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Er- and Eu-doped GaP-oxide porous composites for optoelectronic applications

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We demonstrate the controlled preparation of Er- and Eu-doped GaP-oxide porous composites. The fabrication procedure entails the use of porous semiconductor templates and the impregnation of rare earth ions from a rare earth salt solution in alcohol and thermal treatment. The composites exhibit strong green and red emission that comes from finely dispersed $ErPO_4$ and $EuPO_4$ oxide submicron phases in the composite. These materials may prove useful in future generations of optoelectronic and photonic devices.

1 Introduction A great deal of research efforts are directed nowadays towards the development of random lasers based on disordered medium. Recently, Cao [1] reported a lasing process in highly disordered semiconductor nanostructures. The stimulated emission in a random laser may come either from near-bandgap electronic effects (exciton–exciton scattering or electron–hole plasma) as in the case of lasers based on ZnO compounds, or from transition metal and rare earth elements doped into the radiation emitting and amplifying phase.

Most of the random lasers demonstrated to date are based on powders, microspheres, nanocrystallite clusters, polycrystalline films, or disordered organic materials. However, these lasers are not suitable for integration with other optical or electronic functions. Composite materials prepared from porous semiconductor templates offer greater possibilities in this regard. Porous GaP networks are the most promising ones due to their strong photonic properties [2]. It has been demonstrated that macroporous gallium phosphide filled with air has the highest scattering efficiency among the known materials, due to the high refractive index of the bulk GaP.

Recently, an attempt was undertaken to dope a porous GaP template with an Eu impurity [3]. It was supposed that the observed strong visible emission comes from Eu^{3+} ions incorporated into the porous GaP host. However, it is well known that rare earth ions are rarely if ever found at the tetrahedrally coordinated sites of a III–V host because of their large ionic radii [4]. Rare earth ions prefer a coordination number higher than six. It was demonstrated that the presence of oxygen is imperative for achieving efficient emission from rare earth ions introduced into a III–V material [5]. The oxygen co-doping leads to the formation of quasi-molecular centers at low impurity density [4, 5] and to the segregation of an oxide phase at higher doping levels [6].

In this letter, we identify the nano-phases and the electronic transitions responsible for the strong visible emission from nanocomposites prepared from porous GaP templates doped with Eu and Er lanthanides and propose a new approach for the design of multiphase random media based on porous semiconductor templates.

2 Experimental details (100)-oriented n-GaP:S wafers cut from Czochralski-grown ingots were used for the