The comparison of photoluminescence decay in YAG:Er, ZnO and SiO_2 crystals

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We report on the intensity and time resolved photoluminescence (PL) measurements in the visible spectral range at wavelengths 350-800 nm using the phase delay method under sine wave UV excitation. Yttrium aluminium garnet ($Y_3Al_5O_{12}$, YAG), zinc oxide (ZnO) and silicon oxide (SiO_2) are crystalline materials, known for their excellent optical properties and mechanical, chemical and temperature stability. The YAG:Er crystals were grown by the micro-pulling-down method at the Institute of Physics in Prague [1], ZnO crystals by hydrothermal growth at the Institute of Chemistry in Bratislava [2] and the SiO_2 micro powder was purchased from Sigma-Aldrich and expoosed to inductively coupled plasma (ICP) at the Institute of Physics to create surface-related defects. Their PL spectra were measured at a room temperature using the UV LED sine wave modulated by 50 MHz Keithley 3390 generator, dispersive monochromator, 10 MHz red-enhanced photomultiplier, 1 MHz current amplifier 10^5 V/A, 200 MHz oscilloscope, and a 100 kHz lock-in amplifier. The sensitivity of the oscilloscope is about 3 orders of magnitude lower than the sensitivity of the lock-in amplifier. Our setup allows to measure the mean PL decay with a time resolution of about 10 ns at 100 kHz. While YAG:Er shows well resolved PL peaks with mean decay time of several μs related to the Stark splitting of Er^{3+} ($4f^{11}$) states, the defect-related PL spectra of ZnO and SiO_2 show broad defect-related bands with significantly faster mean decay times (in the order of tens or hundreds ns in ZnO, depending on doping, and below 10 ns in SiO_2).

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[1] M. Buryi, et al., The role of Er3+ content in the luminescence properties of Y3Al5O12 single crystal: Incorporation into the lattice and defect states creation, Crystals 13 (2023) 562(1-14).

[2] M. Buryi, at al., Peculiarities of erbium incorporation into ZnO microrods at high doping level leading to up conversion and the morphology change. Influence on excitonic as well as shallow donor states, Appl. Surf. Sci. 611 (2023) 155651(1-14).