherng, K.-M. Lu, W. K. Pang, V. K. Peterson, S. Mahlik, G. Leniec and R.-S. Liu, *Chem. Mater.*, 2024, 36, 3941–3948.

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