Characterization of MBE grown {Zn(Mg)O/ZnCdO}$_m$ superlattices doped in-situ with Eu

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Zinc oxide (ZnO) is a well-known n-type semiconductor with a wide, direct bandgap - 3.37 eV at room temperature and a high exciton binding energy (60 meV) and potentially has wide applications in optoelectronics [1]. The synthesis of Zn(Cd,Mg)O ternary alloys and quantum structures (heterostructures, multiquantum wells and superlattices) enables bandgap engineering in a wide spectral range from ultraviolet to green [2]. The red luminescence can be obtained in oxide structures by doping with Eu. ZnO nanostructures doped with rare earth elements are synthesized by various techniques, however, a method for obtaining quantum structures with a predetermined location of Eu has not yet been developed. The molecular beam epitaxy (MBE) technology makes it possible to place Eu either in barriers or/and in quantum wells.

In this work we present the properties of in situ Eu-doped {Zn(Mg)O/ZnCdO}$_m$ short-period superlattices (SLs) grown on sapphire substrates (Al_2O_3) by MBE. The thicknesses of the ZnMgO and ZnCdO:Eu layers are 15±3 nm and 2±1 nm, respectively. Eu impurity was introduced into quantum wells. The obtained structures were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and secondary-ion mass spectrometry (SIMS). The optical properties were tested by photo- / cathodoluminesence (PL/CL) measuments and UV-Vis spectroscopy. The XRD pattern of Eu-doped {Zn(Mg)O/ZnCdO}$_m$ SLs indicated hexagonal crystal structure. The formation of good quality SLs were confirmed by TEM and XRD measurements. Studies of the CL spectra for as grown in situ Eu-doped {Zn(Mg)O/ZnCdO}$_m$ SLs showed at room temperature emission bands at ~617 nm, due to the $^5D_0 - {}^7F_2$ intra-4f-shell transition of Eu^{3+} ions (Fig. 1). We have determined the optimal conditions for amplifying the red emission. All structures were annealed for 1 minute in an O_2 environment at various temperatures. The highest intensity of the $^5D_0 - {}^7F_2$ peak was observed after annealing at 700°C. The decrease in intensity after annealing at high temperatures can be associated with the destruction of the superlattice structure due to Cd and Mg diffusion [3].

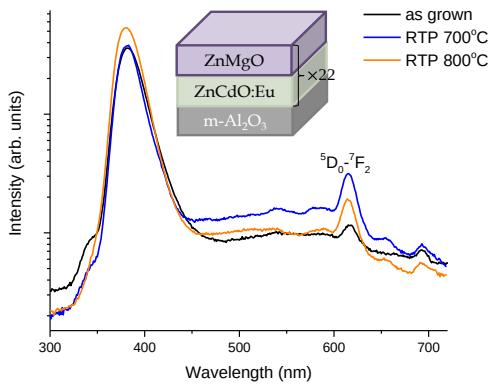

Fig. 1. RT-CL spectra of as-grown and annealed {ZnMgO/ZnCdO:Eu}$_{22}$ SLs.

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