High-Resolution Characterization of Dislocations in GaN Substrates using Synchrotron X-ray Topography

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Introduction

Gallium nitride (GaN) is a promising material for next-generation power devices. Commercial GaN substrates contain many dislocations that cause device degradation [1]. Back-reflection X-ray topography using synchrotron radiation is a powerful tool as it reveals dislocations across the entire substrate over a short period of time and successfully provides clear images with detailed information on the types and positions of dislocations.

Until now, such topography images have mainly been recorded using X-ray films and nuclear emulsion plates as analogs to meet the requirement for high resolution (below 1 μm/pixel). The recent progress in high-resolution X-ray cameras has enabled high-resolution digital topography images. In this study, we compared digital and analog images using nuclear emulsion plate methods.

Experimental Procedures

We used ammonothermally grown *n*-type GaN substrates for this study. To obtain high-resolution X-ray topography images, we employed synchrotron radiation from beamline BL16B2 at SPring-8. We selected 1124 diffraction vectors. The X-ray camera prepared in this beamline is characterized by both low and high magnitudes, with a resolution of 3.76 μm/px and 0.723 μm/px, respectively.

Results and Discussion

Figure 1 (a) and (b) show the topography images which were recorded using the high-magnitude X-ray camera and nuclear emulsion plate, respectively. Spots were identified across both images. Because the spot size depends on the Burgers vector of the dislocation [2], the smaller spot corresponds to an edge dislocation, while the larger spot corresponds to a mixed or screw dislocation. An X-ray camera has a deep dynamic range and enables real-time observations. In contrast, observations with nuclear emulsion plates provide a wide field of view for a short duration. In future work, we will examine the merits of the two recording methods and their application across our research aims.

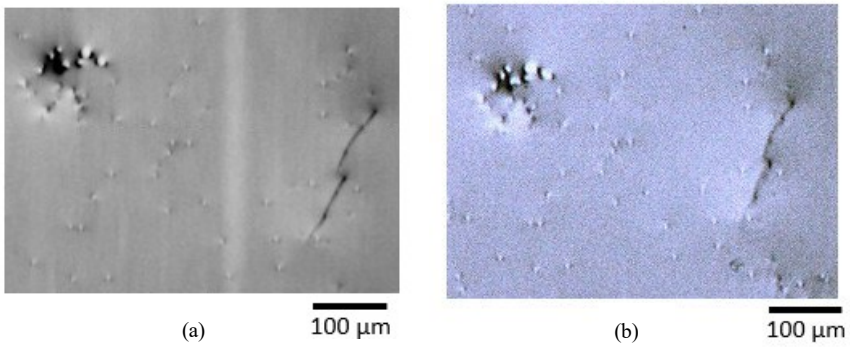

Figure 1 X-ray topography images (a): by X-ray camera. (b): by nuclear emulsion plate.

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References

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