Two-Inch High-Quality (001) Diamond Heteroepitaxial Growth on Sapphire Substrate

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Diamond semiconductors, with their ultra-wide bandgap of 5.47 eV and superior physical properties compared to SiC and GaN, are promising candidates for next-generation high-power electronic devices. However, the development of inch-scale diamond wafers remains a critical challenge.

In this study, we successfully grew high-quality diamond (001) layers with a diameter of two inches on a-plane (11-20) sapphire substrates misoriented by 7° towards the [1-100] direction. The use of misoriented substrates enabled step-flow growth, which effectively released tensile strain in the diamond layer. As a result, the diamond layer naturally delaminated from the substrate without cracking, even without employing the microneedle technique [1].

The grown diamond layers exhibited exceptional crystallinity, with full-width at half-maximum (FWHM) values of 98.35 arcsec for the (004) and 175.3 arcsec for the (311) X-ray rocking curves—both representing the lowest values reported to date. Furthermore, the curvature radii of the diamond (004) plane were measured to be 99.64 cm in the [1-100] direction and 260.21 cm in the [0001] direction of the substrate, indicating the highest flatness achieved so far.

In addition, surface roughness, a key factor influencing device performance and integration, was significantly reduced by mechanical polishing. AFM measurement results revealed atomically flat surface. This improvement in surface morphology enhances the potential for high-quality diamond wafers and reliable device fabrication.

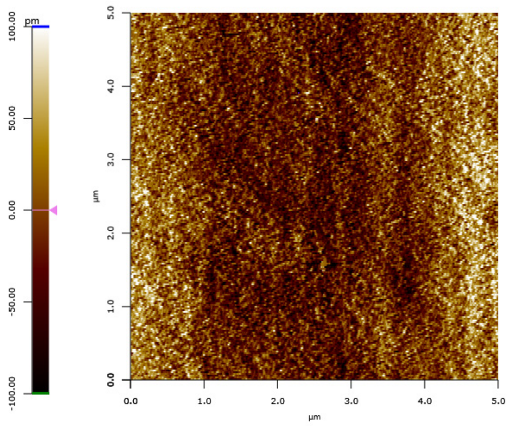

Figure 1. AFM image of diamond surface after polishing. Surface roughness Sa was 0.03 nm.

Reference

[1] S.-W. Kim et al., Appl. Phys. Lett. 117, 202102 (2020).