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*Grzegorz Jurczak,*
*Toby D. Young*
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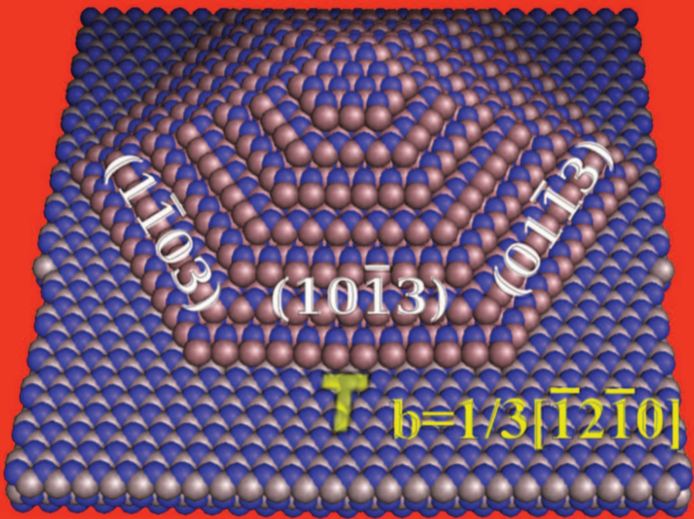


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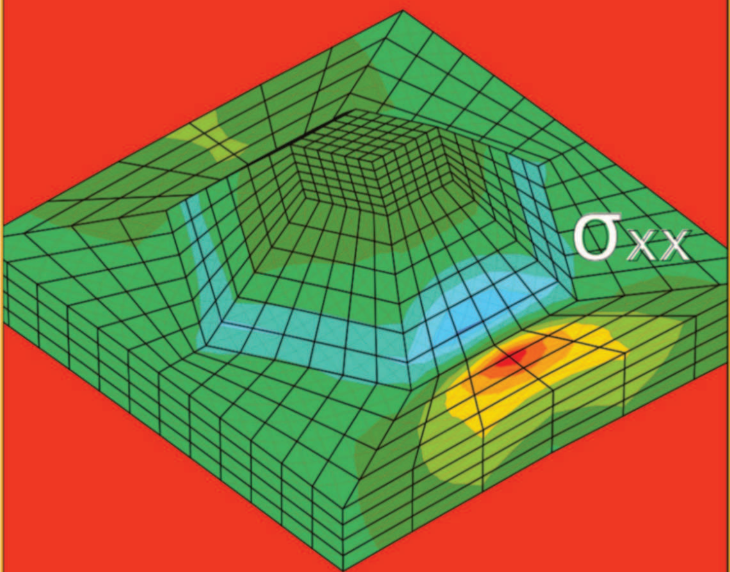


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# Elastic and electric properties of a semi-polar $(11\bar{2}2)$ GaN/AlN quantum dots

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In an effort to reduce the strong built-in electric field that is present in wurtzite heterostructures, Quantum Dots (QDs) orientated in a direction other than the polar direction have recently become a topic of intensive research. Alternative growth directions induce different QD geometries that in turn induce different stress/strain states and a reduced electric field intensity in the dot and its vicinity. The reduced intensity of the internal electric field in the case of semi-polar orientated nanostructures may allow for higher internal quantum efficiency of optoelectronic devices based on a semi-polar heterostructure. One candidate for this is the $(11\bar{2}2)$ -orientation.

A study with Transmission Electron Microscopy (TEM) of a $(11\bar{2}2)$ -orientated GaN/AlN heterostructure grown by plasma-assisted molecular beam epitaxy revealed three main QD geometries within the same sample [1]. Two of the QD geometries featured in the sample are described by rectangular- and trapezoidal-based truncated pyramids and lie in nominal-$(11\bar{2}2)$ plane. The third main geometry is described by a kite-based truncated pyramid whose base lies in the $(10\bar{1}1)$ plane, *ie.*, it is slightly inclined with respect to the nominal growth direction. This variation in QD geometry is probably due to local deviations of the growth plane from the nominal orientation that is caused by threading dislocations. The average size of the QDs at their base was around $25\,\mathrm{nm}$ .

