PHOTOLUMINESCENCE OF MULTI-PHASE YTTRIUM ALUMINIUM OXIDE DOPED WITH EU^{3+} IONS FOR LIGHTING APPLICATIONS

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In this work, several channels of excitation of Eu^{3+} luminescence in multi-phase yttrium aluminum oxide was identified. The possibility of selective excitation of Eu^{3+} localized in two non-equivalent sites in the monoclinic phase was shown.

Yttrium aluminum oxide is of interest as a host for creating materials for light-emitting devices. The Al_2O_3-Y_2O_3 system is characterized by four polymorphs, among which the least studied is the monoclinic structure ($Y_4Al_2O_9$). Europium ions as activators provide not only intense orange-red luminescence, but also serve as markers for assessing the local environment, especially in low-symmetric hosts. The Al_2O_3-Y_2O_3 nanopowders doped with Eu^{3+} ions (3 mol. %) were synthesized by solution combustion method. The structural-phase analysis showed that the synthesized Al_2O_3-Y_2O_3: Eu system consists of four crystalline phase: $Y_4Al_2O_9$ – monoclinic structure (71.7 %), Y_2O_3 – cubic structure (22.8 %), $YAlO_3$ – orthorhombic perovskite structure (2.9 %), $Y_3Al_5O_{12}$ – cubic garnet structure (2.6 %).

A set of emission bands in the spectral range of 575 – 715 nm is associated with 4f-4f optical transitions of Eu^{3+} ions (5D0 → 7FJ, J = 0, 1, 2, 4). The luminescence intensity corresponding to the electric dipole transition (5D0 → 7F2) is an order of magnitude higher than the luminescence intensity associated with the magnetic dipole transition (5D0 → 7F1), which indicates the localization of Eu^{3+} ions mainly in non-centrosymmetric sites in the host lattice. The analysis of luminescence excitation spectra revealed three types of optical transitions: (i) Eu-O charge transfer band at 258 nm; (ii) wide bands at 326 and 338 nm, presumably associated with intrinsic defects of the host; (iii) a set of narrow bands in the range of 360 – 460 nm associated with intercenter excitation of Eu^{3+} ions. A distinctive feature of the luminescence spectrum at excitation wavelengths of 326 and 338 nm is the characteristic splitting of emission lines. The splitting of 5D0 – 7F0 transition (two peaks at 577.2 nm and 578.8 nm) indicates that Eu^{3+} ions occupy two different structural positions in the host. Since the monoclinic phase is dominant in the studied samples, it can be assumed that this splitting is related with Eu^{3+} ions replacing YO_6 and YO_7 sites in $Y_4Al_2O_9$ structure. The excitation bands at 326 and 338 nm, in turn, are associated with defects in the monoclinic phase. On the contrary, at intercenter excitation (392 nm) and excitation through the Eu-O charge transfer band (258 nm), no splitting of emission lines is observed. The broadening of the luminescence bands in these cases is inhomogeneous and is associated with the distribution of Eu^{3+} ions in several phases and several structural positions within each phase.

The results indicate that in the monoclinic structure of yttrium aluminum oxide, the most effective excitation of Eu^{3+} luminescence is realized due to the energy transfer from the intrinsic defects of the host. The obtained nanophosphors, characterized by intense red luminescence under UV excitation, can be used to develop LEDs, displays and energy conversion devices.

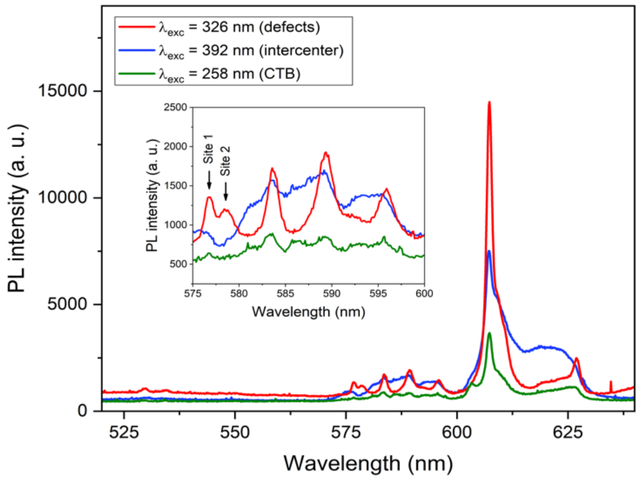

Fig. 1. Room-temperature luminescence spectra of yttrium aluminium oxide doped with Eu^{3+} ions under different excitations. Inset: an enlarged fragment of luminescence spectra in the wavelength range 575 - 600 nm.

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