MBE growth of wide band gap wurtzite MgZnO superlattices doped with Eu for effective visible emission

M. Stachowicz [1], J.A. Mathew [1], J.M. Sajkowski[1], R. Jakiela[1], Y. Zhydachevskyy[1], S. Magalhaes[2], E. Alves[2], A. Kozanecki[1]

[1]*Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46 PL-02-668 Warsaw, Poland*
2 Centro Tecnológico Nuclear, Instituto Superior Técnico, Universidade de Lisboa, P-2686953 Sacavém, Portugal

Zinc oxide became of increasing technological importance, in particular for the development of light emitting diodes and lasers operating in the visible and ultraviolet region. Such devices contain heterojunctions and active areas based on quantum structures. Rare earth elements can be introduced into semiconductors either via ion implantation or by in-situ doping for extension of spectral range of emission of those. Epitaxial growth and in-situ doping allows to avoid problems with incomplete reconstruction of the crystal lattice which are common problems in the case of implantation method. Molecular Beam Epitaxy is perfectly suited for the production of thin crystalline layers, complex multilayer structures and for selective doping of carefully chosen layers, such as quantum wells. It can also be expected that some RE dopants can be stabilized in various oxidation states, including less common states like for example Ce^{4+}, Yb^{2+}, Eu^{2+} and other lanthanide ions [1]. Such a possibility is particularly interesting in the case of Eu, which when incorporated into the same host material, often coexists in two ionic states: 2+ and 3+ [2].

Wurtzite MgZnO alloys in form of superlattice structures have been grown by molecular beam epitaxy on variously oriented sapphire substrates on high-quality ZnO buffer layers. The widened band gap energy of utilized MgZnO layers was large enough to play a role whether as a barrier or quantum well selectively doped with Eu ions. The concentrations and distributions of Eu atoms in the respective hosts were analysed using Secondary Ion Mass Spectrometry, which confirmed successful doping around the level of similar to 1%. Optical properties of the samples were investigated by room temperature photoluminescence and Photoluminescence excitation measurements. The results obtained with Secondary Ion Mass Spectrometry were verified with Rutherford Backscattering spectrometry, which included not only random spectra but also angular measurements of main channels in order to shed light on eventual strains present in the structures and acting upon Eu ions. All performed analysis suggest the co-existence of 2+ and 3+ ionic states of Eu in the SL structures, and only 3+ ionic state after thermal treatment. Futhermore, optical measurements revealed strong enhancement of $^5D_0 \rightarrow {}^7F_J$ intra-4f-shell transitions of Eu^{3+} in MgZnO based superlattices.

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