GaN/AlGaN (11-22) semipolar nanostructures: Observations by theory and experiment

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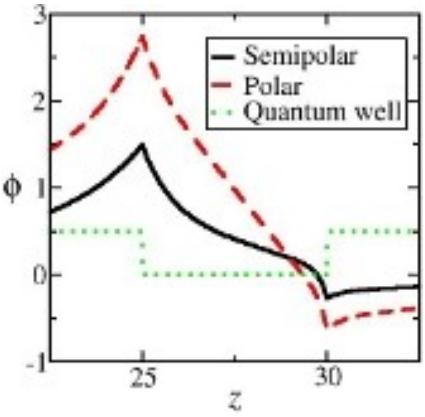
III-Nitride structures grown along nonpolar and semipolar crystallographic directions are attracting attention as promising materials for next-generation nitride-based optoelectronic devices. Where for the nonpolar case we can expect a lack of a built-in electric field, for semipolar direction the electric field exists but is effectively reduced by the crystallographic reorientation. Different thickness of GaN/$Al_{0.5}Ga_{0.5}N$ Quantum Dot (QD) structures were grown by ammonia molecular beam epitaxy along the (11-22) direction. As a substrate we used 2 μm thick (11-22) GaN layer grown by metal organic vapour phase epitaxy on m-plane sapphire substrate. During QD formation, when a small amount of GaN is deposited, the geometrical morphology is dominated by the presence of isolated islands but with increased GaN fraction. The nanostructures are elongated along the (1-100) direction and formed structures resembling quantum wires rather than dots [1].



Analysis of the observed photoluminescence spectrum is facilitated by theoretical means within a framework where by a coupled electro-elastic model is solved, followed by an 8-band k.p Schrödinger equation [2]. This amounts to calculating the electronic structure quantum mechanically and under conditions that reproduce those of the experimental analysis, at finite temperatures of up to 300K. To gain insight into the dimensionality of the electron-hole confinement (dots/wires), numerical experiments are performed on a series of multi-dimensional systems and their opto-electronic behaviour referred back to the experimentally obtained data. These structures are found to exhibit strong photoluminescence excitations despite the embodiment of a large density of basal stacking faults in the samples. The emission energy is shifted towards higher energies due to reduction in the built-in electric field (see figure) and, due to this, a reduction of the quantum confined Stark effect is observed. These effects are explained by examining a self-consistently determined electron density function and exciton energy levels, that are significantly perturbed by the morphology and the growth direction of the sample.

References

[1] A.Kahouli et al. *J.Appl.Phys.* **110**, 084318 (2011).
[2] P. Harrison, *Quantum Wells, Wires and Dots*, John Wiley & Sons, Chpt. 3 (2005).