Abstract

This doctoral dissertation is devoted to the investigation of the optical properties of inorganic luminescent materials doped with Ni^{2+} ions, with particular emphasis on their emission in the second near-infrared window (NIR-II). The research encompasses both materials solely doped with Ni^{2+} ions and systems co-doped with Cr^{3+} and Ni^{2+} ions, in which the interactions between luminescent centers and their influence on the spectroscopic properties of the materials were examined. The dissertation is based on a collection of five thematically related scientific publications presenting comprehensive studies of selected luminescent materials.

The spectroscopic properties of Ni^{2+} ions were investigated under varying external pressure and in materials with modified chemical compositions. This approach enabled the determination of the influence of changes in the local environment of Ni^{2+} ions, particularly the crystal field strength, on their energy-level structure and luminescence processes. In addition, detailed measurements of emission spectra and luminescence decay kinetics as a function of temperature were carried out to identify the mechanisms responsible for thermal quenching of luminescence. Based on the results obtained for α-$LiGaO_2$:0.01Ni^{2+} and the solid-solution series $Li(Ga_{1-x}Al_x)_5O_8$:0.05Ni^{2+}, x=0.0–1.0, semi-empirical energy level diagrams were developed to describe the dependence of the Ni^{2+} energy levels on crystal field strength.

The second research area focused on materials co-doped with Cr^{3+} and Ni^{2+} ions, in which $Cr^{3+} \rightarrow Ni^{2+}$ energy transfer was utilized to enhance the emission efficiency of Ni^{2+} ions. The investigations were carried out on solid-solution systems based on $LiGa_5O_8$ and $MgGa_2O_4$, whose chemical compositions were modified by partially substituting Ga^{3+} ions with either larger Sn^{4+} ions or smaller Al^{3+} ions. This strategy enabled the simultaneous exploitation of energy transfer from Cr^{3+} ions and the tuning of Ni^{2+} emission energy through modifications of the crystal field strength. The developed phosphors were subsequently applied in pc-LEDs, resulting in efficient emissions within the NIR-II.