

Photoluminescence Properties of Eu doped ZnO Films under Thermal Treatment

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Abstract: ZnO is a well-established semiconductor, widely used for applications such as biomedical applications due to its wide bandgap and high excitation binding energy. However, challenges such as high operating temperatures and poor selectivity limit its potential. In order to optimize optical properties of this material researchers often explore a dual modification strategy: doping with europium (Eu) [1]. In this paper we present preliminary results on ZnO:Eu³⁺ emission spectra related to their technological treatment.

Experimental methods: The films were synthesized via a chemical solution approach, followed by thermal annealing [1]. Photoluminescence spectra were recorded at room temperature using as an excitation source a laser diode at 375 nm (Thorlabs, USA). The measurement setup was described elsewhere [2].

Results: The PL spectrum of the ZnO:Eu³⁺ films measured under laser excitation 375 nm (Fig. 1) display a broad emission band that extends between 450 and 720 nm with a maximum at around 500 nm.

One can distinguish a number of emission bands, that can be attributed to intra-configurational 4f–4f transitions of the Eu³⁺ ion. These bands are related to radiative transitions of the Eu³⁺ ion ⁵D₀–⁷F_J (J=0-4), with the barycenter at about ~610 nm (⁵D₀–⁷F₂), ~650 nm (⁵D₀–⁷F₃), and ~700 nm (⁵D₀–⁷F₄). The wide band between 450 and 600 nm can be assigned, as accepted by

most of the researchers, to various defects, and specifically to oxygen vacancies V_O [3]. When the samples are treated at 550 or 650 °C there is a remarkable change of the emission spectrum with diminishing of the band intensity as well as of the band spectral character. It appears that thermal treatment diminishes the contribution of the radiative centers related to 500-700 nm range. On the other side thermal treatment at 550 °C and 650 °C clearly reveals the vacancies related band at ~ 505 nm, as well as the Eu^{3+} related band ${}^5\text{D}_0\text{-}{}^7\text{F}_4$ at ~ 700 nm.

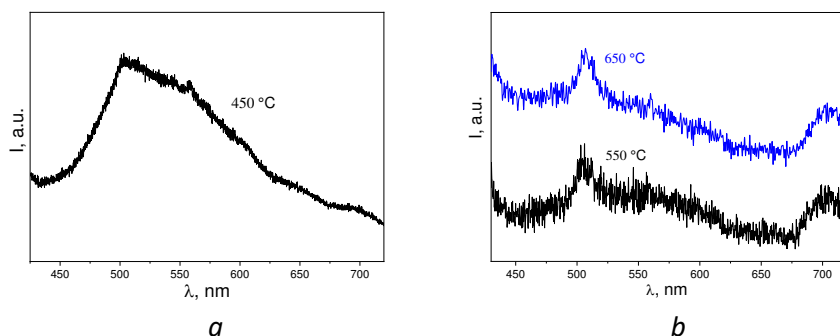


Fig. 1. PL emission spectrum of $\text{ZnO}:\text{Eu}^{3+}$ film treated at different temperatures (450, 550 and 650 °C). $\lambda_{\text{exc}} = 375$ nm. $\text{P}_{\text{LD}} = 7$ mW.

Conclusions: It was found that variation of annealing temperature of $\text{ZnO}:\text{Eu}^{3+}$ films from 450 to 750 °C alters the character of emission spectrum. On the one side, it reduces the PL emission related to the visible range about 510 – 675 nm, and, on the other side, reveals two distinctive bands at ~ 505 nm, and at ~ 700 nm.

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