In this work, finite element (FE) analysis was used to solve the boundary-value problem for a piezoelectric material and investigate the residual elastic and electric fields for three isolated semi-polar QDs based on the main geometries described above. The numerical results show that, in comparison with polar QDs the general character of elastic relaxation does not change much [2], though the basal in-plane compression and tension perpendicular to the basal plane are only slightly modified by the different geometry. The distribution of the electrostatic dipole potential is largely orientation dependent. In polar QDs the positive and negative regions are localised around the top and bottom facets of the dot respectively and in semi-polar QDs the localisation of the dipole continues to manifest itself along the $c$ -direction. The intensity of electric field in semi-polar QDs is reduced by an increased physical separation of the potential peaks as well as by a reduction of its peak-to-peak intensity. From the classical bulk band-edge structure, modified by the piezoelectric field, an estimation of the emission spectra and carrier localisation is obtained.

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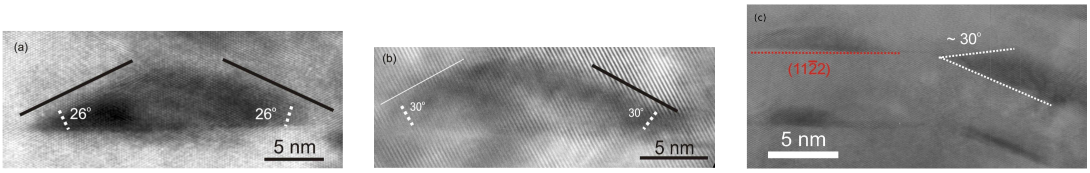


Figure 1: TEM images of a semi-polar (11$\bar{2}$2) and (10$\bar{1}$1) QDs.

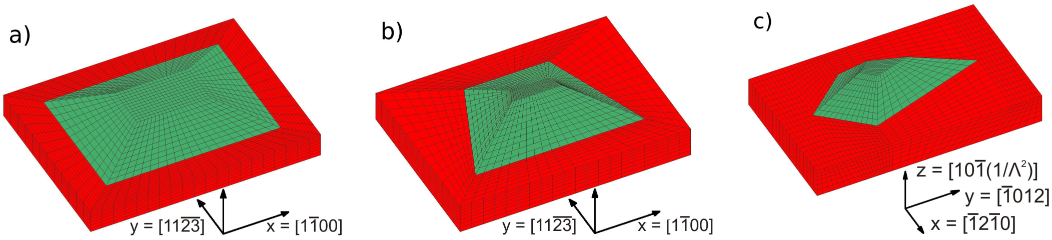


Figure 2: FE mesh of a semi-polar QDs: a) rectangular, b) trapezoidal, and c) inclined.

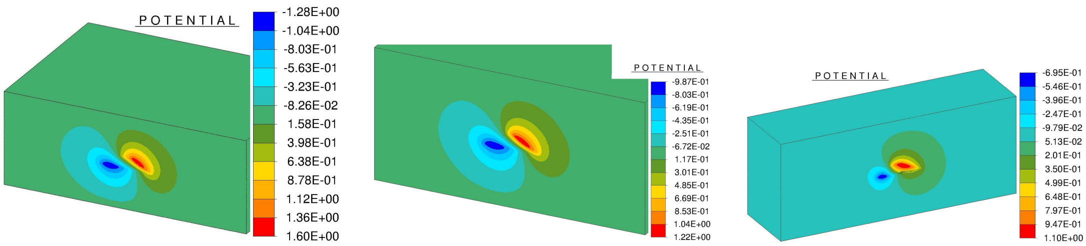


Figure 3: Electrostatic potential field in a semi-polar QDs: a) rectangular, b) trapezoidal, and c) inclined.