Optical anisotropy in [0001] oriented $Al_xGa_{1-x}N$/AlN quantum wells under pressure

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Abstract. The question of possible switching of polarization of the emitted light from the wide gap nitride based quantum wells is very important in designing surface emitting devices. We investigate the influence of external pressure on optical anisotropy of GaN/ $Al_xGa_{1-x}N$ quantum wells (QWs) grown along the *c*-crystallographic direction on unstrained AlN substrates. Our theoretical study reveals that in the structures with properly chosen Al content in the QW layer a pressure-dependent switching of polarization of emitted light may occur. This switching of polarization primarily originates from reordering of the topmost valence subbands having different symmetries.

In the unstrained bulk GaN, the top subband is of Γ_9 character, leading to the emission of light with polarization perpendicular to the *c* axis whereas in the bulk AlN, due to the negative value of the crystal field splitting energy, the sequence of sub-bands is inverted with the topmost subband having Γ_7 symmetry favoring light emission with polarization parallel to the *c* axis. This inversion occurs also in AlGaN alloys at high enough concentration of Al. Using various material combinations such as AlGaN and GaN or AlN and AlGaN as barrier and quantum well materials gives a possibility to modify the symmetry properties of the top of the valence band states in a quantum well structure [1].

In the present study, we investigate the effect of the external hydrostatic pressure on the valence band structure and optical anisotropy of nitride QWs grown along the c-axis. To this end we have developed a model of optical transitions which fully takes into account (i) the influence of strain and the built-in electric fields on the conduction and valence band states in the QW and (ii) the excitonic effects which contribute significantly to the conditions for the reordering of corresponding optical transitions in emission and absorption spectra [2]. The optical spectra for different values of external pressure are obtained in two stages. First the effective one-particle Hamiltonian for the quantum well including the influence of strain and the electric field due to the spontaneous polarization and piezoelectric effect is diagonalized in order to obtain one-electron spectra in the valence and conduction subbands. In the second stage the optical spectra are obtained by solving the Bethe-Salpeter exciton equation in the envelope function representation using Landau orbitals basis set to describe the relative electron-hole motion [2].

We present the results of our calculations performed for narrow, 1.5nm wide $Al_xGa_{1-x}N$/AlN QWs with *x* equal to 0.7 and 0.8. The structures were assumed to be lattice matched to AlN substrates. We show that in the considered cases the difference in the exciton binding energies modifies the simple condition for polarization switching defined as the point of crossing of the valence subbands with different symmetry. We also present the evolution of theoretical absorption and photoluminescence spectra with pressure.

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