Study on the origin of the hillock density reduction on the N-face of homo-epitaxial GaN layers.

A.R.A. Zauner[a,*], H.W. Zandbergen[b], V. Kirilyuk[a], J.L. Weyher[a,c], J.J. Schermer[a], S. Porowski[c], P.R. Hageman[a], and P.K. Larsen[a]

[a]Research Institute for Materials, University of Nijmegen, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands
[b]Laboratory of Material Science, National Centre of HREM, Delft University of Technology, Rotterdamseweg 137, 2628 AL Delft, The Netherlands
[c]High Pressure Research Center, Polish Academy of Sciences, Sokolowska 29/37, 01-142 Warsaw, Poland
[*]Corresponding author. E-mail address: andyz@sci.kun.nl (A.R.A. Zauner)

The surface morphology of homo- and hetero-epitaxially grown GaN layers depends significantly on the polarity of the layers. Layers grown in the $[000\bar{1}]$ direction (N-face) tend to form hexagonal hillocks whereas layers grown in the [0001] direction (Ga face) can lead to smooth films. In previous work [1] it was demonstrated that the use of GaN substrates misoriented to the $[10\bar{1}0]$ direction leads to a suppression of hillock formation on the N-face (Fig. 1).

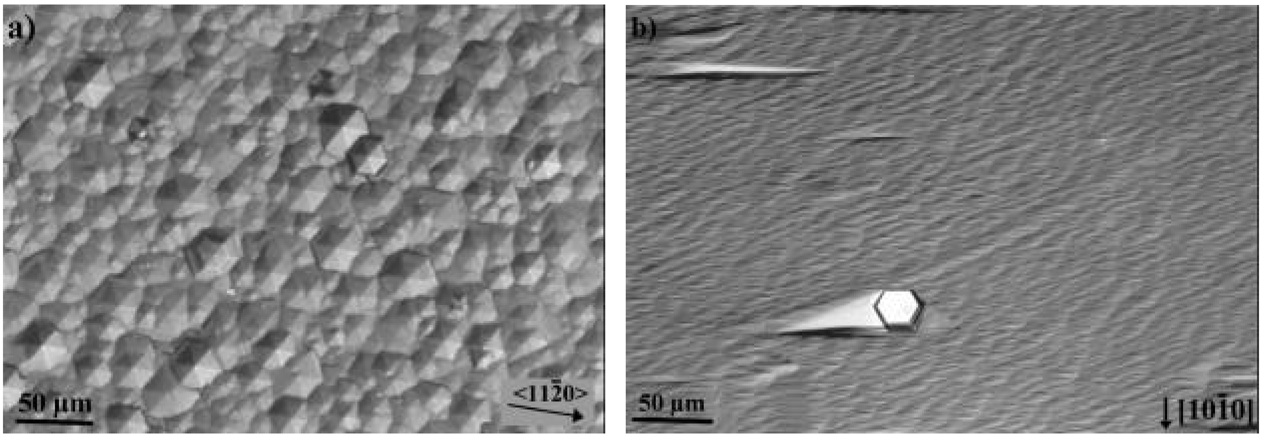

Fig. 1. Differential interference contrast microscopy images of homo-epitaxial GaN layers grown on the N-face of a single crystal with (a) exact orientation and (b) 4° misorientation towards the $[10\bar{1}0]$ direction.

Besides the improvement in surface morphology the 4° misorientation resulted in a strong improvement of the material quality of the N-face. Photoluminescence measurements (5K) revealed donor bound excitonic recombinations with FWHM's below 1 meV. Free excitonic transitions could be resolved for the homo-epitaxial layers grown on the misoriented substrates [2].
In the present work homo-epitaxial layers were grown on the N-face of GaN substrates with 2° and 4° off-angle orientations towards $[10\bar{1}0]$ and $[11\bar{2}0]$ using low-pressure MOCVD. Improvements in surface morphology are realised by the overgrowth of hillocks, and their step sources in the centres, by steps introduced by the misorientation. Besides dislocations [3], inversion domains at the core of the growth hillocks (Fig. 2) were found to act as a step source for this defect [4].

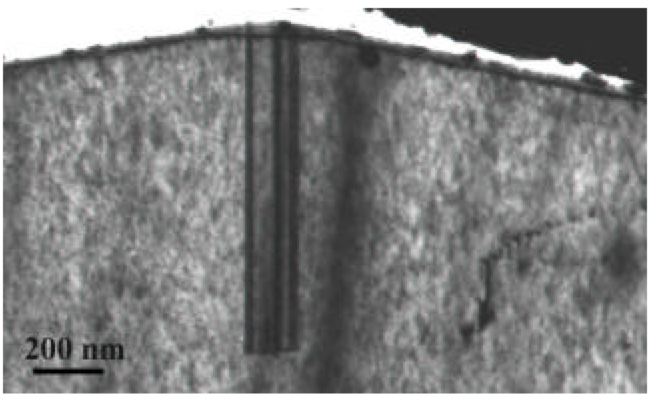

Fig.2. TEM cross-sectional image of a homo-epitaxial GaN film showing an inversion domain at the core of a hillock [4].

The essential element of the overgrowth process is that the activity of the step source at the centre of the hillock changes during growth. During a period of low activity the step density arising from the misorientation exceeds the step density emerging from the centre of the hillock and as a consequence the hillocks can be overgrown.
So far the mechanism behind the sudden changes in rate of step generation at the hillock centre is unknown. Transmission Electron Microscopy (TEM) measurements were performed on the samples to unriddle this detail. The Focused Ion Beam technique was used to prepare site-specific cross-sectional foils through the original centre of the hillock. The results of these investigations will be presented at the conference.

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