High-Resolution Synchrotron X-ray Topography of 4H-SiC Wafers Using a Wide-Field Detector at SPring-8 BL16B2

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Silicon carbide (SiC) is considered a promising semiconductor material for power devices due to its excellent physical properties, such as a wide band gap, a high breakdown electric field, and superior thermal conductivity. Although SiC-based devices have already been commercialized, further cost reduction is crucial to accelerate widespread adoption. This requires larger wafers and higher device yield, making accurate wafer-level evaluation of remaining crystal defects essential.

Synchrotron X-ray topography (XRT) is known as a highly accurate method for evaluating crystal defects in SiC. However, traditional nuclear emulsion plates commonly used as two-dimensional detectors make wafer-scale measurements difficult. Recently, X-ray imaging cameras have undergone rapid development, and detectors with sub-micron pixel sizes are now available. Nevertheless, their typical field of view remains limited to approximately 1 mm, rendering them unsuitable for assessing large-area samples such as semiconductor wafers.

To overcome this limitation, we have developed an X-ray topography system that offers both a wide field of view and high spatial resolution. This system has been installed at SPring-8 BL16B2[1]. In this paper, we report the application of this system to the evaluation of 4H-SiC wafers.

Figure 1 shows an example of XRT measurements on a 4H-SiC wafer. The measurements were conducted using 8.5 keV X-rays and the 1 1 -2 8 reflection. The two-dimensional detector used comprises 14192 × 10640 pixels, with an effective pixel size of 0.72 μm and a field of view of 10 × 8 mm. The stripe-like contrast running parallel to the g-vector (indicated by the arrow) arises from non-uniformity in the incident X-rays and is unrelated to the sample. The dark, dot-like contrasts correspond to Treading Screw Dislocations (TSDs), which are clearly visualized. In addition to TSDs, linearly arranged Treading Edge Dislocations (TEDs) are also observed. An enlarged view confirms that individual TEDs can be distinctly resolved. Despite the submicron resolution, clear contrast was obtained with an exposure time of only 10 seconds. At the presentation, we will also show measurement results from the entire wafer and from experiments conducted in transmission geometry.

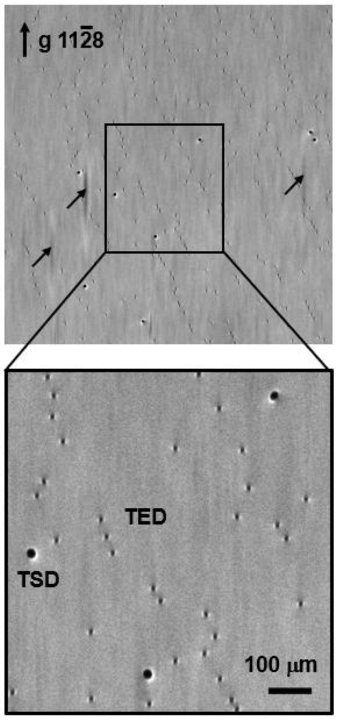

Fig. 1 Synchrotron XRT image of a 4H-SiC wafer measured at SPring-8 BL16B2.

This research was partially supported by the SACLA/SPring-8 Basic Development Program.

[1] T. Shimura *et al.*, The 86th JSAP Autum Meeting 2025, submitted.