Absence of Optical Polarization Switching in M-Plane InGaN/GaN and AlGaN/AlN Quantum Wells

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An interesting feature of m-plane nitride quantum wells (QWs), grown along the [1-100] crystallographic direction, is strong anisotropy of the photoluminescence emission in two different in-plane polarizations, along and perpendicular to the crystalline c axis of the wurtzite structure. This effect depends substantially on strain arising from the lattice mismatch between QWs and barriers [1, 2]. The influence of strain on the electronic band structure is described by the deformation potentials which together with the Luttinger band parameters constitute essential input for the k·p method. Recently, using the density functional theory calculations, we have determined the deformation potentials for random AlGaN and InGaN alloys [3]. We have shown that these deformation potentials properly describe the optical polarization properties of c-plane AlGaN/AlN and m-plane AlGaN/AlN and InGaN/GaN QWs. In particular, it has been demonstrated that for 3 nm wide m-plane InGaN/GaN QWs and for 3.8 nm wide m-plane AlGaN/AlN QWs, the obtained differences between the interband transition energies for light polarized parallel and orthogonal to the crystalline c axis agree well with the experimental data [2, 4].

In this work, we continue our study of the optical polarization properties of m-plane InGaN/GaN and AlGaN/AlN QWs. We investigate the influence of the QW width and the composition of QWs on the difference between the interband transition energies in two polarization modes. We assume that InGaN/GaN (AlGaN/AlN) QWs are grown pseudomorphically on unstrained GaN (AlN) substrates with no interfacial disorder and dislocations causing strain relaxation. The interband transition energies for the two linear light polarizations are obtained using the k·p method with the single parabolic band Hamiltonian for electrons and the 6x6 Rashba-Sheka-Pikus Hamiltonian for holes [3].

The calculations have been performed for two sets of InGaN/GaN QWs [(a) In content between 10% and 30% and the QW width between 1 to 3 nm, and (b) In content between 50% and 100% and the QW width between 0.6 to 1.4 nm] and one set of AlGaN/AlN QWs with Al content changing from 10% to 80% and the QW thickness varying between 1 and 5 nm. In all InGaN/GaN QWs, we have found that the interband transition energy for light polarized orthogonal to the crystalline c axis is always smaller than the interband transition energy for light polarized parallel to the c axis. In all AlGaN/AlN QWs opposite behavior of these two optical transition energies is observed. Polarization switching is observed neither in InGaN/GaN nor in AlGaN/AlN QWs. In both cases, the difference between the two transition energies increases with the QW width and also with the In or Al content in the QWs.

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