STRAIN DISTRIBUTION AND OPTICAL PROPERTIES OF GaN/ALN QUANTUM DOTS GROWN ALONG A NON-POLAR DIRECTION.

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Nitride-based heterostructures (GaN, AlN, InN and their alloys) are widely used for the implementation of optoelectronic devices in the UV-visible range. Due to the wurtzite structure characteristic of these materials and the large value of their piezoelectric constants, a large internal electric field (up to 7 MV/cm [1]) is usually present along the polar *c* axis. As a consequence of the resulting quantum confined Stark effect, the oscillator strength of the radiative transitions is severely reduced with an additional shift of the emission to low energies. To overcome this difficulty, the growth of heterostructures along non-polar directions has been proposed [2]. Recently, Daudin and co-workers have demonstrated the growth of self assembled GaN/AlN quantum dots (QDs) on a *a*-plane 6H-SiC substrate [3]. Since the internal electric field arises as a result of the interplay of piezoelectric and spontaneous polarization, it is necessary to study in detail the strain distribution in these nanostructures.

In this work we have performed computations of the strain distribution in GaN/AlN QDs. The model employed is based on the Eshelby's inclusion method [4] and make use of the Green's function technique developed by Andreev and O'Reilly [5] to calculate the three-dimensional strain distribution in semiconductor QD structures of wurtzite crystal symmetry with arbitrary shape. For definiteness the QD is represented as a truncated square-based-pyramid, with its axis perpendicular to the wurtzite *c* polar axis. From the results of the model we have calculated the piezoelectric and spontaneous contributions to the electric potential in these structures (see Fig.1). The results show a considerable reduction of the built-in electric field within the QDs when compared with the more common GaN/AlN QDs grown along the *c* axis. To illustrate the impact of this reduction on the electronic structure we also have calculated the energy levels and optical transitions of the QDs including the effect of quantum confinement, strain and built-in electric potential.

Finally, the theoretical results described above are used to interpret the Photoluminescence (PL) spectra of a 20 periods GaN/AlN QD superlattice grown on *a*-plane 6H-SiC. The measurements of the emission were performed as a function of excitation power (see Fig. 2).

The polarization characteristics of the emission were studied, and it was found that there is a 20 meV blue shift of the $\boldsymbol{E} \parallel c$ PL maximum with respect to the $\boldsymbol{E} \perp c$ one. The PL is centered at 3.83 meV ($\boldsymbol{E} \parallel c$), almost 400 meV higher than bulk GaN. This feature and the absence of a shift of the emission with power indicate a strong reduction of the internal electric field in *a*-plane QDs with respect to those grown along the wurtzite *c* axis.

References:

[1] J. Simon, N. T. Pelekanos, C. Adelmann, E. Martinez-Guerrero, R. Andre, B. Daudin, L. S. Dang, H. Mariette, Phys. Rev. B, **68** (2003) 35312.

[2] P. Waltereit, O. Brandt, A. Trampert, H. T. Grahn, J. Menniger, M. Ramsteiner, M. Reiche, and K. H. Ploog, Nature, 406, (2000) 865

[3] S. Founta, F. Rol, T. Andreev, B. Gayral, E. Bellet-Amalric, C. Moisson, H. Mariette, and B. Daudin., Phys. Stat. Sol. C, **2** (2005) 2341.

[4] J. D. Eshelby, Proc. R. Soc. London, Ser. A **241** (1957) 376.

[5] A. D. Andreev, E. P. O'Reilly, Phys. Rev. B, **62** (2000) 23.

Figures:

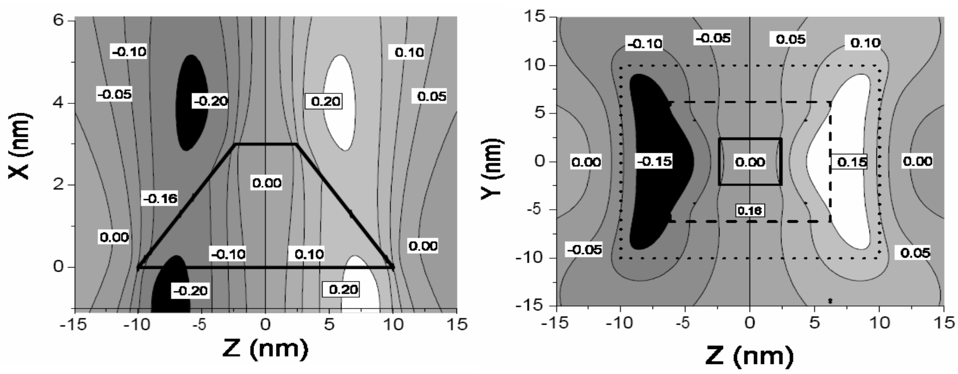

Figure 1: Contour plot of the total electrostatic potential (piezoelectric plus spontaneous contributions) for a truncated square-based-pyramid quantum dot in planes ZX (Y=0) and YZ (X=1.5 nm). The pyramid height is 3.0 nm. The labels over the contour show the magnitude of the potential in eV. The dark and bright areas correspond to the regions of low and high potential, respectively.

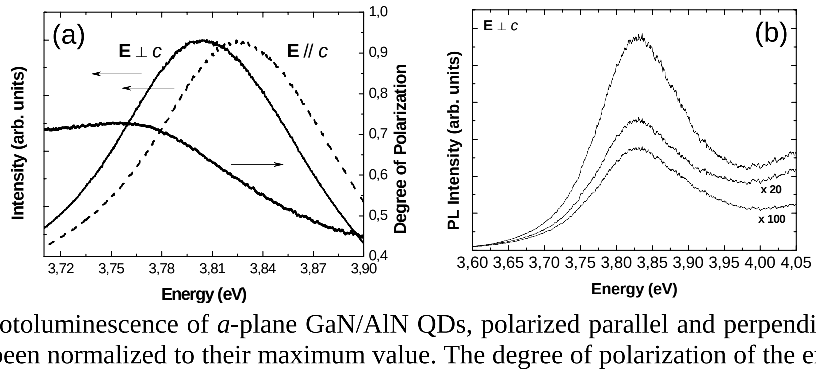

Figure 2: *(a)* Photoluminescence of *a*-plane GaN/AlN QDs, polarized parallel and perpendicular to *c*-axis. The intensities have been normalized to their maximum value. The degree of polarization of the emission is shown as a function of the PL energy. *(b)* PL emission for three values of the excitation power: 0.047, 0.46 and 4.3 mW.