Large-Domain Bi_2O_2Se Nanosheets Grown on Sapphire via Chemical Vapor Deposition

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Abstract. The rapid advancement of flexible electronics requires materials that deliver high electrical and optoelectronic performance while maintaining strong mechanical durability. Two-dimensional (2D) bismuth oxyselenide (Bi_2O_2Se) has emerged as a promising candidate due to its high carrier mobility and excellent optoelectronic properties. However, realizing large-area, high-quality Bi_2O_2Se nanosheets suitable for device fabrication remains a challenge. Here, we report the growth of high-quality, large-domain Bi_2O_2Se nanosheets on c-plane sapphire substrates via chemical vapor deposition. By optimizing growth temperature, precursor weight, and growth time, well-defined nanosheets with lateral domain sizes up to 98 μm and thicknesses ranging from a few layers to the bulk regime are achieved. The smooth and chemically inert sapphire surface suppresses excessive nucleation while promoting adatom diffusion, enabling preferential lateral growth. Optical microscopy and scanning electron microscopy reveal uniform, clean nanosheets with minimal parasitic deposition. Atomic force microscopy confirms precise thickness control, while Raman spectroscopy shows a characteristic A_{1g} mode (~160–166 cm^{-1}). X-ray diffraction shows dominant (00l) reflections from tetragonal Bi_2O_2Se, confirming a strong out-of-plane orientation, and X-ray photoelectron spectroscopy verifies the expected chemical states, confirming high chemical purity. These findings establish a reliable and scalable approach for synthesizing device-quality Bi_2O_2Se, and confirm sapphire as an optimal substrate for large-area 2D integration.

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