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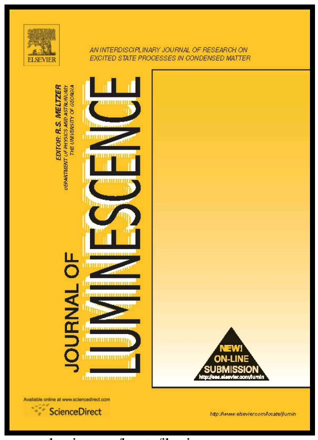

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How activator ion concentration affects spectroscopic properties on $Ba_4Y_3F_{17}$: Er^{3+}, Yb^{3+}, a new perspective up-conversion material

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Abstract
$Ba_4Y_3F_{17}$ with Er^{3+} and Yb^{3+}, a promising material for up-conversion luminescence, was synthesized. Excellent isomorphic capacity was detected. Low-temperature measurements show that erbium ions are incorporated in multiple lattice positions, which is inconsistent with the current model of $Ba_4Y_3F_{17}$ crystal lattice structure. Activator ion concentration has a different impact on $^4S_{3/2}$ and $^4F_{9/2}$, states (for the green and red luminescence, respectively) depopulation. Energy transfer from Er^{3+} $^4S_{3/2}$ state to Yb^{3+} is observed even at low temperature (15 K) while Er-Er cross-relaxation is observed from 120 K and above. Yb^{3+} concentration has a great impact to red-to-green up-conversion luminescence intensity ratio. Spectroscopic measurements allow to conclude that red up-conversion luminescence origins from 2.6 energy transfer steps form Yb^{3+} to Er^{3+} and violet up-conversion –3.5. Calculation shows that for the green up-conversion luminescence band, the internal quantum yield is in range 1.6–2.8% and for the red up-conversion luminescence, in the range –2.2–3.9%.

Keywords
$Ba_4Y_3F_{17}$, up-conversion luminescence, temperature dependence, excitation spectra, luminescence kinetics, quantum yield

1. Introduction

Optical system adjustment often requires tracing the light path even if this light is not visible to the human eyes, for example, infrared radiation. This invisible light needs to be converted to an electric signal or temperature increment in the sensor. These sensors display results in an external display, which is usually separate from sensor-detecting infrared radiation. Direct visualisation of infrared radiation would allow for the faster tuning of optical systems. Such direct light conversion could be achieved using materials featuring the up-conversion process. When such a process occurs, a material emits photons in a visible (even ultraviolet) spectral region after it absorbed infrared photons [1].

The up-conversion luminescence processes have been investigated in various hosts [2–5]. Among others, fluoride crystals such us YF_3 [6], $NaLaF_4$ [7], LaF_3[8] are attractive hosts for rare-earth ions either due to their low phonon energy or multisite structure. Particular interest has been paid to rare-earth doped $NaYF_4$, which has been widely studied [9]. The search for such materials is still ongoing. Recently, we have developed interest in $Ba_4Y_3F_{17}$ doped with different rare-earth elements, which could be a potential candidate for this purpose. Only a few works have researched spectroscopic properties of $Ba_4Y_3F_{17}$ as glass ceramics with Er^{3+} [10] and as nanofibers doped with Er^{3+} [11]. To the best of our knowledge, research of spectroscopic properties of crystalline $Ba_4Y_3F_{17}$ doped with Er^{3+} and Yb^{3+} has not be published. Therefore, this work is devoted to studying spectroscopic properties of $Ba_4Y_3F_{17}$ doped with Er^{3+} and Yb^{3+}.

In this work, $Ba_4Y_3F_{17}$ doped with different Er^{3+} and Yb^{3+} concentration has been synthesized. For synthesized samples Er^{3+} and Yb^{3+}, luminescence and up-conversion luminescence spectra were measured at different temperatures. Results from low temperature