Fe^{3+} Near-Infrared Luminescence in Single and Eutectic Crystals

Y. Smortsova[1], R. Tomala[2], M. Szymczak[2], M. Yoshino[3], V. Babin[4], D. Szymńaski[2], Y. Zhydachevskyy[5], L. Marciniak[2], G. Bai[6], Y. Yoshikawa[6], K. Bartosiewicz[4,#]

[1]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, Hamburg 22607, Germany
[2]Institute of Low Temperature and Structure Research, PAS, Okólna 2, Wrocław 50422, Poland,
[3]Institute for Materials Research, Tohoku University, 2-1-1 Katahira Aoba-ku, Sendai, Japan
[4]Institute of Physics, Czech Academy of Sciences, Na Slovance 1999/2, Praha 18200, Czechia,
[5]Institute of Physics, Polish Academy of Sciences, Warsaw, 02-668, Poland
[6]College of Science, China Jiliang University, Hangzhou 310018, China

The development of efficient near-infrared (NIR) luminescent materials is important for applications ranging from night vision and bioimaging to non-destructive optical testing. Although Cr^{3+}-activated phosphors have long dominated this field, their practical implementation is often constrained by spectral overlap with ambient light and by the need for a carefully matched host crystal-field environment to achieve efficient emission, which limits compositional flexibility. Ni^{2+}-doped systems are likewise restricted by relatively limited wavelength tunability. In this context, Fe^{3+} represents an attractive and sustainable alternative, since its NIR luminescence is highly responsive to local coordination, ligand-field strength, defect chemistry, and phase constitution, thereby offering broad opportunities for deliberate emission tuning in structurally diverse materials. The Fe^{3+}-related luminescence characteristics of $Lu_3Al_5O_{12}$:Ce (LuAG:Ce) single crystals and $Y_3Ga_5O_{12}$–Ga_2O_3 (YGG–Ga_2O_3) eutectic heterostructures were evaluated. In the LuAG host, Ce^{3+}-codoping enhanced the Fe^{3+} near-infrared emission through modification of the local crystal-field and defect chemistry. In the eutectic system, the coexistence of chemically and crystallographically distinct phases improved excitation in the blue spectral range, enabling efficient pumping with commercial blue LEDs. Moreover, eutectic crystallization facilitates spatial localization of the excitation within the Ga_2O_3 phase, whose emission around 500 nm allows selective excitation of the green and NIR luminescence. The results demonstrate that targeted crystal-chemical and phase engineering provide an effective route for Fe^{3+}-based NIR luminescent materials compatible with blue-LED excitation and relevant to illumination, thermometry, and radiation detection.

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corresponding author: bartosiewicz@fzu.cz