NN.4P SEMICONDUCTOR-OXIDE NANOCOMPOSITES ON THE BASIS OF POROUS SEMICONDUCTORS

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Over the last years, there has been considerable interest in optical properties of rare-earth-ion doped nanocrystals dispersed in a transparent medium as potential optoelectronic materials. This issue becomes especially important in connection with the growing interest in the development of random lasers. Most of the random lasers elaborated to date are based on powders, microspheres, nanocrystallite clusters, polycrystalline films, and disordered organic materials. However, these lasers are not suitable for integration with other optical or electronic functions. Nanocomposite materials prepared on the basis of porous semiconductor templates are more perspective in this regard. We propose to use porous semiconductor based nanocomposites for the formation of random laser cavities. Recently we developed technological methods for the preparation of semiconductor-oxide nanocomposites with controlled composition and oxide-phases content. In this paper, we report on the possibility to dope and to activate the rare earth ions in nanocomposites prepared on the basis of porous GaP and GaAs templates.

The porous GaP and GaAs templates were prepared by electrochemical etching of wafers cut from Czochralsky-grown ingots. Eu^{3+} and Er^{3+} ions were incorporated into the por-GaP layer from $EuCl_3$:C_2H_5OH and $ErCl_3$:C_2H_5OH solutions, respectively. Just after infiltration of the solution, the sample is rinsed in ethanol and dried by nitrogen gas. Afterwards, the samples were annealed in a nitrogen flow containing less than 1 % of oxygen by using a halogen lamp heater. The samples were annealed during different periods of time ranging from several minutes to several hours at definite temperatures from the interval 500 to 1000 ^{o}C. We found that this technology allows one to prepare GaAs/β-phase Ga_2O_3 composites with a controlled ratio of phases, the Eu^{3+} and Er^{3+} ions being effectively incorporated and activated into the Ga_2O_3 phase.

In contrast with GaAs, the technology applied to the GaP templates results in the segregation of a rare earth containing oxide phase incorporated in the form of nanocrystals in the basic semiconductor/oxide composite. The basic GaP oxide proves to be the low-cristobalite $GaPO_4$, while the rare earth containing oxide is the xenotime $ErPO_4$ or monazite $EuPO_4$, as shown in Figure 1. The phase content of the composite is controlled by the technological conditions. The $ErPO_4$ and $EuPO_4$ nanocrystals ensure the bright green and respectively red emission from the composite, as shown in Figure 2.

The mechanisms of the rare earth ion excitation and the stark spitting of the $^{2S+1}L_J$ multiplet manifold due to the crystal electric fields of the host is deduced from the analysis of luminescence related to Eu^{3+} and Er^{3+} intrashell transitions for all the nanocomposites prepared on the basis of GaP and GaAs templates.

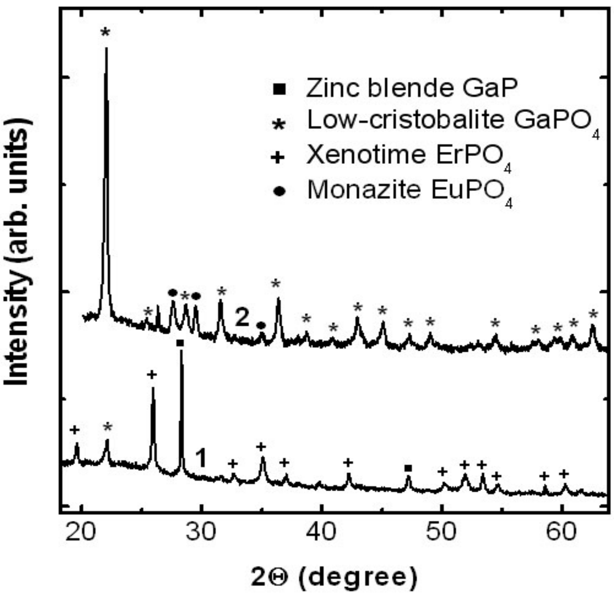

Fig. 1. XRD analysis of GaP based nanocomposites doped with Er (curve1) and Eu

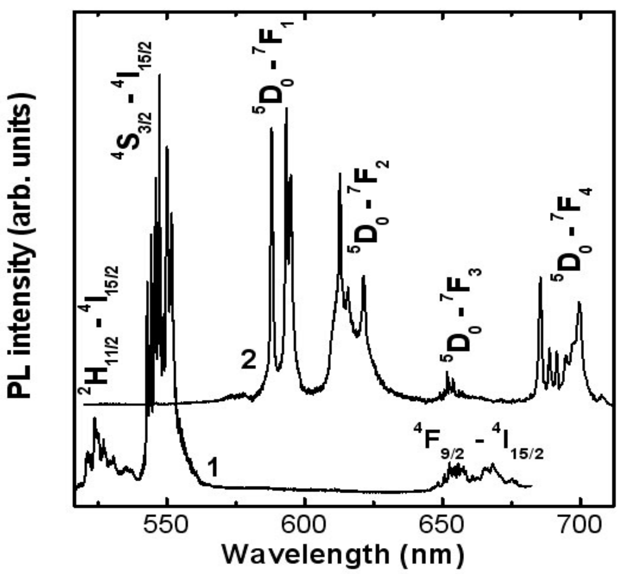

Fig. 2. PL spectra of samples doped with Er (curve 1) and Eu (curve 2) ions.