Synchrotron Radiation X-Ray Topography of Homoepitaxial GaN

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Due to its many applications in optoelectronics, GaN is a material that has attracted a lot of attention. Heteroepitaxial GaN films are strained and suffer from a large amount of dislocations, which are mainly caused by the mismatch of lattice constants and thermal expansion coefficients between GaN and the common substrates, such as sapphire [1]. Several techniques for reduction of dislocation density, including growth on patterned substrates and epitaxial layer overgrowth have been proposed [2, 3]. In this report homoepitaxial GaN grown by metal organic vapour phase epitaxy (MOVPE) on ammonothermal GaN substrate [4] is examined by synchrotron radiation x-ray topography (SR-XRT). The thicknesses of the substrate and the epilayer are 545 μm and 3.7 μm, respectively. The microstructure of a crystalline material is conveniently and non-destructively examined by synchrotron radiation X-ray topography. In SR-XRT, a beam with a continuous wavelength spectrum satisfies the Bragg condition of diffraction for several diffraction planes simultaneously. Each reflection or topograph, provides an image of the microstructure. Defects introduce a local variation in the distance between lattice planes. This microstrain shows as contrast in a topograph [5]. SR-XRT is a technique that is highly sensitive to microstrain and is thus very useful for imaging defects. For a more detailed review on SR-XRT of electronic materials, see reference [6].

Figure 1 shows a 002 back reflection topograph. The image was recorded with the sample tilted 8° about the vertical axis perpendicular to the beam and a sample to film distance of 60 mm. In back reflection SR-XRT, information is collected from the topmost layers and the image in figure 1a therefore corresponds to the epitaxial layer. Individual dislocations are seen as dark lines in 1a, since distorted lattice regions around dislocations diffract more strongly. The crystal quality of the sample is very good, with nearly perfect regions visible between dislocations. Figure 1b shows a 500×500 μm^2 square, from which a dislocation density of $1.2 \times 10^4/\mathrm{cm}^2$ has been deduced. This is an exceptionally small number for GaN if it is compared with GaN grown on sapphire substrates, having a typical dislocation density of $10^8/\mathrm{cm}^2$.

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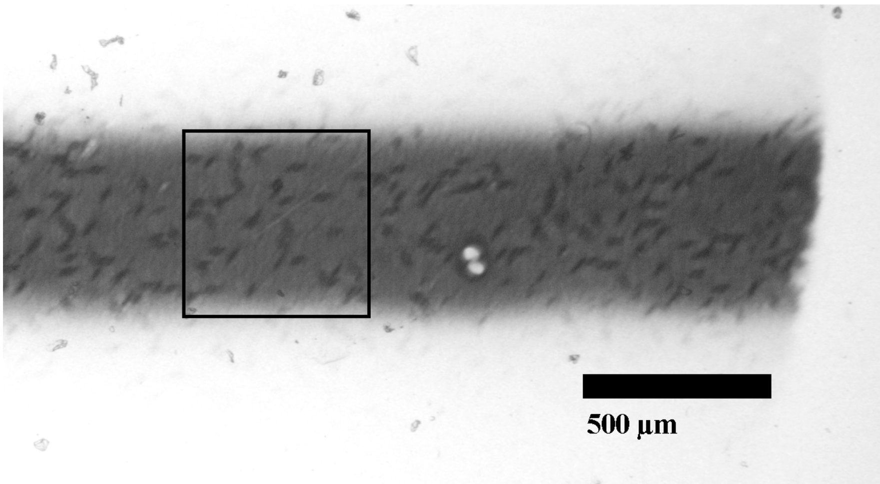
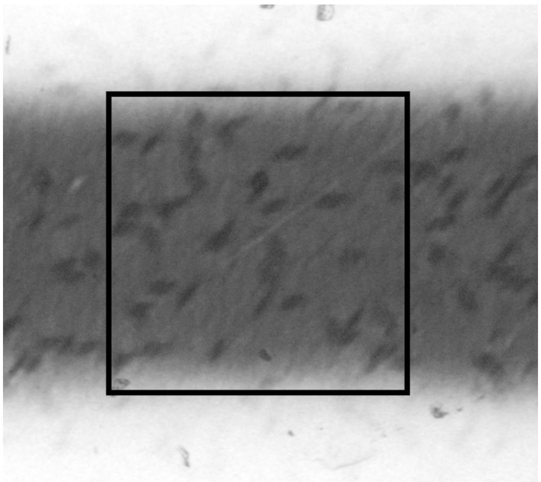


(a)



(b)

Figure 1: (a) 002 back reflection topograph of GaN sample (b) 500×500 μm^2 square used for evaluation of dislocation density

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