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Defect analysis of star defects in GaN thin films grown on HVPE GaN substrates

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The potential of GaN-based power electronics is limited by defects, most of which result from lattice parameter mismatch with the substrate. Use of GaN substrates manufactured with halide-vapor phase epitaxy (HVPE) reduces these defects but can introduce different defects. This study investigates one such defect, the star defect, recently reported in the literature [1]. These defects are hundreds of microns in size and may be related to defects reported in GaN substrates [2]. Understanding the structure of these defects is crucial to developing growth processes to prevent them or mitigate their effect on device performance. The films investigated were deposited with metal-organic vapor phase deposition (MOVPE) to 10 microns in thickness. The film was n-doped to 5×10^{16} cm^{-3} net electron concentration.

The star defects in the film were investigated using a combination of two scanning electron microscopy techniques, electron channeling contrast imaging (ECCI) and high-resolution electron backscatter diffraction (HREBSD). ECCI was used to detect the defects and probe their abundance across the film, while HREBSD was using to identify the smaller defects comprising the star defects using a novel variant of Nye-Kröner analysis. The star defects appear as intersections of straight lines on the surface aligned with the < 1 0 -1 0 > directions hundreds of microns in length. HREBSD analysis shows that these defects are in fact low-angle tilt boundaries made up of regular arrays of < a >-type pyramidal edge dislocations spaced between 100 and 200 nm apart, with each ray having a different Burgers vector in the family. In addition to the low-angle tilt boundaries the "rays" of the star defect are composed of, the "cores" were also composed of unique defects, including a significant amount of threading dislocations. Unlike the rays of the star defects, which varied only in length, the cores have significant variability (see Figure 1 for an example of a star defect core).

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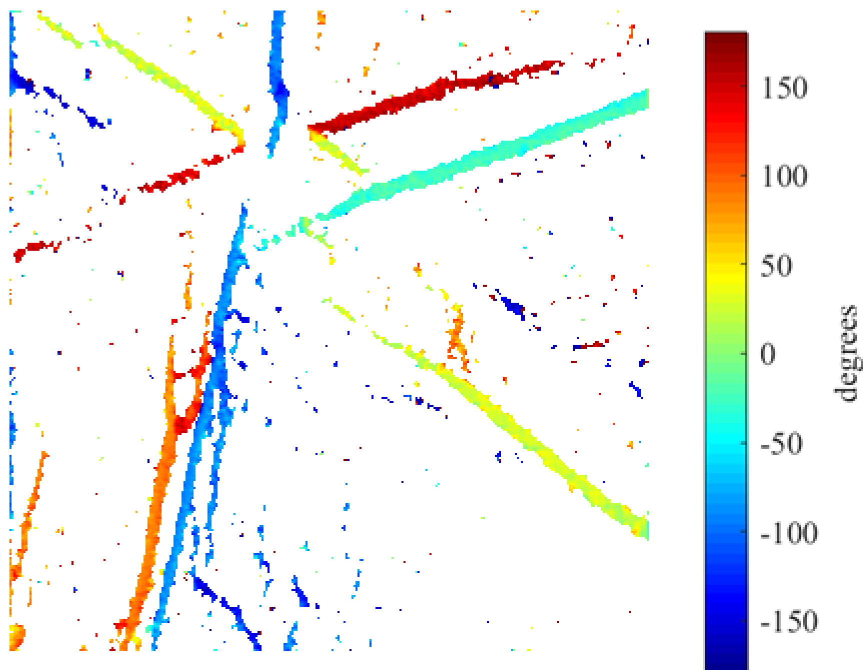

Figure 1. A map of the angle of Burgers vector with respect to the crystallographic reference frame of the core of a star defect. Regions with low signal (where it is presumed there is no defect content) were blanked out for visual clarity. The scan is 24 microns square.

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