ENERGY CONVERSION OF X-RAY, ULTRAVIOLET AND INFRARED RADIATION IN Gd_2O_3 CRYSTALS DOPED WITH Er^{3+} IONS

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The phosphors based on lanthanides represent the perspective class of materials for photovoltaic and optical-electronic devices. In rare earth (RE) ions, the variety of $f \rightarrow f$ radiation transitions in a wide spectral range has the potential to be used for down- and up-conversion processes. These energy transfer mechanisms are the basis for the functioning of the so-called luminescent solar concentrators. Such structure allows using the additional fractions of solar spectrum in UV and NIR region and, therefore, enhancing the conversion efficiency [1, 2].

The present paper studies the processes of electromagnetic radiation energy conversion of wide energy range to visible range by study of $f \rightarrow f$ radiation transitions in Er^{3+} ions.

The objects were microstructured powders ($E_g = 6.2$ eV) that were synthesized and certificated by XRD methods in Institute of Physics, Polish Academy of Sciences [1]. Spectra of X-ray excited luminescence (XRL), photoluminescence excitation spectra, photoluminescence (PL) spectra and PL decay kinetics under excitation with different energy E_{exc} were studied at room temperature and at $T = 90$ K. We used the following energies of exciting photons E_{exc} : a) in fundamental absorption region ($E_{\text{exc}} \geq E_g$); b) in intracenter excitation region ($E_{\text{exc}} < E_g$); c) in infrared region ($E_{\text{exc}} \ll E_g$) with using a laser 980 nm diode as source of exciting photons (up-conversion processes).

Some basic results are shown in Fig. 1. Both XRL spectra as well as PL spectra under different E_{exc} contain a set of narrow lines which correspond to $f \rightarrow f$ radiative transitions in Er^{3+} ions. $^4S_{3/2} \rightarrow ^4I_{15/2}$ radiative transition is dominant in $\text{Gd}_2\text{O}_3:\text{Er}$ and it forms PL lines in green light region. The PL efficiency of Gd_2O_3 doped with both Er^{3+} and Zn^{2+} ions in green region decreases and $^4F_{9/2} \rightarrow ^4I_{15/2}$ radiation transitions dominate in red region in both XRL and PL spectra. This effect also appears in anti-Stokes luminescence spectra, Fig.1-b. Doping with zinc ions creates additional anion vacancies (F-like centers) in crystalline lattice to provide local charge compensation. PL decay kinetics measurements under selective excitation by photons with various excitation energy E_{exc} show significant decrease of $^4S_{3/2}$ excited state lifetime in $\text{Gd}_2\text{O}_3:\text{Er}^{3+}+\text{Zn}^{2+}$ (approximately from 110 to 8 μs at intracenter excitation with $\lambda_{\text{exc}} = 380$ nm). This indicates a nonradiative energy transfer from this impurity center to defect. On the other hand, variation of defect concentration makes it possible to regulate the energy conversion efficiency as well as the color of phosphorus luminescence.

Fig. 1. a – PL spectra of Gd₂O₃:Er under different λ_{exc} ; b – PL ($\lambda_{exc} = 980$ nm) and XRL spectra of Gd₂O₃:Er (1,2) and Gd₂O₃:Er+Zn (3,4)

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2. Kuznetsova Yu.A., Zatsepin A.F., Tselybeev R.A., Rychkov V.N., and Pustovarov V.A., Journal of Physics: Conf. Series, 741, 012089 (2016).

DOWNHOLE TELEMETRY SYSTEM RELIABILITY CALCULATION AND IMPROVEMENT

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Downhole telemetry systems are widely used in oil mining industry for oil extraction control and monitoring. These systems consist of ground-based and subterranean units, connected by communication line. The main unit – subterranean – contains temperature and pressure sensors, analog-to-digital convertors, microcontrollers etc. Being used deeply underground, downhole system is exposed to high temperatures (up to 200 °C), high pressure, vibration and other factors of harsh environment. Tests show that maximum non-failure operation time for downhole systems made in Russia does not exceed 200 days, and mean time to failure is approximately 100 days [1].

Present work reviews the methods of reliability improvement for the given downhole telemetry system in severe operating conditions. Calculations were made for the device under development at Ural Federal University.

At the first stage mean time to failure at temperature 150 °C was estimated to be approximately 250 days. The transistor module of the downhole unit was found to be