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Non-destructive Imaging of Extend Defects in III-nitride Thin film Structures Using Electron Channelling Contrast Imaging

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Irrespective of the substrates, the growth plane, or the growth conditions employed, extended defects such as threading dislocations, stacking faults, misfit dislocations and grain boundaries are generally observed in the as–grown III-nitride thin film structures. Often extended defects are electrically active and are problematic for minority carrier devices, such as AlGaN based ultraviolet light emitting diodes and high electron mobility transistors. This is why structural characterisation techniques which are simultaneously rapid to use, and structurally definitive on the nanoscale become a prerequisite. Electron channelling contrast imaging (ECCI) performed in a scanning electron microscope (SEM) is a quick and non-destructive structural characterisation technique for imaging, identifying and quantifying extended defects in nitride thin films [1, 2].

In our presentation, we will briefly describe the principle of electron channelling and the experimental setup and conditions required to image extended defects via ECCI. We will discuss results from (a) *c*-plane GaN on sapphire revealing threading dislocations, (b) *m*-plane GaN on $LiAlO_2$ and (11-22) oriented GaN on sapphire, revealing basal plane stacking faults and partial dislocations, (c) *a*-plane GaN on sapphire showing prismatic stacking faults, (d) *c*-plane AlGaN HEMTs on Si revealing misfit dislocations (e) *c*-plane InAlGaN HEMTs on sapphire showing grain boundaries and (f) *c*-plane InAlN on sapphire showing atomic steps. Figure 1 shows some example ECCI micrographs from a range of III-nitride thin films. Due to the wide field of view of ECCI, the spatial distributions of threading dislocations can be investigated and statistical analysis has been carried out using in-house software. Our results demonstrate the applicability of ECCI to a wide range of III-nitride structures with threading dislocation densities in the range of 10^5 to 10^{10} cm^{-2}. The sample morphology may affect the channelling contrast; however appropriate crystal and detector orientation may be used to minimise the effect of sample topography [3].

Comparing simulated and experimental ECCI micrographs can provide further information on the features that are present. Previous work [4] has shown that for threading dislocations, modelling the defect strain profile being sampled by the diffraction conditions allows prediction of the ECCI contrast behaviour and identification of the dislocation type. This would be a step forward in reducing the time required for quantitative analysis of extended defects using ECCI [5].

References:

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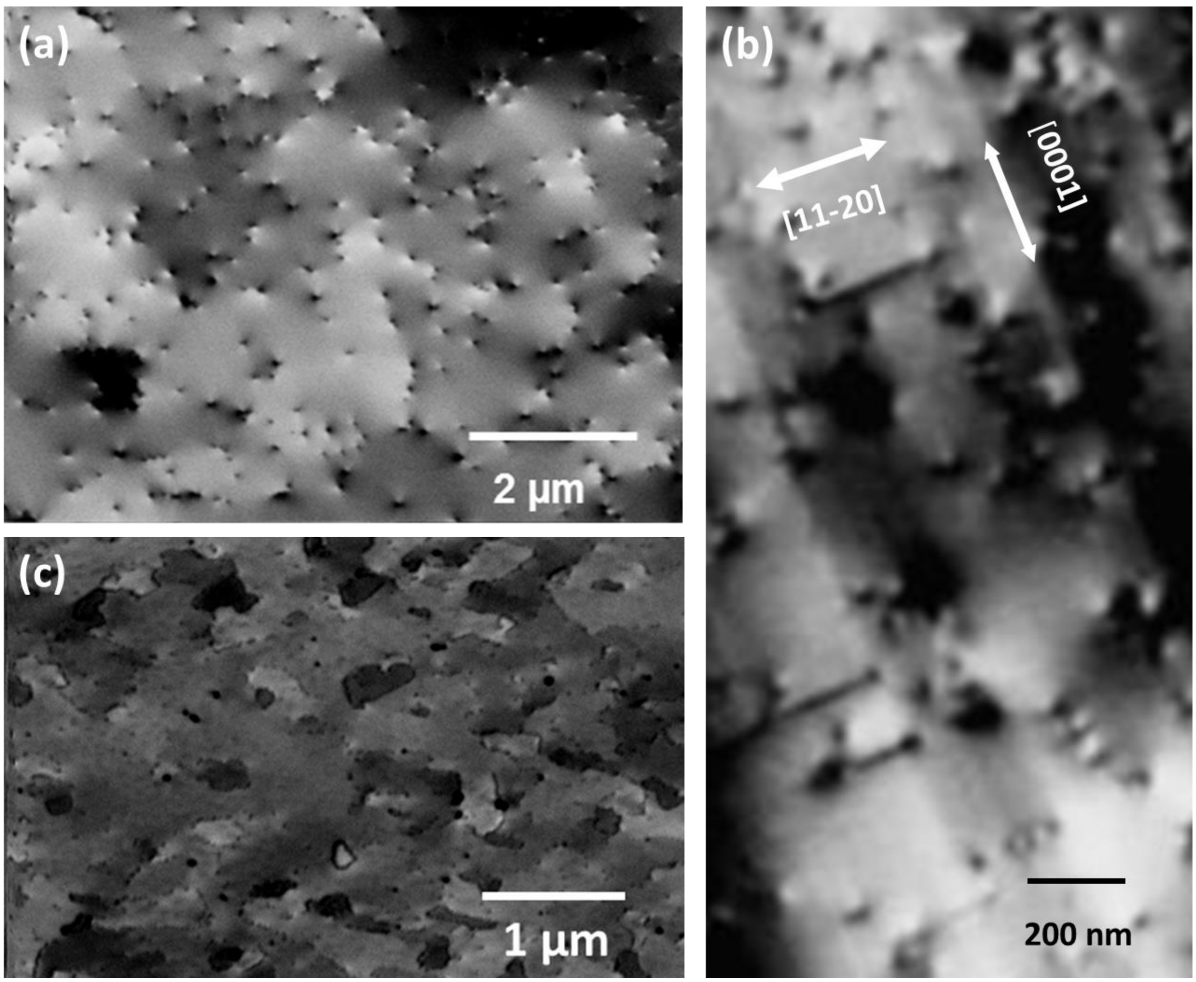

Figure 1. ECCI of III-nitride structures acquired using the forward scattering geometry. (a) Threading dislocations along [0001] in *c*-plane GaN, (b) basal plane stacking faults along [11-20] in *m*-plane GaN and (c) low angle sub-grain boundaries in a *c*-plane InAlN thin film.