Evaluation of crystal quality of 3C-SiC layers grown on vicinal carbon-face 4H-SiC substrates with various off-orientations and off-angles

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Growth of high-quality 3C-SiC layers on C-face 4H-SiC substrates is crucial for realizing SiC-based high electron mobility transistors (HEMTs) [1]. One major challenge during growth is twin formation in the 3C layer [2]. We have reported that a 3C-SiC layer with a lower twin density can be grown on a step-controlled substrate [1], where a vicinal 4H-SiC substrate misoriented towards the <1-100> direction was utilized. To further examine whether the method is applicable to device fabrication, the impact of the off-orientation and off-angle on 3C-SiC quality needs to be investigated. For this purpose, we measured X-ray rocking curves (XRCs) for 3C-SiC layers grown on vicinal C-face 4H-SiC substrates with various off-orientations and off-angles.

We prepared a C-face 4H-SiC substrate with a convex surface, where the off-orientation continuously varied in the circumferential direction and the off-angle increased continuously from about 0° to 0.14° in the radial direction. The substrate had a fan shape and was used for 3C-SiC growth. A 1-μm-thick 3C-SiC layer was grown on the 4H-SiC substrate using a hot-wall CVD apparatus. The crystal quality of the grown layer was evaluated based on the full width at half maximum (FWHM) of the 3C-SiC 111 XRC peak. The area irradiated by X-rays in each measurement was 2×2 mm.

Figure 1 shows a photograph of the 3C-SiC layer with the evaluation positions indicated. Figure 2 plots the XRC FWHM versus the azimuthal angle from the [11-20] direction for three off-angles. The FWHM profiles have a minimum in an angular range of about 30 to 40°, which roughly corresponds to the [01-10] direction, with little effect of the off-angle. Thus, the off-orientation of the substrate must be precisely controlled in the <1-100> direction to grow 3C-SiC with high crystal quality.

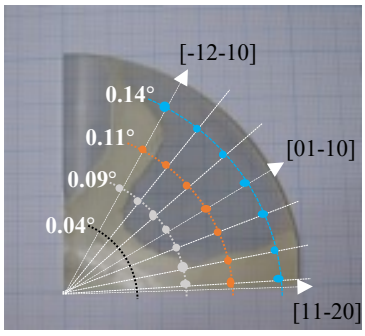

Fig. 1 Photograph of grown 3C-SiC layer. The colored points indicate the XRC measurement points. The angles in white are the off-angles determined from the step width measured by atomic force microscopy.

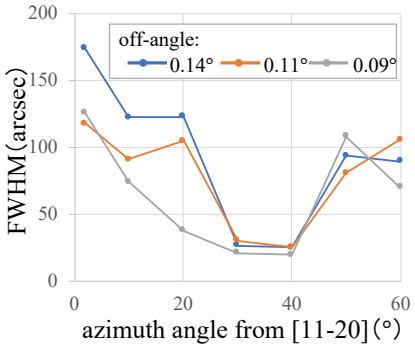

Fig. 2 Dependence of FWHM of 3C-SiC XRC on off-orientation for different off-angles.

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References

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