High-resolution Electron Holography Study of Basal-plane Stacking Faults in (11-20) GaN

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GaN based light-emitting-diodes (LEDs) have been commercially available. However, their luminescence efficiency in the UV and green part of the spectrum remains limited by a number of factors, one of which is the internal electric field across the quantum wells (QWs) generated by the spontaneous and piezoelectric polarization along the polar crystallographic *c*-axis [0001], which lowers the radiative recombination efficiency. The growth of QW structures along a non-polar direction, e.g. [11-20] eliminates the internal fields across the QWs and potentially leads to more efficient UV and green emitting LEDs. However the heteroepitaxial growth of (11-20) GaN films introduces high numbers of microstructural defects including basal-plane stacking faults (BSFs), prismatic stacking faults (PSFs) and partial dislocations (PDs).

In these non-polar GaN films, with the polar c-axis now lying in the growth plane, charge segregations at the BSFs have been proposed and the corresponding built-in electric fields have been calculated [1, 2]. The presence of the internal fields has been supported by recent studies of THz radiation from non-polar GaN with a high BSF density [3]. Evidences of internal electric fields associated with stacking faults have also been shown in other related materials, such as 4H-SiC [4]. However, the internal electric field in non-polar GaN has never been directly measured.

We have studied BSFs in non-polar (11-20) a-plane GaN using high-resolution electron microscopy and electron holography. The sample was grown by metal-organic vapour phase epitaxy (MOVPE) on (1-102) r-plane sapphire. High-resolution holograms were acquired on the FEI Tecnai F20/Cs-corrected TEM at 200 kV with a carrier frequency of 14.5 nm^{-1}. Over forty BSFs have all been determined to be I1 type. Peaks at the stacking fault regions have been observed in the phase profile, which may indicate the presence of free carrier segregations and built-in electric fields. However, quantitative results have not yet been derived, due to uncertainties in the interpretation of the phase images, in particular the contribution of diffraction contrasts.

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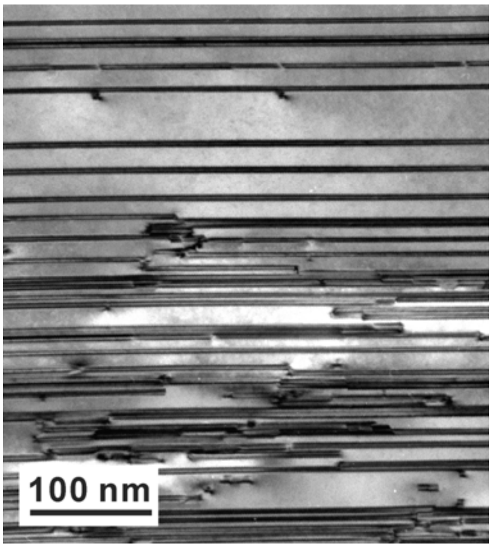

Figure 1 Bright field TEM image showing BSFs bounded by PDs and PSFs

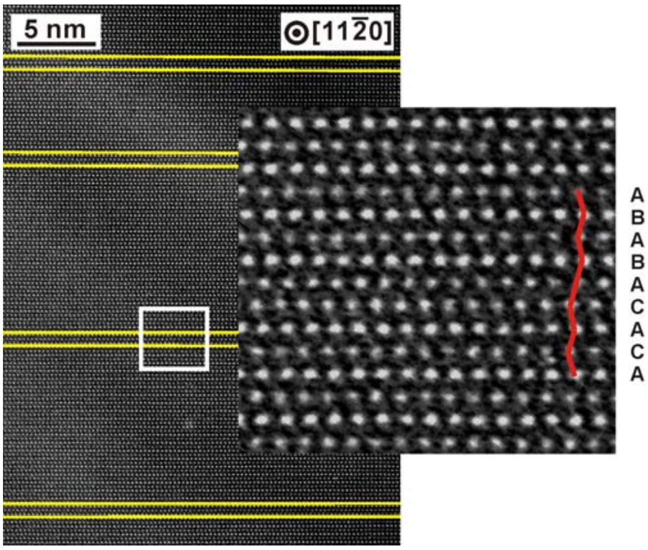

Figure 2 High-resolution TEM image showing the structure of the BSFs in the non-polar GaN

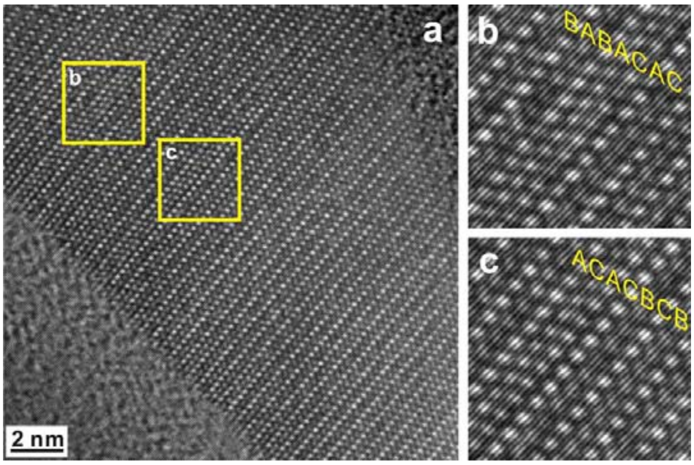

Figure 3
(a) High-resolution electron hologram taken along the [11-20] zone axis showing two BSFs; the areas in the squares are shown magnified in:
(b) Stacking sequence changes from BA to AC
(c) Stacking sequence changes from AC to CB

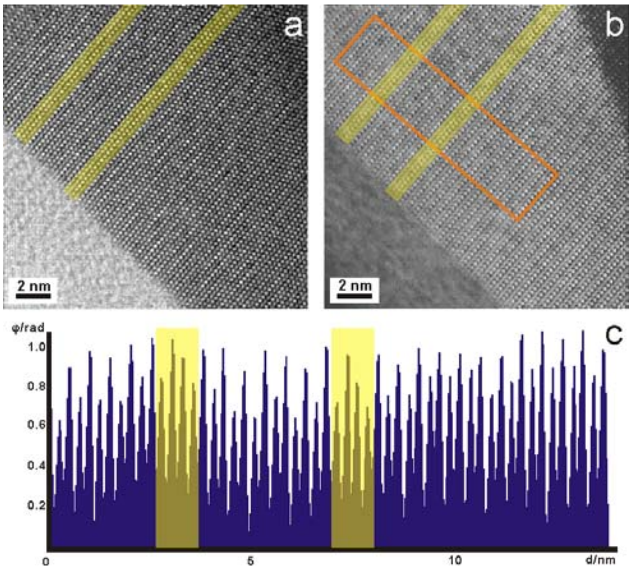

Figure 4
(a) Amplitude and
(b) Phase image reconstructed from the electron hologram shown in figure 3a
(c) Integrated line profile of the quoted area in b. The BSFs are highlighted in all three figures.

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