Luminescence Investigations of ZnGa$_2$O$_4$ Polycrystals Co-doped with Mn$^{2+}$ and Eu$^{3+}$ Ions

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More and more attention has been paid to metal gallate spinel compounds focusing on the developing of different types of display technologies due to advantage over sulfide phosphors. Zinc gallate spinel compounds are one of the promising materials with possible applications in vacuum fluorescent displays and field emission displays [1]. Metal gallate spinel modified by doping with rare-earth ions and transition metals exhibits promising results. Spinels doped with Mn$^{2+}$ and Eu$^{3+}$ ions show excellent luminescent properties in “green” and “orange-red” spectral regions, respectively [2].

In this work, ZnGa$_2$O$_4$: 0.05 mol.% Mn$^{2+}$ and ZnGa$_2$O$_4$: 0.05 mol.% Mn$^{2+}$, 4 mol.% Eu$^{3+}$ ceramic samples have been synthesized via high-temperature solid-state reaction method at ~1200 °C in air. X-ray diffraction measurements confirmed single-phase nature of all samples. The luminescence properties were investigated under different excitation wavelengths at room and liquid nitrogen temperature.

Intense Mn$^{2+}$ ions excitation was found in 230-280 nm region of spectra. Doping with Eu$^{3+}$ ions leads to suppression of Mn$^{2+}$ excitation in the ZnGa$_2$O$_4$: Mn$^{2+}$, Eu$^{3+}$. The f-f excitation lines (350-550 nm) and a broad band in 250-350 nm spectral region were found on excitation spectra of ZnGa$_2$O$_4$: Mn$^{2+}$, Eu$^{3+}$ with registration at 617 nm. The UV excitation band is asymmetrical and related with charge transfer from O$^{2-}$ to Eu$^{3+}$ ions.

Complex broad band in 325-475 nm spectral region corresponds to matrix luminescence and intense band peaking around 505 nm related to Mn$^{2+}$ emission were found at 240 nm excitation. Together with above mentioned bands Eu$^{3+}$ emission was found in 575-650 nm spectral region at 290 nm excitation. These lines correspond to $^5$D$_0$$\rightarrow$$^7$F$_j$ ($j$ = 0, 1, 2) transitions in 4f$^6$ configuration of Eu$^{3+}$ ions. Incorporation of Eu$^{3+}$ ions leads to suppression of both kinds of luminescence.

Changing of excitation wavelength and temperature leads to the redistribution of luminescence intensities in three spectral regions corresponding to the matrix luminescence, emissions of Mn$^{2+}$ and Eu$^{3+}$ ions.